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Improving the Leaf Nutrient and Mineral Elements of Constituents (*Moringa oleifera* L.) by Application of Certain Biostimulants and Biofertilizer

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Increasing the need for food as a result of global population growth negatively impacted the ecology and soil. As a result of an increase in the demand for industrial chemical fertilizers and inefficient crop management. In this research, the effect of some biofertilizers, amino acids, and seaweed extracts on the chemical composition of the leaves of moringa plant was evaluated. The results showed that bio-fertilization with Phosphorein biofertilizer associated with amino acids and seaweed extracts at 700 mg/L (T25) was the most effective treatment for improving and maximizing the leaf nitrogen content. Also, Herein, T26 (soil bio-fertilized with cerealine plus bio-fertilizer with amino acid and seaweed extracts as foliar spray each at 700 mg/L) was the most effective treatment in improving the leaf contents of phosphorus, potassium, calcium, vitamin C, total carbohydrates which produced a better response than using each treatment separately.

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Keywords: Moringa oleifera; biofertilizers; Phosphorein; cerealine; amino acids; seaweed extract; vitamin C.

1. INTRODUCTION

Moringa oleifera Lam (syn. M *ptreygosperma* Gaertn), globally recognized as a 'superfood' due to its high nutritional content, it is rich in phytochemicals and bioactive organic substances [1]. Is one of 13 species of genus Moringa, which is the only genus in the Moringaceae family, originating from India and spreading in Africa, especially in Ethiopia, Kenya, Sudan and Egypt, and it grows in the tropics [2]. Moringa plant can grow in all types of soils, but loam and clay loam soils are optimal for its cultivation [3]. In recent years, researchers around the world have paid much attention to this tree because of its great nutritional and medical importance, which makes it have a major role in raising the global and local economic level for its producing countries [4 and 5]. It can be established like a crop, living fence, continuous windbreaker, and agroforestry system. It tolerates extreme pruning and has excellent regrowth capacity [6]. It can be consumed as tea, fresh, dry, tablets, capsules, or a vegetable that can be added to the typical foods of each region [7]. The nutritional value of the leaves can be used to complement the nutrition of human people and animals [8]. The nutritional content gives it a great nutritional and medicinal potential that can be used to treat or prevent different types of nutritional diseases [9]. By the phytochemical analysis of *M. oleifera,* researchers from different countries have shown that the leaves are particularly rich in potassium, calcium, phosphorus, iron, vitamin D, essential amino acids, as well as known antioxidants such as carotene, vitamin C, and flavonoids [10].

Moringa leaves contain large amounts of nutrients, and being a perennial species, they are available throughout the year [11 and 12]. For this reason, organizations such as FAO, promote its cultivation and consumption [13 and 14]. In recent decades, the need to meet the growing demand for food due to the increase in population has led to the demand for the consumption of agricultural products, [15]. In this quest to improve the production rate, elemental nutrients, such as phosphorus, potassium, and nitrogen were supplied to soils by the application of chemical fertilizers [16]. Fertilizers increase crop yields; however, it has been observed that the constant use of chemical-based fertilizers affects the quality of soils and poses a health risk to consumers [17]. Therefore, producers currently prefer to change production techniques towards green agricultural practices with the use of new biotechnologies, such as the use of biofertilizers [18]. Biofertilization has emerged as a possible substitute for chemical fertilizers in terms of cutting down on sources of environmental pollution. In addition to chemical and organic fertilizers, it involves adding inoculants and biological extracts to the soil, seeds, seedlings, or leaves. Biological fertilizers cannot be used as a substitute for chemical fertilizers, but rather they are supplementary fertilizers for mineral fertilization, as they contribute in increasing the effectiveness and efficiency of chemical fertilizers [19 and 20]. The nutritional and functional qualities are affected by multiple factors, and when ignored, they limit the maximum nutritional use of the leaves [21 and 22]. Several previous studies indicated the effect of different types of bio-fertilizers and the role and mechanism these fertilizers play in their impact on plant growth. Shareef [23] pointed out the importance of using bio-fertilizers in providing some of the important nutrients for the plant, such as nitrogen, phosphorous, and potassium, as well as the secretion of some hormones and acids that act as plant growth regulators. While, Al Dayel [24] confirmed the existence of a significant difference when using biofertilizer, which increases the percentage of nitrogen, as an important element to increase vegetative growth in the Moringa plant. To maximize the production and nutritional use of the moringa plants in Egypt, there is a need to understand the effect of some biofertilizers, amino acids, and seaweed extracts on the nutritional qualities of this plants. As far as we know, there is little scientific literature about the multiple factors that affect the nutritional quality of moringa leaves. Therefore, the objective of this study was to identify the effects of some biofertilizers, amino acids, and seaweed extracts on the nutritional content of *M. oleifera* leaves, and reduce the intensive use of chemical fertilizers.

2. MATERIALS AND METHODS

Two field experiments were carried out at the Faculty of Agriculture (Saba Basha), Alexandria University's experimental farm in the Abees district of Alexandria governrate, Egypt, during the 2020 and 2021 growing seasons. The experiments were designed to assess the effects

of soil bio-fertilization (Phosphorein and cerealine), spraying with varying rates of amino acids, and seaweed extract on the chemical composition of moringa leaves (*Moringa oleifera* L.).

