Impact of Mulching, Organic Fertilization, and Nano-NPK on Some Growth Characteristics of Three Olive Cultivars

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Abstract

A field experiment was conducted during the 2024 growing season in the orchard of the College of Agriculture, University of Diyala, using three olive cultivars (Arbequina, Ba'ashiqa,, and Improved Nabali). The study aimed to evaluate the response of olive saplings to two soil mulching levels (mulched vs. non-mulched) and four fertilization treatments (control, Shambalan organic fertilizer, nano-NPK fertilizer, and a combination of Ceratophyllum demersum and nano-NPK), along with their interactions, on plant growth parameters.. Results showed that Ba'ashiqa significantly outperformed the other cultivars in terms of stem diameter increment6.938 mm, number of secondary branches 10.25 branches, and number of crown branches 10.88 branches. Improved Nabali had the highest fresh weight 4.023 g, while Arbequina showed the greatest increase in sapling height 26.06 cm. Soil mulching significantly enhanced all studied growth traits. Application of C. demersum and nano-NPK fertilizers significantly improved main stem diameter, number of secondary and crown branches 11.25 and 11.75 branches respectively, fresh weight, and sapling height. Moreover, both two and three-way interaction effects were statistically significant for all measured parameters.

Keywords: olive, mulching, C. demersum, nano NPK, cultivars

.1 Introduction

Olive (Olea europaea L.) an evergreen subtropical species, is one of the most important oil-producing crops worldwide. Belonging to the Oleaceae family and native to the Mediterranean Basin, the olive tree holds significant economic, social, and environmental value. Over 2,629 olive cultivars have been identified globally, with more than 40 cultivars present in Iraq (1). Olive fruits are widely consumed as food, and olive oil is considered one of the finest vegetable oils. It helps prevent atherosclerosis and supports cardiovascular health. It is also recommended in diabetic diets due to its role in hepatic fat metabolism. Additionally, olive oil is used in topical formulations for treating burns, particularly first-degree burns (19.(

Globally, Spain ranks first in olive tree numbers, followed by Italy and Greece. Among Arab countries, Tunisia leads in olive cultivation (9). In Iraq, Ninawa Province has the highest number of olive trees among all governorates. The total number of olive trees in Iraq (excluding the Kurdistan Region) is estimated at approximately 400,000. The estimated olive production for Iraq in 2022 during the summer season was 33,912 tons, with an average tree yield of about 24.2 kg. Al-Anbar Governorate ranked first in production (approximately 120.50 tons), followed by Ninawa (91.83 tons) and Baghdad (91.53 tons) (7.(

The Spanish olive variety "Arbequina" is one of the most widely cultivated varieties for olive oil production in the Mediterranean

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region and other countries in the Northern and Southern hemispheres (16). The oil content in its fruits ranges between 15-22% and it is a variety that can adapt well to the intensive cultivation method, due to its good qualities of resistance to unfavorable environmental conditions and the small structure of the tree (14). Bashyki variety is one of the most famous varieties grown in Iraq, It is one of the local varieties with good specifications and is distinguished by its high oil content of about 12-15% (11). While Nabali Mohassan variety is a two -purpose Palestinian variety with medium-sized fruits, with an oil content of 26%. It was introduced to Iraq in 2002 (5.(

Mulching is a widely recognized and effective soil conservation technique, considered one of the most promising practices in sustainable agriculture. It helps maintain soil physical and chemical properties—such as temperature—reduces evaporation, conserves soil moisture, suppresses weed growth, limits pest spread, and encourages the proliferation of beneficial soil microorganisms, thereby enhancing crop growth and productivity (12). found (10) that mulching improves aeration around plant roots, promotes soil particle aggregation, enhances soil fertility and permeability, and acts as an insulating layer that protects the soil from extreme high and low temperatures. It helps retain soil moisture, especially during summer, by reducing evaporation, prevents soil erosion and weed growth, reduces competition for nutrients, and can lower soil pH, thereby improving nutrient availability to plants.

