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THE EFFECTS OF FOLIAR NANO-FERTILIZER AND SEAWEED EXTRACT ON THE GROWTH AND NUTRIENT STATUS OF PISTACIA SEEDLINGS

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Abstract

This study was conducted to determine the effects of nano-fertilizer foliar application of Loenergy Plus® and seaweed extract on *Pistacia vera* L seedlings. The experiment was conducted under a vegetable lath house at department of Horticulture and landscaping, college of Agriculture, University of Kerbala. The objective was to rapidly achieve mass production of strong seedlings that acclimate to different external environments. The research tested three levels of seaweed extract (0, 1, and 2 ml L^{-1}) and three levels of Loenergy Plus® (0, 0.5, and 1 ml L^{-1}). The following parameters seedlings height, stem diameter, leaf area, total chlorophyll concentration and stored: nutrients (nitrogen, phosphorus and potassium) were recorded Both Loenergy Plus® and seaweed extract significantly enhanced seedling height (up to 41.44 cm), stem diameter (0.72 mm), leaves number (46.48 leaves $plant^{-1}$), leaf area (23.44 cm^2), chlorophyll content (53.65 SPAD), and leaf N (2.83%), P (0.33%), and K (1.84%) concentrations. The best results were obtained with 1 ml L^{-1} Loenergy Plus® combined with 2 ml L^{-1} seaweed extract is actionable for nurseries, with all main effects and interactions significant ($p \leq 0.05$). It appears that a combination of nano-fertilizers and Seaweed extract might be effective in promoting the growth, vigor, and nutrient status of Pistacia seedlings.

Key words: *Pistacia vera* L.; Nano-fertilizer; Loenergy Plus®; Seaweed extract

Introduction

The pistachio tree, or *Pistacia vera* L., is a deciduous fruit tree that belongs to Anacardiaceae family. *Pistacia vera* is the only species in the Pistacia genus that is widely grown and traded worldwide due to its high economic and nutritional value Its seeds contain high level of oils content, proteins, carbohydrates and essential vitamins and minerals that are good for human health, such as calcium, iron and magnesium (Costa *et al.,* 2019). It is thought that the pistachio tree is native to East Asia and Western Asia and then spread to countries around the Mediterranean Sea (Mir-Makhamad *et al.,* 2022). The United States, Iran, Turkey, China, Syria, Greece, Italy, and Tunisia are some of the biggest producers of pistachios. Together, they produce around 15.6 million tonnes of pistachios per year (Anon., 2022). Most of Iraq's agricultural production occurs in the northern provinces, especially Nineveh and Kirkuk. However, growth is still constrained, even if the climate is good for commercial cultivation. Urban growth, rising groundwater levels, inappropriate selection of rootstocks and poor pest management and inadequate fertilization practices. are the main reasons for this problem (Mohammed & Salih, 2024). Commonly, pistachio trees are grown from seeds to produce rootstock seedlings, which are then grafted with selected cultivars, either male or female. Aleppo pistachio is considered superior rootstock as it is compatible with many pistachio cultivars and is resistant to soil-borne pests, such as nematodes, and fungal pathogens (Karimi, 2025; Tiwari *et al.,* 2025). Pistachio seedlings, tend to develop slowly and typically require more than one growing season to achieve the graftable diameter of 0.6–0.7 cm in slandered nursery conditions (Esmaeilpour *et al.,* 2015). The longer nursery duration seedlings, raises production costs and delays field planting. Alternate methods are required to accelerate the seedling growth. One effective technique is to application of foliar fertilizers, which send important nutrients straight to the leaves. This accelerates seedling growth by producing nucleic acids, proteins, enzymes, energy and cell division (Taiz *et al.,* 2015; Hasddin & Ulyasniati, 2025). Nano-fertilizers and seaweed extracts are two of the most promising agronomic inputs. Both have been shown to help plants develop while being environment friendly (Miransari, 2011; Khudair *et al.,* 2015; Alkarawi *et al.,* 2024). Nano-fertilizers are very tiny particles (1–100 nm) that plants can easily absorb and move around quickly in their tissues. They have been shown to improve fruit size, shape and physiological function. For example, foliar application of NPK nano-fertilizer on Kalamata olive seedlings resulted increase in height and number of leaves (Hagagg *et al.,* 2018). Similarly treatments on pistacia produce seedlings taller, thicker stems, more leaves, more chlorophyll content and more nutrients in the leaves (Mohammed, 2022). However, seaweed extracts are also significant for helping plants embellishment. These chemical substances like growth hormones (auxins, gibberellins, cytokinins), amino acids, and vitamins that improve important metabolic pathways (El-Motty *et al.,* 2010). Researchers have confirmed that foliar application

