Journal of Applied Horticulture, 27(3): 494-500, 2025

https://doi.org/10.37855/jah.2025.v27i03.90

Journal of Applied Horticulture
ISSN: 0972-1045

Toward sustainable oliviculture: Effects of replacing mineral with organic nitrogen on floral behaviour, fruit quality and yield

Hamed H. Hamed[1,2], Ahmed A Abdelhafez[3], Ahmed A. Rashedy[1]* and Sameh Shaddad[4]

*[1]Pomology Department, Faculty of Agriculture, Cairo University, Egypt. [2]Organic Crop Production Department, Faculty of Organic Agriculture, Heliopolis University, Egypt. [3]Biotechnology Department, Faculty of Organic Agriculture, Heliopolis University, Egypt. [4]Department of Soil Sciences, Faculty of Agriculture, Zagazig University, Egypt. *E-mail: ahmed.Rasheedy@agr.cu.edu.eg*

Abstract

The agriculture sector is in a dilemma as most of the time, high productivity is at the cost of the environment and human health. Organic agriculture is a way to come out of this quandary since it minimizes the use of synthetic inputs and enhances ecological balance.The present investigation was undertaken on olive to substitute mineral nitrogen (1 kg/tree) with organic sources (25 kg compost/tree treated once and bio inoculants with a combination of *Azotobacter chroococcum, Bacillus megaterium* and *Bacillus circulans* three times per tree). The number of inflorescences per shoot and flowers per inflorescence were also enhanced by the organic treatments, with up to 22 and 14% increases compared with mineral nitrogen. It also increased flower sex ratio and fruit set at both initial and final fruit set by 7–14% and decreased the fruit drop by almost 30%. Yield, fruit weight and size were all significantly increased and fruit weight was increased by more than 50% in both years. These results indicate that organic nitrogen sources can be used to enhance flowering, fruiting and fruit yield characteristics of the Toffahi olive variety under saline water irrigation, and may be a promising, environmentally friendly approach to sustainable cultivation under climate stress conditions.

Key words: *Olea europaea*, organic farming, nitrogen, farm, fruit yield, fruit quality, *Azotobacter chroococcum, Bacillus megaterium* and *Bacillus circulans*

Introduction

The olive tree (*Olea europaea* L.) is an evergreen that has been cultivated for 8000 years. It is growing in the Mediterranean region and arid regions with economic impact, with different purposes, including oil and table olives. In 2021, global olive cultivation was around 11 million ha with 3 to 3.5 million metric tons production (FAO, 2021). Oliviculture around the Mediterranean basin is essential for the region's economic development. About 7. 7 million hectares are cultivated with olive crops in the Mediterranean (García Martín *et al.*, 2020). In Egypt, it is cultivated from the Pharaohs' era. For table olives, Egypt produce 23% of global production (520.000 tonnes) and rank as the 3rd largest exporter country outside the EU (IOC 2025). Toffahi olive cultivar is considered as one of the most olive table cultivar with the biggest size.

Increasing soil fertility is the most critical factor for boosting agricultural production to keep pace with the world's growing population. It is also essential for achieving high crop yields and quality (Güneş *et al.*, 2023). In traditional agriculture, chemical fertilizers can pollute water, air and soil, which harms the long-term sustainability with high input costs due to the rise of chemical fertilizer prices. So, the organic fertiliser strategies are considered as more efficient and eco-friendly alternative (Mohamed *et al.*, 2023).

Increasing chemical fertilization application led to some environmental problems such as increasing water pollution, soil degradation, as well as reducing plant responses, pest resistance, and food quality. Reduction in the use of chemicals while improving plant growth without harmful fingerprint environment can be achieved via organic and biofertilizers (Moradzadeh *et al.*, 2021). Different compost sources (plant or chicken manure, and vermicompost) are beneficial in improving soil fertility, plant growth, soil structure, microbial activity, nutrient uptake, water retention and improving plant tolerance to abiotic stresses (Kareem and Hamed 2024). For achieving Sustainable Development Goals, soil management is necessary, through reducing the use of synthetic chemical fertilizers, and promoting organic or biofertilizers for increasing crop production as well as supporting environmental sustainability (Moradzadeh *et al.*, 2021).

Desserts in arid regions have coarse sandy soils with low organic matter content, considered major agricultural challenges, which include poor retention of water and nutrients, high pH and calcium carbonate content, which restricts sustainable agriculture, leading to low yields (AlGhamdi, 2018; Ibrahimi and AlGhamdi, 2022; Musei *et al.*, 2024). Compost, derived from decomposed organic matter, is a valuable soil conditioner due to high nutrient content, organic matter which improves soil texture, water retention, increases fine particles and nutrient availability (El-Elsonbaty and El-Sherpiny, 2024). Also, it enhances soil fertility and crop quality via decomposing organic residues as well as producing nutrient-rich materials beneficial for agriculture (Rashwan *et al.*, 2024). Furthermore, compost increases fine colloidal particles. In olives, green forage vermicomposts surpass sheep manure in activating plant enzymes and yield (Arji *et al.*, 2021). Recent findings reveal that compost with biochar improves soil health and benefits olive trees (Fornes *et al.*, 2024).

Nitrogen, which is the most important nutrient mineral to the growth of olives, is a very important mineral in photosynthesis, and its deficiency seriously reduces the process (Fernandez-Escobar *et al.*, 2011). When ammonium nitrate was applied to olives (0-6 kg/tree) in the study of Kalinioti, the higher yield was 62.5 kg/tree at 4 kg/tree, which increased the growth of shoots without affecting the oil content (Kotsias *et al.*, 2024). This study aimed to assess the impact of replacing mineral nitrogen with compost and microbial inoculants on flowering, fruit quality, and yield of the 'Toffahi' olive cultivar under saline irrigation, as a step toward sustainable oliviculture.

