Impact of feldspar and liquid Bio-fertilizer on fruit quantity and quality of olive trees Picual cv.

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Abstract. The present investigation was carried out in two consecutive seasons (2022 and 2023) on eight-year-old olive trees "Picual" cv., planted at 4×6m apart around (420 trees / Fed). Trees irrigated with drip irrigation system, at a private orchard. The experiment included 3 rates of Feldspar as source of naturel potassium at 2, 4, and 6 kg/ tree and potassium dissolving bacteria as liquid Bio-fertilizers supplemented (25 ml) at two or three times to investigate the yield and fruit quality of Picual olive trees. Data indicated that the yield of Picual olive trees fertilized with feldspar and liquid Bio-fertilizer increase to 70% over control. Picual olive trees treated with (4 kg Feldspar + 25 ml liquid Bio-fertilizer at three doses) achieved the highest increase in the yield for the both seasons and also gave the highest fruit weight, volume and fruit flesh/stone ratio of olive trees Picual cv. Concerning leaf nitrogen percentage (N%) The highest percentage of N% for the both years was recorded by treatment (6 kg Feldspar + 25 ml liquid Bio-fertilizer at three doses). With respect to leaf phosphor and potassium percentage, it could be seen that most treatments gave more or less results similar to the control.

1 Introduction

The olive tree (*Olea europaea* L.) has been cultivated for approximately 6000 years in Mediterranean countries where about 95% olive resources are located. The Mediterranean climate, which is defined by hot, dry summers and relatively mild winters, dictates its habitat. The proverbial adaptation of the olive tree to the Mediterranean climate is the reason why it is basically a dry-formed crop [1].

According to statistical of Food and Agriculture Organization [2], the world area cultivated with olive trees is about 12763184 ha and the world production of olive fruits is 23640307 tons. About 932927 tonnes of olives were produced in Egypt from acreage of 100826 ha; most of them are processed primarily as table olives.

Potassium is essential for all plant growth and reproduction processes, such as translocation of photosynthesis, protein synthesis, water use and stress tolerance, ion balance regulation, and many other processes [3]. Potassium is required for the activation of

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more than 80 different enzymes [4, 5, 6, 7]. Potassium is particularly important for large quantities of production. The high demand for this element can be attributed to its crucial role in the synthesis of starch and sugars. Additionally, potassium decreases freezing damage, while this acts as a solute in cell cytoplasm.

In Egypt, to optimise crop yields per unit area and compensate the decline in K content in soils due to crop uptake, runoff, leaching, and soil erosion, a large quantity of K-chemical fertilisers should be applied [8]. The high prices of these fertilizers are also responsible for the increased cost of production and pollution of the environment.

Potassium is one of the macronutrients and this element is the most abundantly absorbed for the most of plants and can be found in the soil in a variety of forms. Potassium in soluble and exchangeable forms is essential for plant uptake. Because K-solubilizing bacteria can transform potassium from insoluble to soluble forms, employing them as biofertilizers is a sustainable way to improve plant nutrition, growth, root development, and competitiveness while reducing the need for potassium-containing chemical fertilisers [9].

There are strong evidences that soil bacteria are able to convert soil K into forms available for plants [10, 11, 12]. Insoluble K dissolves with the release of low molecular weight organic acids [3].

The use of potassium-releasing bacteria as biofertilizers has been proposed as a sustainable solution to increase plant growth, root growth, nutrition and responses to external stress factors [14]. Furthermore, biofertilizers are important for the humus formation in the soil and the cycling of other minerals linked to organic matter [15]. Currently, these bacteria are widely used in biological K-fertilizers [16, 17]. Bacillus edaphicus and Bacillus mucilaginosus are examples of K-solubilizing bacteria that have been demonstrated to enhance K availability in soils and K content in plants [18, 19, 16].

Finally, biofertilization is an alternative method for fertilizing most plants. Furthermore, bio-fertilizer minimizes the use of chemical fertilizers and decreases the negative impacts they cause to the environment and human health [20, 21].

