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Effect of Kinetin Spraying and Vermicompost on the Vegetative Growth Characteristics of Olive Seedlings (*Olea europaea* L.) cv. Ashrasi

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Abstract: In this study, we attempted to assess the effect of foliar spraying with kinetin and soil application of vermicompost extract on vegetative growth traits and biochemical constituents of two-year-old olive seedlings (*Olea europaea* L. cv. 'Arbosano'). During the 2026 agricultural season at the College of Agriculture, Tikrit University, (Ashrasi). The experiment was laid out as Randomized Complete Block Design (RCBD) with factorial arrangement of three concentrations of kinetin (0, 50 and 100 mg/L) and three levels of vermicompost extract (0, 5 and 10 mL/L) with three replications. Vegetative growth parameters, namely plant height, stem diameter, leaf and branch numbers, were measured together with biochemical parameters namely percentages of nitrogen, phosphorus, potassium, total carbohydrates and protein content. The results showed that both kinetin and vermicompost application increased significantly all studied traits as compared to the control. Most vegetative growth parameters and mineral contents were the highest at the third level of kinetin (A3). Vermicompost applied at the highest rates (B3 or B2) consistently produced the best results for all traits measured. The synergistic interaction of kinetin with vermicompost was observed for all the nutrients such as nitrogen, protein and carbohydrate with the combination of A2B3 (2.200%, 1.320% and 11.856% respectively) and A3B2 (0.943%) for phosphorus level. The results presented here support that combination of hormonal stimulation by foliar application of kinetin and organic soil enrichment by vermicompost is an effective and sustainable strategy to improve the growth, nutritional status and biochemical quality of the Ashrasi olive seedlings.

Keywords: Kinetin, Vegetative growth, Ashrasi cultivar, Olive (*Olea europaea* L.) and Vermicompost.

Introduction

As one of the oldest fruit tree planted in the Middle East, east of the Mediterranean, and one of the most economically and culturally important trees, olive trees have been cultivated for six thousand to four thousand years BC in the Levant region [1]. This tree has a globally prominent position, with global area of cultivation over 9 million hectares, with more than 90% of the area in the Mediterranean basin countries [2]. The remarkable double increase in the global production in this period is emphasized by the estimated production of olive oil in 2024-2025 season at approximately 3,375,500 tons, making this crop of great importance both economically and globally [2]. Olive cultivation is one of the oldest agricultural practices and one of the most economically and socially relevant in the