Materials and methods

This study was conducted through two seasons (2022 and 2023) in a private orchard located in Belbies city, Sharqia governorate, Egypt (30.375 N, 31.596 E). This investigation took place on a 2-acre olive farm (approximately 0.83 ha) featuring twenty-year-old Toffahi olive trees, which were planted in a 5 x 5 meter. The trees were cultivated in sandy soil under a drip irrigation system. The trees were uniform in shape and treated with standard horticultural practices. The analysis of the orchard soil is presented in Table 1, and the irrigation water analysis is detailed in Table 2 (Wild *et al.*, 1985).

Soil and water samples collection and analysis

Soil samples: Representative soil samples were collected from the soil at three depths, i.e topsoil (0- 10cm), 10- 30 cm and 30- 60 cm. The collected soil samples were then air-dried, crushed and sieved through a 2 mm sieve and finally they were subjected to the following analysis: EC, pH and soluble ions (Mg, Ca, Na, K, CO_3, HCO_3, SO_4, Cl). Electrical conductivity (EC, dSm^{-1}) was measured in 1:5 soil water extract, while pH was measured in soil water extract (Jackson, 1973).

Table 1. Physical and chemical analysis of the soil

Parameter	Depth of sample		
	0 -10 cm	10-30 cm	30-60 cm
pH (1:2.5)	7.96	8.10	8.03
EC (dSm^{-1})	3.70	0.80	1.68
Soluble cations (meq\L)			
Ca^{2+}	6.00	2.50	3.00
Mg^{2+}	4.00	1.50	1.50
Na^{+}	28.60	4.40	12.90
K^{+}	0.10	0.10	0.80
Soluble anions (meq\L)			
CO_3^{2-}	-	-	-
HCO_3^{-}	4.40	2.40	2.00
Cl^{-}	27.20	5.00	13.00
SO_4^{2+}	7.10	1.10	3.20

Irrigation water sampling: A water sample was collected from the well after one hour of operation to ensure that the collected sample is representative of the irrigation water used during the study. Electrical conductivity (EC) and pH of irrigation water were measured in the fresh sample collected by using calibrated field Orion portable meters (Thermo Scientific, Singapore). The collected sample was kept in iceboxes and sent to the laboratory for chemical analysis. The measured anions and cations in groundwater were sodium (Na^+), calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}), chloride (Cl^-), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and sulphate (SO_4^{2-}). Ca and Mg contents were measured via EDTA titration using Eriochrome black T as an indicator. A flame photometer was used for Na and K determination. CO_3^{2-} and HCO_3^- contents were measured by acid-base titration. While Cl was measured by silver nitrate titration. SO_4^{2-} content was measured using a colorimetric spectrophotometer. A detailed description of the techniques commonly used for the analysis of irrigation water is available (Bresler *et al.*, 1982). Sodium adsorption ratio (SAR) was calculated to investigate the potential sodicity of irrigation water on soil.

Table 2. Chemical characteristics of water used for irrigation

Parameter	Value
pH	7.1
EC (dSm^{-1})	4.1
Soluble cations (meq\L)	
Ca^{2+}	7.2
Mg^{2+}	5
Na^{+}	32.6
K^{+}	0.1
Soluble anions (meq\L)	
CO_3^{2-}	-
HCO_3^{-}	1.6
Cl^{-}	39.2
SO_4^{2-}	4.1
SAR	13.1

Table 2 shows the chemical analysis of the irrigation water used during the period of this trial. In terms of pH value, irrigation water can be classified as suitable for irrigation, whereas EC indicates it as highly saline water with a severe restriction for usage. The most predominant ions present in irrigation water are Na and Cl, indicating that the continued use of such water was the reason behind the predominance of Na and Cl ions existing in the soil.

Experimental design: The treatments were arranged in a randomized complete block design (RCBD); the experiment contained two farming systems (organic and conventional), each contained three replicates and each replicate was represented by 10 trees. The normal horticulture practices used in the farm were applied to all Toffahi olive trees.

Mineral nitrogen source: According to the Ministry of Agriculture, Egypt, olive trees require 1000 g of actual nitrogen per tree annually, which is equivalent to 5 kg of ammonium sulfate (20.6% N) per tree per year.

Organic nitrogen source: Each tree received 25 kg of compost during November in each season. Biofert (bio fertilizer) was applied at a rate of 160L/acre (1 L/tree) 3 times during the season. Biofert is a mixture of *Azotobacter chroococcum, Bacillus megaterium* and *Baciilus circulance* at a concentration of $1x10^7$.

At the beginning of January for each season, 20 randomly selected one-year-old branches were labelled around the outer part of each tree, with 5 branches chosen in each direction. This was done to facilitate the following measurements.

Flowering characteristics: On the marked twenty branches number of inflorescences per shoot and the number of flowers per inflorescence were recorded. The number of inflorescence per meter were recorded by dividing the number of inflorescences by the distance in meters. Flower sex ratio was calculated by dividing perfect flowers number to total flowers. Pollen germination percent was gathered from inflorescence samples before pollen

Table 3. Analysis of the compost used in the organic system

Parameter	Value	Parameter	Value
Weight of one m^3	650 kg	Nitrogen N (%)	1.1
Humidity (%)	25	Total P (%)	1.2
pH (1:10)	6.8	Total K (%)	0.95
EC (1:10)	5.5	Iron (ppm)	500
Organic matter (%)	33	Zinc (ppm)	60
C/N ratio	17:1	Mn (ppm)	100
Ash (%)	67	Cu (ppm)	130
Nematode	No	Weed seeds	No

release immediately, and then they were preserved overnight in the laboratory at room temperature. Afterwards, the pollen grain germination % was evaluated following a day of incubation (25°C) in Petri dishes, using a liquid medium consisting of 0.01 ppm tetracycline and 10 % sucrose. In each replicate, 3 drops of the pollen-containing medium were positioned on one side, and the count of non-germinated and germinated pollen grains was recorded (Fernández-Escobar and Martin, 1987).