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of seaweed extract on peach and apricot trees improves growth and develop and also improve uptake of nutrients (Al-Rawi *et al.,* 2016; Al-Tamimi *et al.,* 2019). Commercial pistachio cultivation from seedlings takes more 5 years to produce marketable fruit, significantly less time than traditional seedling methods, which can take up to 10 years. Pre-made seedlings are known for their longevity. Using premium seedlings leads to faster results and quicker profits compared to older approaches. Pistachio trees have a long lifespan, which guarantees a steady income. Pistachio trees are tough; they handle drought and extreme temperatures well, which makes them a good investment in dry areas (Marino *et al.,* 2026). The objective of present study was to assess effect of Loenergy Plus® nano-fertilizer and seaweed extract on growth of *Pistacia vera* L. seedling rootstocks. The major concern was to boost seedling growth and shorten nursery time and make them to be ready for grafting in a nursery earlier.

Materials and Methods

Study area and sample collection: During March to October 2022, the experiment was conducted in Lath house area, Department of Horticulture and Landscape Engineering, College of Agriculture, University of Kerbala. The objective was to assess effect of foliar application of Loenergy Plus® nano-fertilizer and seaweed extract, both alone or in combination, on growth and development of pistachio (*Pistacia vera* L.) seedlings at nursery stage. The study used 81 uniform seedlings of six months age. Each seedling was transplanted in a plastic container that weighed 10 kg and was filled with a combination of sandy loam and peat moss in a 1:3 ratio.

Experiment design and treatments protocol: The experimental design used a Randomized Complete Block Design (RCBD) with three replicates and a factorial arrangement (3 × 3). There were nine seedlings in each set of experimental unit, three seedlings for each treatment. Loenergy Plus®, manufacturer by AGRI Sciences Tarim, Turkey. A commercial nano-fertilizer with 10% nitrogen (N), 12% phosphorus (P), and 12% potassium (K), was the initial experimental factor. It was applied at three different concentrations (0, 0.5, and 1 mlL^{-1}). The second factor was seaweed extract, (Energy Plus) manufacturer by Agroplasma, Spain., which contain 15% organic matter, 0.4% alginic acid, 30 ppm gibberellic acid and 0.4% potassium oxide. It was applied at three different concentrations (0, 1, and 2 mlL^{-1}) during March to August, 2022. Foliar application was done after every 30 days interval using a manual sprayer. All foliar applications were done during morning. Approximately, 1 ml L^{-1} of Tween-20 surfactant was added to make sure the leaves were completely soaked. The control plants were sprayed with distilled water. Plants were irrigated one day before foliar application of all treatment combinations to optimize nutrient absorption (Niu *et al.,* 2021).

