ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(6): 368-376
www.agriculturaljournals.com
Received: 08-04-2026
Accepted: 12-05-2026

Marwa Noman Hussein
Department of Horticulture, College of Agriculture, Tikrit University, Tikrit, Iraq

Khalid Abdulla Sahar Al-Hamdani
Department of Horticulture, College of Agriculture, Samarra University, Samarra, Iraq

Shatha Ahmed Mahdi
Department of Food Science, College of Agriculture, Samarra University, Samarra, Iraq

Corresponding Author:
Marwa Noman Hussein
Department of Horticulture, College of Agriculture, Tikrit University, Tikrit, Iraq

The effect of spraying with gibberellin and the amino acid tecamine max on the growth of grafted *Christi thorn* seedlings

Marwa Noman Hussein, Khalid Abdulla Sahar Al-Hamdani and Shatha Ahmed Mahdi

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i6e.1619

Abstract
In this research the effect of the addition of both seaweed extract and GA3 to the vegetative growth characteristics and chemical constituents of grafted Sidr seedlings was studied from 1st October 2024 until 5th December 2025 at the wooden canopy of Samarra University - the Department of Horticulture and Landscape Design/ College of Agriculture. The experiment had two factors with three levels, the first factor was the concentration of seaweed extract with three levels; 0, 4 and 8 ml Lt-1, and the second factor was the concentration of growth regulator GA3 with three levels; 0, 50, and 100 mg Lt-1 were used as foliar sprays to investigate the effects on total vegetative growth. The research utilized the Randomized Complete Block Design (RCBD) with two factors and three replications (3 replications per experimental unit) for a total of 6 replications (2 seedlings/experimental unit). The data was analyzed for differences between mean values using Duncan's Multiple Range Test at the 5% significance level. The major findings are summarized as follows: Seaweed applications to the foliage at the 8 ml/l level resulted in leaf count, main branch count and secondary branch count of 85.33 cm, 3.82 mm and 84.44 cm respectively (when calculated as average per seedling) and 5.33 main branches per seedling and 9.0 secondary branches per seedling, compared to the control treatment, which exhibited the lowest average values for these variables. The results indicate that using algae extract as a foliar spray creates a substantial variation in the level of chlorophyll, nitrogen, phosphorus, potassium and carbohydrates at T_2, which is the highest level at 8mg/L, with increments of 1.31 for chlorophyll, 0.24 for nitrogen, 1.10 for phosphorous and potassium; the lowest levels of T_0 where 1.18 for chlorophyll, 0.18 nitrogen, and 1.01 phosphorus and potassium were observed. Furthermore, GA3 is a plant growth hormone that has an affirmative affect on growth (e.g., plant height, stem diameter, number of leaves, number of main branches and number of secondary branches), particularly at a concentration of 100 mg/L(s); 91.0 cm, 3.75 mm, 82.0 leaves, 5.0 main branches, and an excess of 2.0 branches are noted as the results of GA3 application. The treatment with seedling-no. 1 recorded the lowest moral quantity of these characteristics compared to treatment 2, which had the highest moral quantity of those characteristics (plant height and stem diameter). Both treatments showed a significant increase in nitrogen levels when gibberellic acid was added to their respective treatments. Maximum levels of nitrogen were observed at the addition of GA2 at 100 mg/liter of GA3. Statistically significant differences existed between treatments when marine algae extract was used in conjunction with gibberellic acid on all the characteristics examined. Both treatments produced significant differences from each other, the treatment with T_2GA100 provided the greatest level of the above characteristics, while T_0 (GA0) provided the lowest level. Statistically significant increases were noted as a result of the combinations between marine algae powder and gibberellic acid on the chemical content of sidr tree leaves. T_2GA2 recorded the greatest amount of total chlorophyll, nitrogen, phosphorus, potassium, and total carbohydrate content. The findings indicated that these values were more ethical than the other coefficients, which demonstrates the efficacy of using combined marine algae and gibberellins for enhancing photosynthesis and metabolic functions of plants through leaf spraying.