Fruiting and yield: Initial fruit set was determined by dividing the number of fruit set by the total number of flowers. Also, the final fruit set was determined by dividing the number of fruit set at 60 days after pollination by the total number of flowers (Fernandez and Gomez, 1985). Finally, fruit drop% was calculated by the following equation:

Fruit drop % =[(Initial fruit set - Final fruit set) / Initial fruit set] × 100.

At the maturity stage (around mid-September), the fruits from each individual tree were collected separately. The fruit yield was recorded by weighing of fruit trees and the yield was expressed in kg per tree.

Fruit quality: Thirty fruits were collected randomly from each replicate to evaluate the fruit quality through many parameters. Fruit weight was determined using a scale balance and expressed as grams. Fruit volume was determined by immersing the fruit in a cylinder (100 mL) with a certain amount of water (40 mL) and expressed as mL. Fruit length was determined by digital calliper and expressed as cm. Fruit diameter was determined using a digital calliper and expressed as cm. Fruit shape was determined by dividing the fruit length by the fruit diameter ratio. Pulp and seed weight was expressed as grams by weighing them using a digital scale. Finally pulp/ seed ratio was determined after weighing both of them by dividing the pulp weight by the seed weight.

Economic feasibility study: It was calculated according to the mean of yield per tree and the price of nitrogen fertilization cost, as well as the price of both organic and inorganic fruits.

Statistical analysis: The data collected throughout this experiment underwent analysis of variance (ANOVA) following the methodology outlined by Snedecor and Cochran (1980). The analysis was conducted using the MSTAT program. To compare means between various treatments, the Least Significant Ranges (LSR) approach was employed at a significance level of 5%.

Results

Soil parameters of the initial soil: The soil reaction values of the soil at the three different depths indicate that the soil is slightly alkaline with values of 7.96, 8.12 and 8.03 pH for the samples collected from topsoil and downward, respectively. The soil salinity level along 3 different depths indicates that the topsoil sample had a higher salinity level, then it tends to decrease at 30 cm depth, and it increases again at 60 cm depth. Although the salinity of the initial soil is high, it is expected that olive trees could grow normally as they are salt-tolerant crops. With regards to the soluble ions the most predominant ions are Na and Cl along the whole depth of the collected soil samples. This might be attributed to the over-exaggeration and additions of chemical fertilizers during the previous years and before starting the experiment.

Flowering characteristics: Flowering characteristics were significantly affected by the nitrogen source used in the two studied seasons (Fig. 1). The mineral nitrogen source had the lower average number of inflorescences per shoot and meter, with values of 15.34 and 16.74 for inflorescences per shoot and 57.86 and 60.11 for inflorescences per meter in the first and second season, respectively. In contrast, organic nitrogen application had the higher number of inflorescences per shoot, with values of 18.76 and 19.09, and inflorescences per meter, with values of 62.67 and 69.25, in the first and second seasons, respectively. Moreover, the organic nitrogen source had the higher number of flowers per inflorescence, with values of 27.55 and 29.82, while the mineral nitrogen source had the lower values of 24.23 and 29.82, for the two studied seasons, respectively. It can be concluded that organic nitrogen source increased inflorescence number per meter, inflorescence number per shoot and flowers number per inflorescence by 8.13 and 15.20%, 22.29 and 14% and 13.70 and 8.20% for the first and second seasons, respectively.

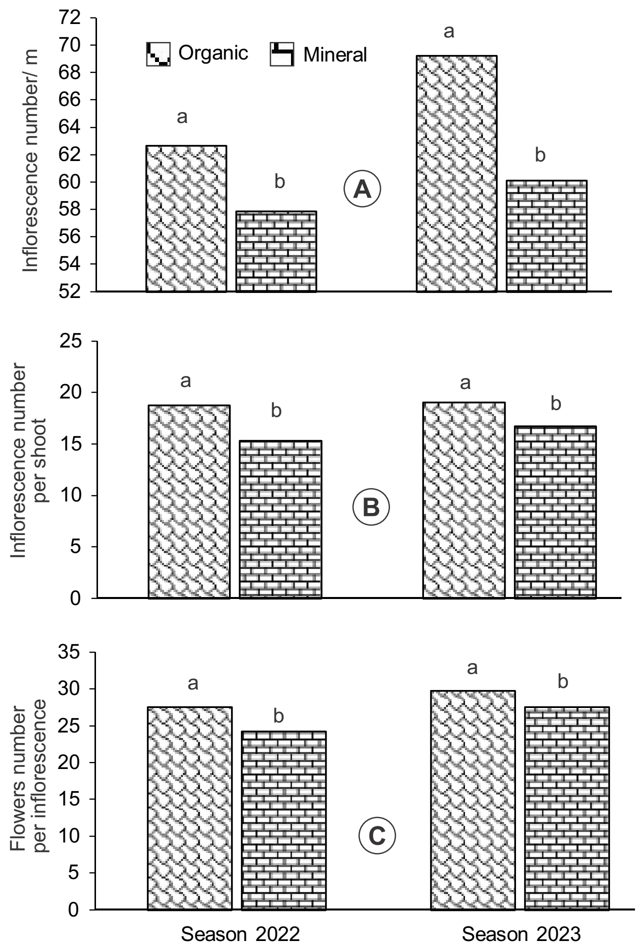

Fig. 1. Effect of nitrogen source (organic or mineral) on inflorescence number per meter (A), inflorescence number per shoot (B) and flowers number per inflorescence (C) of Toffahi olive cultivar during two seasons.