Moringa plants were obtained from the Egyptian Association of Moringa, National Research Center, Cairo, Egypt. The trials' soil was tilled, split into rows and plots, and then planted in 2.5 × 2.5 m sections in March. All research plots received the same applications of mineral fertilizers: 600 g/tree of ammonium nitrate (33.5% N), 250 g/tree of calcium superphosphate (15.5% P2O5), and 300 g/tree of potassium sulfate (48% K2O). One dose of calcium superphosphate was mixed into the top soil at a depth of 0.15 meters around the tree trunk. Three equal doses of nitrogen and potassium fertilizer were applied; the first dose was given after 20 days of sowing, the second dose was given after the first cut, and the third dose was given after the second cut. Furthermore, biofertilizers, such as Phosphorein (containing P-dissolving bacteria such as Bacillus sp.) and cerealine (produced by the Egyptian Ministry of Agriculture and containing *Bacillus polymyxa* and *Azotobacter chroococcum* bacteria at 107 colony-forming units (CFU)/g carrier), were also used as nitrogen sources. And amino acids and seaweed extract (0, 350, and 700 mg/l) were administered as a foliar spray three times: after planting, after the first cut, and after the second one. Control plants were doused with water. The plants were harvested three times during the first and second seasons by cutting the vegetative sections to get the nutritional quality of moringa leaves data.

The following characteristics were measured in the dry leaves at the harvest: leaf nitrogen content [25], leaf phosphorus content [26], leaf potassium content [26], leaf calcium content [26], vitamin C [27], and total carbohydrates [28].

Statistical analysis: The split-split plot design was used to arrange the 27 treatments, with each treatment being repeated three times. All data collected throughout the two research seasons were statistically examined using the analysis of variance approach described by [29]. The least significant differences test (L.S.D.) at 0.05 was used to compare the means of the various treatments.

3. RESULTS AND DISCUSSION

Leaf nitrogen content: With respect to leaf nitrogen content of *M. oleifera* plants as affected by the different investigated treatments, data presented in Table 1 indicated that bio-fertilization with Phosphorein biofertilizers associated with amino acid and seaweed extracts each at 700 mg/L (T_{25}) was the most effective treatment in enhancing and maximizing leaf nitrogen content, with a mean value for both seasons of 427.3 mg/100g, followed by spraying with amino acid and seaweed extracts at 700 mg/L and cerealine bio-fertilizer (T_{26}) with a mean value for both seasons of 421.4 mg/100g, which ranked second in the frame of treatments evaluation. While treatment with each individual, Phosphorein treatment (T_1) alone gave a mean leaf nitrogen content of 258.8 mg/100g, seaweed alone (T_6) gave 284.6 mg/100g, and amino acid alone (T_{18}) gave 356.8 mg/100g. On the other hand, the untreated plants (control) (T_0) contained the lowest value of leaf nitrogen content of 6.92 mg/100g for both seasons. Data showed that spraying with amino acids and seaweed extracts with soil bio-fertilization produced a better response than using each component separately.

The findings are consistent with those of [30 and 31], who found that spraying seaweed extract had a beneficial effect on the mineral contents; furthermore, they claimed that plants treated with seaweed spray had mineral levels that were noticeably greater than those of untreated plants. Moreover, Mazher [32] observed that Phosphorein biofertilizer enhanced the nitrogen content of *M. oleifera* in leaves and stems when compared to the control. Also, Radwan [33] found that bio-fertilization enhanced the chemical composition of nitrogen percentage when applied to moringa plants. In another study**,** Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *Moringa oleifera,* and *Moringa ovalifolia* plants gave the highest amount of leaf nitrogen content. Also, Haider [35] reported that foliar spraying of seaweed extract improved the nitrogen content of potato tubers.

Leaf phosphorus content: Data concerning the relationship between the leaf phosphorous content of *M. oleifera* plants and the different investigated treatments are tabulated in Table 2. The data display that the investigated parameter was significantly responded to the different studied treatments. Herein, the most effective treatment that reflected the peak of leaf phosphorous content was observed with those

plants that were soil bio-fertilized with cerealine bio-fertilizer with amino acid and seaweed extracts foliar spray each at 700 mg/L (T26) with a mean value for both seasons of 197.7 mg/100 g, followed by spraying with amino acid and seaweed extracts at 700 mg/L, and Phosphorein bio-fertilizer (T25) with a mean value for both seasons of 195.3 mg/100 g, came in the second rank in this respect. While that treatment with each individual, cerealine (T2) treatment alone gave a mean leaf phosphorous content of 172.8 mg/100 g, seaweed alone (T6) gave 171 mg/100g, and amino acid alone (T18) gave 182.5 mg/100 g. On the other hand, the control (untreated plants) (T0) revealed the lowest mean value of leaf phosphorous content of 170.5 mg/100 g for both seasons. Based on the data, spraying amino acid and seaweed extracts with soil bio-fertilization led to better results than utilizing each component alone. The results are in tone with the findings of Zhang [36], who claimed that the foliar application of seaweed extract plays a significant function in promoting cell membrane Likewise, Radwan [33] found that bio-fertilization enhanced the chemical composition of phosphorus percentage when applied to moringa plants. Zayed [37] demonstrated that *M. oleifera* seeds were grown in soil inoculated with mixed cultures of *Saccharomyces cerevisiae*, *Azotobacter chroococcum*, *Bacillus circulans*, and *Azot. chroococcum*, which produced the highest levels of phosphorous. Likewise, Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *M. oleifera*, and *M. ovalifolia* plants gave the highest amount of leaf phosphorus content.

Leaf potassium content: Data in Table 3 clearly show that the peak of leaf potassium content was detected with either those sprayed plants with amino acid and seaweed extracts at 700 mg/L with soil bio-fertilized cerealine bio-fertilizer (T_{26}), which achieved the highest significant mean values1.379 mg/100g of leaf potassium content for both seasons, followed by soil biofertilization Phosphorein with foliar application of amino acids and seaweed extracts at 700 mg/L (T_{25}) with a mean value for both seasons of 1.374 mg/100 g, came in the second rank in this respect. While that treatment with each individual, cerealine (T_2) treatment alone gave a mean leaf potassium content of 0.600 mg/100 g, seaweed alone (T_6) gave 0.924 mg/100g, and amino acid alone (T_{18}) gave 1.316 mg/100g. On the other hand, the control (untreated plants) (T_0) revealed the lowest mean value of leaf potassium content of 0.530 mg/100 g for both seasons. Based on the data, foliar spraying seaweed extracts and amino acids with soil bio-fertilization produced greater results than using each component separately. These findings are in accordance with Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *M. oleifera*, and *M. ovalifolia* plants gave the highest amount of leaf potassium content. Likewise, Mazher [32] reported that Phosphorein biofertilizers increased the potassium content of *M. oleifera* in leaves and stems as compared with the control. Yang [38] reported that seaweed extracts increased the levels of potassium, in apples. Also, Radwan [33] found that bio-fertilization enhanced the chemical composition of potassium percentage when applied to moringa plants. As indicated by El-Leithy [39], nitrobien and phosphorein both raised potassium percentages in the herb compared to the control in the first and second cuttings of the first and second seasons.

