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POMEGRANATE (*PUNICA GRANATUM* L.) RESPONSE TO MARINE ALGAE EXTRACT IN INTERACTION WITH HUMAX ACID FOR GROWTH TRAITS

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SUMMARY

The study commenced in March-September, 2023, in the canopy of the University of Kerbala, Kerbala, Iraq. The experiment's implementation relied on a completely randomized block design (RCBD) with three factors. The first was pomegranate (*Punica granatum* L.) cultivars (Wonderful and Slimi), the second was the marine algae extract at three concentrations (0, 1.5, and 3 ml L^{-1}), and the third was the Humax acid at three concentrations (0, 0.25, and 0.50 g L^{-1}). The most important results revealed the Wonderful cultivar significantly superior to the Slimi cultivar in all studied vegetative traits, recording the highest average of the following: increases in the seedling height, seedling stem diameter, the number of leaves per seedling, the total leaf area, relative moisture content in the leaves, and dry matter percentage. The marine algae treatment of 3 ml L^{-1} showed significant superiority to other extract concentrations in the vegetative growth trait. It included increases in the seedling height, seedling stem diameter, number of leaves per seedling, total leaf area, relative moisture content in the leaves, and dry matter percentage. Humax acid treatment of 0.50 g L^{-1} was notably better than the other Humax acid concentrations in all studied vegetative traits.

Keywords: Pomegranate (*P. granatum* L.), cultivars, marine algae extract, Humax acid, growth traits

Key findings: The treatment of the cultivar Wonderful with 3 ml L^{-1} of marine algae extract and 0.50 g L^{-1} of Humax acid recorded the highest average in all vegetative growth traits of the pomegranate (*P. granatum* L.).

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INTRODUCTION

Two *Punicaceae* species in cultivation comprised the first of *Punica granatum* L., which produces sweet and sour pomegranate fruits. The second one is *Punica protopunica* L., which is a decorative pomegranate with infrequent distribution characteristic in Su Qatra Island in Yemen (Al-Bayati and Al-Shammari, 2020). Its origin is likely Iran and northwest India. It is a commercially grown crop in Spain, Italy, Florida, southern US states, Cyprus, Saudi Arabia, Iraq, Syria, Lebanon, and Egypt (Al-Douri and Al-Rawi, 2000).

In pomegranate juice, the anthocyanins, phenolics, and tannins seemingly strengthen the heart, treat stomach problems including indigestion, and prevent tapeworms (Jumaa and Al-Sumaidaie, 2016). It is rich in the B1 and B2 vitamins, which help fend off infections and cancer (Ghasemi-Soloklui *et al*., 2023). Numbering 6,495,705, pomegranate fruit trees yield 37.2 kg each tree and a total of 242,671 tons yearly (CSO, 2020). Expediting seedling growth—essential to fruit production—required applying plant extracts to the foliar feed.

Modern methods for leaf nutrient absorption include foliar nourishment, especially when the soil has salinity, high calcium or gypsum content, or a tendency to precipitate or stabilize nutrients, which reduces root absorption (Fernández *et al*., 2013). With its mineral elements, growth regulators, vitamins, and organic acids, as well as, plants' ease of absorption and low cost, marine algae extract had high usage in recent studies to reduce chemical fertilizers' negative effects on human health and pollution (Khudair *et al*., 2015).

Rising organic fertilizer uses to improve food product quality and safety from pesticide residues and chemical fertilizers are due to their ability to lower soil pH and increase essential element availability with organic acids (humic and fulvic), which chelate elements in complex formulas (Stion *et al*., 2009). This improves pomegranate seedling vegetative development. Adhbib *et al*. (2018) found spraying the cultivar Wonderful pomegranate seedlings with marine algae at 4 ml L^{-1} generated the highest average stem height, diameter, and leaf area.