This study aims to replace costly chemical potassium fertilisers with feldspar, a natural potassium fertiliser that is the least expensive resource for supplying potassium to Picual olive trees.

2 Materials and methods

This experiment was conducted in a private olive orchard at Cairo-Ismailia Desert Road, Ismailia governorate, Egypt through two successive seasons (2022 and 2023). The experiment was conducted on 8 years old olive trees of Picual cv., planted at 4 X 6 m apart grown in sandy soil, under drip irrigation system. The selected trees were received the common horticultural practices. The water and soil were analyzed according to (Wilde et al 1979) as presented in Table (1) and Table (2).

Table 1. Analysis of the orchard well water.

	Soluble salts		Cations			anions			
parameters	PH	EC	Ca^{+2}	Mg^{+2}	K^{+}	HCO_3^{-}	CO_3^{-2}	Cl^{-}	SO_4^{-}
Unit		Ds/m	Meq/L	Meq/L	Meq/L	Meq/L	Meq/L	Meq/L	Meq/L
Sample	7.84	6.27	15.0	10.50	0.20	1.9	-	43.5	22.9

Table 2. Analysis of chemical properties of the orchard soil.

	Depth parameters of simple (cm)		
Parameters	Superficial sample	30 cm	60 cm
pH (1:2.5)	8.19	8.58	8.62
EC(dSm-1) (1:5)	1.23	0.97	0.45

Soluble cations (meq/l)			
Ca++	2.7	4.5	1.8
Mg++	1.3	1.5	0.6
Na+	7.5	3.6	2.0
K+	1.0	0.7	0.4
Soluble anions (meq/l)			
CO3=	-	-	-
HCO3	1.0	0.9	0.6
Cl−	10.0	2.8	2.6
SO4=	1.5	6.6	1.6
N (ppm)	53.3	36.18	19.04
P (ppm)	22.4	19.5	0.12

To investigate this experiment, twenty-one olive trees (seven treatments each treatment obtained three replicates with one tree for each replicate) trees were selected as mostly uniform in vigorous growth, healthy, fruitful, no visual nutrient deficiency symptoms and were subjected to the same agriculture practices adopted in the farm program.

Feldspar was added by rate (2, 4 or 6 kg per tree / year); compost used as organic fertilizer which added by rate of 2 Kg compost (2:3 % N) + 0.5 kg agricultural sulfur per tree for all treatments. All applications added by digging and burying in the soil at the last week of December. Biofertilizers (Microbial cultures) consisted of liquid cultures of Bacillus Circulans bacteria kindly provided by the microbiology department, agricultural and biological institute, National Research Centre. Liquid Bio-fertilizers was used as potassium releasing bacteria which add to olive trees for two times at January and March or add for three times at (January, March and May) during the season. The dose of liquid Bio-fertilizers used each time was 25 ml.

The experiment including the following treatments:

T1: untreated (control)
T2: 2 kg feldspar + bacteria at two times
T3: 2 kg feldspar + bacteria at three times
T4: 4 kg feldspar + bacteria at two times
T5: 4 kg feldspar + bacteria at three times
T6: 6 kg feldspar + bacteria at two times
T7: 6 kg feldspar + bacteria at three times

Measurements:

1- Yield: At maturity on the second week of October in each season, all fruits / tree were collected and weighted which gave the average yield/tree (kg).
2- Fruit quality: For each season, sample of 30 fruits / tree were randomly taken for the evaluation of physical fruit properties: Fruit weight (g), fruit volume(cm^3), flesh weight (g), stone weight (g), fruit length and diameter (cm) of olive trees Picual cv.
3- Leaf mineral content: Nitrogen, Phosphor and Potassium were determined. Nitrogen was determined by the Micro- Kjeldahlmethod [22], phosphorus was determined by the spectrophotometer [23] and potassium was determined by a flame photometer [24].

Statistical analysis

The obtained data were statistically analyzed by using the analysis of variance as reported by [25]. Means were differentiated by using Duncan's multiple range tests at 5 % [26].