Data collection: To evaluate the effects of the applied treatments, plant growth parameters were measured at two time points: before the initial application and at the end of the experimental period. Seedling height (cm) was measured using a measuring scale, and the mean increase in height was calculated for each treatment group. Stem diameter (mm) was assessed at the same time intervals using a vernier caliper, and average changes were recorded accordingly. The number of leaves per seedling was manually counted, all fully expanded leaves on each plant, and mean number of leaves was calculated across replicates. For leaf area estimation (cm^2), three fully developed leaves were randomly selected from each seedling. After detaching: The petioles, a 1 cm^2 disc was excised from each leaf and oven-dried at 70°C for 48 hours. The total leaf area was then calculated based on the ratio of the dry weight of the entire leaf to that of the disc, following a standard gravimetric method.

$$\text{Leaf area } (cm^2) = \frac{\text{Weight of leaf (g) x Area of cut part } (cm^2)}{\text{Dry weight of cut part (g)}}$$

Chlorophyll content was determined using a portable SPAD-502 chlorophyll meter (Minolta, Japan). Readings were taken from three fully expanded leaves per seedling, and the mean SPAD value was calculated for each treatment group. For leaf nutrient analysis, total nitrogen (N), phosphorus (P), and potassium (K) concentrations were measured. Total nitrogen was estimated using the Micro-Kjeldahl method. Phosphorus content was determined following wet acid digestion, with subsequent spectrophotometric quantification using ammonium molybdate and ascorbic acid as reagents. Potassium levels were measured using a flame photometer according to the procedure described by (Varley, 1966).

Statistical analysis: Statistical analysis was conducted using analysis of variance (ANOVA) appropriate for a factorial experiment arranged in a randomized complete block design (RCBD) with three replicates per treatment. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level ($p \leq 0.05$) to determine the significance of observed differences among treatments. All statistical computations and data analyses were performed using GenStat software, version 12.1 (Al-Rawi & Khalafallah, 2000; Singh, 2024).

Results and Discussion

Plant height: Table 1 shows that both Loenergy Plus and seaweed extract significantly increased pistachio seedling height. The maximum seedling height (41.44 cm) was measured with foliar application of 1 ml L^{-1} Loenergy Plus combined with 2 ml L^{-1} seaweed extract. It was observed that all treatments with 1 ml L^{-1} Loenergy Plus were significantly higher as compared to control (29.32 cm), as indicated by LSD values (Loenergy: 2.14, Seaweed: 2.14, Interaction: 3.68) at $p < 0.05$. These results indicates positive synergistic effect of combining nano-fertilizer and seaweed extract on pistachio seedling height. Such treatments could be significant for improving early plant development which lead to early grafting and minimize the cost of plant production at nursery level.

The results of current study were aligned with Fadhil & Al-Rawi (2025), who reported that the seaweed extract and nano-fertilizer foliar application is helpful for early seedling growth.

Similarly, significant increase in pistachio seedling height with foliar application of Loenergy Plus nano-fertilizer and seaweed extract (Table 1) aligns with recent studies indicating efficacy of nano-fertilizers to improve nutrient uptake and promoting vigorous plant growth in nursery (Karimi *et al.,* 2020; Khan *et al.,* 2023). Nano-fertilizers, due to their tiny particle size, improve absorption of nutrients as compared to conventional fertilizers (Singh *et al.,* 2024). Similarly, seaweed extracts are rich in bioactive compounds such as growth hormones and polysaccharides, which triggers cell division and elongation, ultimately contributing to improvement in growth parameters (García-Gómez *et al.,* 2022).

Stem diameter: The results (see Table 2) display at higher concentrations of both Loenergy Plus® nano-fertilizer and seaweed extract gradually improved stem diameter in pistachio seedlings. Average increase in stem diameter was 0.52 mm was recorded without application (0 ml L^{-1}) seaweed extract while, 0.68 mm was recorded at 2 ml L^{-1}, representing a positive association with dose response. Similarly, higher Loenergy Plus® levels (0.5 and 1 ml L^{-1}) resulted in averages of 0.64 mm and 0.66 cm respectively, while in control group 0.41 mm stem diameter was measured. These averages indicate overall beneficial impact of both treatments, with combined applications resulting highest improvements, brominating their potential for improving seedling stem diameter.