Keywords: Growth regulator, gibberellin, humic acid, marine algae extract

1. Introduction
Christi thorn L.is one of the evergreen fruits, Of the family Rhamanaceae, there are about 58 different genera with 3 main genera, which all come from different parts of the world where they are widely grown (Hauenschild *et al*., 2016) [21]. Of these, the most common and well-known being the genus Sidr, whose original home believed to be southern Europe, southern

Asia (the Himalayas) and northern China; however, may also be found in northern Africa, Sudan and the Arab region (as far south as South America). Many areas in Iraq cultivate different varieties of sidr fruit; the first variety is found mostly in northern Iraq, the second is found mostly in southern Iraq, especially in Basra, the third is found mostly in the desert areas of southern and western Iraq, and the fourth is found in both the central and southern areas of Iraq (Al-Fadil, 2021; Al-Rubaie, 1998) [7, 11] As a result of where people grow these kinds of fruits, there are many differences between the four types that exist.

According to Verkleij (1992) [30], marine algae are an effective source of organic materials for agriculture and act as a complement to chemical fertilizers, not a replacement. Marine algae also provide a variety of nutrients along with a group of plant growth regulators including gibberellins, auxins, and various amino acids that enhance both vegetative and root systems of plants. Marine algae can also help improve the quality and increase plant resistance to disease (Spinelli *et al*., 2010) [28]. When used properly, marine algae can promote improved plant growth by spraying algae onto the plant's total vegetative area (Kuwada *et al*., 2006) [25] and (Zodape *et al*., 2011) [32].

By adding marine algae (which contain amino acids) to some fruit seedlings (such as Sidr), the nutrients available to these plants in their soil have increased. This has also helped develop and strengthen the vegetative and root systems of these seedlings, while improving how much of the nutrition needed to support the leaves of these seedlings can be found therein (Al-Alaf, 2017) [4]. Marine algae based student extracts are examples of organic inputs for agricultural production; they can complement chemical fertilizers but cannot replace them. They provide a way to enhance and better utilize chemical fertilizers while also decreasing production costs. Worldwide there has been an average use of over 15 million tons of student based extracts per year across agricultural applications; many of them contain more than one class of plant growth stimulant (such as oxins, vitamins, and amino acids) andmost extracts contain many diverse saccharides; these can perform a variety of stimulating functions on plant life activities. Petaine is a nitrogen source at low levels and regulates osmosis at higher levels. The influence of these extracts on salinity and drought resistance in plants has been studied (Morales & Norrie, 2010) [26]. Spring (Al-Rubaie, 2011) [12] used marine algae extract (0, 100, or 125 ml/L), and depending on the type of olive (Olea Oeuropa), resulted in increased length of the main stem and root, dry weight, and chlorophyll in leaves, with 125 ml/L having the greatest effect. (Al-Obaidi, 2016) [9] researched using marine algae extract rata in Nepali olive trees at a lower concentration (20 ml). The study conducted with the use of tree-1 resulted in a significant increase in two seasons as measured by the area of paper as well as the chemical composition. In addition, Al-Dulaimi, Mohammaed and Ali (2016) confirmed that when applied to olive seedling of the variety Asharisi, the addition of Kelpak marine extract (in the concentrations of 0, 2, and 4 ML) resulted in a significant increase in almost all of the measured variables with the greatest effect of treatment being found at the 4 ML L-1 treatment where the length of main stem, number of branches, paper area, percentage of dry matter in the leaves and chemical content all increased significantly. Whereas the 2 ML L-1 treatment resulted in an increase in number of leaves and their chlorophyll content. The comparison (0 ML) treatment had the lowest average values for many of the measured variables. According to Al-Qaisi (2018) [10], the use of halwani and kamali grapes with marine extract Alga600 in grape plants has also improved performance in the kamali variety, with a concentration of 2 g/L demonstrating the best performance across many of the studied parameters for both root and vegetative growth. Performance measures included root system, leaf area, number of leaves, number of branches, leaf chlorophyll content, wet weight of leaves and dry weight of leaves.