The aquatic plant Ceratophyllum demersum L., locally known as Shambalan, is an important submerged aquatic plant that remains evergreen year-round. Its powdered form serves as a growth medium capable of retaining water at 4–6 times its own weight and contains appreciable amounts of nitrogen, potassium, and calcium, along with smaller amounts of phosphorus. The plant also produces numerous bioactive compounds, including amino acids, lipids, carbohydrates, alkaloids, glycosides, flavonoids, polyphenols, and polysaccharides (17). In a study by (2) conducted on a farm in Najaf Governorate during the 2018–2019 season, the effect of adding C. demersum at two levels (0 and 5 tons ha^{-1}) on eggplant (Solanum melongena L.) growth was investigated. The study demonstrated a positive impact of adding aquatic plant powder on all vegetative growth parameters (rate of increase in seedling height and main stem diameter) compared to the control treatment (distilled water spray), which yielded the lowest values .

Nano fertilizers are nutrient carriers with particle sizes between 30–40 nm, facilitating better absorption and tissue penetration. Their high surface area allows soil colloids to retain higher nutrient ion concentrations, enabling slow, steady release aligned with crop demands. Crop response depends on application timing and frequency (13.(

A study by (3), tested nano NPK fertilizer at four concentrations (0, 100, 200, 300, and 400 kg ha^{1}) on six-month-old pomegranate saplings (Punica granatum L., cv. Wonderful). The 400 kg ha^{-1} treatment significantly increased sapling height, main stem diameter, and leaf fresh weight.

Therefore, this study aimed to investigate the effect of soil mulching combined with the use of a widespread aquatic plant in Iraqi waters for fertilization, promoting sustainable agriculture by utilizing this plant for fertilization and addressing its proliferation in Iraqi rivers and marshes. Additionally, the study explored the impact of applying nano-NPK fertilizer, its mixture with C. demersum, and their effects on the growth of three olive varieties.

.2 Materials and Methods

A field experiment was conducted in the orchard of the College of Agriculture, University of Diyala (opposite the Horticulture and Landscape Engineering Department) during the 2024 growing season on six-month-old saplings of three olive cultivars (Arbequina, Ba’shiqa, and Improved Nabali). The study aimed to evaluate the response of olive saplings to two levels of soil mulching using Sun Proof material (mulched and non-mulched) and four levels of soil fertilization (control, C. demersum, nano-NPK, and a mixture of C. demersum + nano-NPK). Nano-NPK was applied at a concentration of 0.75 mL L^{-1}, and C. demersum (an aquatic plant) was applied at a 2:1 ratio of C. demersum powder to soil, representing the volume of C. demersum powder relative to the corresponding soil volume. Treatments were applied monthly for eight months, starting from the fourth month. Orchard maintenance included irrigation, fertilization, weeding, replanting, removal of unwanted growth, and pest control as needed during the growing season. A 0.5 mL L^{-1} solution of the fungicide Uniform was applied to all saplings in two doses.

The experiment followed a factorial split-plot arrangement within a Randomized Complete Block Design (RCBD) with three factors (cultivars, mulching, and fertilization). Cultivars represented the main plots while mulching and fertilization treatments were randomly assigned to sub-plots, with four replications totaling 96 saplings (32 saplings per cultivar). Data were statistically analyzed using SAS (2003) software, with means compared with Duncan's multiple range test at $p \leq 0.05$. The study measured the following growth parameters :

(1Stem diameter increment (mm) : measured 5-10 cm above soil level with the difference between initial and final measurements representing growth.

(2 Secondary Shoots Number (Shoot .Plant-1): counted as new lateral branches.

(3 Leaves Fresh weight (g): of 20 middle leaves from new growth.

(4 Crown Shoots Number (Shoot .Plant-1) : measured at experiment end.

(5 Sapling height increment (cm) : calculated as the difference between initial and final measurements from soil surface to top shoot.