Kadhem and Hadi (2015) showed spraying kaki seedlings with 4 ml L^{-1} marine algae extract and humic acid produced the greatest average height and leaf count. Hussein (2017) found 50 ml L^{-1} humic acid gave fig seedlings the highest average stem diameter and leaf count. This study investigated the best cultivar and concentration of marine algae extract and Humax acid and their effect on vegetative growth to address the lack of studies on marine algae extract and Humax acid in pomegranate seedling growth. Moreover, to reduce the time, effort, and cost of obtaining seedlings suitable for transfer to a permanent farm.

MATERIALS AND METHODS

The study's implementation occurred in the canopy of the University of Kerbala, Kerbala, Iraq, for the period of March-September, 2023. It sought to investigate the effect of spraying with marine algae extract and adding Humax acid on vegetative growth traits of two cultivars of pomegranate (*Punica granatum* L.) seedlings. Two hundred seventy seedlings' selection at 10 months old were as homogeneous as possible in size and vegetative growth. Their previous growing ensued in sandy soil in black plastic bags made of polyethylene with a capacity of 1.25 kg. Their transplanting into pots with a 10-kg soil capacity continued on March 10, 2023.

The experiment's design as factorial based on the randomized complete block design (RCBD) of three factors. The first factor was the pomegranate cultivars (Wonderful and Slimi), the second factor was the marine algae, and the third was Humax acid fertilizer, in three replicates, containing 90 seedlings per replicate, and distributed to five seedlings per experimental unit. The seedlings received spraying four times per month, starting from March 20, 2023, using a 2-liter hand sprinkler. With each concentration, adding 1 ml of detergent, as a diffuser (instead of the Tween-

20), helped reduce the surface tension of the water molecules to get the vegetative plant parts completely wet. The seedlings' spraying with the marine algae extract used Algazone as a foliar fertilizer at three concentrations (0, 1.5, and 3 ml L^{-1}) early in the morning. The control treatment sustained spraying with distilled water and detergent only.

Irrigating the seedlings happened a day before applying the spray treatment to increase the plant's efficiency to absorb the sprayed material because moisture is vital in the process of swelling the guard cells and opening the stomata. Additionally, watering before spraying reduces the concentration of solutes in the leaf cells and increases the penetration of ions of the spray solution into them (Al-Sahhaf, 1989). The following day, Humax acid addition at three concentrations (0, 0.25, and 0.50 g L^{-1}) continued five times with a month's interval between one addition and the next, starting on February 21, 2023. All service practices, including irrigation and weeding, proceeded equally and whenever needed. Data collection transpired at the end of the study on September 20, 2023.

Data recorded

The seedling height (cm) measurement consisted of finding the difference in stem height before and after applying the treatments. Using a graduated measuring tape, gauging began from the soil surface to the main stem top, and then, calculating the average in each experimental unit for all treatments and for all replicates in the study. The calculation of stem diameter (mm) occurred before and after the study treatments at a distance of 5 cm from the soil surface with a digital Vernier. The average calculation included each experimental unit for all treatments in the study and their replicates.

Computing the total number of leaves (leaves per seedling) for each seedling ensued at the end of the study, after which, calculating the average number of leaves in each experimental unit comprised the treatments and all replicates. The leaf area (cm^2) calculation based on dry weight had five leaves taken for each fully expanded seedling, and then, taking another five pieces with an area of 0.5 cm^2 from the leaves. The leaves and pieces sustained drying in an electric oven at a temperature of 70 °C until the weight stabilized; afterward, recording the dry weight of the leaves and the pieces followed, with the average calculated for them. Finally, the leaf area's calculation used the following equation:

$$Plant\ leaf\ area\ (cm^2) = \frac{leaf\ weight\ (g) x\ area\ of\ the\ part\ cut\ from\ the\ leaf}{weight\ of\ the\ part\ cut\ from\ the\ leaf\ (g)}$$

Computing the total plant leaf area relied on the following equation:

Plant leaf area (cm^2) = leaf area (cm^2) × number of leaves per seedling.