The notable improvement in seedling stem diameter following foliar application of Loenergy Plus® nano-fertilizer and seaweed extract (Table 2) strengthens evidence that nano-fertilizers enhance nutrient uptake and promote secondary growth in plants (Zhang *et al.,* 2023). The tiny particles improve nutrient provision at key growth points, which can trigger cambial activity and result in increased stems diameter (Pattapulavar *et al.,* 2025). Nano-fertilizers boost cambial activity in plants mainly by ensuring a steadier, more effective delivery of nutrients (mainly N, Zn, and Fe) to tissues that are growing spurs, enhancing cell division, vascular growth, and metabolic activity (Kumar *et al.,* 2025). Seaweed extracts provide auxin- and cytokinin-like substances that stimulate changes in root architecture, resulting in a greater surface area for nutrient absorption. This stimulates cell division in both roots and shoots, leading to better growth (Nikoogoftar-Sedghi *et al.,* 2023). Seaweed extracts, contain plant hormones such as cytokinins and auxins, have also significant role in cell division and expansion, contributing to increase in stem thickness (González *et al.,* 2022).

Moreover, dose dependent response, with maximum seedling stem diameter at 1 ml L^{-1} Loenergy Plus® combined with 2 ml L^{-1} seaweed extract, aligns with observations recorded by Kumar *et al*., (2023), who confirmed synergistic effects of combined biostimulant and nano-fertilizer treatments on growth parameters in fruit plant seedlings. Such integration of nano-fertilizer and natural biostimulants provides a promising approach for sustainable nursery management.

Number of leaf plant^{-1}: Results presented in Table 3 showed that both Loenergy Plus® and seaweed extract statistically significant increase number of leaves per pistachio seedling. The maximum number of leaves were counted (46.48 Leaf plant^{-1}) were counted when plants were treated with 1 ml L^{-1} Loenergy Plus® combined with 2 ml L^{-1} seaweed extract. Gradual increase in concentration of either factor Loenergy Plus® or seaweed extract alone even in combination improves leaf number. The averages increase in umber of leaves was recorded from 33.54 leaves at 0 ml L^{-1} seaweed extract to 41.09 leaves at 2 ml L^{-1} and from 32.29 leaves at 0 ml L^{-1} Loenergy Plus® to 42.07 leaves at 1 ml L^{-1}. These results suggest that application of Loenergy Plus® and seaweed extract significantly increases the number of leaves per plant. Nano-sized particles enhance nutrient absorption and utilization efficiency in plant tissues. The plant makes additional leaves to increase its energy output since leaves are where most of the photosynthesis happens. This formulation may also help the plant's hormones stay in balance, especially by increasing the action of growth hormones like auxins and cytokinins, which directly help leaf buds expand and branches grow faster. So, the increase in the number of leaves may be due to the direct stimulation of meristematic tissues that enhances vegetative growth (Sharma *et al.,* 2022).

Foliar application of Loenergy Plus® nano-fertilizer combined with seaweed extract notable improved number of leaves per pistachio seedlings, consistent with recent studies indicating that nano-fertilizers enhance uptake of nutrient and seaweed extracts offer growth promoting bioactive compounds (Singh *et al.,* 2024; García-Gómez *et al.,* 2022). The synergistic effect results from increase in photosynthetic activity and hormonal trigger, strengthening vigorous vegetative growth (Patel & Kumar, 2023).

Leaf area: Application of Loenergy Plus® nano-fertilizer and seaweed extract notably improved leaf area in pistachio seedlings grown in nursery (Table 4). The highest leaf area (23.44 cm²) was recorded when pistachio seedlings were subjected to foliar application (1 ml L^{-1} Loenergy Plus® and 2 ml L^{-1} seaweed extract) in combination, highlighting a synergistic effect. The results also depicted that when Loenergy Plus® and seaweed extract were applied with gradual increase in concentration also led to substantial improvement in leaf area of seedlings, with mean leaf area increasing from 15.51 cm² to 21.51 cm² and from 16.47 cm² to 21.60 cm², respectively. These results suggest that the combined foliar application of nano-fertilizer and seaweed extract promotes leaf expansion, potentially improving photosynthetic activity and overall seedling health.