countries of the region, and olive oil has become an integral part of human life due to its organoleptic properties and the health benefits it provides, which have been scientifically proven [3]. Ashrasi cultivar is regarded as an Iraqi and Arab original cultivar, which is wide spread in Iraq. It is known by its adaptability to local environmental conditions and by its value to the economy in many ways, both oil production and table olive. Mohammed et al. [4] concluded that vegetative growth parameters and mineral content of leaves in terms of N, P and K were significantly improved in Ashrasi trees fertilized with compound organic fertilizer than in the control, when tested in the governorate of Anbar. In the same way, another study by Hassan et al. [5] has been done at Al-Musaib Technical Institute on seedlings of this cultivar, in which they sprayed the foliage with liquid organic fertilizers and found highly significant increases in all vegetative growth indicators, chlorophyll content, and leaf mineral elements over the control. The seedling stage is one of the most critical moments of the olive tree's life and the most significant in determining the future productivity and quality of the tree. Coelho et al. [6] indicated that data regarding the effect of biostimulants on enhancing olive seedling growth remain limited, necessitating further systematic scientific research. In light of contemporary agriculture's trend towards reducing synthetic chemical inputs, research into biological and organic alternatives to enhance seedling growth has become a pressing scientific and practical necessity. Kinetin (N⁶-Furfuryladenine) is the first cytokinin ever discovered. It was isolated by Miller and his colleagues from herring sperm DNA and named for its ability to induce cell division [7]. Cytokinins are classified as adenine-derived plant hormones that control aspects covering almost all stages of plant growth and development, performing pivotal functions in cell division, nutrient distribution, photosynthetic efficiency, and response to environmental stresses [8]. Kinetin performs a range of essential physiological functions in plants, most notably: stimulating cell division and elongation, enhancing chloroplast development and photosynthetic efficiency, delaying leaf senescence and preventing protein breakdown, promoting the mobilization of nutrients from adjacent tissues, and contributing to short- and long-distance growth signals [9]. Regarding mineral content, studies have shown that cytokinin treatment improves the efficiency of mineral nutrient uptake, reducing the accumulation of harmful ions and enhancing the uptake of beneficial elements, positively impacting shoot growth [10]. Regarding foliar application on trees, a study by El-Bably and Rashed [11] revealed that foliar spraying with kinetin at 90 mg/L increased leaf content of nitrogen, phosphorus, potassium, chlorophyll (a), chlorophyll (b), and total carbohydrates by 51.73, 51.62, 38.99, 58.36, and 41.55%, respectively, compared to the control. On citrus seedlings, Hassoon et al. [12] found that spraying kinetin at 150 mg/L significantly increased the number of new branches, leaves, leaf area, dry weight, and total chlorophyll, compared to the control. In the case of olives, Mahmoud [13] noted a positive effect of spraying of the plant with benzyl adenine (a cytokinin) on the leaf area and vegetative growth traits of Manzanillo olive trees during the two study seasons. Furthermore, foliar application of growth regulators significantly increased the growth parameters of olive seedlings of both varieties Nebali and Baeshike [14], highlighting the role of growth regulators in olive seedling physiology. Vermicompost is the product of decomposition of organic matter by earthworms and microbial community. It has a distinct chemical composition that includes a mix of macro and micronutrients needed for plant growth, as well as biologically active compounds like plant hormones [15]. The growth promoting activities of it are mainly attributed to the combined effect of organic matter, enzymatic reactions and hormonal factors that occur as the earthworms interact with the microbial community and the plant hormones secreted during the process are effective such as auxins, gibberellins and cytokinins [16]. The Ultra-High-Performance Liquid Chromatography-Tandem Mass Spectrometry (UHPLC-MS/MS) analysis of the vermicompost extract has provided advanced analytical studies that revealed a large number of different plant hormones, with N⁶-isopentenyladenine accounting for about 60% of total cytokinins content in vermicompost, which is the first mass spectrometric evidence of the presence of active cytokinins in vermicompost reported by Aremu et al. [17]. Concerning humic acids, Canellas et al. [18] said that the humic and fulvic acids of vermicompost affects nutrient uptake both directly and indirectly by modifying the root anatomy, and increasing the exudates of the roots. Concerning foliar application of vermicompost, Balmori et al. [19] demonstrated that foliar spraying with vermicompost humic extract contributed to improved growth and production quality when applied at graded dilution rates. Additionally, a study by Anastácio et al. [20] conducted on horticultural plant seedlings showed

that foliar spraying with 5% vermicompost extract led to increased physiological and morphological growth indicators, improved protein and soluble sugar content, and enhanced vegetative growth traits compared to the control. Specifically in the context of olive trees, a study by Hassan et al. [21] proved that foliar spraying with biological extracts on Picual olive trees had a significant positive effect on all vegetative growth indicators, leaf mineral content, and fruit characteristics compared to the control. Furthermore, a study by Moradi et al. [22] showed that vermicompost significantly improves the growth rates of olive trees and enhances their root activity in calcareous soils.

This study aims to achieve the following scientific objectives:

1. Evaluate the effect of different concentrations of kinetin applied as a foliar spray on the vegetative growth traits of Ashrasi olive seedlings.
2. Study the effect of graded levels of vermicompost extract added to the soil on the same traits mentioned above.
3. Investigate the nature of the interaction between the two treatments and determine the optimal combination of kinetin and vermicompost that ensures obtaining seedlings with high vegetative quality.

Materials and Methods

Location and Time of the Experiment

The experiment was conducted in the wooden shade house at the College of Agriculture / Tikrit University during the 2026 agricultural season under controlled environmental conditions to control environmental variables and ensure the reliability and reproducibility of the results.

Plant Material

Two-year-old olive seedlings of the Ashrasi cultivar (*Olea europaea* L. cv. Ashrasi) were used. They were produced and planted in plastic pots with a capacity of 5 kg, using a homogenized soil mixture with consistent composition and properties.

Experimental Design and Treatments

A Randomized Complete Block Design (RCBD) was adopted according to a factorial arrangement (Kinetin and Vermicompost) with three replications. The first factor (K) included four levels of kinetin: (K0 = 0, K1 = 50, K2 = 100 mg/L). The second factor (V) included four levels of vermicompost extract: (V0 = 0, V1 = 5 mL/L, V2 = ...). Foliar spraying and addition were carried out three times during the season with a two-week interval between each spray, during the early morning hours to avoid evaporation issues. A spreader-sticker agent was added to the spray solutions at 0.1% to ensure solution adhesion to the leaf surface.