Leaf calcium content: Data dealing with the response of leaf calcium content to the different investigated treatments are presented in Table 4. Such recorded data obviously display that leaf calcium content significantly responded to the studied treatments. Furthermore, soil bio-fertilization Cerealine bio-fertilizer with either amino acid and seaweed extracts at 700 mg/L (T_{26}) maximized leaf calcium content with a mean value of 2.355 mg/L for both seasons, followed by soil bio-fertilizer Phosphorein with either amino acid and seaweed extracts at 700 mg/L (T_{25}) arranged in the second rank. While that treatment with each individual, cerealine (T_2) treatment alone gave a mean leaf calcium content of 0.144 mg/100 g, seaweed alone (T_6) gave 0.302 mg/100 g, and amino acid alone (T_{18}) gave 1.626 mg/100 g. On the other way around, the minimum value of such an investigated parameter (leaf calcium content) was associated with untreated plants (control-T_0), with a mean value of leaf calcium content of 0.530 mg/100 g for both seasons. Based on the data, foliar spraying seaweed extracts and amino acids with soil bio-fertilization produced greater results than using each component separately. Our results dealing with the beneficial impact of bio-fertilizers on enhancing the leaf nutritional status of *M. oleifera* plants are supported by the early findings of some investigators. As demonstrated by Ghoneim and EL-Araby [40] who reported some enhancing effects on the concentrations of

calcium in jew's mallow leaves as a result of inoculation either with Nitrobein biofertilizer. Also, Youssef [41] reported that applying biofertilizer treatments to M. *oleifera* plants resulted in higher leaf calcium levels compared to the control. Likewise, Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *Moringa oleifera*, and *Moringa ovalifolia* plants gave the highest amount of leaf calcium content. Moreover, previous research has demonstrated that applying seaweed extract to plants' leaves enhances nutrient absorption and raises the concentrations of macro- and micronutrients such as calcium in the plants [42, 31 and 38].

Vitamin C: Data concerning leaf vitamin C content are presented in Table 5, such data display that the optimum value of such a parameter was recorded with cerealine soil bio-fertilization and either amino acid and seaweed extract foliar spray each at 700 mg/L (T_{26}) with a mean value for both seasons of 17.49 mg/100g, followed by spraying with amino acid and seaweed extracts at 700 mg/L and Phosphorein bio-fertilizer (T_{25}) with a mean value for both seasons of 17.34 mg/100 g, which ranked second in the frame of treatment evaluation, while that treatment with each individual, where cerealine (T_2) treatment alone gave a mean vitamin C content of 14.22 mg/100g, seaweed alone (T_6) gave 14.32 mg/100g, and amino acid alone (T_{18}) gave 14.85 mg/100g. On the other way around, the untreated plants (control) (T_0) revealed the lowest value of leaf vitamin C of 14.14 mg/100 g for both seasons. Data showed that spraying with amino acid and seaweed extracts with soil bio-fertilization produced a better response than using each component separately. In light of this, several reports indicated that Radwan [33] found that bio-fertilization enhanced the chemical composition of vitamin C percentage when applied to moringa plants. Also, Radwan [43] demonstrated that all treatments, including biofertilization cerealine and phosphorein on fertilization, enhanced the chemical composition, including vitamin C content, of the leaves of the parsley plant. In the same direction. Furthermore, Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *Moringa oleifera*, and *Moringa ovalifolia* plants gave the highest amount of leaf vitamin C content.

Total Carbohydrate: Concerning the impact of different investigated treatments on *M. oleifera* plants leaf total carbohydrates content, the data presented in Table 6 indicates that leaf total carbohydrates content was significantly responded to the studied treatments. Furthermore, the plants that were sprayed with the amino acid and seaweed extract each at 700 mg/L with cerealine soil bio-fertilization (T_{26}) produced plants with the highest total carbohydrates content, with a mean value for both seasons of 34.66 mg/100g as compared with the other investigated treatments. Followed by spraying with amino acid and seaweed extracts at 700 mg/L and Phosphorein bio-fertilizer (T_{25}) with a mean value for both seasons of 34.50 mg/100 g, which came in second rank. Such a trend was true during both seasons of study.

While that treatment with each individual, where cerealine (T_2) treatment alone gave a mean total carbohydrates content of 17.32 mg/100g, seaweed alone (T_6) gave 18.29 mg/100g, and amino acid alone (T_{18}) gave 25.32 mg/100 g. On the other way around, the untreated plants (control) (T_0) revealed the lowest value of leaf total carbohydrates of 17.06 mg/100 g for both seasons. Data showed that spraying with amino acid and seaweed extracts with soil bio-fertilization produced a better response than using each component separately.

These findings are in accordance with; Radwan [33] found that bio-fertilization enhanced the chemical composition of total carbohydrate percentage when applied to moringa plants. Also, Mazher [32] stated that they treated moringa plants with Phosphorein, Nitrobine, and Microbine biofertilizers and found that total carbohydrates increased compared to the control. Likewise, Abd El-baset [34] showed that using high concentration of amino acids as foliar sprays on both *Moringa oleifera*, and *Moringa ovalifolia* plants gave the highest amount of leaf carbohydrate content. Also, Abdelkader [44] demonstrated that adding amino acids to mung beans and snap beans improved the total carbohydrates. Moreover, Gajewski [45] found that adding fertilizer containing the algal extract *A. nodosum* and phosphorus improved the vitamin C content compared to the untreated cabbage.