Application of Loenergy Plus® nano-fertilizer and seaweed extract leads to significant improvement in leaf area that confirms, these growth promoting substances are helpful to improve vegetative growth in pistachio seedlings (Table 4). Nano-fertilizers improve nutrient use efficacy due to their very small particle size, which improves better penetration and absorption in leaf tissues, thus accelerating cellular processes involved in growth and development of pistachio seedling (Singh *et al.,* 2024). Similarly, seaweed extracts comprises bioactive stimulants such as cytokinins, auxins and polysaccharides that trigger cell division and elongation, leading to larger leaf surface area and improved photosynthetic activity (García-Gómez *et al.,* 2022).There is positive correlation between dose and leaf area as concentration of Loenergy Plus® nano-fertilizer and seaweed extract increases significant increase in leaf area was also observed. These results confirm that there is positive correlation between dose and growth parameters of pistachio seedlings.

Increased leaf area can facilitate greater light interception with leaf surface and carbon assimilation, important for early growth stages and overall plant productivity. Similar findings were reported in fruit crops where combined application of nano-fertilizers and seaweed extracts improved morphological parameters and physiological processes (Patel & Kumar, 2023). These foliar treatments offer a promising approach to improve crop establishment and yield potential, especially under conditions where soil nutrient availability may be limited on sustainable basis.

Total chlorophyll content: The results in Table 5 indicated that chlorophyll content was significantly improved at various concentrations of Loenergy Plus® and seaweed extract. The highest chlorophyll content (53.65 SPAD units) was recorded with combined application of 1 ml L^{-1} Loenergy Plus® and 2 ml L^{-1} seaweed extract, indicating a synergistic effect. Increasing doses of both bioactive substances individually also enhanced chlorophyll levels, with average SPAD values rising from 39.77 at 0 ml L^{-1} seaweed extract to 48.93 at 2 ml L^{-1}, and from 41.08 at 0 ml L^{-1} Loenergy Plus® to 49.43 at 1 ml L^{-1}. The LSD values confirm these variations are statistically significant. This suggests that the combined foliar applications significantly improve synthesis of chlorophyll content, potentially enhancing photosynthetic efficiency and overall plant health. The results of the current study were agreed with the findings of (Al-Mousawi *et al.,* 2023) who reported that application of bio-stimulants increases chlorophyll content which leads to improvement in plant growth and development. Similarly, using 2 ml L^{-1} of seaweed extract as a foliar spray significantly increased chlorophyll content, with an average of 48.93 SPAD, as opposed to 39.77 SPAD in the control group that was not treated. Due to its higher concentration of essential macro and micronutrients, particularly magnesium and nitrogen, seaweed extract is probably superior. These substances improve photosynthetic activity and allow the plant to absorb more light (Nikoogoftar-Sedghi *et al.,* 2023; Al-Hattali *et al.,* 2024). The optimal concentration of chlorophyll, averaging 53.65 SPAD, was attained by combining 1 ml L^{-1} of Loenergy Plus with 2 ml L^{-1} of seaweed extract. On the other side, the control treatment had week interaction value across board, averaging 35.11 SPAD.