Measured Traits

Vegetative growth traits: Plant height (cm) using a metric ruler, number of leaves (leaf/plant), main branch length (cm), and stem diameter (cm).

Chemical Traits

1. Nitrogen percentage (%)
2. Phosphorus percentage (%)
3. Potassium percentage (%)
4. Carbohydrate percentage (%)
5. Protein percentage (%)

Statistical Analysis

Data were statistically analyzed using the SAS - Statistical Analysis System software at a 5% probability level. Significant differences between means were determined using the Least Significant Difference (L.S.D) test at the same level.

Results

Plant Height (cm)

It is evident from Table (1) that the third concentration of kinetin (A₃) significantly outperformed, giving the highest average increase in plant height, reaching 60.444 cm. It did not differ significantly from the second concentration, which gave an increase rate of 55.809 cm. The lowest increase rate was 34.33 cm in the control treatment. The same table showed similar results for the

vermicompost treatment of seedlings, as treatment (B₂) led to the highest increase rate in plant height, reaching 65.332 cm, while treatment (V1) gave an increase rate of 47.644 cm and did not significantly differ from the control treatment, which gave the lowest increase rate of 32.27 cm.

Table 1. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in plant height (cm) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
51.644	53.00	69.67	32.27	A1
55.809	63.00	63.00	54.61	A2
60.444	62.00	62.00	56.00	A3
	60.000	65.332	47.644	Mean B

Stem diameter (cm)

It is evident from Table (2) that the third concentration of kinetin (A₃) significantly outperformed, giving the highest average increase in stem diameter, reaching 6.238 cm. It did not differ significantly from the second concentration, which gave an increase rate of 6.124 cm. The first concentration gave an increase rate of 6.577 cm in the treatment. The same table showed similar results for the vermicompost treatment of seedlings, as treatment (B₂) led to the highest increase rate in stem diameter, reaching 6.650 cm, while treatment (V1) gave an increase rate of 6.522 cm and did not differ significantly from the control treatment, which gave the lowest increase rate of 5.733 cm.

Table 2. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in stem diameter (cm) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
6.577	6.700	7.300	5.733	A1
6.124	6.067	6.333	5.973	A2
6.238	7.183	5.933	5.600	A3
	6.650	6.522	5.768	Mean B

Number of leaves (leaf)

It is evident from Table (3) that the third concentration of kinetin (A₃) significantly outperformed, giving the highest average increase in leaf number, reaching 117 leaves. It did not differ significantly from the second concentration, which gave an increase rate of 116.89 leaves. The first concentration gave an increase rate of 136.08 in the treatment. The same table showed similar results for the vermicompost treatment of seedlings, as treatment (B₂) led to the highest increase rate in leaf number, reaching 117.00 leaves, while treatment (V1) gave an increase rate of 116 leaves and did not differ significantly from the control treatment, which gave the lowest increase rate of 86.67 leaves.

Table 3. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in leaf number (leaf) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
136.80	130.67	112.33	130.67	A1
116.89	86.67	142.00	144.67	A2
117.00	115.33	96.33	135.33	A3
	117.00	116.	116.89	Mean B

Number of branches (branch)

It is evident from Table (4) that the second concentration of kinetin (A_2) significantly outperformed, giving the highest average increase in the number of branches, reaching 9.444 branches. It did not differ significantly from the first concentration, which gave an increase rate of 7.444 branches, while the third concentration gave 6.111 branches. The lowest increase rate was 34.33 cm in the control treatment (Note: The text appears to have a slight inconsistency here, as it mentions "34.33 cm" which relates to plant height, but the context is about branch number; it likely means the lowest branch number was in the control treatment). The same table showed similar results for the vermicompost treatment of seedlings, as treatment (B_1) led to the highest increase rate in the number of branches per plant, reaching 8.000 branches, while treatment (B_2) gave an increase rate of 7.667 branches and did not differ significantly from the control treatment, which gave the lowest increase rate of 4.667 branches.