.3 Results

Stem diameter increment

The data in Table (1) indicate significant differences among olive cultivars in the increase in main stem diameter. The Ba'ashiqa cultivar recorded the highest value (6.938 mm), whereas Improved Nabali showed the lowest value (5.125 mm.(

Soil mulching significantly enhanced stem thickening, with mulched treatments averaging 6.667 mm compared to 4.958 mm in the non-mulched treatment. Fertilization treatments also had a notable effect, with nano NPK application producing the greatest increase (6.833 mm), followed closely and without a significant difference by C. demersum (6.625 mm). The combination of nano NPK + C. demersum resulted in a moderate increase (5.792 mm), while the unfertilized control showed the smallest increase (4.000 mm.(

Regarding the two-way interactions, the combination of Ba'ashiqa with mulching recorded the highest stem diameter (8.313 mm), while Arbequina without mulching had the lowest (4.438 mm). In the interaction between cultivars and fertilization, Ba'ashiqa with nano NPK gave the highest value (7.625 mm), whereas Arbequina without fertilization recorded the lowest (2.875 mm). For the interaction between mulching and fertilization, the highest increase was observed in mulching + nano NPK (8.250 mm), while the lowest

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was in the non-mulched + unfertilized treatment (3.583 mm.(

As for the three-way interaction, Ba'ashiqa combined with mulching and nano NPK fertilization achieved the greatest increase in main stem diameter (9.750 mm). In contrast, the lowest values were recorded in Arbequina without mulching and without fertilization, as well as in Improved Nabali without mulching and without fertilization.

This trend highlights the synergistic effect of genetic potential (Ba'ashiqa), soil mulching, and nano NPK application in promoting stem thickening. The results are consistent with the role of mulching in conserving soil moisture and regulating temperature, and with the efficiency of nano NPK in supplying nutrients in a readily available form, both of which contribute to improved vegetative growth.

Table 1. Impact of Mulching, Organic Fertilization, and Nano-NPK on Stem diameter increment (mm) of Three Olive Cultivars

Olive cultivars	Mulching	Fertilization				Cultivars × Mulching
		Control	*C. demersum*	NPK	*C. demersum* +NPK	
Arbequina	No	2.750 h	5.750 c-g	4.750 d-	4.500 e-h	4.437 c
	Mulching	3.000	8.000 abc	9.000 ab	5.250 c-h	6.313 b
Ba'ashiqa	No mulching	5.250 c-h	6.500 c-f	5.500 c-h	5.250 c-h	5.563 bc
	Mulching	6.500 b-	7.500 a-d	9.750 a	9.500 a	8.313 a
Improved Napali	No mulching	2.750 h	5.500 c-h	6.000 c-f	5.250 c-h	4.875 c
	Mulching	3.750	6.750 b-e	6.000 c-	5.000 d-h	5.375 bc
						Cultivars
Cultivars × Fertilization	Arbequina	2.875 e	6.875 ab	6.875 ab	4.875 cd	5.375 B
	Ba'ashiqa	5.875	6.875 ab	7.625 a	7.375 a	6.938 A
	Improved Napali	3.250 de	6.125 abc	6.000 abc	5.125 bc	5.125 B
						Mulching
Mulching × Fertilization	No mulching	3.583 e	5.833 dc	5.417 de	5.000 de	4.958 B
	Mulching	4.415	7.417 ab	8.250 a	6.583 bc	6.667 A
Fertilization		4.000	6.625 AB	6.833 A	5.792 B	

*Treatments with similar letters do not differ significantly from each other at the 0.05 probability level according to Duncan's multiple range test.