Relative moisture content of leaves (%)

The estimation of moisture content in the leaves of pomegranate seedlings followed the procedure of Siddique *et al.* (2000). It included weighing 20 fresh leaves for each seedling of the experimental units with a sensitive balance at a sensitivity of 0.0001 and recording their fresh weight. Next, their immersion in distilled water took 16–18 hours at room temperature (23 °C – 25 °C) under low light conditions to saturate the leaves with distilled water and record the turgid weight. Then, drying the leaves in the electric oven had a temperature of 70 °C ± 1 °C until the weight was stable for recording the dry weight of the leaves. Then, the relative moisture content calculation of the leaves relied on the following equation:

$$\text{Relative moisture content of leaves (\%)} = \frac{leaf\ fresh\ weight - leaf\ dry\ weight}{Turgid\ Weight - \ leaf\ dry\ weight}$$

Statistical analysis

Data collection and analysis proceeded at the end of the study for a factorial experiment comprising three factors (2 × 3 × 2) for the two pomegranate cultivars, Wonderful and Slimi, the marine algae extract, and Humax acid. The experiment had three replicates, relying on the RCBD, with the means compared according to the least significant difference test ($LSD_{0.05}$) (Al-Rawi and Khalafallah, 2000).

RESULTS

Seedling height

Significant effects of the cultivars, the concentrations of marine algae extract, Humax acid, and their interaction were evident on the average seedling height in pomegranates (Table 1). The Wonderful cultivar outperformed the Slimi cultivar, giving the highest average increase, amounting to 59.148 cm, higher than the Slimi cultivar, with the lowest average of 54.863 cm by 7.810%. Spraying marine algae extract substantially affected this trait, and increasing the extract concentration to 3 ml L^{-1} raised the seedling height average by 67.067 cm, higher than the lowest increase (47.111 cm) recorded at the control treatment by 42.359%.

Raising the Humax acid to 0.50 g L^{-1} resulted in an elevation of 60.600 cm in the seedling height, exceeding the lowest value (53.567 cm), recorded in the control treatment by 13.129%. The binary interactions between the study factors significantly affected this trait average. The Wonderful cultivar, when treated with 3 ml L^{-1} of marine algae extract, gave the utmost average, reaching 68.744 cm, while the lowest average was for the Slimy cultivar, treated with the control treatment (45.389 cm), with an increase of 51.455% between them. The Wonderful cultivar treated with a concentration of 0.50 g L^{-1} Humax acid gave the premier average increase for the seedling height (62.444 cm), with the lowest average from the Slimi cultivar without the Humax acid addition, amounting to 51.000 cm. They had a difference of 22.439% between them.

The effect of the interaction between marine algae extract and Humax acid was significant on the average increase in pomegranate seedling height. The treatment of 3 ml L^{-1} of marine algae extract with the treatment 0.50 g L^{-1} Humax acid provided the topmost height length increase, averaging 70.700 cm, outperforming the lowest average at the control treatment (0 seaweed extract + 0 Humax acid) of 43.850 cm, by an increase of 61.231%. The effect of the triple interaction was noteworthy in raising the average of this trait. The interaction treatment of Wonderful cultivar with a concentration of 3 ml L^{-1} of marine algae extract and 0.50 g L^{-1} of Humax acid gave the highest average increase in plant height. It reached 71.333 cm, outperforming the treatment of the Slimy cultivar without the marine algae extract or Humax acid addition, giving the lowest average of 42.200 cm by 69.035%.

Table 1. Effect of the cultivars, marine algae extract, Humax acid, and their interaction on the seedling height in pomegranate (*Punica granatum* L.).