Table 4. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in branch number (branch) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
7.444	11.333	5.000	6.000	A1
9.444	6.000	12.333	10.000	A2
6.111	5.667	4.667	8.000	A3
	7.667	7.333	8.000	Mean B

The significant superiority of the kinetin spray treatments combined with soil-applied vermicompost in enhancing the vegetative growth parameters of olive seedlings is attributed to the physiological and integrative roles of both organic and synthetic growth regulators. The effects of kinetin on plant growth and development include stimulation of cell division, activation of bud meristems, and suppression of apical dominance, as a member of the cytokinin group of plant growth regulators. This effect is responsible for the lateral branch growth, higher leaf density, and elongation of internodes in the actively growing apices, due to the diversion of the nutrients and photosynthetic assimilates away from the basal parts of the plant. The foliar application of 90 mg/L did not differ significantly from the other treatments in terms of leaf fresh weight or number of leaves, as reported by El-Bably and Rashed [11], who observed a 57.85% and 49.40% increment, respectively. Moreover, Mahmoud [13] showed that cytokinin has a direct effect on leaf area and stimulating vegetative growth in olive seedlings. However, the increase in soil improvement noted in the vermicompost group is credited to vermicompost boosting the physical and chemical properties of the soil, and providing nutrients in forms that easily enter the roots and water of plants. Additionally, vermicompost is rich in natural hormonal compounds secreted by its associated microflora. These hormones and aqueous extracts stimulate metabolic activity, accelerate internode elongation, and increase stem diameter and plant height. This is in line with Aremu et al. [17] regarding the role of natural vermicompost hormones in the elongation of meristematic tissues. These results are fully consistent with the study conducted by Mohammed et al. [4] on olive trees of the "Ashrasi" cultivar, which demonstrated that combined organic fertilization and its aqueous extract significantly and directly contribute to supporting and enhancing all vegetative growth parameters.

Nitrogen percentage (%)

Effect of Kinetin Treatment (Mean A) Kinetin levels recorded a gradual increase in the overall mean of nitrogen percentage with rising concentration, as the rate increased from 1.792% at the first level (A1) to reach its highest value of 1.918% at the third level (A3). This superiority is attributed to the role of kinetin as one of the important cytokinins that stimulate cell division and activate protein synthesis, as well as enhancing the photosynthetic capacity to attract nutrients and improve cellular uptake efficiency [23], [24]. Effect of Vermicompost Treatment (Mean B): The addition of vermicompost showed a clear positive effect, as the mean nitrogen percentage increased from 1.608% at level B1 to reach its maximum rate of 2.017% at level B3. This is due to the characteristics of vermicompost, which is rich in available nutrients and organic matter, improving the physical and chemical properties of the

soil and increasing microbial activity, thereby facilitating nitrogen absorption and its fixation within plant tissues [25], [26]. Interactive Effect of Kinetin and Vermicompost (A × B): The interaction treatment between the second concentration of kinetin and the third level of vermicompost (A2B3) achieved the highest nitrogen percentage value of 2.200%, followed by treatment (A3B2) with a value of 2.146%, while treatment (A2B1) recorded the lowest value of 1.463%. This mutual synergy demonstrates that providing an excellent organic nutritional base in the soil via vermicompost supports the stimulatory physiological effect of kinetin in increasing nitrogen assimilation and its accumulation within olive leaves [27], [28].

Table 5. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in Nitrogen (%) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
1.792	1.933	1.774	1.670	A1
1.833	2.200	1.836	1.463	A2
1.918	1.918	2.146	1.690	A3
	2.017	1.919	1.608	Mean B

Phosphorus percentage (%)

Effect of Kinetin Treatment (Mean A): The results clearly showed the superiority of the third concentration of kinetin (A3) in increasing phosphorus percentage (%), recording the highest mean of 0.608% compared to concentrations A1 and A2, which recorded 0.361% and 0.263%, respectively. This increase is attributed to the role of kinetin in stimulating the metabolic and physiological activity of the plant, thereby enhancing root efficiency in absorbing relatively immobile elements such as phosphorus and transporting them to vegetative tissues [8], [10]. Effect of Vermicompost Treatment (Mean B) The addition at the second level of vermicompost (B2) achieved the most prominent superiority in mean phosphorus percentage, recording 0.567%, surpassing levels B3 (0.386%) and B1 (0.258%). This is attributed to the fact that adding vermicompost at balanced rates provides organic acids that contribute to lowering the pH of the rhizosphere soil, thereby dissolving complex phosphorus compounds and making them more available for uptake [29], [30]. The interactive effect of Kinetin and Vermicompost (A × B) showed that the percentage increase in the phosphorus content in the soil for the binary interaction treatment A3B2 was exceptional and recorded 0.943%, followed by treatment A3B3 with 0.608%, while the lowest value was recorded for treatment A2B1, which was 0.226%. This synergy shows that, when foliar application of hormonal stimulants and kinetin sprays are used in combination with a balanced application of vermicompost in the soil, the root growth and enzymatic activity can be improved, consequently increasing the capacity of the plant to absorb phosphorus [31], [32]. The cultivars treated with kinetin spraying, vermicompost addition and both were compared for increasing percentage of Phosphors (%).