Growth regulators can be derived from either natural or synthetic processes. They are either naturally occurring plant hormone compounds or created ex vivo and encourage or alter certain physiological processes at certain concentrations in the organism. One group of compounds, referred to as phenolic compounds (metabolites with an oral ring system), have been shown to be very important for the overall growth and development of a plant, ultimately influencing stem elongation by modulating cellular division (cell division acceleration), altering the cell wall's capacity for expanding, controlling flowering induction, and influencing flowering (plant flowering), fruit development and ripening, seed germination, etc.

Growth regulators have had significant impact on enhancing the quality of plant vegetative growth. The use of Jibriline as a plant growth regulator increases stem elongation through its ability to elongate plant cell walls; additionally, Jibriline will impact the quantity of flower branches produced thus contributing positively toward greater amounts of flowers and fruit being produced ultimately increasing the quantity of produce produced by a plant (Hartmann *et al* 2002) [20]. Several studies have shown that the use of seaweed extract can improve both the quality and yield of fruit crops such as apples, strawberries, almonds, grapes, kiwi, and apricots (Al-Saif *et al* 2023), (Abo-Zaid *et al* 2019) [2]. Other studies examining mango, grape and strawberry trees have shown that marine algae extracts when applied by way of foliar application, will improve the leaf area, nutrient levels, levels of vitamins, and provide fruits with greater quality (Al-Marsoumi *et al* 2020) [8], (Abo-Zaid *et al* 2019) [2].

One of the major groups of plant hormones is gibberellins, consisting of many different gibberellins that stimulate plant growth along with over 135 different types of gibberellin. The most commonly used gibberellin is gibberellic acid (GA3) (Salman & Ali Wan, 2013) [23]. The effect of gibberellin on plant growth increases the length of the stem and increases the space between leaves by stimulating cell elongation and the ability of the plant to efficiently absorb nutrients, resulting in increased overall plant growth (Abu Zaid, 2000) [3]. Judge (2013) [24] found that applying gibberellic acid at two concentrations (0 mg. liter-1 and 100 mg. liter-1) to the leaves of olive seedlings produced by crossing the male with the female resulted in significantly increasing the diameter of the olive seedlings' main stems and also in the number of branches per seedling. (Abboud & ABD Aoun, 2013) [1] found that stimulating gibberellic acid application (500 mg. liter-1) on two varieties of olive trees (Al-Nabali and Al-Khudairi) stimulated nitrogen, phosphorus and potassium levels significantly more than non-treated trees, resulting in an average of 0.97% nitrogen (compared to 0.70% non-treated trees), 0.69% phosphorus (0.72% non-treated) and 0.74% potassium (0.54% non-treated) respectively). In a follow up study, (Ghazi & Mohamed, 2016) [27] reported that seedlings of carob were treated with gibberellic acid at concentrations of 0, 100, 200 and 300 mg. L-1) received a considerable increase in vegetative total dry weight (13.64g) and overall chlorophyll concentration in leaves (2.23g) as a result of the concentration level at 300 mg. Litre-1 with a total increase of 57.04% compared to control. The objective of the trial was to determine how spray treatment using seaweed and gibberellin would affect vegetative growth of sidr seedlings.

2. Materials and Methods

Research was carried out as part of the wooden canopy of the Department of Horticulture and Garden Engineering/Faculty of Agriculture, Samarra University for the duration of 1/10/2024 through 12/5/2025 to examine the relationship between the levels of seaweed (marine algae), GA3, and the vegetative qualities of grafted for the purpose of assessing the relationship between factors to promote healthy vegetable growth. The research used sidr trees that had been grafted at the age of 1; the trees were relatively equal in their growth 90-100 cm (height) and 9-6 mm (diameter) and were planted into 5 kg plastic planters.

2.1. Study Factors

2.2.1. The first factor: The extract of marine algae (Tecamine Max) contains (a group of amino acids 14.40%, free amino acids 13%, organic nitrogen 8.0%, organic substance 50.0% and PH 6.6) fertilizer produced by a Spanish company and used a spray on the vegetative total in three concentrations: the comparison treatment (without addition) and its symbol is T_0 and 4 ml T 1 and its symbol is T_1 and 8 ml T 1 and its symbol is T_2

2.2.2. The second factor: spraying with Gibraltaric acid (GA3) in three concentrations: the comparison treatment (without addition) and its code is GA0 and 50 mgL-1 and its code is GA50 and 100 mgL-1 and its code is GA100.