Table 1. Means of Leaf Nitrogen content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons

Treatments	Leaf Nitrogen (mg/100g)						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	295.1	293	220.2	224.8	252.5	254.2	256.6
T_1 Phosphorein	306.1	304	218.9	215.5	253.9	254.6	258.8
T_2 Cerealine	310.7	304.2	223.7	232.5	253.5	253.5	263.0
T_3 Seaweed 350mg/l	298.3	309.8	236.4	255.9	271.4	259.9	271.9
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	321.9	317.1	233.3	241.3	269.7	265.1	274.7
T_5 Seaweed 350mg/l + Cerealine 350mg/l	317.4	320.6	254.1	254.8	263.8	258.1	278.1
T_6 Seaweed 700mg/l	315.9	305.7	277.8	262.7	271.5	274	284.6
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	324.6	315	285.6	276.9	266.4	266.5	289.2
T_8 Seaweed 700mg/l + Cerealine 700mg/l	345.3	321.3	291.6	259.8	232.6	246.9	282.9
T_9 Amino 350mg/l	298.5	307.2	306.3	311	274.1	242.4	289.9
T_{10} Amino 350mg/l + Phosphorein	329.5	324.7	309.4	307.8	289.6	290.1	308.5
T_{11} Amino 350mg/l + Cerealine	341.9	322.4	306.7	309.5	281.9	273.2	305.9
T_{12} Amino 350mg/l + Seaweed 350mg/l	338.5	308.3	335.5	309.3	286.2	280.6	309.7
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	347.3	342.2	344.9	316.3	296.3	285.9	322.2
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	342.2	354.9	348.1	330.9	303.7	332.9	335.5
T_{15} Amino 350mg/l + Seaweed 700mg/l	313.9	321.8	350.3	332.7	282.5	292.7	315.7
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	354.9	363.3	356.5	335.7	307.9	307	337.6
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	339.5	365.6	390.7	348.15	314.4	306	344.1
T_{18} Amino acid 700mg/l	395.4	308.5	414	383.8	326.7	312.5	356.8
T_{19} Amino acid 700mg/l + Phosphorein	411.6	414.5	413.3	420.2	356.9	345.9	393.7
T_{20} Amino acid 700mg/l + Cerealine	413.7	420.2	417.7	423.5	289	367.6	388.6
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	404.4	352	415	433.8	393.7	386.6	397.6
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	417.5	420.5	417.7	436.9	414.9	402.2	418.3
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	417.9	424.9	415	437.6	414.5	413.8	420.6
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	415.7	355.8	418.3	439	419.7	418.4	411.2
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	418.1	425.8	424.6	440.9	422.6	431.6	427.3
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	413.1	412.8	418.2	440.8	421.2	422.5	421.4
L.S.D	18.5	57.1	12.9	29.2	4.02	29.6	

Table 2. Means of Leaf Phosphorus content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons

Treatments	Leaf Phosphorus (mg/100g)						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	170.3	166.9	170.6	170.9	170.6	173.7	170.5
T_1 Phosphorein	177.6	173.6	167.9	171.6	170.4	171.4	172.1
T_2 Cerealine	175.1	178	165.9	173.8	171.3	172.8	172.8
T_3 Seaweed 350mg/l	177.6	166.9	168.5	173.5	169.9	174.4	171.8
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	178.4	177.6	164.8	171.2	172.3	175.3	173.3
T_5 Seaweed 350mg/l + Cerealine 350mg/l	180.3	177.4	171.9	175.9	171.1	173.8	175.1
T_6 Seaweed 700mg/l	183.5	162.7	166.9	170.4	170.9	171.7	171.0
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	186.2	177.5	172	172.1	171.3	171.4	175.1
T_8 Seaweed 700mg/l + Cerealine 700mg/l	173.8	179.5	171.3	174.2	171.2	174.7	174.1
T_9 Amino 350mg/l	176.3	158.9	172.0	170.8	171.1	173.3	170.4
T_{10} Amino 350mg/l + Phosphorein	175.4	175.5	173	172.4	176	172.4	174.1
T_{11} Amino 350mg/l + Cerealine	174.7	177.8	175.8	172.9	173.5	174.0	174.8
T_{12} Amino 350mg/l + Seaweed 350mg/l	177.2	165.4	187.5	176.3	179.5	172.7	176.4
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	178.9	179.5	184.9	177.7	180.5	180.4	180.3
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	180.4	183.6	188.2	177.9	180.6	180.3	181.8
T_{15} Amino 350mg/l + Seaweed 700mg/l	180.4	180.2	188.3	179.9	181.6	183.6	182.3
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	183	186.2	179	181	183.6	188.5	183.6
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	182.1	190.2	178.1	180	181.5	185.1	182.8
T_{18} Amino acid 700mg/l	183.0	179.9	184.5	182.4	180.5	184.5	182.5
T_{19} Amino acid 700mg/l + Phosphorein	184	183.1	186.2	187.7	188.5	185.8	185.9
T_{20} Amino acid 700mg/l + Cerealine	184.7	181.9	185.3	189.2	187.9	186.5	185.9
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	185.8	186.1	196.5	192.9	190.3	187.2	189.8
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	186.2	188.4	196.7	194.7	195.9	194.3	192.7
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	188.4	191.3	191.2	193.5	195.4	196.2	192.7
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	190.7	192.2	195.9	196.8	194.2	194.3	194.0
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	194.4	193.9	194.3	196.9	194.4	198.1	195.3
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	197.6	197.7	197.8	199	198.9	195.2	197.7
L.S.D	2.09	4.26	4.42	4.26	4.22	5.92	

Table 3. Means of Leaf Potassium content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons

