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Effect of Pro.Sol, Folicist and Cultivar on Leaf Nutrients of Olive (*Olea europaea*L.) Transplants

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Abstract

This study was carried out during the growing season (2014) at Bakrajo Nursery Station/ Sulaimani, Kurdistan Region-Iraq. Two years old, uniform and healthySorani and Picual olive cultivars transplants were grown in 5 kg pots filled with soil in order to investigate the effect of three concentrations of Pro.Sol (0,100 and 200)$mg.l^{-1}$ and three Folicist concentrations (0, 60 and 120) $mg.l^{-1}$as well as their interactions on leaf mineral contents of the two olive cultivar transplants. The results showed that 120 $mg.l^{-1}$folicist significantly affected the leaf (N, K, Ca and Fe), while 60 $mg.l^{-1}$significantly affected the leaf P content. However, 100$mg.l^{-1}$Pro.Sol affected significantly leaf (N, P and Fe), whereas 200 $mg.l^{-1}$affected leaf (N,K and Ca) contents. However, Sorani cultivar was superior significantly to the Picual with regard to (N, K and Fe) leaf contents while the last cultivar was superior significantly to the first with respect to (P and Ca) contents.

Introduction

Olea europaea L. is a member of the Oleaceae which comprises 600 species in 25 genera. However, only (*Olea europaea* L.) produces edible fruit, the olive fruit is a drupe [2, 17].

The cultivated olive (*Olea europaea*L., Oleaceae) is a long-lived, evergreen tree native to the Mediterranean basin*[15]*. It is valued for its fruit and oil. Mediterranean countries account for around 95% of the world's olive cultivation (8,702,000 ha). In these regions, 90% of the olive trees are grown for the oil [25]. Oleaceae is a medium-sized fruit tree distributed in all continents except the Antarctic, from northern temperate to southern subtropical regions and from low to high elevations [26]. Olive growing is also of great importance in the other Mediterranean countries in addition to Cyprus, France, Palestine, Lebanon and Yugoslavia. Major producing countries are Algeria, Greece, Jordan, Morocco, Portugal, Syria, Tunisia and Turkey [8].

In Egypt, the cultivated area with olive increases gradually and reached 158,000 feddan (one feddan=4200 m^2) [18]. Picual olive cv. was introduced from Spain to Egypt and considered one of the best and main widely planted cultivar. Sorani is known as rich oil content olive cultivar, grown under rain-fed conditions in Syria and considered one of the relatively late fruit ripening cultivar. The two mentioned cultivars have been introduced recently into Iraqi Kurdistan region.

It is expected that ancestors of currently grown olive cultivars have been domesticated in the mountainous territory south the Caucasus, covering todayś Syria, western Iran, eastern Turkey, Lebanon, Palestine and Northern Iraq [7] and has been cultivated in the Mediterranean for over 4000 years.

[27] studied mineral nutrient uptake by Coratina cultivar olive trees for six years from the date of planting under irrigated condition and they noticed that the nutrient demand was relatively steady during the early years of the plant age. The demand for P and K was minimal during the first four years after planting and could have been fulfilled by P and K exist naturally in the soil. Low doses of N should be applied. [20] found

that young olive trees benefit from low levels of NPK and N alone, additional fertilizers did not havesignificant effect on the growth. However, NPK is considered essential for plant growth and development. 16 g NPK and 32 g N per plant resulted the highest shoot and root dry weight which may be due to the role of nitrogen in increasing dry matter accumulation in roots and decreasing shoot: root ratio. [19] reported that organic wastes fertilization did not lead to any significant increase in olive mineral leaf contents in the first year trial. [12] observed that N and K contents in leaf of Picual cultivar increased significantly with applying 100% organic fertilizer (poultry manure) but no significant difference was noticed in leaf P content during both seasons. They also found that some treatments gave the highest Fe leaf content in both seasons while Mn and Zn recorded the highest only in the second season. [9] mentioned that under field conditions, foliar application of leonardite [a rich source of Humic acid (up to 90%)] promoted shoot growth as well as accumulation of K, B, Mg, Ca and Fe in leaves. However, when the contents of both N and K in leaves were below the threshold limit for the sufficiency range, foliar application of humic substances was ineffective to promote accumulation of nutrients in the leaves.

The objectives of the study were:

1- Improvement of transplant leaf nutrient contents.
2- Comparison between Pro.Sol and Folicist sprays through their effects on leaf nutrients.
3- Impact of the two olive cultivars on transplant leaf nutrient contents.