3 Results and Discussion

Data presented in Table (3) revealed that all applied treatments increased significantly the yield of Picual olive trees as compared to control treatment. And it can be seen that the yield increase with the increase in the times of adding bacteria, so that adding bacteria for

three times was better than adding bacteria twice for the same dose of feldspar. The highest increase in the yield for the both years was recorded by treatment (4 kg Feldspar + 25 ml bacteria at three doses) followed by treatment (4 kg Feldspar + 25 ml bacteria at two doses), and these increase in the first season reached about (67.3 and 52.7% respectively) compared with control while in the second year were (75 and 60% respectively).

Table 3. Effect of feldspar and liquid Bio-fertilizer on yield, fruit weight and fruit volume of olive trees Picual cv. in 2022 and 2023 seasons.

Treatments	Yield (kg/tree)		Fruit weight (g)		Fruit volume(cm^3)	
	2022	2023	2022	2023	2022	2023
T1	27.50 d	30.00 d	7.08 ab	7.25 bc	7.50 b	7.50 c
T2	33.00 c	37.00 cd	6.28 de	7.08 bc	6.50 d	7.17 c
T3	37.50 bc	42.00 bc	6.01 e	6.90 c	6.00 e	7.33 c
T4	42.00 ab	48.00 ab	7.69 a	7.92 a	8.00 a	8.17 ab
T5	46.00 a	52.50 a	7.79 a	8.23 a	8.00 a	8.33 a
T6	32.00 cd	35.00 cd	6.65 cd	6.99 c	7.00 c	7.67 bc
T7	35.00 c	39.00 c	6.86 bc	7.71 ab	7.00 c	8.17 ab

Mean in each column with similar letter(s) are not significantly different at 5 % level.

Regarding the effect of adding feldspar with bacteria on fresh weight and volume, in both seasons it can be noted that, treating Picual olive trees with 4 kg of feldspar + bacteria either twice or three times gave the highest significant values of fresh weight and volume compared to the control and other treatments. Where the average of fruit weight for both seasons reached from 7.17 g for control to 7.81 and 8.1 g for the two treatments respectively. While trees treated with 2 kg of Feldspar + bacteria (2 or 3 times) gave the lowest values of fresh weight and volume.

Data in Table (4) indicate that the fruit flesh weight of olive trees Picual followed a somewhat similar pattern to that of the fruit weight.

Concerning to the stone weight, treated Picual trees with (4 kg feldspar + bacteria at two times) and (6 kg feldspar + bacteria at three times) gave the highest increase in the stone weight compared to the control and other treatments. On the other hand the lowest increase observed when treated with 2 kg feldspar + bacteria at two times.

For the flesh/ stone ratio, It could be seen that the flesh/ stone ratio reached its highest value in trees treated with (2 kg feldspar + bacteria at two times) followed by trees treated with (4 kg feldspar + bacteria at three times).

Table 4. Effect of feldspar and liquid Bio-fertilizer on fruit flesh weight, stone weight and flesh/stone ratio of olive trees Picual cv. in 2022 and 2023 seasons.

Treatments	Fruit flesh weight (g)		Fruit stone weight (g)		Fruit flesh/stone ratio	
	2022	2023	2022	2023	2022	2023
T1	6.25 b	6.39 cd	0.83 c	0.86 bc	7.53 b	7.43 b
T2	5.61 cd	6.30 cd	0.67 d	0.78 d	8.35 a	8.09 a
T3	5.30 d	6.06 d	0.71 d	0.84 cd	7.47 b	7.37 b
T4	6.79 a	6.89 b	1.00 a	1.03 a	6.76 cd	6.68 cd
T5	6.86 a	7.31 a	0.83 c	0.92 b	8.26 a	8.00 a
T6	5.82 c	6.12 d	0.82 c	0.87 bc	7.06 c	6.94 c
T7	5.95 bc	6.65 bc	0.91 b	1.05 a	6.54 d	6.35 d

Mean in each column with similar letter(s) are not significantly different at 5 % level.

From data in Table (5) fruit length, diameter and fruit shape index (L/ D) did not seem to be much affected by treatments and it was not necessarily connected with mean fruit weight , also there was no definite trend in changes of fruit length, diameter and fruit shape index (L/ D ratio).