Sex expression and pollen germination: Fig. 2 illustrates two parameters for Toffahi olive trees: the proportion of perfect flowers to total flowers (Fig. 2A), referred to as the sex ratio, and the pollen germination percentage (Fig. 2B). The results showed that using an organic nitrogen source produced the most favorable outcomes. It significantly increased the sex ratio to 70.74% and 74.27% in the first and second seasons, respectively, 9% and 14% higher than when using mineral nitrogen.

Conversely, the mineral nitrogen source resulted in the lower sex ratio, with values of 64.89% and 65.12% across the two seasons. The organic nitrogen treatment resulted in the higher pollen germination rates, achieving 81.37% in the first season and 89.21% in the second (Fig. 2B). The data indicate a rise of 19.70% and 30.70%, respectively, in comparison to the mineral nitrogen treatment, which exhibited the lower germination percentages of 67.98% and 68.26%.

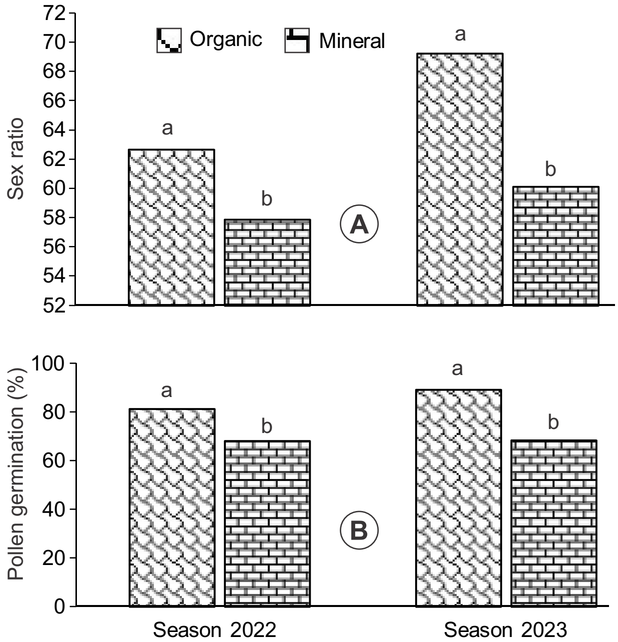

Fig. 2. Effect of nitrogen source (organic or mineral) on sex ratio of flowers (A) and pollen germination % of Toffahi olive cultivar during two seasons

Initial and final fruit set (%): The proportion of initial and ultimate fruit set of Toffahi olive fruit was considerably influenced by various nitrogen sources across the two seasons (Fig. 3). The organic nitrogen source exhibited the higher initial fruit set, with 60.41% and 61.25% in the first and second seasons, respectively. In contrast, conventional farming exhibited the lower first fruit set of 55.19% and 57.32% across the two seasons analysed. The ultimate fruit set data illustrated in Fig. 3B indicates that it mirrored the trend of the initial fruit set across both studied seasons. It can be inferred that the organic nitrogen source enhanced initial and ultimate fruit set by 8.97% and 6.86%, and 11.54% and 8.67% compared to the mineral nitrogen source in the first and second seasons, respectively.

Fruit drop (%): As shown in Fig. 4A, the application of mineral nitrogen resulted in the higher fruit drop percentages for Toffahi olive trees in both the first and second seasons—43.78% and 40.67%, respectively. In contrast, trees treated with organic nitrogen exhibited the lower fruit drop, with values of 29.57% and 28.56%. This represents a reduction of 32.46% and 29.78% in fruit drop compared to the mineral nitrogen treatment across the two seasons.

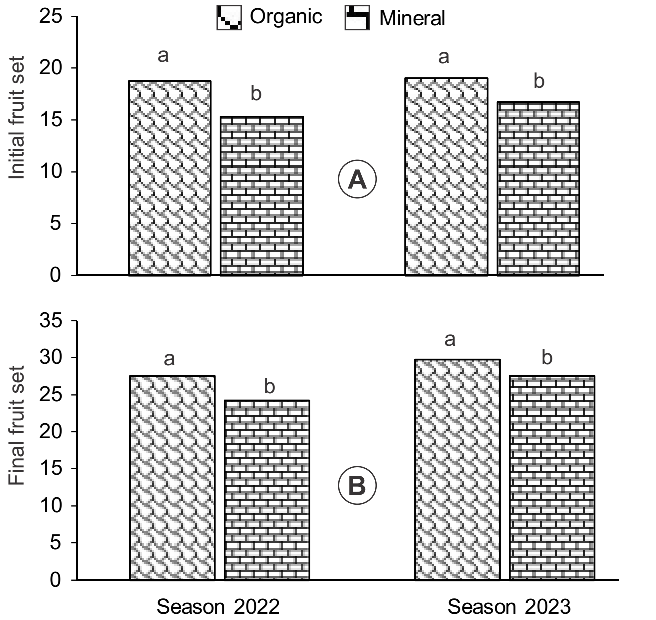

Fig. 3. Effect of nitrogen source (organic or mineral) on initial fruit set (A) and final fruit set (B) of Toffahi olive cultivar during two seasons.

Fruit yield: Data in Fig. 4B indicate that the organic nitrogen source significantly enhanced the total fruit yield of Toffahi olive trees compared to the mineral nitrogen source. Trees receiving organic fertilization yielded 70.57 kg and 76.27 kg per tree in the first and second seasons, respectively. In contrast, mineral nitrogen application resulted in the lower yields: 61.98 kg and 65.26 kg. The increase in fruit yield due to organic nitrogen was 13.86% and 16.87% in the respective seasons.

Fruit and pulp weight (g): Throughout both study seasons, the application of different nitrogen sources had a significant impact on the fruit and pulp weight of Toffahi olives, as shown in Fig. 5A and Fig. 5B. According to Fig. 5A, trees treated with organic nitrogen produced the heaviest fruits, with average weights of 7.38 g and 7.98 g in the first and second seasons, respectively. In contrast, the inorganic nitrogen source resulted in the lower fruit weights, measuring 5.19 g and 5.32 g in the respective seasons.