The spraying process was carried out on three dates, the first date 1/10/2024 and the second date 21 days after the first date and so on for the third date.

The study was designed in a working trial using the R.C.B.D design of two-factor, three-repeat and two-breeders for each pilot. Thus, the number of seedlings used in the experiment (2 *3*3*3 = 54 seedlings)

2.2. The traits studied

2.2.1 Increase in seedling height (cm): Measured at the beginning and end of the experiment and extracted the difference between them using a tape measure from the grafting area to the top of the main stem of the seedling.

2.2.2. Increase in seedling diameter (mm): Vernier was used, above the grafting area at the beginning and end of the experiment and the differences between them were extracted.

2.2.3. Increase in the number of leaves for each seedling: The number of leaves for each seedling and for each experimental one was calculated at the beginning and end of the experiment and the difference between them was extracted.

2.2.4. Number of secondary branches: The number of secondary branches was calculated for each seedling and for each experimental one at the beginning and end of the experiment and the differences between them were extracted.

2.2.5. Number of main branches: The number of main branches for each seedling and each experimental one was calculated at the beginning and end of the experiment and the differences between them were extracted.

2.2.6. Relative total chlorophyll content (mg. g-1 Soft weight): The total chlorophyll content of the leaves was estimated based on the Goodwin method (Goodwin, 1976) [17].

2.2.7. Nitrogen concentration (%): Nitrogen concentration was measured according to the method (Cresser & Parsons, 1979) [15] and on the Macrokjeldhal device.

2.2.8. Phosphorus concentration (%): The concentration of phosphorus was measured according to the method (Cresser & Parsons, 1979) [15] using a spectrophotometer at a wavelength of 420 nm.

2.2.10. Potassium concentration (%): The element potassium was estimated according to the method (Cresser & Parsons, 1979) [15] using the flame emission photometer.

2.2.11. Percentage of total carbohydrates (%): The content of the leaves of carbohydrates was estimated according to the method of (Thimmaiah & Campus, 2004) [29] and using the Spectrophotometer on optical absorption 490 nm.

2.3. Statistical analysis: The results were analyzed statistically using the computer within the SAS program and the averages of the transactions were compared using the Duncan polynomial test under the 5% probability level.

3. Result and Discussion

3.1. Plant height rate (cm) and stem diameter (mm)

According to Figure (2 and 3), application of the marine algae extract resulted in significant differences. Results indicate the height of the plant and the diameter of its stem were significantly greater when treated with marine algae extract than not treated. The average amount of increase in plant height and plant stem diameter for the highest treatment (T_2) was 85.33 cm and 3.82 mm, respectively. The average height of the plant and diameter of the stem for the second highest treatment (T_1) was 79.67 cm and 3.40 mm, respectively. The lowest amount of increase in plant height and plant stem diameter occurred with no algae treatment (T_0); average values were 73.67 cm and 2.73 mm, respectively.

In regard to the impact of GA (Gibberellic Acid), there are notable differences among various levels of GAs for height increase, (i.e., GA100 has the greatest increase with 91 cm and 3.75 mm consecutive), while the second best GA50 increased down to 78.67 cm and 3.47 mm respectively; however, GA0 has the lowest height increases at 69 cm (2.73 mm consecutive).

The bilateral interaction of gibberellic acid and algae extracts had a large impact on height and circumference of each of the plants, T_2GA100 treated plants have the largest increases in height and stem circumference (97 cm and 4.15 mm respectively) whereas the T_0GA0 control group had the smallest growth. of 62cm, 2.0 mm in succession.