Secondary Shoots Number

The results in Table (2) show significant differences among olive cultivars in the number of secondary branches. Ba’ashiqa recorded the highest mean value (10.25 branches plant^{-1}), followed closely and without a significant difference by Arbequina (9.094 branches plant^{-1}), whereas Improved Nabali exhibited the lowest value (3.594 branches plant^{-1}.(

Soil mulching had a positive effect, with mulched treatments producing an average of 9.208 branches plant^{-1} compared with only 6.083 branches plant^{-1} in the non-mulched treatment. Fertilization also significantly increased branch number, with the

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combination of nano NPK + C. demersum achieving the highest value (11.25 branches plant⁻ ¹). This was followed, with a significant difference, by C. demersum alone (8.458 branches plant⁻ ¹) and nano NPK alone (6.958 branches plant¹). The unfertilized control recorded the fewest secondary branches(3.917 branches plant¹.(

In terms of two-way interactions, Ba'ashiqa combined with mulching produced the highest value (12.50 branches plant⁻ ¹), while Improved Nabali without mulching recorded the lowest (3.188 branches plant⁻ ¹). For the interaction between cultivar and fertilization, Ba'ashiqa with nano NPK + C. demersum gave the greatest number of branches (14.63 branches plant⁻ ¹), whereas Improved Nabali without fertilization had the fewest (1.750 branches plant⁻ ¹). The interaction between mulching and fertilization also showed that mulching combined with nano NPK + C. demersum was superior (13.83 branches plant⁻ ¹), while the lowest value occurred in non-mulched plants without fertilization (3.333 branches plant⁻ ¹.(

The three-way interaction revealed that Ba'ashiqa with mulching and nano NPK + C. demersum achieved the maximum number of secondary branches (19.00 branches plant⁻ ¹). Conversely, Improved Nabali without mulching and without fertilization recorded the minimum (1.250 branches plant⁻ ¹.(

These results clearly demonstrate the combined benefits of genetic potential (Ba'ashiqa), soil moisture conservation through mulching, and the nutrient-rich effect of integrating nano NPK with C. demersum in promoting branching—an important trait for enhancing canopy structure and potential yield in olive cultivation.

Table 2. Impact of Mulching, Organic Fertilization, and Nano-NPK on Secondary Shoots Number (Shoot .Plant-1) of Three Olive Cultivars.

Olive cultivars	Mulching	Fertilization Control	*C.*	NPK	*C.*	Cultivars ×
Arbequina	No	3.750 f-	6.750	7.250	10.50 cde	7.063 b
	Mulching	6.000	12.75	9.000	16.75 ab	11.13 a
Ba'ashiqa	No	5.000	8.500 d-h	8.250	10.25 c-f	8.000 b
	Mulching	5.250	15.75 abc	10.00	19.00 a	12.50 a
Improved Napali	No	1.250 i	3.000 ghi	3.250	5.250 e-i	3.188 c
	Mulching	2.250	4.000 e-i	4.000	5.750 e-i	4.000 c
Cultivars × Fertilization						Cultivars
	Arbequina	4.875	9.750 bc	8.125 dc	13.63 ab	9.094 A
	Ba'ashiqa	5.125	12.13 abc	9.125	14.63 a	10.25 A
	Improved Napali	1.750 e	3.500 e	3.625 e	5.500 de	3.594 B
Mulching × Fertilization						Mulching
	No	3.333 e	6.083 cde	6.250	8.667 bc	6.083 B
	Mulching	4.500	10.83 ab	7.667	13.83 a	9.208 A
Fertilization		3.917	8.458 B	6.958 B	11.25 A	

*Treatments with similar letters do not differ significantly from each other at the 0.05 probability level according to Duncan's multiple range test.