Treatments	Leaf Potassium (mg/100g)						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	0.734	0.629	0.413	0.578	0.414	0.414	0.530
T_1 Phosphorein	0.904	0.619	0.538	0.574	0.452	0.497	0.597
T_2 Cerealine	0.899	0.617	0.556	0.575	0.485	0.469	0.600
T_3 Seaweed 350mg/l	0.944	0.753	0.764	0.637	0.687	0.472	0.709
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	0.937	0.648	0.838	0.748	0.546	0.573	0.715
T_5 Seaweed 350mg/l + Cerealine 350mg/l	0.952	0.727	0.940	0.775	0.897	0.788	0.847
T_6 Seaweed 700mg/l	1.002	0.718	0.921	0.916	0.882	1.103	0.924
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	1.11	0.758	1.01	1.190	1.102	1.103	1.046
T_8 Seaweed 700mg/l + Cerealine 700mg/l	1.13	0.906	1.12	1.183	1.104	0.937	1.063
T_9 Amino 350mg/l	1.20	1.36	1.13	1.263	0.951	0.427	1.055
T_{10} Amino 350mg/l + Phosphorein	1.18	0.798	1.19	1.285	1.124	1.125	1.117
T_{11} Amino 350mg/l + Cerealine	1.24	1.28	1.24	1.274	1.206	1.191	1.239
T_{12} Amino 350mg/l + Seaweed 350mg/l	1.22	1.26	1.24	1.283	1.144	1.142	1.215
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	1.23	1.27	1.23	1.328	1.144	1.149	1.225
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	1.23	1.24	1.235	1.345	1.142	1.143	1.223
T_{15} Amino 350mg/l + Seaweed 700mg/l	1.235	1.204	1.253	1.318	1.237	1.222	1.245
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	1.246	1.279	1.253	1.34	1.331	1.345	1.299
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	1.260	1.257	1.249	1.329	1.326	1.319	1.290
T_{18} Amino acid 700mg/l	1.314	1.255	1.349	1.391	1.268	1.318	1.316
T_{19} Amino acid 700mg/l + Phosphorein	1.312	1.302	1.362	1.449	1.338	1.338	1.350
T_{20} Amino acid 700mg/l + Cerealine	1.305	1.266	1.349	1.463	1.311	1.311	1.334
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	1.319	1.302	1.349	1.465	1.224	1.230	1.315
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	1.347	1.334	1.354	1.475	1.391	1.376	1.379
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	1.336	1.344	1.362	1.476	1.314	1.316	1.358
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	1.308	1.311	1.332	1.454	1.252	1.34	1.333
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	1.312	1.356	1.318	1.469	1.369	1.421	1.374
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	1.339	1.382	1.344	1.464	1.392	1.356	1.379
L.S.D	0.11	0.23	0.06	0.17	5.85	2.85	

Table 4. Means of Leaf Calcium content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons

Treatments	Leaf Calcium (mg/100g)						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	0.08	0.08	0.36	0.06	0.09	0.09	0.13
T_1 Phosphorein	0.08	0.08	0.08	0.09	0.06	0.12	0.09
T_2 Cerealine	0.08	0.15	0.08	0.09	0.24	0.20	0.14
T_3 Seaweed 350mg/l	0.09	0.19	0.08	0.18	0.39	0.39	0.22
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	0.09	0.35	0.08	0.15	0.09	0.38	0.19
T_5 Seaweed 350mg/l + Cerealine 350mg/l	0.08	0.38	0.08	0.16	0.25	0.36	0.22
T_6 Seaweed 700mg/l	0.08	0.18	0.11	0.64	0.33	0.44	0.30
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	0.09	0.36	0.18	0.88	0.09	0.51	0.35
T_8 Seaweed 700mg/l + Cerealine 700mg/l	0.09	0.10	0.28	0.89	0.98	0.53	0.48
T_9 Amino 350mg/l	0.39	0.14	0.81	0.60	0.08	0.94	0.50
T_{10} Amino 350mg/l + Phosphorein	0.69	0.17	0.71	0.95	1.08	0.91	0.75
T_{11} Amino 350mg/l + Cerealine	0.66	0.12	0.87	1.00	1.10	0.89	0.77
T_{12} Amino 350mg/l + Seaweed 350mg/l	1.41	1.31	1.30	1.13	1.21	1.22	1.26
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	1.55	1.41	1.35	1.32	1.20	1.34	1.36
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	1.62	1.60	1.40	1.41	1.35	1.46	1.47
T_{15} Amino 350mg/l + Seaweed 700mg/l	1.83	1.70	1.59	1.67	1.24	1.24	1.55
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	1.93	1.74	1.74	1.82	1.56	1.20	1.67
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	1.97	1.89	1.81	1.91	1.69	1.27	1.76
T_{18} Amino acid 700mg/l	1.91	1.93	1.20	1.92	1.25	1.52	1.62
T_{19} Amino acid 700mg/l + Phosphorein	1.93	1.90	1.61	2.11	1.80	1.85	1.87
T_{20} Amino acid 700mg/l + Cerealine	2.00	1.96	1.75	2.12	2.00	1.91	1.96
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	2.00	1.95	2.00	2.00	2.02	2.39	2.06
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	2.03	2.07	2.00	2.04	2.01	2.08	2.04
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	2.67	2.00	2.00	2.11	2.01	2.37	2.19
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	2.00	2.14	2.00	2.07	2.00	2.37	2.09
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	3.00	2.02	2.00	2.11	2.16	2.26	2.26
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	3.00	2.13	2.04	2.72	2.10	2.14	2.35
L.S.D	0.16	0.21	0.36	0.37	.037	2.78	

Table 5. Means of Vitamin (C) content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons