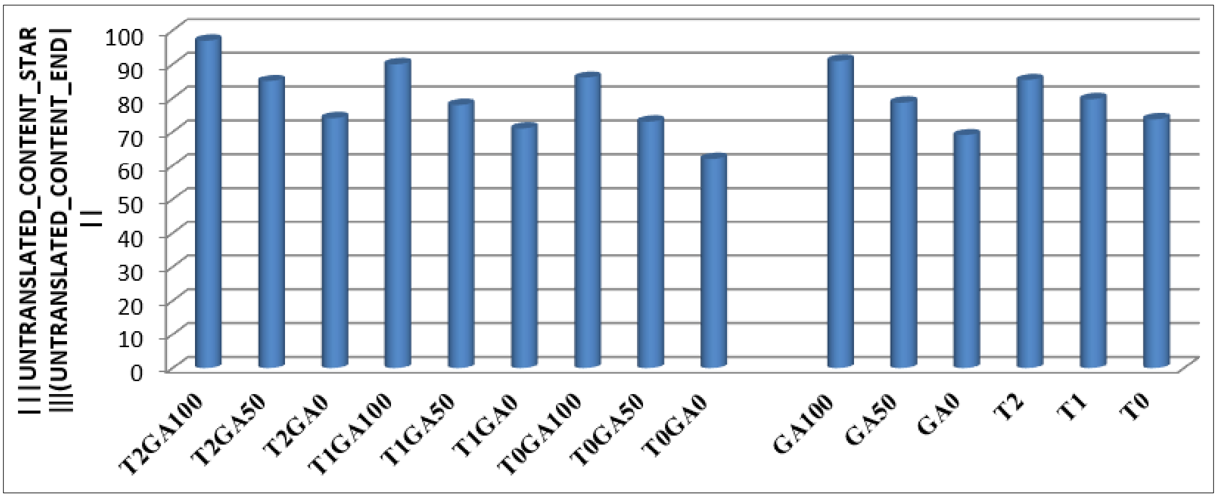

Fig 1: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the rate of increase in plant height (cm) of sidr seedlings.

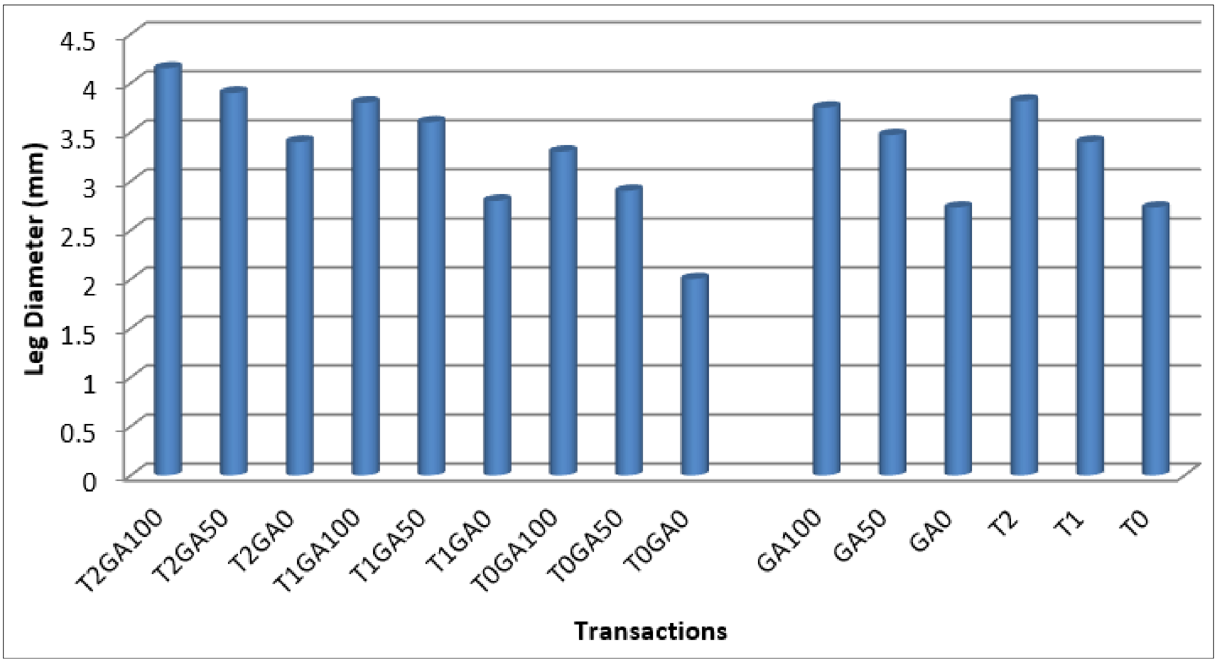

Fig 2: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the rate of increase in the stem diameter (mm) of sidr seedlings.