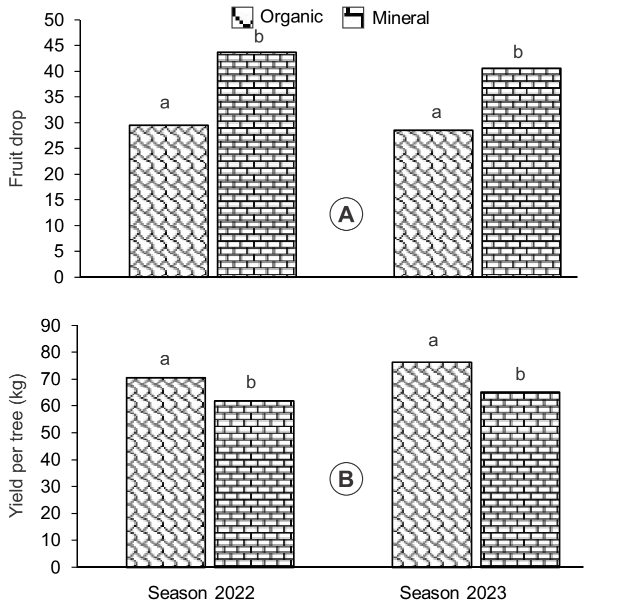

Fig. 4. Effect of nitrogen source (organic or mineral) on fruit drop (A) and yield kg per tree (B) of Toffahi olive cultivar during two seasons.

Table 4. Compost analysis used in the organic system

Tree	Mineral N source	Organic N source
Fruit price/kg LE	30	50.5
Yield /tree kg	28.13	30.35
Yield price LE/tree	843.9	1532.7
Fertilization cost/ tree	77	10.75 compost + 48 biofertilizers = 58.75
Cost benefit for fertilization LE /tree	843.9-77 = 766.9	1532.7-58.75 = 1473.95
Horticultural practices* /tree	500	500
Cost benefit for tree LE	266.9	973.95
Cost benefit for feddan LE (168 trees)	44839.2	163623.6

*Horticultural practices include pruning, harvesting, irrigation, pest control, weed control, etc.

Regarding pulp weight (Fig. 5B), the higher values were also observed under the organic nitrogen treatment—5.12 g in the first season and 5.65 g in the second. Meanwhile, trees receiving inorganic nitrogen showed the lower pulp weights, recording 4.97 g and 4.45 g across the two seasons. The increase in fruit weight attributed to the organic nitrogen source was 50.86% in the first season and 50% in the second, compared to the inorganic treatment.

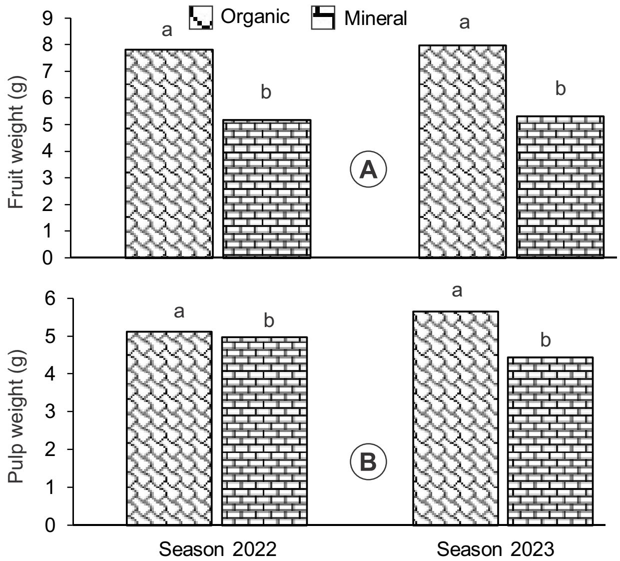

Fig. 5. Effect of nitrogen source on fruit weight (A) and pulp weight (B) of Toffahi olive cultivar during two seasons.

Seed weight (g) and pulp/seed ratio: Weight of seed and the ratio of pulp to seed of Toffahi olive cv. were significantly impacted by different forms of organic and inorganic nitrogen sources (Fig. 6). The results showed that the higher seed weight was in the organic nitrogen treatment during both seasons, while the lower seed weight was recorded in the inorganic nitrogen treatment during both seasons. The data in the same Fig. (Fig. 6B) also confirmed that the pulp/seed ratio was significantly affected by different nitrogen sources. The higher pulp/seed ratio was found in the organic nitrogen treatment (6.57 and 6.46) during the first and second seasons, respectively. Conversely, the lower pulp/seed ratio was observed in inorganic nitrogen source (5.98 and 5.62) during the two studied seasons.

Fruit volume (cm^3) and length (cm): The results in Fig. 7 indicate that nitrogen sources significantly affected the fruit volume and length of Toffahi olive (Fig. 7A, 7B). Organic nitrogen resulted in the higher fruit volume (8.23, 8.91 cm^3) and length (2.33, 2.31 cm), while inorganic nitrogen gave the lower values (7.21, 7.65 cm^3; 2.01, 2.03 cm) across both seasons. Organic nitrogen increased fruit volume by 14.15% and 16.47%, and length by 15.92% and 13.79%, in the first and second seasons, respectively.