Treatments	Vitamin C						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	14.20	13.23	14.17	14.33	14.43	14.47	14.14
T_1 Phosphorein	14.50	13.47	14.27	14.47	14.37	14.37	14.24
T_2 Cerealine	14.53	13.03	14.27	14.57	14.33	14.60	14.22
T_3 Seaweed 350mg/l	14.27	13.60	14.43	14.47	14.40	14.24	14.24
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	14.43	13.60	14.57	14.57	15.63	14.37	14.53
T_5 Seaweed 350mg/l + Cerealine 350mg/l	14.37	14.10	14.50	14.57	14.20	14.43	14.36
T_6 Seaweed 700mg/l	14.47	14.40	14.13	14.30	14.27	14.37	14.32
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	14.33	14.33	13.90	14.53	14.43	14.57	14.34
T_8 Seaweed 700mg/l + Cerealine 700mg/l	14.53	14.27	13.63	13.63	14.33	14.50	14.15
T_9 Amino 350mg/l	14.73	14.47	14.43	13.50	14.33	14.57	14.34
T_{10} Amino 350mg/l + Phosphorein	14.83	14.33	14.30	14.53	14.57	14.42	14.50
T_{11} Amino 350mg/l + Cerealine	15.33	14.67	14.43	14.50	14.30	14.47	14.62
T_{12} Amino 350mg/l + Seaweed 350mg/l	15.37	14.40	14.30	13.60	13.43	14.53	14.27
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	15.47	14.47	14.23	13.92	14.43	14.57	14.52
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	15.53	14.47	14.30	13.77	14.13	14.67	14.48
T_{15} Amino 350mg/l + Seaweed 700mg/l	14.53	14.47	14.47	13.67	18.63	14.67	15.07
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	14.57	14.57	14.63	13.73	14.27	15.04	14.47
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	14.53	14.27	14.90	13.73	14.80	15.20	14.57
T_{18} Amino acid 700mg/l	14.43	15.23	15.13	14.77	14.50	15.04	14.85
T_{19} Amino acid 700mg/l + Phosphorein	15.43	15.31	15.33	14.67	15.30	14.93	15.16
T_{20} Amino acid 700mg/l + Cerealine	15.57	14.70	15.47	14.53	15.33	14.85	15.08
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	15.87	16.03	15.73	14.60	15.30	15.27	15.47
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	16.20	15.93	16.37	15.33	16.23	15.57	15.94
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	16.23	17.40	17.03	16.33	16.30	15.89	16.53
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	17.20	17.73	17.20	17.43	15.83	15.21	16.77
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	17.30	17.37	17.23	17.47	17.43	17.25	17.34
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	17.33	17.57	17.80	17.73	17.27	17.22	17.49
L.S.D	0.26	0.66	0.42	0.32	0.38	0.41	

Table 6. Means of Carbohydrate content of *Moringa oleifera* as affected by Bio-fertilizers, Amino acids, and Seaweed extracts and their combinations during 2020 and 2021 growing seasons.

Treatments	Carbohydrate (%DW)						Mean
	Season2020			Season2021			
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	
T_0 Untreated	17.33	17.33	16.67	16.30	17.30	17.40	17.06
T_1 Phosphorein	18.07	17.33	16.37	16.50	16.67	16.37	16.89
T_2 Cerealine	18.70	17.20	17.20	17.53	16.57	16.73	17.32
T_3 Seaweed 350mg/l	17.33	17.10	17.23	17.70	17.30	16.83	17.25
T_4 Seaweed 350mg/l + Phosphorein 350mg/l	19.37	16.97	18.03	18.63	17.83	17.50	18.06
T_5 Seaweed 350mg/l + Cerealine 350mg/l	19.33	16.53	18.60	18.47	17.50	17.53	17.99
T_6 Seaweed 700mg/l	18.50	17.20	18.50	18.37	18.17	19.00	18.29
T_7 Seaweed 700mg/l + Phosphorein 700mg/l	19.87	17.40	18.23	18.33	16.37	19.33	18.26
T_8 Seaweed 700mg/l + Cerealine 700mg/l	19.40	17.53	18.43	18.63	18.87	18.60	18.58
T_9 Amino 350mg/l	30.40	17.37	19.13	18.30	18.10	18.41	20.29
T_{10} Amino 350mg/l + Phosphorein	20.37	18.43	19.57	20.17	19.43	19.40	19.56
T_{11} Amino 350mg/l + Cerealine	19.87	18.60	19.67	20.13	19.17	19.20	19.44
T_{12} Amino 350mg/l + Seaweed 350mg/l	20.40	19.13	20.53	24.57	19.12	19.57	20.55
T_{13} Amino 350mg/l + Seaweed 350mg/l + Phosphorein	22.00	16.43	20.50	24.40	20.41	20.4	20.69
T_{14} Amino 350mg/l + Seaweed 350mg/l + Cerealine	23.37	19.53	20.83	24.50	20.42	20.24	21.48
T_{15} Amino 350mg/l + Seaweed 700mg/l	20.37	20.13	21.43	29.93	20.20	20.50	22.09
T_{16} Amino 350mg/l + Seaweed 700mg/l + Phosphorein	21.53	21.33	22.97	30.43	22.63	21.00	23.32
T_{17} Amino 350mg/l + Seaweed 700mg/l + Cerealine	22.83	22.83	24.20	30.4	23.33	22.00	24.27
T_{18} Amino acid 700mg/l	23.57	23.80	24.13	31.60	24.77	24.07	25.32
T_{19} Amino acid 700mg/l + Phosphorein	24.47	25.67	28.00	31.60	26.43	26.10	27.05
T_{20} Amino acid 700mg/l + Cerealine	25.57	24.77	28.67	33.43	26.13	26.80	27.56
T_{21} Amino acid 700mg/l + Seaweed extract 350mg/l	25.67	23.70	30.87	30.03	39.47	29.17	29.82
T_{22} Amino acid 700mg/l + Seaweed extract 350mg/l + Phosphorein	27.30	24.67	32.37	34.43	30.30	30.07	29.86
T_{23} Amino acid 700mg/l + Seaweed extract 350mg/l + Cerealine	30.50	30.97	34.30	34.53	30.20	31.53	32.01
T_{24} Amino acid 700mg/l + Seaweed extract 700mg/l	31.37	33.07	34.53	35.53	31.20	31.60	32.88
T_{25} Amino acid 700mg/l + Seaweed extract 700mg/l + Phosphorein	32.50	33.43	35.13	35.50	35.57	34.84	34.50
T_{26} Amino acid 700mg/l + Seaweed extract 700mg/l + Cerealine	32.67	34.60	33.80	36.30	35.13	35.43	34.66
L.S.D	0.90	1.98	1.58	2.92	2.48	1.82	