Nitrogen %: The results depicted that the tested concentrations were significantly different from each other in Table 6. The 1 ml L^{-1} Loenergy Plus® treatment had the greatest average nitrogen content at 2.19%, while the control treatment had the lowest average at 1.61%. The reason for this improvement is because foliar absorption of readily accessible nitrogen molecules is more effective, which leads to more protein synthesis and enzymatic activity in plant cells (Nikoogoftar-Sedghi *et al.,* 2024; Almakh *et al.,* 2025). There were also significant inconsistencies between the concentrations of seaweed extract. The treatment with 2 ml L^{-1} had an average nitrogen content of 2.49%, while the control treatment had an average nitrogen content of 1.42%. This impact is possibly because the seaweed extract can help roots take up more nitrogen and due to presence of organic amino acids that help make proteins and enzymes essential for plants , which means more nitrogen builds up in plant tissues (Dawood *et al.,* 2012; Salman *et al.,* 2024).

There was a significant interaction between the two elements. The maximum nitrogen content, with an average of 2.83%, was found when Loenergy Plus® was combined with seaweed extract at 1 ml L^{-1} and 2 ml L^{-1}. The lowest interaction, on the other hand, was found in the control treatment for both components, with an average of 1.21%.

Phosphorus %: Based on the findings in Table 7, it was noted that the concentration of phosphorus in leaves changed dramatically with concentration of Loenergy Plus®. With a foliar spray of 1 ml L^{-1}, phosphorus levels were improved to 0.27%, as opposed to 0.18% in the control group. Since phosphorus is essential for ATP synthesis and other basic metabolic pathways in plant cells, its improved mobility and absorption by leaves is likely to blame for this uptake (Alkarawi & Zotz ,2014 ; Rohi Vishekaii *et al.,* 2023). The addition of 2 ml L^{-1} of seaweed extract also resulted in a significant increase in phosphorus levels (0.26%) when compared to control treatment (0.18%). The bioactive components of extract are likely responsible for this improvement; these substances promote the development of root hairs, which allows plant to more easily absorb phosphorus from the soil (Muhsin , 2025). A plant's ability to transport energy and make nucleic acids depends on phosphorus levels within plants (Radhi & Alkarawia, 2021; Mousavi *et al.,* 2024). In addition, two elements had a powerful synergistic effect on one another. The maximum phosphorus content of 0.33% was obtained by combining seaweed extract (2 ml L^{-1}) with Loenergy Plus® (1 ml $L^{-}\mu$). With a mean value of just 0.13% for both measures, the untreated control group performed worst. Phosphorus absorption and utilisation efficiency are both improved by combination of nano-fertilizers with natural bio-stimulants.

Potassium %: The findings demonstrated significant variance in potassium levels across the various Loenergy Plus® concentrations. Seedlings sprayed with 1 ml L^{-1} accumulated the most potassium (1.51%), whereas the control group had a much lower amount (1.25%) see Table 8. This rise is likely owing to the efficacy of foliar spray in increasing direct potassium absorption through leaf tissues, hence supporting the plant's physiological processes. Potassium regulates osmotic pressure, activates important enzymes, and influences glucose metabolism all of which are required for proper plant development (Norozi *et al.,* 2019; Amjad *et al.,* 2024). Similarly, foliar treatment with seaweed extract at 2 ml L^{-1} significantly increased potassium levels to an average of 1.58%, compared to 1.11% in the untreated control. This finding may be attributable to seaweed's high mineral and bioactive content, which is thought to improve root efficiency and nutrient delivery. Potassium, in particular, is essential for stomatal function and helps plants deal with environmental challenges (Al-Rawi *et al.,* 2016; Alkarawi, 2025). The combination of Loenergy Plus® at 1 ml L^{-1} and seaweed extract at 2 ml L^{-1} resulted in the highest potassium level of all treatments, reaching 1.84%. In comparison, seedlings that got no treatment had the lowest value (0.75%). This connection implies a complimentary mechanism between the nano-fertilizer and biostimulant, indicating that their combination might be a potential technique for increasing potassium feeding and strengthening stress resilience in nursery-grown seedlings.