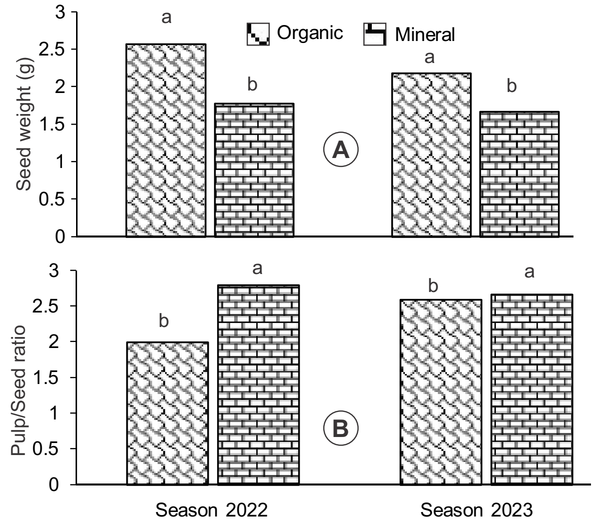

Fig. 6. Effect of nitrogen source on seed weight (A) and pulp/seed weight (B) of Toffahi olive cultivar during two seasons.

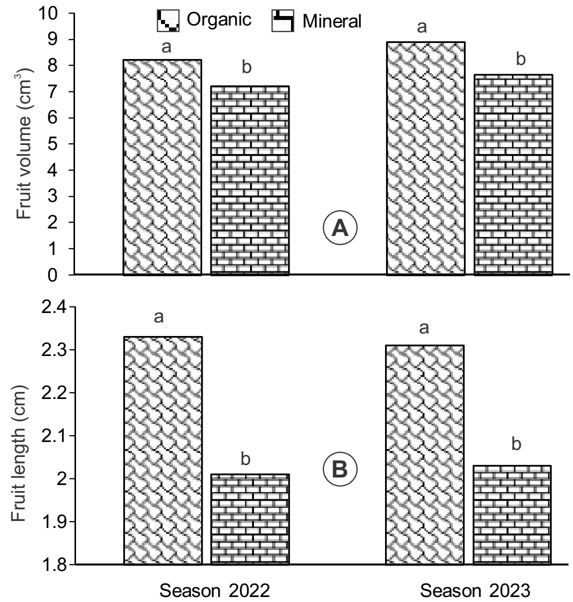

Fig. 7. Effect of nitrogen source (organic or mineral) on fruit volume (A) and fruit length (B) of Toffahi olive cultivar during two seasons.

Fruit diameter (cm) and shape index: Data in Fig. 8 show that farming systems significantly affected fruit diameter (Fig. 8A) and shape index (Fig. 8B) of Toffahi olive across both seasons. Organic nitrogen (compost and biofertilizers) yielded the higher fruit diameter (2.17, 2.24 cm) and shape index (1.07, 1.03), while inorganic nitrogen resulted in the lower values (diameter: 1.90, 1.99 cm; shape index: 1.05, 1.02). Organic nitrogen increased fruit diameter by 14.21% and 12.56% in the first and second seasons, respectively.

Economic feasibility study: The economic study showed that, organic nitrogen fertilizers increased the economic return for olive orchard mainly due to increasing fruit price besides increasing fruit yield, which increased than 2 folds (264.9%) of Egyptian pounds than mineral nitrogen fertilization.

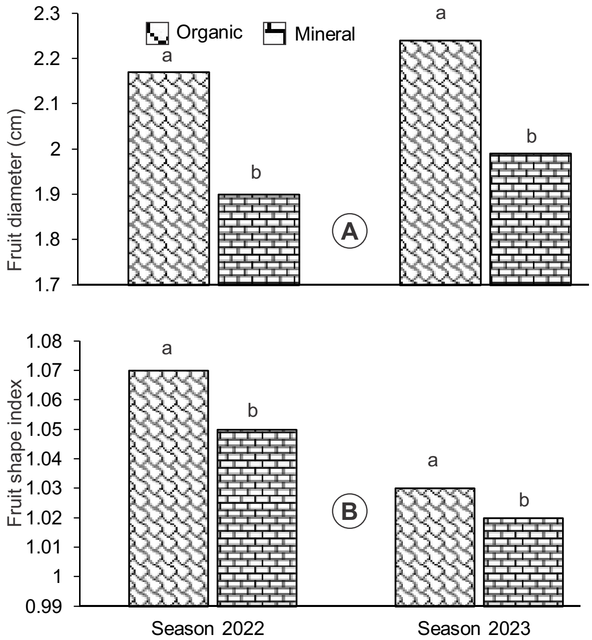

Fig. 8. Effect of nitrogen source (organic or mineral) on frit diameter (A) and fruit shape index (B) of Toffahi olive cultivar during two seasons.

Discussion

The results indicate that organic nitrogen systems positively influence fruit set and yield. Hegazi *et al.* (2007) reported that organic fertilization helps maintain leaf mineral levels in olive trees, enhancing yield. The higher fruit set and reduced fruit drop observed may be attributed to the slow-release nature of compost, which provides essential nutrients like Zn and B that support pollen germination. These findings align with Fayed (2005), who found that organic practices led to the highest fruit set in Anna apple trees, and Chehab *et al.*, (2019), who noted significant improvements with compost-organic fertilizer combinations. Citrus fruits also showed strong responses, with Arji *et al.* (2021) reporting the highest yields using chicken manure alongside mineral fertilizers. Moreover, El-Alakmy *et al.* (2018) reported that fish scrap at 2.5 kg per tree increased fruit set and yield of Kalamata olive trees compared to other organic fertilization sources (goat manure 16.8 kg, chicken manure 7.8 kg and olive pomace 8.5 kg). Also, the use of nitrobein biofertilizer N-fixing bacteria at 50 g per tree plus amino acid mixture at a concentration 1.5 % increased Kalamata yield (El-Alakmy *et al.*, 2018).