Cultivars	Marine algae extract concentration (ml L^{-1})	Humax acid concentration (g L^{-1})			Cultivars x Algae extract
		0	0.25	0.50	
Wonderful	0	45.500	48.300	52.700	48.833
	1.5	56.600	59.700	63.300	59.867
	3	66.300	68.600	71.333	68.744
Slimi	0	42.200	45.367	48.600	45.389
	1.5	50.300	53.533	57.600	53.811
	3	60.500	65.600	70.067	65.389
$LSD_{0.05}$		0.2098			0.1211
Humax acid's means (cm)		53.567	56.850	60.600	
$LSD_{0.05}$	0.0856				Cultivars' means (cm)
Variety x Humax acid	Wonderful	56.133	58.867	62.444	59.148
	Slimi	51.000	54.833	58.756	54.863
$LSD_{0.05}$		0.1211			0.0699
Algae extract x Humax acid					Algae extract's means (cm)
	0	43.850	46.833	50.650	47.111
	1.5	53.450	56.617	60.450	56.839
	3	63.400	67.100.	70.700	67.067
$LSD_{0.05}$		0.1483			0.0856

Table 2. Effect of the cultivars, marine algae extract, Humax acid, and their interaction on the seedling stem diameter in pomegranate (*Punica granatum* L.).

Cultivars	Marine algae extract concentration (ml L^{-1})	Humax acid concentration (g L^{-1})			Cultivars x Algae extract
		0	0.25	0.50	
Wonderful	0	1.896	2.324	2.463	2.227
	1.5	2.593	2.637	2.707	2.645
	3	2.852	2.925	3.872	3.216
Slimi	0	1.753	1.793	1.935	1.827
	1.5	2.345	2.455	2.524	2.441
	3	2.618	2.788	3.144	2.850
$LSD_{0.05}$		0.027			0.015
Humax acid's means (mm)		2.342	2.487	2.774	
$LSD_{0.05}$		0.01108			Cultivars' means (mm)
Cultivars x Humax acid	Wonderful	2.447	2.628	3.014	2.696
	Slimi	2.238	2.345	2.534	2.372
$LSD_{0.05}$		0.015			0.009
Algae extract x Humax acid					Algae extract's means (mm)
	0	1.824	2.059	2.199	2.027
	1.5	2.469	2.546	2.615	2.543
	3	2.735	2.856	3.508	3.033
$LSD_{0.05}$		0.019			0.011

Stem diameter

Substantial variations were apparent due to pomegranate cultivars, marine algae extract, Humax acid, and their interaction in the seedling stem diameter (Table 2). Wonderful had the largest average rise in seedling stem diameter at 2.696 mm, exceeding Slimi, which had the lowest average at 2.372 mm, by 13.654%. The 3 ml L^{-1} treatment had the highest average increase in stem diameter at 3.033 mm, 13.65% higher than the control treatment's 2.027 mm. The high concentration of 0.50 g L^{-1} Humax acid raised seedling stem diameters by 2.774 mm, on average, 18.421% more than the control treatment of 2.342 mm. The characteristic remarkable influences from the binary interaction between variables.

The Wonderful cultivar treated with 3 ml L^{-1} marine algae extract had the greatest average for this attribute (3.216 mm), 76.028% greater than the Slimy cultivar at the control treatment (1.827 mm). The cultivar Wonderful treated with Humax acid at 0.50 g L^{-1}, increased seedling stem diameter by 3.014 mm, 34.658% more than the Slimi at 2.238 mm. The interaction between nutrient factors affected the trait, as increasing marine algae concentration to 3 ml L^{-1} and Humax acid to 0.50 g L^{-1} enhanced stem diameter by 3.508 mm, 92.256% more than the control treatment (0 marine algae + 0 Humax acid) of 1.824 mm. Triangular interaction of examined factors substantially altered the characteristic. The treatment with 3 ml L^{-1} marine algae extract and 0.50 g L^{-1} Humax acid gave the Wonderful cultivar the highest average rise in seedling stem diameter (3.872 mm). It outperformed the Slimi cultivar without marine algae extract or Humax acid, which gave the lowest average of 1.753 mm, by 120.895%.