3.2. The average number of leaves per sapling (fol.1-

The differences in leaf counts for the seeded plants compared to each test treatment were quantified on Table (5). T_2 Test Treatment yielded the highest number of leaves at 84.44, T_1 yielded the next most number of leaves at 69.33. Test treatment T_1 yielded the least amount of leaves at 61.33.

Regarding how Jibriline acid functions as a growth regulator, the results presented in the table above indicate statistically significant differences between treatments as GA100 caused the most considerable increase with 82, GA50 caused a lesser yet significant increase of 73.67, and GA0 was the least effective resulting in an increase of just 59.44.

The influence that the joint usage of a seaweed extract and a gibberellic acid plant growth regulator had on plant growth regarding leaf count was noted. For example, the highest average leaf count per plant of 97 leaves was observed in the T_2GA100 treatment, while the lowest average leaf count of 50 leaves per plant was seen in the T_0GA0 treatment.

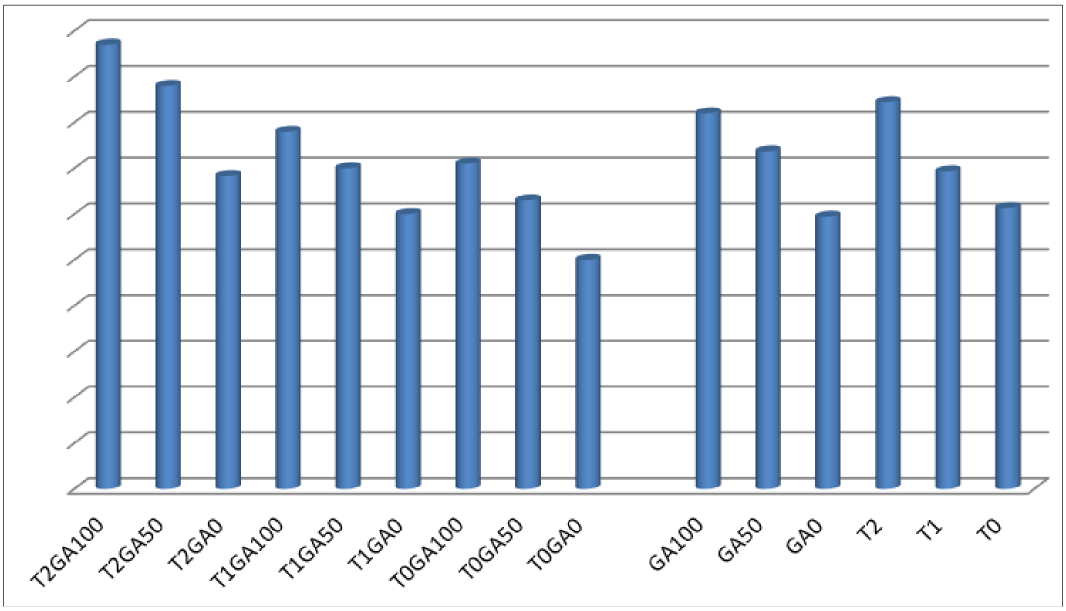

Fig 3: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the rate of increase in the number of total leaves (folio. Seedling $^{-1}$) for Sidr Seedlings.

3.3. The rate of the number of main and secondary branches per seedling (branch. 1-

The figures in (6) indicate how many branches there were per seedling, and that differences in the number of main and secondary branches (T_3) increased with the use of the plant growth regulator jasmonic acid. The transactional group (T_4) produced the most branches, producing 5.3 of each type of branch in one transaction, while there was a statistically significant difference in the number of either of the two branch types produced in the other transaction groups.

The statistical analyses shown previously in this table indicate significant differences as a result of applying the gibberellin acid growth regulator, with the GA100 treatment having the highest branch counts at 5.0 and 9.0 main and secondary branches (saplings -1) in succession. The second highest treatment was the GA50 treatment with average branch counts (saplings -1) of 3.67 and 7.0 branches, respectively. The GA0 treatment had the lowest average branch counts at 2.33 and 3.67 (saplings -1) in succession.