The increase in fruit yield resulted from increasing initial and final fruit set, which resulted from moderate nitrogen application at 4 kg NH_4NO_3/tree while higher nitrogen levels at 6 kg/tree decreased fruit set and fruit yield (Kotsias *et al.*, 2024). as well as at 160- 200 kg N/ha in the Mediterranean Basin region (Fernández-Escobar, 2011) and young Picual olive plants above 600 ppm (Fernandez-Escobar *et al.*, 2014). The improvement in fruit yield due to compost application was recorded in peaches (Fayed *et al.*, 2019) and pomegranate due to humic application (Rashedy *et al.*, 2022). The results indicated that organic nitrogen source improved fruit length, diameter and weight. These results were aligned with previous research by Hegazi *et al.* (2007), who found that compost was the most effective organic fertilizer source for improving the physical properties of olive fruit. The study also showed that olive cultivars with higher fruit weights tended to have greater flesh weights, which is consistent with findings by Maksoud (2000) that different olive cultivars vary significantly in flesh weight due to the influence of organic fertilization. These findings are similar to the research conducted by Salama (2002) on Balady mandarins, and Osman (2003) on Zaghloul dates. Osman found that bio-fertilizer treatments produced the best results in terms of yield and fruit characteristics for the Zaghlool cultivar. Also, Arji *et al.* (2021) found an increase in fruit and flesh weight by organic fertilization application alone or combined with inorganic fertilizers. Improving fruit quality due to organic fertilizers was reported on Kalamata olive (El-Alakmy *et al.*, 2018). The improvement in fruit quality due to compost application was recorded in peaches (Fayed *et al.*, 2019) and pomegranate due to humic application (Rashedy *et al.*, 2022).

High flowering efficiency under organic nitrogen fertilizers could be attributed to the ability of soil microorganisms to release growth regulators like cytokinins, auxins and gibberellins, which positively impact the flowering process and nutrient absorption (Martin *et al.*,1989). Maksoud (2000) found that the application of various organic fertilization to olive trees led to increased numbers of inflorescences per shoot and flowers per inflorescence. Additionally, these results closely parallel the findings of Abou Taleb *et al.* (2004), who demonstrated that the most effective enhancement of total flower count per inflorescence and the sex ratio of olive trees was achieved through *Bacillus* inoculation combined with 500 g of nitrogen. Hegazi *et al.* (2007) also reported that the utilization of diverse organic fertilization methods, such as compost, significantly boosted the density of flowering and sex ratio in olive trees of the picual cultivar. More recently, chicken manure led to the production of the highest number of inflorescences per twig and flower number per inflorescence growth when combined with mineral fertilizers or vermicompost, cow, and sheep manures (Arji *et al.*, 2021).

Application of nitrogen source at 25 kg/tree combined with 1 L of *Azotobacter chroococcum, Bacillus megaterium* and *Baciilus circulance* at three times for Toffahi olive trees, outperformed inorganic nitrogen source in enhancing inflorescence and flower numbers, improved flower sex ratios, fruit set, and yield, while it reduced fruit drop. Organic nitrogen source is considered the most effective and sustainable alternative in the face of climate change challenges. Recently, biochar as sustainable soil application improved flowering and productivity of Zebda mango trees (Shaban *et al.*, 2025).

In conclusion, the results demonstrate that organic nitrogen fertilization significantly improved flowering, fruit set, yield, and fruit quality of Toffahi olive trees compared with mineral nitrogen. It also reduced fruit drop and increased economic returns. Therefore, the use of organic nitrogen sources can be recommended as a sustainable and efficient nutrient management strategy for enhancing olive productivity and fruit quality.

Funding: This research study was funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 861924, Project SustInAfrica (Sustainable Intensification of Food Production through Resilient Farming Systems in West and North Africa).

Acknowledgments

We thank the farmers who participated in the SustInAfrica project for providing their time and data. We also extend our thanks to all project partners and colleagues for their valuable contributions and support throughout the study.

References

Abou–Taleb, A. Safia, Abou El-Khashab, A. M. and Sead, T. Wafaa (2004) Growth and productivity of olive trees as affected by some bio and mineral nitrogen fertilizers. *Minufiya J. Agric. Res. Egypt.*, 29(4): 933-963.

Alghamdi, A.G., 2018. Biochar as a potential soil additive for improving soil physical properties—A review. *Arab. J. Geosci*., 11(24): 766.

Arji, I., M. Safari, I. Hadawi 2021. Effects of Different organic manures and chemical fertilizers on yield and yield component of olive (*Olea europaea* L.) cv Zard in Kermanshah province. *Agrotechniques in Industrial Crops*, 1(2): 61-70: 2021.

Bresler, E, B.L. McNeal and D.L. Carter 1982. Saline and sodic soils. Principles-dynamics-modeling. Advanced Series in Agricultural Sciences 10. Springer-Verlag, Berlin/Heidelberg/New York, 236 pp

Chehab, Hechmi, Tekaya, Meriem, Ouhibi, Mohamed, Gouiaa, Mohamed, Zakhama, Houda, Mahjoub, Zoubeir, Laamari, Salwa, Sfina, Hanene, Chihaoui, Badreddine, Boujnah, Dalenda and Mechri Beligh, 2019. Effects of compost, olive mill wastewater and legume cover cropson soil characteristics, tree performance and oil quality of olive trees cv.Chemlali grown under organic farming system. *Scientia Hortic*., 253. 10.1016/j.scienta.2019.04.039.

El-Alakmy, D.A., M.A. Nagaty, M.M. Sourour and M.D. El-Deeb, 2018. Effect of bio and organic fertilizers on flowering, yield, and fruit quality of Kalamata olive trees under north Sinai conditions. *J. Plant Production, Mansoura Univ.*, 9(11): 939-945.

El-Elsonbaty A.E., M.A. El-Sherpiny, 2024. Improving the yield and quality of faba bean grown in alkaline soils using agricultural gypsum, organic fertilizers and cobalt. *Egypt. J. Soil Sci.*, 64(3): 1285–1303.

Fayed, T.A. 2005. Effect of some organic manures and biofertilizers on Anna apple trees. 2-Yield and fruit characteristics. *Egypt. J. App. Sci.*, 20(1): 176-191.