Leaves per seedling

Pomegranate cultivars, marine algae extract, and Humax acid significantly affected leaf count (Table 3). The Wonderful cultivar generated the most leaves, averaging 413.143 leaves $seedling^{-1}$, compared with the Slimi's 382.836 leaves $seedling^{-1}$, by 7.914%. Marine algae extracts reduced leaf growth in pomegranate seedlings. Increasing the extract content to 3 ml L^{-1} yielded the highest average (511.374 leaves $seedling^{-1}$), by 73.534% from the control treatment's 294.686 leaves $seedling^{-1}$. Humax acid at 0.50 g L^{-1} yielded 443.435 leaves $seedling^{-1}$, 20.024% more than the control treatment's 369.440 leaves $seedling^{-1}$. Results also demonstrated binary interaction treatments considerably altered pomegranate's seedling leaf count. The Wonderful cultivar, treated with 3 ml L^{-1} of marine algae extract, produced the highest average number of leaves, 522.320 leaves

Table 3. Effect of the cultivars, marine algae extract, Humax acid, and their interaction on the number of leaves per seedling in pomegranate (*Punica granatum* L.).

Cultivars	Marine algae extract concentration (ml L^{-1})	Humax acid concentration (g L^{-1}) 0	0.25	0.50	Cultivars x Algae extract
Wonderful	0	281.230	288.400	365.650	311.760
	1.5	377.220	392.207	446.840	405.422
	3	482.410	492.680	591.870	522.320
Slimi	0	264.250	278.070	290.680	277.666
	1.5	356.260	362.470	392.690	370.473
	3	455.270	473.450	572.880	500.533
$LSD_{0.05}$		1.657			0.957
Humax acid's means (leaf seedling^{-1})		369.440	381.212	443.435	
$LSD_{0.05}$		0.676			Cultivars' means (leaf seedling^{-1})
Variety x Humax acid	Wonderful	380.270	391.090	468.070	413.143
	Slimi	358.530	371.310	418.670	382.836
$LSD_{0.05}$		0.957			0.552
Algae extract x Humax acid					Algae extract's means (leaf seedling^{-1})
	0	272.730	283.230	328.100	294.686
	1.5	366.750	377.372	419.705	387.942
	3	468.820	483.001	582.303	511.374
$LSD_{0.05}$		1.172			0.676

seedling^{-1}. It surpassed Slimi, which produced 277.666 leaves seedling^{-1}.

The Wonderful cultivar treated with 0.50 g L^{-1} of Humax acid produced 468.07 leaves seedling^{-1}, 30.552% more than the Slimi cultivar untreated with Humax acid, which produced 358.53 leaves seedling^{-1}. The 3 ml L^{-1} marine algae extract with 0.50 g L^{-1} Humax acid had the highest trait value, averaging 582.303 leaves seedling^{-1}, compared with the lowest value of the control treatment (0 marine algae + 0 Humax acid). It produced 272.730 leaves seedling^{-1}, a 113.531% less. The three research components' triple interaction substantially influenced pomegranate seedlings' average leaf count. The Wonderful cultivar treated with 3 ml L^{-1} marine algae extract and 0.50 g L^{-1} Humax acid produced the most leaves, averaging 591.870 leaves seedling^{-1}, and a significant increase over Slimi's 264.250 leaves seedling^{-1}, reaching 123.996%.

Leaf area

Results demonstrated the notable effect of the cultivars, spraying the marine algae extract, and adding Humax acid on the leaf area in pomegranates (Table 4). The cultivar Wonderful, producing an average leaf area of 8037 cm^2, was superior to the other cultivar, Slimi, which produced 6499-cm^2 leaf area, with an increase of 23.665%. Spraying the marine algae extract also affected the plant leaf area, increasing it to 11061 cm^2 when the sprayed extract concentration was 3 ml L^{-1}, markedly outperforming the control treatment with the lowest leaf area of 4013 cm^2 by 175.629%. Adding Humax acid also significantly modified this trait. Increasing the Humax acid concentration to 0.50 g L^{-1} resulted in the highest plant leaf area reaching 8767 cm^2, higher than the lowest value at the control treatment (6144 cm^2) by 42.692%.