4. CONCLUSION

Numerous variables that interact to either positively or negatively affect the chemical composition of the leaves are responsible for the substantial diversity in *M. oleifera*'s nutritional content. In the context of agronomic management, fertilization is the factor that most affects the chemical composition of the leaves. The results showed that bio-fertilization with phosphorein biofertilizers associated with amino acid and seaweed extracts each at 700 mg/L (T25) was the most effective treatment for enhancing and maximizing leaf nitrogen content. Also Herein, the most effective treatment that reflected the peak of leaf (phosphorus, potassium, calcium, vitamin C, and leaf total carbohydrates) content was observed with those plants that were soil bio-fertilized with cerealine bio-fertilizer with amino acid and seaweed extracts foliar spray each at 700 mg/L (T26) produced a better response than using each treatment separately. So, *M. oleifera* leaves that have a high nutritional content can be employed in human nutrition and protect against ailments caused by nutritional deficiencies. Thus, moringa leaves can serve as food to alleviate protein-energy malnutrition in food-insecure countries.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mahaveerchand H, Abdul Salam AA. Environmental, industrial, and health benefits of *Moringa oleifera*. Phytochem Rev. 2024;1-60.
2. Bhargave A, Pandey I, Nama KS, Pandey M. *Moringa oleifera* Lam. Sanjana (Horseradish Tree) A miracle food plant with multipurpose uses in Rajasthan-India an overview. Int J Pure Appl Biosci. 2015;3(6):237–248.
3. Dania SO, Akpansubi P, Eghagara OO. Comparative effects of different fertilizer sources on the growth and nutrient content of Moringa (*Moringa oleifera*) seedling in a greenhouse trial. Adv Agric. 2014;1:1-6.
4. Anwar F, Latif S, Ashraf M, Gilani AH. *Moringa oleifera*: a food plant with multiple medicinal uses. Phytother Res. 2007;21(1):17-25.
5. Coppin JP, Xu Y, Chen H, Pan M-H, Ho C-T, Juliani R, Wu Q. Determination of flavonoids by LC/MS and anti-inflammatory activity in *Moringa oleifera*. J Funct Foods. 2013;5(4):1892–1899.
6. Nouman W, Basra SMA, Siddiqui MT, Yasmeen A, Gull T, Alcayde MAC. Potential of *Moringa oleifera* L. as livestock fodder crop: a review. Turk J Agric For. 2014;38:1-14.
7. Rajput H, Prasad SG, Srivastav P, Singh N, Suraj L, Chandra R. Chemical and phytochemical properties of fresh and dried *Moringa oleifera* (PKM-1) leaf powder. Chem Sci Rev Lett. 2017;6(22):1004-1009.
8. Melesse A. Comparative assessment on chemical compositions and feeding values of leaves of Moringa stenopetala and *Moringa oleifera* using in vitro gas production method. Ethiop J Appl Sci Technol. 2011;2(2):31-41.
9. Gopalakrishnan L, Doriya K, Kumar DS. *Moringa oleifera*: A review on nutritive importance and its medicinal application. Food Sci Hum Wellness. 2016;5:49-56.
10. Al_husnan LA, Alkahtani MDF. Impact of Moringa aqueous extract on pathogenic bacteria and fungi in vitro. Ann Agric Sci. 2016;61(2):247-250.
11. Mendieta-Araica B, Spörndly E, Reyes SN, Salmerón MF, Halling M. Biomass production and chemical composition of *Moringa oleifera* under different planting densities and levels of nitrogen fertilization. Agrofor Syst. 2013;87(1):81-92.
12. Abd El-Hack ME, Alagawany M, Elrys AS, Desoky ESM, Tolba HMN, Elnahal ASM, Elnesr SS, Swelum AA. Effect of forage *Moringa oleifera* L. (Moringa) on animal health and nutrition and its beneficial applications in soil, plants, and water purification. Agric (Switz). 2018;8(9):2–22.
13. Ganatra T, Joshi U, Bhalodia P, Desai T, Tirgar P. A panoramic view on pharmacognostic, pharmacological, nutritional, therapeutic and prophylactic values of *Moringa oleifera* Lam. Int Res J Pharm. 2012;3(6):1-7.
14. FAO. Moringa: cultivo tradicional del mes. Organización de las Naciones Unidas para