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Leaves Fresh weight

The results in Table (3) reveal significant differences among the olive cultivars in fresh weight. Improved Nabali recorded the highest value (4.023 g), followed by Arbequina with a significantly lower value (3.031 g), while Ba'ashiqa showed the lowest (2.313 g.(

Soil mulching enhanced fresh weight, with mulched treatments averaging 3.306 g compared to 2.939 g in the non-mulched treatment. Fertilization also had a pronounced effect: C. demersum application produced the highest fresh weight (4.095 g), followed, with a significant difference, by both nano NPK and the nano NPK + C. demersum combination (3.148 g each). The unfertilized control recorded the lowest value (2.098 g.(

Regarding two-way interactions, Improved Nabali with mulching achieved the highest fresh weight (4.245 g), while Ba'ashiqa without mulching recorded the lowest (2.136 g). In the interaction between cultivar and fertilization, Improved Nabali with C. demersum application yielded the greatest fresh weight (5.125 g), whereas Ba'ashiqa without fertilization produced the lowest (1.605 g). The interaction between mulching and fertilization showed that mulching combined with C. demersum gave the highest value (4.263 g), while non-mulched plants without fertilization recorded the lowest (1.942 g.(

The three-way interaction demonstrated that Improved Nabali with mulching and C. demersum fertilization achieved the maximum fresh weight (5.495 g). Conversely, Ba'ashiqa without mulching and without fertilization recorded the lowest value (1.475 g.(

Table 3. Impact of Mulching, Organic Fertilization, and Nano-NPK on Leaves Fresh weight(g) of Three Olive Cultivars .

Olive cultivars	Mulching	Fertilization: Control	*C. demersum*	NPK	*C. demersum* +NPK	Cultivars × Mulching
Arbequina	No	1.870	4.120 cd	3.225	2.305	2.880 d
	Mulching	1.935	3.885	3.540	3.370	3.183 c
Ba'ashiqa	No	1.475 k	2.905 gh	1.925	2.240 ij	2.136 f
	Mulching	1.735	3.410	2.440	2.375	2.490 e
Improved Napali	No	2.480	4.755 b	3.760	4.205 bc	3.800 b
	Mulching	3.095	5.495 a	4.000	4.390 bc	4.245 a
						Cultivars
Cultivars × Fertilization	Arbequina	1.903	4.003 b	3.383 c	2.838 d	3.031 B
	Ba'ashiqa	1.605 f	3.158	2.183 e	2.308 e	2.313 C
	Improved Napali	2.788 d	5.125 a	3.880 b	4.298 b	
						Mulching
Mulching × Fertilization	No	1.942	3.927 b	2.970	2.917 d	2.939 B
	Mulching	2.255 e	4.263 a	3.327 c	3.378 c	3.306 A
Fertilization		2.098	4.095 A	3.148 B	3.148 B	

*Treatments with similar letters do not differ significantly from each other at the 0.05 probability level according to Duncan's multiple range test

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Crown Shoots Number

The results in Table (4) indicate significant differences among olive cultivars in the number of crown branches. Ba’ashiqa recorded the highest value (10.88 branches plant^{-1}), followed by Improved Nabali with a significantly lower value (6.281 branches plant^{-1}), while Arbequina showed the lowest (4.969 branches plant^{-1}.(

Soil mulching significantly increased the number of crown branches, with mulched treatments averaging 8.583 branches plant^{-1} compared to 6.167 branches plant^{-1} in the non-mulched treatment. Fertilization also had a strong effect, with the nano NPK + C. demersum combination producing the highest number of crown branches (11.75 branches plant^{-1}), followed, with a significant difference, by C. demersum alone (9.958 branches plant^{-1}). Nano NPK alone resulted in a moderate increase (5.000 branches plant^{-1}), whereas the unfertilized control recorded the fewest branches (2.792 branches plant^{-1}.(

Regarding two-way interactions, Ba’ashiqa combined with mulching recorded the highest crown branch number (11.75 branches plant^{-1}), while Arbequina without mulching had the lowest (3.375 branches plant^{-1}). In the interaction between cultivar and fertilization, Ba’ashiqa with nano NPK + C. demersum showed a remarkable increase, reaching 21.63 branches plant^{-1}, whereas Arbequina without fertilization produced the lowest value (0.875 branches plant^{-1}). For the interaction between mulching and fertilization, mulching combined with nano NPK + C. demersum was superior (12.92 branches plant^{-1}), while non-mulched plants without fertilization recorded the lowest number (1.917 branches plant^{-1}.(

The three-way interaction revealed that Ba’ashiqa with mulching and nano NPK + C. demersum achieved the highest number of crown branches (23.25 branches plant^{-1}). In contrast, Arbequina without mulching and without fertilization produced no crown branches (0.000.(

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Table 4. Impact of Mulching, Organic Fertilization, and Nano-NPK on Crown Shoots Number (Shoot .Plant-1) of Three Olive Cultivars .