Materials and methods

The study was carried out during 2014growing season at Bakrajo nursery station / Sulaimani, Iraqi Kurdistan region located 15km southwestern of the city with $35^0 55$ N and $45^0 35$ E and 760 meters above sea level. Two years old, uniform and healthy Sorani and Picual olive cultivars transplants were planted in 5 kg pots filled with soil on May 23, 2014 [22].

Factorial experiment of three factors: cultivars with two levels (sorani and picual), pro.sol and folicist with three concentration levels (0,100,200 and 0, 60, 120) $mg.l^{-1}$for both of them was used consequently in a randomized complete block design with three replicates, each replicate was assigned with a treatment combination (Cultivar × Pro.sol × Folicist) consisted of five transplants grown in five pots and the number of treatment combinations was eighteen (total number was 54). The transplants were sprayed twice; first on May 25 and the other, a month later (June 25). The data were taken on November 25, 2014, they were then tabulated and subjected to analysis of variance using SAS system, [23]. Treatment means were compared according to Duncan s multiple range test at 0.05 level.

**Pro.Sol 20-20-20 (U.S.A. product) contains 20% total N, 20% available phosphate (P_2O_5), 20% soluble potash (K_2O) in addition to0.020%boron(B), 0.050%copper (Cu), 0.100% iron (Fe),0.05%manganese (Mn), 0.0005%molybdenum (Mo) and 0.05% zinc (Zn).*

**Folicist(Italy product) contains Acetyl-thioproline (ATCA), Folic acid, Glycine betaine, Ascophyllumnodosum seaweed extract, Alfalfa extract*

Parameters:

The following measurements were recorded:

Leaf Mineral content:

Twenty five fully expanded leaves were taken from the middle of the shoots of each cultivar, washed thoroughly with tap water and then treated with 0.1% HCl for 20 seconds. The samples were rinsed with distilled water and dried at 70^0C until weight constant after 2-3 days*[3 and 11]*.

0.5 g of the dry matters of leaves were used from each experimental unit and digested with diacid H_2SO_4:$HClO_4$ (4:1) *[3 and 24]*. Methods used for determination of some nutrients in the leaves were shown below (5):

1-Nitrogen: Micro Kjeldahl.
2-Phosphorus: colorimetric using Spectrophotometer Pharmacia LKB.
3-Potassium: flame photometer.
4-Calcium and Iron: Atomic Absorption Spectrophotometer.

RESULTS

1- Leaf Nitrogen%

Table (1) shows no significant differences between 100 and 200 (mg.l^{-1})Pro.sol in respect to transplant leaf N content and both were superior significantly to the control, 120 (mg.l^{-1}) folicist surpassed significantly both 60 (mg.l^{-1})folicist and the control, also 60 (mg.l^{-1})folicist was superior significantly to the control. Sorani transplants exceeded significantly that of picual.

Sorani combined with 100 (mg.l^{-1})prosol dominated all other cultivar × Pro.sol combinations except picual combined with 200 (mg.l^{-1})Pro.sol with Sorani interacted with 120 (mg.l^{-1}) folicist *was* superior significantly to all other synonymous cultivar × folicit interactions. 100 (mg.l^{-1}) prosol combined with 120 (mg.l^{-1}) folicist texceeded significantly all other prosol × folicit combinations.

Finally, sorani transplants interacted with 100 (mg.l^{-1})Pro.sol and 120(mg.l^{-1})folicist was superior significantly to the rest of the three way interactions.

Table (1): Effect of Pro.sol, Folicist and cultivars with their interactions on transplants leaf N%

Cultivars	Folicist($mg.l^{-1}$)	Pro.Sol($mg.l^{-1}$) 0	100	200	Cv.×Foli.	Cultivars
Sorani	0	0.920 d-g	0.790 gh	0.813 f-h	0.841 d	1.024 a
	60	0.903 d-g	1.063 b-d	1.097 bc	1.021 c	
	120	1.117 b	1.423 a	1.093 bc	1.211 a	
Picual	0	0.870 e-g	0.777 gh	1.000 b-e	0.882 d	0.964 b
	60	0.697 h	0.953 c-f	1.063 b-d	0.904 d	
	120	1.063 b-d	1.100 bc	1.157 b	1.107 b	
Pro.Sol		0.928 b	1.018 a	1.037 a	Folicist	
Cv. × Pro.	Sorani	0.980 c	1.092 a	1.001 bc		
	Picual	0.877 d	0.943 cd	1.073 ab		
Foli. × Pro.	0	0.895 de	0.783 f	0.907 d	0.862 c	
	60	0.800 ef	1.008 c	1.080 bc	0.963 b	
	120	1.090 bc	1.262 a	1.125 b	1.159 a	

Means within columns or rows followed with the same letters are not different significantly from each other according to Duncan's multiple range test at 5% level.