Table 1. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on plant height (cm).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	29.32	31.41	39.56	33.43
0.5	31.23	38.19	37.22	35.55
1	39.77	39.95	41.44	40.39
Average	33.44	36.52	39.41	
L.S.D 0.05	Loenergy plus® 2.14	ALGA 2.14	Interaction 3.68	

Table 2. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on the rate of increase in stem diameter (mm).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	0.41	0.51	0.62	0.51
0.5	0.54	0.68	0.71	0.64
1	0.61	0.66	0.72	0.66
Average	0.52	0.62	0.68	
L.S.D 0.05	Loenergy plus 0.06	ALGA 0.06	Interaction 0.11	

Table 3. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction in leaves number (leaf plant^{-1}).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	28.30	33.11	35.45	32.29
0.5	35.00	39.00	41.34	38.45
1	37.32	42.40	46.48	42.07
Average	33.54	38.17	41.09	
L.S.D 0.05	Loenergy plus 1.52	ALGA 1.52	Interaction 2.88	

Table 4. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction in leaf area (cm²).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	12.17	15.19	19.16	15.51
0.5	18.04	21.55	22.19	20.59
1	19.21	21.87	23.44	21.51
Average	16.47	19.54	21.60	
L.S.D 0.05	Loenergy plus 1.02	ALGA 1.02	Interaction 1.96	

Table 5. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on the total chlorophyll content (SPAD) of leaves.

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	35.11	43.67	44.45	41.08
0.5	41.00	46.00	48.70	45.23
1	43.19	51.45	53.65	49.43
Average	39.77	47.04	48.93	
L.S.D 0.05	Loenergy plus 3.02	ALGA 3.02	Interaction 6.56	

Table 6. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on the leaves nitrogen content (%).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	1.21	1.78	1.85	1.61
0.5	1.49	2.02	2.79	2.10
1	1.56	2.17	2.83	2.19
Average	1.42	1.99	2.49	
L.S.D 0.05	Loenergy plus 0.22	ALGA 0.22	Interaction 0.37	

Table 7. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on the leaves' phosphorus content (%).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	0.13	0.19	0.21	0.18
0.5	0.19	0.22	0.25	0.22
1	0.22	0.27	0.33	0.27
Average	0.18	0.23	0.26	
L.S.D 0.05	Loenergy plus 0.01	ALGA 0.01	Interaction 0.04	

Table 8. Effect of loenergy plus nano fertilizer and seaweed extract and their interaction on the leaves' potassium content (%).

Loenergy plus® (ml L^{-1})	Seaweed extract (ml L^{-1})			Average
	0	1	2	
0	0.75	1.46	1.53	1.25
0.5	1.27	1.49	1.56	1.44
1	1.32	1.56	1.66	1.51
Average	1.11	1.50	1.58	
L.S.D 0.05	Loenergy plus 0.16	ALGA 0.16	Interaction 0.31	

Conclusions and Recommendations

Combined foliar application of Loenergy Plus® and seaweed extract (1 ml L^{-1} + 2 ml L^{-1}) boosts the growth of *Pistacia vera* seedlings. Significant difference was observed in treated and control plants on the basis of growth parameters like seedling height, leaf area, stem diameter, chlorophyll content and nutrient status of plants. This is probably due to more chlorophyll and were better up taking of nutrients. The notable advantage of this treatment lies not only in the individual effects of Loenergy Plus® and seaweed extract but also in their synergistic interaction, which significantly accelerated seedling growth. From the point of view of nursery management, this looks like a viable way to speed up the development cycle and provide strong, consistent rootstocks that are better for grafting and adapting to the field.

Conflict of Interest: Authors declare no conflict of interest

Author's Contribution: Harith M. Al-Tamimi and Ahmed Z. Resan handled the research conception, design, experimentation, and data collection. Hussein Ali Abbas Al-Janaby helped with data analysis and interpretation, as well as refining the methodology and supervising the lab. The manuscript was drafted by Harith M. Al-Tamimi and Hussein Ali Abbas Al-Janaby. The manuscript's final version was read and approved by all authors.

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