The binary interaction between each of the two factors of the study radically influenced the trait. The cultivar Wonderful, when sprayed with the 3 ml L^{-1} of marine algae extract, achieved the broadest plant leaf area of 11,994 cm^2, significantly superior to the lowest value of 3,520 cm^2, obtained from the cultivar Slimi without spray, by 240.738%. Concerning the interaction between the cultivar and Humax acid, the Wonderful cultivar plus 0.50 g L^{-1} of Humax acid recorded a 9,817 cm^2 leaf area, superior to Slimi without Humax acid, with the lowest leaf area (5,593 cm^2) by 75.522%. The interaction between marine algae and Humax acid revealed 3 ml L^{-1} of the marine algae extract combined with 0.50 of Humax acid was

Table 4. Effect of the cultivars, marine algae extract, Humax acid, and their interaction on the total leaf area in pomegranate (*Punica granatum* L.).

Cultivars	Marine algae extract concentration (ml L^{-1})	Humax acid concentration (g L^{-1})			Cultivars x Algae extract
		0	0.25	0.50	
Wonderful	0	3501	4100	5917	4506
	1.5	6647	7409	8777	7611
	3	9937	11288	14758	11994
Slimi	0	3237	3517	3806	3520
	1.5	5310	5798	6438	5848
	3	8232	9242	12907	10127
$LSD_{0.05}$		412.119			238.000
Humax acid's means (cm^2)		6144	6892	8767	
$LSD_{0.05}$		168.3			Cultivars' means (cm^2)
Variety x Humax acid	Wonderful	6695	7599	9817	8037
	Slimi	5593	6186	7717	6499
$LSD_{0.05}$		238.202			137.411
					Algae extract's means (cm^2)
Algae extract x Humax acid	0	3369	3809	4862	4013
	1.5	5978	6603	7607	6730
	3	9085	10265	13832	11061
$LSD_{0.05}$		291.420			168.301

Table 5. Effect of the cultivars, marine algae extract, Humax acid, and their interaction on the relative moisture content in the leaves of pomegranate (*Punica granatum* L.).

Cultivars	Marine algae extract concentration (ml L^{-1})	Humax acid concentration (g L^{-1})			Cultivars x Algae extract
		0	0.25	0.50	
Wonderful	0	40.558	43.313	45.336	43.069
	1.5	47.438	49.535	51.695	49.556
	3	53.738	55.425	61.326	56.830
Slimi	0	38.986	40.710	42.745	40.814
	1.5	45.095	47.487	48.847	47.143
	3	51.557	55.097	56.874	54.510
$LSD_{0.05}$		0.917			N.S
Humax acid's means (%)		46.229	48.595	51.137	
$L.S.D_{0.05}$		0.374			Cultivars' means (%)
Variety x Humax acid	Wonderful	47.245	49.424	52.786	49.818
	Slimi	45.213	47.765	49.489	47.489
$LSD_{0.05}$		0.529			0.305
					Algae extract's means (%)
Algae extract x Humax acid	0	39.772	42.012	44.041	41.941
	1.5	46.266	48.511	50.271	48.349
	3	52.648	55.261	59.100	55.670
$LSD_{0.05}$		0.648			0.374

superior. They produced the widest leaf area, reaching 13,832 cm^2, which was substantially higher than the area of 3,369 cm^2 produced by the control treatment (0 marine algae + 0 Humax acid) by 310.566%. The triple interaction effect of the studied factors was noteworthy in the plant leaf area. The Wonderful cultivar treated with 3 ml L^{-1} of marine algae extract and 0.50 g L^{-1} of Humax acid produced the highest average of the leaf area. It reached 14,758 cm^2 and was significantly superior to the Slimi cultivar with no treatment of the marine algae extract or Humax acid by 355.915%.