2- Leaf Phosphorus%

Table (2) indicates that both 100 (mg.l^{-1})prosol and the control were superior significantly to 200 (mg.l^{-1})prosol with regard to transplant leaf P content. 60 (mg.l^{-1}) folicist dominated both 120 (mg.l^{-1}) folicist and the control. Picual surpassed significantly sorani cultivar.

No significant differences were found among most of the combinations between cultivars and pro.sol level interactions and they were superior significantly to sorani cultivar interacted with 200 (mg.l^{-1})pro.sol. Picual cultivar combined with 60 (mg.l^{-1}) folicist gave the highest leaf P percentage which exceeded significantly sorani transplants combined with both 0 and 120 (mg.l^{-1}) folicist. 100 (mg.l^{-1}) pro.sol combined with 60 (mg.l^{-1}) folicist gave the highest leaf P content which were superior significantly to most other prosol × folicist combinations.

Finally, sorani cultivar interacted with 100 (mg.l^{-1}) prosol and 60 (mg.l^{-1}) folicist recorded the highest value which was superior significantly to most three way interactions.

Table (2): Effect of Pro.sol, Folicist and Cultivars with their interactions on transplantsleaf P%.

Cultivars	Folicist$(mg.l^{-1})$	Pro.Sol$(mg.l^{-1})$ 0	100	200	Cv. ×Foli.	Cultivars
Sorani	0	0.355 b-d	0.342 b-d	0.294 cd	0.331 bc	0.338 b
	60	0.386 ab	0.439 a	0.301 cd	0.375 a	
	120	0.334 b-d	0.302 cd	0.286 d	0.307 c	
Picual	0	0.334 b-d	0.353 b-d	0.391 ab	0.359 ab	*0.369 a*
	60	0.381 ab	0.409 ab	0.370 a-c	0.387 a	
	120	0.386 ab	0.393 ab	0.303 cd	*0.361 a*	
Pro.Sol		*0.363 a*	0.373 a	0.324 b	Folicist	
Cv.× Pro.	Sorani	0.358 a	0.361 a	0.294 b		
	Picual	*0.367a*	0.385 a	0.355 a		
Foli. × Pro.	0	0.345 bc	0.348 b	0.343 bc	0.345 b	
	60	0.384 ab	0.424 a	0.335 bc	0.381 a	
	120	*0.36 ab*	0.348 b	0.294 c	*0.334 b*	

Means within columns or rows followed with the same letters are notdifferent significantly from each other according to Duncan's multiple range test at 5% level.

The interactions between folicist and cultivar had significantly increase in phosphorus content % the picual transplant when treated with 60mg Folicist.L^{-1} gave the highest value (0.386%) and the lowest value (0.307%) in Sorany transplant when treated with 120mg Folicist.L^{-1} .

3- Leaf K %

No significant differences were noticed among the three levels of prosol in respect to transplant leaf K content, no significant differences were observed between 120 and 60 $(mg.l^{-1})$ folicist, while both levels were superior significantly to 0 $(mg.l^{-1})$ folicist, also no significant differences were recorded between the two olive cultivars. Sorani transplants interacted with 200 $(mg.l^{-1})$ prosol resulted in the greatest value but with no significant differences with most cultivar transplants combined with pro.sol levels.

Table (3): Effect of Pro.Sol, Folicist and Cultivars with their interactions on transplantsleaf K%

Cultivars	Folicist$(mg.l^{-1})$	Pro.Sol$(mg.l^{-1})$ 0	100	200	Cv.×Foli.	Cultivars
Sorani	0	0.030 b	0.029 ab	0.043 ab	*0.034*ab	0.038 a
	60	0.040 ab	0.037 ab	0.047 ab	0.041 ab	
	120	0.030 b	0.040 ab	0.047 ab	0.039 ab	
Picual	0	0.037 ab	0.033 ab	0.030 b	0.033 b	0.038 a
	60	0.040 ab	0.037 ab	0.030 b	0.036 ab	
	120	0.040 ab	0.050 a	0.043 ab	0.044 a	
Pro.Sol		0.036 a	0.038 a	0.040 a	Folicist	
Cv. × Pro.	Sorany	0.033 b	*0.035ab*	0.046 a		
	Picual	0.039 ab	0.040 ab	0.034 b		
Foli.×Pro.	0	0.034 a	*0.031 a*	0.037 a	0.034 b	
	60	0.040 a	0.037 a	0.038 a	0.038 ab	
	120	0.035 a	*0.045 a*	0.045 a	0.042 a	

Means within columns or rows followed with the same letters are not different significantly from each other according to Duncan's multiple range test at 5% level.