Olive cultivars	Mulching	Fertilization				Cultivars × Mulching
		Control	*C. demersum*	NPK	*C. demersum* +NPK	
Arbequina	No	0.000 h	4.500 efg	2.500	6.500 cde	3.375 d
	Mulching	1.750	9.750 bc	5.500	9.250 bcd	6.563 bc
Ba'ashiqa	No	3.750 e-	10.75 b	5.500	20.00 a	10.00 a
	Mulching	4.750	13.00 b	6.000	23.25 a	11.75 a
Improved Napali	No	2.000	9.250 bcd	4.000	5.250 d-g	5.125 cd
	Mulching	4.500	12.50 b	9.250	6.250 c-f	7.438 b
						Cultivars
Cultivars × Fertilization	Arbequina	0.875 e	7.125 c	4.000 d	7.875 c	4.969 B
	Ba'ashiqa	4.250 d	11.88	5.750	21.63 a	10.88 A
	Improved Napali	3.250 de	10.88 b	5.250 cd	5.750 cd	6.281 B
						Mulching
Mulching × Fertilization	No	1.917 e	8.167 c	4.000	10.58 b	6.167 B
	Mulching	3.667 e	11.75	6.000 d	12.92 a	8.583 A
Fertilization		2.792	9.958 B	5.000 C	11.75 A	

*Treatments with similar letters do not differ significantly from each other at the 0.05 probability level according to Duncan's multiple range test.

Sapling height increment

The results in Table (5) show that Arbequina achieved the greatest increase in sapling height (26.06 cm), followed closely and without a significant difference by Ba'ashiqa (20.44 cm), while Improved Nabali recorded the lowest value (17.28 cm.(

Soil mulching significantly promoted height growth, with mulched plants averaging 23.40 cm compared to 19.13 cm for non-mulched plants. Fertilization with nano NPK + C. demersum resulted in the tallest saplings (25.67 cm), followed closely and without a significant difference by C. demersum alone (24.13 cm). Nano NPK alone yielded 21.58 cm, while the unfertilized control produced the lowest height increase (13.67 cm.(

Regarding two-way interactions, Arbequina with mulching recorded the highest height increase (28.94 cm), whereas Improved Nabali without mulching had the lowest (15.75 cm). In the interaction between cultivar and fertilization, Arbequina with C. demersum application achieved the highest value (30.38 cm), while Improved Nabali without fertilization recorded the lowest (7.500 cm). The mulching × fertilization interaction showed that mulching combined with nano NPK + C. demersum was superior (27.67 cm), while non-mulched saplings without fertilization had the lowest increase (12.50 cm). For the three-way interaction, Arbequina with mulching and Champlain application achieved the highest value at 34.50 cm, while the interaction of Improved Nabali with no mulching and no fertilization recorded the lowest at 6.00 cm.

Table 5. Impact of Mulching, Organic Fertilization, and Nano-NPK on Sapling height increment (cm) of Three Olive Cultivars.