Fayed, T.A., A.M. Hussein, A.A. Rashedy and M.S. Elaksher, 2019. Effect of different types of organic fertilizers on the growth and productivity of peach cv "Florida prince". *Middle East J. Agric. Res.,* 08(1): 347-355.

Fernández Escobar, R. and G.C.C. Martin, 1987. “Swan Hill” an ornamental olive cultivar. *Olea*, 18: 51-53.

Fernandez, E.R. and G.V. Gomez, 1985. Cross-pollination in Gordal Sevillano olives. *Hortscience*, 202: 191-192.

Fernandez-Escobar, R., M.F. Antonaya-Baena, M.A. Sunchez Zamora and C. Molina-Soria, 2014. The amount of nitrogen applied and the nutritional status of olive plants affect nitrogen uptake efficiency. *Sci. Hortic*.**,** 167:1–4.

Fernández-Escobar, R., J.M. García-Novelo and H. Restrepo Díaz, 2011. Mobilization of nitrogen in the olive bearing shoots after foliar application of urea. *Sci. Hortic.,* 127: 452–454.

Fornes, F., Lidón, A., R.M. Belda, G.P.F. Macan, M.L. Cayuela, M. Sánchez-García, and M.A. Sánchez-Monedero, 2024. Soil fertility and plant nutrition in an organic olive orchard after 5 years of amendment with compost, biochar or their blend. *Sci. Rep.*, 14: 16606.

García Martín, J.F., M. Cuevas, C.H. Feng, P.A. Mateos, M.T. García and S. Sánchez, 2020. Energetic valorisation of olive biomass: Olive-tree pruning, olive stones and pomaces. *Processes*, 8: 511.

Guneş A., Y.M. Kece and E. Beyzi, 2023. The effects of using organic and chemical fertilizers on yield and yield parameters in different pepper (*Capsicum annuum* L.) varieties. *Gesunde Pflanzen,* 75: 1945-1952.

Hegazi, E.S., M.R. El-Sonbaty, M.A. Eissa and T.F.A. El-Sharon, 2007. Effect of organic and bio-fertilization on vegetative and flowering of Picual olive trees. *World J. Agric. Sci.*, 3: 210-217.

Ibrahimi K. and A.G. Alghamdi, 2022. Available water capacity of sandy soils as affected by biochar application: A meta-analysis. *Catena*, 214: 106281.

IOC 2025. International Olive Council. https://www.internationaloliveoil.org/sector-statistics-january-2025/.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Kareem, S.S. and B.A. Hamed, 2024. The effect of adding bio and organic fertilizer under two levels of water stress on the readiness of NPK nutrients in the plant and the growth yield of the sorghum plant. In: *IOP Conference Series: Earth and Environmental Science*, 1371(8): 082010). IOP Publishing.

Kotsias, D., V. Kavvadias and C. Pappas, 2024. Response of olive trees (*Olea europaea* L.) cv. Kalinioti to nitrogen fertilizer application. *Physiologia*, 4: 43-53. https://doi.org/10.3390/physiologia4010002.

Maksoud, M.A., 2000. Response of growth and flowering of Manzanillo olive trees to different sorts of nutrients. *Egypt. J. Hortic.*, 27(4): 513-523.

Martin, P., A. Galatzly, W. Klob, H. Omay and W. Shmdidt, 1989. Nitrogen fixing bacteria in the rhizosphere quantification and hormonal effects on root development. *Z. Pflonzyernahr Boodenk*, 152: 237-245.

Moradzadeh, S., S.S. Moghaddam, A. Rahimi, L. Pourakbar and R.Z. Sayyed, 2021. Combined bio-chemical fertilizers ameliorate agro-biochemical attributes of black cumin (*Nigella sativa* L.). *Sci. Rep.,* 11: 11399.

Musei, S.K., S. Kuyah, S. Nyawira, S.K. Ng’ang’, W.N. Karugu, A. Smucker and L. Nkurunziza, 2024. Sandy soil reclamation technologies to improve crop productivity and soil health: A review. *Front. Soil Sci.*, 4: 1345895.

Osman, S.M., 2003. Effect of bio-fertiliser on fruit physical and chemical properties of Zaghloul date palm, *Annals Agric. Sci, Ain Shams Univ.*, Cairo, 48 (1): 297-305.

Rashedy, A.A., M.H. Abd-Elnafea and E.H. Khedr, 2022. Co-application of proline or calcium and humic acid enhances productivity of salt stressed pomegranate by improving nutritional status and osmoregulation mechanisms. *Sci. Rept.,* 12: 14285.

Rashwan, B.R., Basma RA, and Hind M. El-Azazy 2024. Impact of cultivation methods and fertilization by EM (Effective microorganisms) and/or compost on Productivity and water use efficiency of wheat (*Triticum aestivum* L.). *Egypt. J. Soil Sci.*, 64(1): 83-98.

Salama, A.S.M., 2002. Response of some fruit species transplant and trees to organic fertilization. Ph.D. thesis, Fac. Agric, Moshtoher, Zagazig Uni, Benha Branch, Egypt.

Shaban, A., M. Abd El-Migeed, H. Moawad and A.A. Rashedy, 2025. Sustainable biochar outperforms hydrogel in alleviating water stress, enhancing Zebda mango yield and water use efficiency. *Egyp. J. Soil Sci.,* 65(2): 751-768.

Snedecor, G.A. and W.G. Cochran, 1980. *Statistical Methods.* Oxford and J.B.H. Bub Com. 7th Edition.

Wild, S.A., R.B. Corey, J.G. Lyer and G.K. Voigt, 1985*. Soil and Plant Analysis for Tree Culture*. Oxford and IBH Publishing Co., New Delhi, India.

Received: April, 2025 ; Revised: June, 2025 ; Accepted: July, 2025