Regarding a bilateral overlap for both elements of the experiment, the results presented in figure (6) indicate that there are significant differences in the number of main and lateral branches over many weeks following the application of T_2GA100 and T_0GA0 at different rates of branch growth. The treatment (T_2GA100) produced the highest average number of main and lateral branches after both applications (7 branches on seedling 1 and 12 branches on seedling 1) and was significantly greater ($p< 0.05$) than treatment (T_0GA0) which resulted in the lowest average number of main and lateral branches (1 branch on seedling 1 and 2 branch on seedling 1).

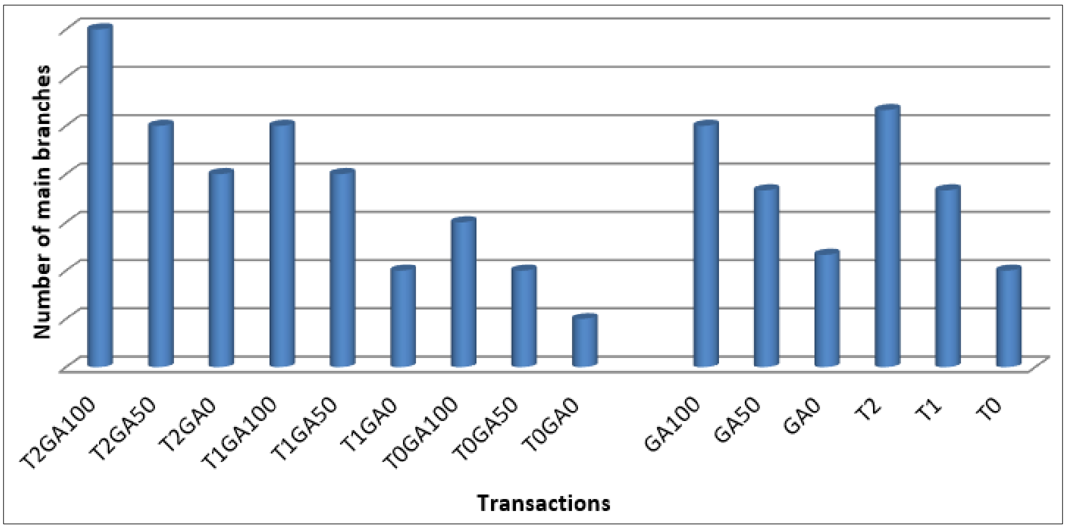

Fig 4: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the rate of increase in the number of main branches (Branch. Seedling $^{-1}$) for Sidr Seedlings.

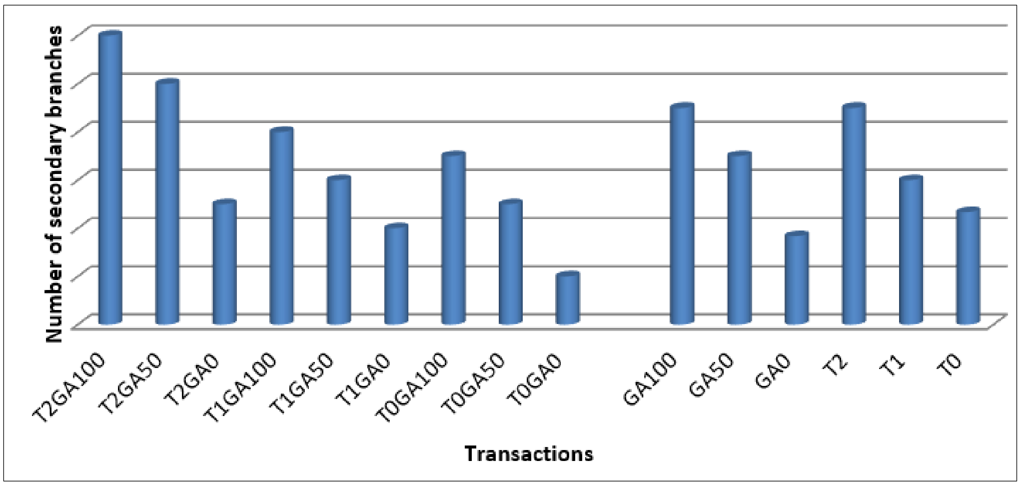

Fig 5: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the rate of increase in the number of secondary branches (branch. Seedling $^{-1}$) for Sidr Seedlings.