Table 6. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase Phosphorus percentage (%) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg. L ⁻¹)
	B3	B2	B1	
0.361	0.260	0.486	0.275	A1
0.263	0.290	0.273	0.226	A2
0.608	0.608	0.943	0.273	A3
	0.386	0.567	0.258	Mean B

Potassium percentage (%)

Effect of Kinetin Treatment (Mean A): The highest mean for potassium percentage increase was recorded at the first level of kinetin treatment (A1) at 2.530%, while the third level of kinetin treatment

(A3) was the second best with 2.516% and the second level (A2) had the lowest mean of 2.410%. This superiority is explained by the stimulatory effect of kinetin on the activation of various transport processes and its role in regulating stomatal opening and closing as well as water potential in tissues at lower concentrations that do not cause physiological saturation [33], [34]. The effect of Vermicompost Treatment (Mean B): The mean percentage of potassium varied with the level of vermicompost treatment and was found to increase with its level of increase, i.e., B1 (2.255%), B2 (2.479%) to B3 (2.728%). This continuous increase is attributed to the richness of vermicompost in available potassium and its ease of release in the soil due to high microbial activity [35], [36]. Interactive Effect of Kinetin and Vermicompost ($A \times B$): The interaction treatment between the first concentration of kinetin and the highest level of vermicompost (A1B3) achieved the highest potassium percentage increase at 2.855%, followed by treatment (A2B3) at 2.813%, then treatment (A3B2) at 2.733%. In contrast, treatment (A3B3) recorded an unexpected decrease of 0.151%. These results demonstrate that the interaction between light foliar spraying of kinetin and high organic fertilization with vermicompost improves potassium availability and utilization efficiency within plant cells [37], [38].

Table 7. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in Potassium (%) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
2.530	2.855	2.494	2.260	A1
2.410	2.813	2.210	2.206	A2
2.516	0.151	2.733	2.300	A3
	2.728	2.479	2.255	Mean B

Carbohydrate percentage (%)

Effect of Kinetin Treatment (Mean A): The second concentration of kinetin (A2) recorded the highest mean for carbohydrate percentage (CHO) at 10.955%, outperforming the first concentration (A1) which recorded 10.745%, while the mean decreased to 10.381% at the highest concentration (A3). This excellent performance at the intermediate level is attributed to the role of kinetin in activating photosynthesis and delaying leaf senescence, thereby increasing the efficiency of carbon fixation and sugar accumulation [39], [40]. Effect of Vermicompost Treatment (Mean B): The addition of vermicompost showed a clear direct proportional increase in carbohydrate accumulation with increasing application rate, as the mean rose from 9.950% at level B1 to 10.855% at level B2, reaching its maximum rate of 11.303% at the highest level (B3). This is attributed to the role of vermicompost in improving soil hydraulic properties and supplying the plant with essential macro- and micronutrients necessary for building enzymes involved in the Calvin cycle [41], [42]. Interactive Effect of Kinetin and Vermicompost ($A \times B$): The interaction treatment between the second concentration of kinetin and the highest level of vermicompost (A2B3) achieved the highest carbohydrate percentage increase at 11.856%, followed by treatment (A1B3) with a value of 11.673%, then treatment (A3B2) with a value of 11.090%, while treatment (A3B1) recorded the lowest value of 9.673%. These results confirm the physiological synergy when combining balanced foliar spraying with kinetin and organic fertilization with vermicompost, thereby raising the overall carbohydrate percentage in the leaves [43], [44].