Picual combined with 120 $(\mathrm{mg.l^{-1}})$ folicist gave the highest value but with no significant differences with most similar combinations except picual transplants combined with 0 $(\mathrm{mg.l^{-1}})$ folicist. On the other hand, no significant differences were obtained among the various interactions between pro.sol and folicist. Finally, picual transplants combined with100 $(\mathrm{mg.l^{-1}})$ prosol and 120 $(\mathrm{mg.l^{-1}})$ folicist exhibited the greatest value which was not different significantly from most other similar combinations.

4- Calcium %

Table 4 indicates that 200 $(\mathrm{mg.l^{-1}})$ pro.sol dominated significantly both 100 $(\mathrm{mg.l^{-1}})$ and the control (0 $\mathrm{mg.l^{-1}}$) prosol with regard to Ca%. 0 $(\mathrm{mg.l^{-1}})$folicist (control) gave the highest value which was not different significantly from 120 $(\mathrm{mg.l^{-1}})$ folicist while both were superior significantly to 60$(\mathrm{mg.l^{-1}})$ folicist. Picual cultivar was superior significantly to sorani.

Picual interacted with 200 $(\mathrm{mg.l^{-1}})$ prosol gave the greatest value which was not different significantly from picual interacted with 0 $(\mathrm{mg.l^{-1}})$prosol, whereas it was different significantly from the other cultivar × prosol interactions. No significant differences were found among most cultivar × folicist combinations and they were superior to sorani combined with 60 $(\mathrm{mg.l^{-1}})$ folicist which recorded the lowest value (0.455%). Interactions of 200 $(\mathrm{mg.l^{-1}})$pro.sol and control folicist resulted in the highest value which was superior significantly to other similar interactions except 200 $(\mathrm{mg.l^{-1}})$ pro.sol interacted with 120 $(\mathrm{mg.l^{-1}})$folicist. Finally, sorani cultivar combined with 200$(\mathrm{mg.l^{-1}})$ prosol and 0$(\mathrm{mg.l^{-1}})$ folicist recorded the greatest value that was superior significantly to most other three way combinations.

Table (4): Effect of Pro.sol, Folicist and Cultivars with their interactions on transplants leafCa%

Cultivars	Folicist$(mg.l^{-1})$	Pro.Sol$(mg.l^{-1})$			Cv. ×Foli.	Cultivars
		0	100	200		
Sorani	0	0.556 bc	0.556 bc	0.730 a	0.614 a	0.545 b
	60	0.453 c	0.467 c	0.446 c	0.455 b	
	120	0.603 ab	0.543 bc	0.554 bc	0.567 a	
Picual	0	0.568 bc	0.559 bc	0.618 ab	0.582 a	0.603 a
	60	0.665 ab	0.541 bc	0.654 ab	0.620 a	
	120	0.553 bc	0.566 bc	0.701 a	0.606 a	
Pro.Sol		0.566 b	0.539 b	0.617 a	Folicist	
Cv. × Pro.	Sorani	0.537 bc	0.522 c	0.577 bc		
	Picual	0.595 ab	0.555 bc	0.658 a		
Foli. × Pro.	0	0.562 bc	0.558 bc	0.674 a	0.598 a	
	60	0.559 bc	0.504 c	0.550 bc	0.538 b	
	120	0.578 bc	0.555 bc	0.627 ab	0.587 a	
Means within columns or rows followed with the same letters are not differentsignificantlyfrom each other according to Duncan's multiple range test at 5% level.						

5- Iron $(mg.l^{-1})$

Control [0 $(\mathrm{mg.l^{-1}})$] prosol obtained the highest value iron% which was not different significantly from 100 $(\mathrm{mg.l^{-1}})$ prosol but surpassed significantly 200 $(\mathrm{mg.l^{-1}})$ prosol. 120 $(\mathrm{mg.l^{-1}})$ folicist was superior significantly to both 60 $(\mathrm{mg.l^{-1}})$ folicist and the control. Sorani cultivar dominated significantly picual transplants.