Leaf relative moisture content

Pomegranate cultivars, marine algae extract, and Humax acid provided sizable effects on the seedling leaf moisture (Table 5). Cultivar Wonderful's 49.818% leaf relative moisture was 4.904% higher than Slimi's 47.489%. At 3 ml L^{-1} extract concentration, spraying marine algae increased the trait to 55.670%, exceeding the control treatment's 41.941% low relative moisture content of the leaf by 32.734%. The maximum trait value was 51.137% with Humax acid at 0.50 g L^{-1}, 10.616% higher than the control treatment of 46.229%. Interaction between cultivar and marine algae was negligible for phenotypic effect of binary interaction between research components. The characteristic had strong influences from the other binary relationships. The Wonderful cultivar treated with 0.50 g L^{-1} Humax acid had 52.786% relative moisture, 16.749% more than the Slimi cultivar's 45.213%. Interaction between marine algae extract and Humax acid altered the trait, since 3 ml L^{-1} of marine algae extract and 0.50 g L^{-1} of Humax acid produced the greatest relative moisture value of 59.100%. With a 48.597% increase above the control treatment (0 marine algae extract + 0 Humax acid), this interaction was better. The triple interaction of the three variables greatly altered this attribute. The Wonderful cultivar had the highest relative moisture content of 61.326% when treated with marine algae extract at 3 ml L^{-1} and Humax acid at 0.50 g L^{-1}, compared with the Slimi cultivar's 38.986% when untreated.

DISCUSSION

Results indicate the Wonderful cultivar was superior to the Slimi cultivar in all vegetative traits, and this may be due to the genetic variance among the cultivars. The increase in vegetative growth traits affected by the marine algae may refer to its role in plant nutrition and growth due to the components it contains, considering it a primary source of organic materials that contain essential compounds. These include sugars, amino acids, DNA, RNA, enzymes, proteins, in addition to macro- and micro-nutrients, especially magnesium and iron, and their role in chlorophyll construction (Fernández *et al.,* 2013).

The magnesium atom represents the center of the chlorophyll molecule, which contributes to many physiological processes. Among these are increasing the plant’s ability to synthesize dissolved substances and their accumulation in the plant, stimulating photosynthesis and increasing its products of carbohydrate, and improving the plant’s vegetative traits (Seif *et al.,* 2016). Spraying seaweed may lead to an increase in the number of leaves. One believes this effect could be a result of the nutrients and other elements provided by the seaweed, which contributes to stimulating plant growth, as reflected in an increase in the number of leaves (Al-Khaqani *et al.,* 2022).

Substances similar to cytokinins increase in plants treated with marine algae extract. The marine algae extract increases the chlorophyll content in leaves because it contains betaine, a nitrogen source important in preventing chlorophyll decomposition and oxidation (Khairy *et al.,* 2011). Raising the concentrations of N, Mg, and Fe in leaves boosts chlorophyll. This refers to its involvement in the structure of its molecules, thus, enriching the food produced due to the efficiency of photosynthesis and the increase in carbohydrates, reflected in the vegetative growth parameters. These results are consistent with the findings of Adhbib *et al.* (2018), and Kadhem and Hadi (2015).

Humax acid contains the organic humic and fulvic acids that increase the absorption of monovalent ions, such as, ammonium and potassium and reduce water evaporation from the soil, especially in sandy lands. Humax acid has a chemical, biological, and environmental role, as it chelates metal ions in alkaline conditions and converts several elements into forms that plants easily absorb (Zarei, 2017; Mahmood and Jaafar, 2024). Humic acid also increases the permeability of cell membranes and the absorption of nutrients. It enriches their concentration in the leaves, which contributes to enhancing the processes of photosynthesis, the constitution of carbohydrates and proteins, and the construction of sugars (Salama and Yassin, 2023), as reflected in an elevated vegetative growth parameters.

These results agreed with the findings of Hussein (2017), where spraying with humic can improve the plant's ability to absorb and retain water, which enhances the moisture level in leaves. This effect can be especially beneficial in dry conditions, or when insufficient moisture absorption threatens the plant, and thus, appear in the response of the rest of the traits to spraying with humic (Roudgarnejad *et al.,* 2021).

CONCLUSIONS

The use of local environmentally friendly marine algae extract product and spraying it on the plant's shoot had a positive role in improving the vegetative growth traits of the pomegranate (*Punica granatum* L.). Humax acid can be reliable as a local organic fertilizer to improve the physical and chemical properties of soil, the readiness to absorb nutrients, and improve the vegetative growth traits.

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