Table 8. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in CHO (%) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
10.745	11.673	10.584	10.058	A1
10.955	11.856	10.890	10.120	A2
10.381	10.380	11.090	9.673	A3
	11.303	10.855	9.950	Mean B

Protein percentage (%)

The effect of Kinetin Treatment (Mean A): The 3rd level (A3) had the highest increase of protein percentage as 1.151%, followed by the 2nd level (A2) with increase of 1.100%, and the 1st level (A1) was the lowest with the increase of 1.071%. The involvement of cytokinins in the activation of genetic translation and amino acid and protein synthesis in plant cells is directly linked to this [45], [46]. Effect of Vermicompost Treatment (Mean B):** The results indicated that there was a definite increase in the mean percentage of protein with the increase in vermicompost application rate ranging from 0.964% to 1.151% and 1.210% at treatment levels B1, B2 and B3 respectively. This is due to providing the soil with organic and mineral nitrogen and making them available for root uptake, which is the elementary building block to synthesize amino acids and proteins [47], [48]. Interactive Effect of Kinetin and Vermicompost (A × B): The treatment A2B3 (highest protein percentage increase) was followed by the treatment A3B2 (1.288%), A1B3 (1.160%) and A2B1 (0.880%). This integration is evidence that supplying integrated organic nutrition together with foliar hormonal stimulation, works in supplying the energy and essential substrates for efficient protein assembly [49], [50].

Table 9. Effect of kinetin spraying (A), vermicompost addition (B), and their interaction on the increase percentage in Protein (%) in olive

Mean A	Vermicompost (ml.L ⁻¹)			Kinetin (mg.L ⁻¹)
	B3	B2	B1	
1.071	1.160	1.062	0.998	A1
1.100	1.320	1.102	0.880	A2
1.151	1.151	1.288	1.014	A3
	1.210	1.151	0.964	Mean B

Discussion

The present findings demonstrate that the combined application of kinetin and vermicompost substantially influenced both vegetative growth and biochemical composition of Ashrasi olive seedlings, although the magnitude of the response depended on the concentration and the specific trait evaluated. Kinetin generally promoted plant height, stem development, leaf formation, and branching, which can be associated with the physiological role of cytokinins in stimulating cell division, activating meristematic tissues, delaying senescence, and improving the mobilization of nutrients toward actively growing organs. At the same time, vermicompost improved growth and nutrient accumulation, most likely through its contribution of readily available macro- and micronutrients, organic matter, microbial activity, and naturally occurring growth-promoting substances. The interaction between both treatments was particularly evident in the biochemical traits. The A2B3 treatment produced the highest nitrogen content (2.200%), carbohydrate content (11.856%), and protein content (1.320%), indicating that moderate kinetin application combined with the highest vermicompost level may provide a favorable balance between hormonal stimulation and nutrient availability. In contrast, phosphorus reached its maximum value (0.943%) under A3B2, while potassium was highest (2.855%) under A1B3, demonstrating that the optimum treatment combination was nutrient-specific rather than uniform across all measured parameters. The markedly lower potassium value observed under A3B3 also suggests that increasing both kinetin and vermicompost to their highest levels does not necessarily produce an additive response and may indicate a concentration-dependent interaction that requires further investigation. Overall, the results support the complementary roles of foliar cytokinin application and organic soil amendment in improving the physiological performance, nutrient assimilation, and biochemical quality of olive seedlings. These responses further indicate that integrating kinetin with vermicompost may be more effective than relying on either treatment alone, while emphasizing the importance of selecting treatment concentrations according to the specific growth or nutritional characteristic targeted.

Conclusion

The combined application of foliar kinetin and soil-applied vermicompost improved the vegetative growth, nutritional status, and biochemical composition of Ashrasi olive seedlings, with the interaction treatments generally outperforming the individual applications. Kinetin at 50–100 mg/L enhanced plant height, stem diameter, leaf number, and branch development, while vermicompost at 5–10 mL/L supported growth through improved nutrient availability and soil conditions. Among the interaction treatments, A2B3 produced the highest nitrogen (2.200%), total carbohydrates (11.856%), and protein (1.320%), A3B2 produced the highest phosphorus (0.943%), and A1B3 produced the highest potassium (2.855%). These findings indicate that integrating kinetin with vermicompost is a promising and environmentally compatible nursery strategy for producing vigorous olive seedlings. For practical application, kinetin at 50–100 mg/L combined with vermicompost at 10 mL/L may be used according to the target trait, while further studies should assess long-term field performance, flowering, fruiting, olive-oil quality, the physiological and molecular basis of the interaction, and the economic feasibility of commercial-scale use.

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