Sorani combined with 100 $(\mathrm{mg.l^{-1}})$ prosol gave the highest value and superior significantly to the other cultivar × pro.sol combinations. Similarly, sorani transplants interacted with 120 $(\mathrm{mg.l^{-1}})$ folicist recorded the highest value with no significant differences compared to sorani interacted with 60 $(\mathrm{mg.l^{-1}})$ folicist while both were superior significantly to the other cultivar × folicist interactions. Control prosol combined

with 120 $(mg.l^{-1})$ folicist resulted in the highest value which dominated significantly the other prosol × folicist combinations except the combination between the control of both pro.sol and folicist.
Finally, sorani transplant cultivar combined with 100 $(mg.l^{-1})$ prosol and 60 $(mg.l^{-1})$ folicist gave the greatest value which was superior significantly to other cultivar × prosol × folicist combinations except sorani transplants combined with both 100 $(mg.l^{-1})$ pro.sol and 120 $(mg.l^{-1})$ folicist.

Table (5): Effect of Pro.sol, Folicist and Cultivars with their interactions on transplantsleaf Fe$(mg.l^{-1})$

Cultivars	Folicist$(mg.l^{-1})$	Pro.Sol$(mg.l^{-1})$ 0	100	200	Cv. × Fol.	Cultivars
Sorani	0	225.233 f-h	230.513 e-h	230.800 e-h	228.849 c	261.253 a
	60	245.600 d-f	295.300 a	278.267 a-c	273.056 a	
	120	287.767 ab	292.100 a	265.700 b-d	281.856 a	
Picual	0	293.867 a	266.367 b-d	208.900 hi	256.378 b	232.419 b
	60	207.933 hi	213.967 h	219.600 gh	213.833 d	
	120	254.933 c-e	186.133 i	240.067 e-g	227.044 c	
Pro.Sol		252.556 a	247.397 ab	*240.556*b	Folicist	
Cv.× Pro.	Sorani	252.867 b	272.638 a	258.256 b		
	Picual	252.244 b	222.156 c	222.856 c		
Foli. × Pro.	0	259.550 ab	248.440 bc	219.850 e	242.613 b	
	60	226.767 de	254.633 bc	248.933 bc	243.444 b	
	120	271.350 a	239.117 cd	252.883 bc	254.450 a	

Means within columns or rows followed with the same letters are not different significantly from each other according to Duncan's multiple range test at 5% level.

Discussion

The study exhibited that some levels of prosol especially 100 $(mg.l^{-1})$ affected significantly leaf (N, P and Fe) % , also some levels of folicist such as 60 $(mg.l^{-1})$ influenced significantly leaf (N, K, Ca and Fe)%. This may be due to the role of pro.sol in increasing cation exchange capacity which affects consequently the retention and availability of nutrients or the mentioned fertilizer may be of certain effect on hormonal balance in the plant or it may have both effects[6]. Furthermore, folicist promotes N uptake as well as enhancing photosynthesis in apple trees. Nitrogen is known as essential component of many compounds in the plant such as chlorophyll, nucleotides, proteins, alkaloids, enzymes, hormones and vitamins [16].When the N content in the plant is beyond optimum, it will result in promoting the growth and development of the above ground organs with relatively poor root growth. Synthesis of proteins and formation of new tissues are also stimulated and thus causing abundant dark green (high chlorophyll) tissues of soft consistency. This increases the risk of lodging and reduces the plants resistance to harsh climatic conditions [1, 4, 21].

Cultivars showed to have effects on leaf nutritional state, for example sorani cultivar exceeded significantly picual contents in N and Fe while picual dominated significantly sorani transplants in P and Ca contents. This may be ascribed to the differences in genotype characteristics which may affect root growth, nutrient absorption efficiency and photosynthesis [13]. Also the response of different cultivars to the local environmental conditions will vary according to the genetic variations among the cultivars [10, 14].

Conclusions

The following conclusions may be obtained:

1- Some levels of both pro.sol and folicist resulted in improving some nutrient contents for both sorani and picual transplants olive cultivars.

2-The two cultivars were different in their contents of leaf nutrients.

3- Generally, the interactions between the two cultivars with the high levels of both pro.sol and picual gave better improvements in the transplants leaf nutrients.
4-High levels of folicist resulted in improving transplants leaf nutrients for both cultivars.

Recommendations

According to the results obtained, the following recommendations can be made:
1-Further studies concerning other cultivars as well as levels of both pro.sol and folicist should be conducted.
2-Other organic fertilizers rather than the two mentioned should be investigated.
3-Various dates of spraying to the vegetative growth and or soil application for both pro.sol and folicist had better to be used in order to appoint the best date for their usages.
4-Anatomical studies for the transplants should be evaluated in order to get familiar with the effect of both organic fertilizers on the anatomy of both cultivars.

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