Olive cultivars	Mulching	Fertilization				Cultivars × Mulching
		Control	*C. demersum*	NPK	*C. demersum* +NPK	
Arbequina	No	17.75 e-	26.25 a-	26.00	22.75 b-h	23.19 b
	Mulching	20.50 c-	34.50 a	29.75	31.00 ab	28.94 a
Ba'ashiqa	No	13.75	16.75 f-i	18.0	25.25 b-f	18.44 cd
	Mulching	15.00	29.00 ab	21.50	24.25 b-g	22.44 bc
Improved Napali	No	6.00 j	19.25 d-	14.75	23.00 b-h	15.75 d
	Mulching	9.00 ij	19.0 d-	19.5	29.00 a-d	18.81 cd
						Cultivars
Cultivars × Fertilization	Arbequina	19.13	30.38 a	27.88	26.88 ab	26.06 A
	Ba'ashiqa	14.38	22.88 b-	19.75	24.75 a-d	20.44 AB
	Improved Napali	7.500 g	19.13 def	17.13 ef	25.38 abc	17.28 B
						Mulching
Mulching × Fertilization	No	12.50 c	20.75 b	19.58	23.67 ab	19.13 B
	Mulching	14.83 c	27.50 a	23.58	27.67 a	23.40 A
Fertilization		13.67	24.13	21.58	25.67 A	

*Treatments with similar letters do not differ significantly from each other at the 0.05 probability level according to Duncan's multiple range test.

.4 Discussion

The reason for the differences in the characteristics of the main stem diameter, seedling height, fresh weight, number of secondary branches, total number of branches, and branch length is attributed to the difference in the nature of growth of each of them as a result of the difference in the genetic makeup of each of them from the other, as it is known that the interaction between the cultivars and environmental factors is what determines the degree of growth and development of the living organism and that the environmental nature in which the crop is grown greatly affects the quantity and quality of the crop, and plant growth is a direct outcome of this interaction with various environmental elements (15.(

The treatment of soil mulching produced the highest values for main stem diameter, number of secondary branches per plant, fresh weight, number of crown branches, sapling height as well as branch length (Table 1). Mulching increases soil moisture content, which in turn influences soil physical properties such as bulk density, porosity and permeability (18), likely responsible for this positive effect. Greater moisture levels increase porosity and permeability of the soil composition by improving water retention and root zone air exchange. It increases nutrient uptake, enhances plant metabolism and eventually the growth traits of saplings (23.(

Use of natural fertilizer C. demersum accelerated all characteristics in the study significant. The nutrient-rich nature of organic amendments could explain their stimulatory effect on plant growth via photosynthetic efficacy and carbohydrate synthesis as well as deposition in plants. Organic fertilizers also restore stomatal function and improves water use efficiency these are the properties increases the photosynthetic rates, uptake of essential nutrients and ultimately yield and plant quality (Wang et al., 2017.(

The influence of the Nano NPK fertilizer was also highly positive on all traits. This could have resulted from the quick uptake and controlled supply of nanoparticles on nutrient release which reduces soil and water pollution from agrochemicals as a result of enhanced nutrient accessibility to plant tissues (8). The special characteristics of Nano fertilizers are the high surface charge density, strong reactivity, better penetration in plant tissues and thermal stability. Moreover they are better in promoting plant growth under different environmental conditions by boosting stress tolerance (21). Moreover, nano fertilizers maintain the controlled release of nutrients in tune with plant growth state and conditions, which enhances chlorophyll formulation, carbon assimilation and vegetative development (4.(

The maximum response of C. demersum with nano NPK fertilizer in almost all traits suggests a synergistic integration of organic and nano nutrient sources from the mentioned treatments. Organic inputs provide necessary macro- and micronutrients, whereas nano fertilizers increase nutrient availability and uptake efficiency for a better developed plant growth (6.(

.5 Conclusion

In the conclusion, the study showed that the display of olive growth is strongly influenced by the choice of cultivar, soil mulching and fertilization strategy. Ba'ashiqa is generally performed excellently in botanical symptoms such as stem diameter, branching and crown development, while Arbequina showed the greatest height growth and Improved Nabali achieved the highest leaf fresh weight. Mulching continuously improved all development parameters by improving soil moisture retention and the availability of nutrients. Both C. demersum and Nano-NPK fertilizers significantly improved growth traits, with their combination producing the most pronounced effects. The results declare the possibility of integrating mulching with combined organic and nano fertilization better to get large vegetative growth and overall vigor in olive cultivation .

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