la Alimentación y la Agricultura. 2014 [cited 2024 Aug 10]. Available: http://www.fao.org/traditional-crops/moringa/es/?utm_source=faohomepage&utm_medium=web&utm_campaign=featurebar.
15. Grageda-Cabrera OA, Díaz-Franco A, Peña-Cabriales JJ, Vera-Nuñez JA. Impacto de los biofertilizantes en la agricultura. Rev Mex Cienc Agrícolas. 2012;3(6):1261-1274.
16. Navarro García G. Fertilizantes. Química y acción. 2nd ed. Barcelona: Ediciones Mundi-Prensa; 2023.
17. Calderón FEJ, Guerra JWC, Lucio DAO. Impacto ambiental provocado por el inadecuado uso de fertilizantes químicos en cultivos de maíz. UNESUM-Ciencias. Rev Cient Multidiscip. 2019;3(1):61-72.
18. Deepika P, MubarakAli D. Production and assessment of microalgal liquid fertilizer for the enhanced growth of four crop plants. Biocatal Agric Biotechnol. 2020;28:101701.
19. AL-Shareefi MJ, Kadhim ZK, Hakim RA. Effect of algae extract and bio-fertilizer on vegetative growth and flowering of *Freesia hybrida* L. J Kerbala Agric Sci. 2019;6(3):16-23.
20. Abbas MK. Effect of foliar fertilizer and some growth regulators on vegetative and anatomical characters of Dill (*Anethum graveolens* L.). Middle East J Sci Res. 2013;13(6):803–811.
21. Reyes NS, Ledin S, Ledin I. Biomass production and chemical composition of *Moringa oleifera* under different management regimes in Nicaragua. Agrofor Syst. 2006;66(3):231-242.
22. Amabye TG, Gebrehiwot K. Chemical compositions and nutritional value of *Moringa oleifera* available in the market of Mekelle. J Food Nutr Sci. 2015;3(5):187-190.
23. Shareef S, Abdullah MO, Dawood ZA. Effectiveness of treating *Pinus halepensis* Mill. seeds with electric shock and periods and gibberellic acid in changes of metabolic some physiological processes of seedlings. Mesopotamia J Agric. 2018;46(1):123-134.
24. Al Dayel MF, El Sherif F. Evaluation of the effects of Chlorella vulgaris, Nannochloropsis salina, and Enterobacter cloacae on growth, yield, and active compound compositions of *Moringa oleifera* under salinity stress. Saudi J Biol Sci. 2021;28(3):1687-1696.
25. Chapman HD, Pratt PF. Method of Analysis for Soil and Water. 2nd ed. Chapter 17:150-161. University of California, Division of Agricultural Sciences; 1978.
26. Jackson ML. Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt Ltd. 1973;183–192.
27. AOAC. Official Method of Analysis of the Association of Official Analytical Chemists. 14th ed. Washington, DC: Association of Official Analytical Chemists; 1984. p. 540.
28. Yemm EW, Willis AJ. The estimation of carbohydrate in extracts by anthrone. Biochem J. 1954;57:508-514.
29. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed. New York: John Wiley & Sons, Inc.; 1984.
30. Petropoulos SA, Sami NR, Benajiba ZRMY, Mohamed MHM. The response of globe artichoke plants to potassium fertilization combined with the foliar spraying of seaweed extract. Agronomy. 2022;12(2):490.
31. Rathore SS, Chaudhary DR, Boricha GN, Ghosh AG, Bhatt SP, Zodapc ST, Patolia JS. Effect of seaweed extract on the growth, yield, and nutrient uptake of soybean (*Glycine max*) under rain-fed conditions. South Afr J Bot. 2009;75(2):351-355.
32. Mazher A, Abdel-Aziz NS, El-Dabh RS, El-Khateeb MA, Abd El-Badaie AA. Effect of bio-fertilization on growth and constituents of *Moringa oleifera* Lam. plants. Middle East J Agric Res. 2014;3(4):793-798.
33. Radwan FI, Abido AI, Shaben EH, Abdel Gabr NA. Effect of mineral, organic, and bio-fertilization on growth and production of Moringa (*Moringa oleifera*, L.) plants. J Adv Agric Res. 2016;21(2):308-324.
34. Abd El-Baset MM. Effect of foliar application of yeast extract and some amino acids on growth and chemical composition of two drumsticks species (*Moringa oleifera* and *Moringa ovalifolia*). J Plant Prod. Mansoura Univ. 2017;8(10):953-959.
35. Haider MW, Ayyub CM, Pervez MA, Asad HU, Manan A, Raza SA, Ashraf I. Impact of foliar application of seaweed extract on growth, yield, and quality of potato (*Solanum tuberosum* L.). Soil Environ. 2012;31(2):157-162.
36. Zhang X, Ervin E. Cytokinin-containing seaweed and humic acid extracts associated with creeping bentgrass leaf

cytokinins and drought resistance. Crop Sci. 2004;44:1737-1745.
37. Zayed MS. Improvement of growth and nutritional quality of *Moringa oleifera* using different bio-fertilizers. Ann Agric Sci. 2012;57(1):53-62.
38. Yang S, Wang H, Wang G, Wang Gu J, Xue X, Chen R. Effects of seaweed-extract-based organic fertilizers on the levels of mineral elements, sugar-acid components, and hormones in Fuji apples. Agronomy. 2023;13(4):969.
39. EL-Leithy A. Effect of irrigation intervals and biofertilization on yield, oil production, and chemical constituents of chamomile (*Matricaria chamomilla* L.) plants. J Prod Dev. 2007;12(1):85-99.
40. Ghoneim IM, EL-Araby SM. Effect of organic manure source and biofertilizer type on growth, productivity, and chemical composition of jew's mallow (*Corchorus olitorius* L.) plants. J Agric Env Sci Alex Univ. 2003;2(2):88-105.
41. Youssef MA. Impact of bio-fertilizers on growth and yield of *Moringa oleifera* Lam. plants. Al-Azhar J Agric Res. 2016; 26(3):127-138.
42. Zodape ST, Kawarkhe VJ, Patolia JS, Warade AD. Effect of liquid seaweed fertilizer on yield and quality of okra (*Abelmoschus esculentus* L.). J Sci Ind Res. 2008;67:1115–1117.
43. Radwan FI, Abido AI, Shaben EH, Saeed DI. Effect of mineral, organic, and bio-fertilization on yield and quality of parsley (*Petroselinum sativum* L.). J Adv Agric Res. 2015;20(1):12-21.
44. Abdelkader AF, Hassanein RA, Ali H. Studies on effects of salicylic acid and thiourea on biochemical activities and yield production in wheat (*Triticum aestivum* var. Gimaza 9) plants grown under drought stress. Afr J Biotechnol. 2012;11(64): 12728-12739.
45. Gajewski M, Katarzyna G, Bobruk J. The influence of Goëmar Goteo biostimulator on yield and quality of two Chinese cabbage cultivars. In: Conference of biostimulators in modern agriculture "vegetable crops"; Warsaw. 2008;23-27.

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