Table 5. Effect of feldspar and liquid Bio-fertilizer on Fruit length, Fruit diameter and Fruit length / diameter ratio of olive trees Picual cv. in 2022 and 2023 seasons.

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit length / diameter ratio	
	2022	2023	2022	2023	2022	2023
T1	2.52 a	2.55 ab	2.10 b	2.17 ab	1.20 ab	1.18 a
T2	2.55 a	2.61 ab	2.05 b	2.13 ab	1.24 a	1.22 a
T3	2.27 b	2.51 b	1.85 c	2.08 b	1.23 a	1.21 a
T4	2.50 a	2.57 ab	2.03 b	2.18 ab	1.23 a	1.18 a
T5	2.53 a	2.67 a	2.25 a	2.25 a	1.12 b	1.19 a
T6	2.43 a	2.49 b	2.14 ab	2.16 ab	1.14 ab	1.15 a
T7	2.52 a	2.61 ab	2.15 ab	2.24 a	1.17 ab	1.16 a

Mean in each column with similar letter(s) are not significantly different at 5 % level.

Data in Table (6) show the Effect of feldspar and liquid Bio-fertilizer on leaf mineral content. Concerning to the leaf nitrogen percentage (N%) it can be noticed that the nitrogen percentage increase with the increase in the times of adding bacteria, so that adding bacteria for three times was better than adding bacteria twice for the same dose of feldspar. The highest percentage of N for the both years was recorded by treatment (6 kg Feldspar + 25 ml bacteria at three doses) followed by treatment (4 kg Feldspar + 25 ml bacteria at three doses). For the leaf phosphor percentage (P %), It could be seen that the leaf phosphor was not affected by treated picual trees with feldspar + bacteria. This effect was true in both seasons.

As for leaf potassium percentage in both seasons, a significant decrease in potassium could be observed when Picual trees were treated with (2 kg Feldspar + 25 ml bacteria either at two or three doses) compared with control, while there were no significant difference between other treatments and control.

Table 6. Effect of feldspar and liquid Bio-fertilizer on leaf N%, P% and K% of olive trees Picual cv. in 2022 and 2023 seasons.

Treatments	(N %)		(P %)		(K %)	
	2022	2023	2022	2023	2022	2023
T1	1.90 b	2.20 ab	0.40 a	0.39 a	0.80 a	1.15 a
T2	1.90 b	2.10 ab	0.37 a	0.32 a	0.60 b	0.80 c
T3	2.10 ab	2.30 a	0.36 a	0.33 a	0.63 b	0.86 bc
T4	2.30 ab	1.90 b	0.34 a	0.30 a	0.76 ab	0.98 ab
T5	2.40 ab	2.30 a	0.34 a	0.34 a	0.80 a	1.00 ab
T6	2.50 a	1.80 b	0.36 a	0.31 a	0.85 a	1.08 a
T7	2.90 a	2.50 a	0.38 a	0.36 a	0.86 a	1.11 a

Mean in each column with similar letter(s) are not significantly different at 5 % level.

On basis of the experimental results, it was stated that the yield quantity of Picual olive trees was significantly increased when treated the soil with feldspar (K) plus adding K dissolving bacteria either twice or three times with improvement the yield quality. These rustles may be caused due to the function of potassium in plants, including the translocation of photosynthesis, protein synthesis, activity enzymes, water consumption and stress tolerance, ion balance regulation, and numerous other processes [3]. Increases in yield with increased times of addition of bacteria added for the same dose of feldspar can be explained by the fact that bacteria can dissolve it thus providing a faster and continuous supply of K for optimal plant growth [14]. Growth promotion by bacteria may also be related to their ability to produce extensive roots and can improve root growth and increase the rate of water and mineral uptake [27]. Obtained results are in harmony with those reported by [9, 20, 21, 28, 29].

4 Conclusion

From the proved results it could conclude that treated Picual olive trees with feldspar 4 kg/tree with bacteria at three times was the best treatment for improving the yield and fruit quantity.

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