3.4. Total chlorophyll content in leaves (mg. Wt. 1gm ◌T ^{1})

The application of Marine Algal Extract (Algae) and Gibberellic Acid (GA3) to the Sidr leaves significantly increased total chlorophyll levels at the 0.05 significance level, as illustrated in Table (1).

As the concentration of gibberellin growth regulator increases, there was a corresponding increase in the mean total chlorophyll content. At a concentration of GA2 (100 mg.1litre), the mean total chlorophyll was 4.42 mg.gram-, compared with GA1 (3.52) and GA0 (2.54). In addition, there was an increase in the mean total chlorophyll in T_2 at an algae extract concentration of (8 mg. litre-1) to 4.00 mg.gram-1, compared with T_1 (3.44) and T_0 (3.04).

The two experimental factors exhibit a strong impact on determining how much total chlorophyll was formed from overlapping each other, as evidenced by substantial differences between them (i.e., T_2GA100=5.45 mg 1 g total dry weight vs. T_0GA0; 2.12 mg ga g total dry).

Table 1: The effect of spraying with marine algae extract and growth regulator gibberelin acid and the overlap between them in the leaf content of chlorophyll (mg. ^{1} g (soft weight) for Sidr plant

Gibberellin growth regulator Marine Algae Extract	Percentage of total chlorophyll (mg. g^{-1} MW)			Marine Algae Modifier
	(0) (GA_0)	50 mg L^{1-} (GA_1)	100 mg L^{1-}(GA_2)	
(0) mg l^{1-} (T_0)	2.12 f	3.30 d	3.70 c	3.04 c
(4) mg l^{1-} (T_1)	2.62 e	3.60 cd	4.10 b	3.44 b
(8) mg l^{1-} (T_2)	2.89 e	3.95 b	5.45 a	4.00 a
Rate of growth regulator gibberellin	2.54 c	3.52 b	4.42 a	

* The averages of each group followed by different letters indicate significant differences between them at the 5% probability level according to the Duncan polynomial test

3.5. Nitrogen, Phosphorus and Potassium

Table (2, 3 and 4) shows the results of the effect of spraying with marine algae extract and gibberelin acid (GA3) and the overlap between them in the percentage of nitrogen, phosphorus and potassium in the leaves of the Sidr plant (%). The results showed significant differences between the coefficients as a result of spraying with algae extract, achieving a concentration of T_2 (8 mg.liters)the highest average of 1.31, 0.24, and 1.10 in succession, while the lowest was at T_0 at 1.18, 0.18, and 1.01% in succession.

Nitrogen also rose with increased gibberelin concentrations, reaching the highest average at GA2 (100 mg.liters) by 1.31,0.23, and 1.12% respectively, followed by a significant difference GA1 by 1.31,0.20, and 1.07% respectively, while the lowest average was recorded at GA0 at 1.17, 0.19, and% respectively.

The highest percentage of nitrogen was recorded when treating the interference between marine algae extracts at a concentration of 8 mg.1 litre (T_2) and 100 mg gibberelin.liters(GA2), reaching 1.42%, 0.26, and 1.17respectively, a value that was morally superior to most other transactions.

Table 2: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the nitrogen content of the leaves (%) of the sidr plant

Gibberellin growth regulator Marine Algae Extract	Percentage (%)			Marine Algae Modifier
	(0) (GA_0)	50 mg L^{1-} (GA_1)	100 mg L^{1-}(GA_2)	
(0) mg l^{1-} (T_0)	1.11 e	1 a.23 cd	1.20 d	1.18 c
(4) mg l^{1-} (T_1)	1.18 d	1.28 bc	1.31 b	1.26 b
(8) mg l^{1-} (T_2)	1.22 d	1.30 b	1.42 a	1.31 a
Rate of growth regulator gibberellin	1.17 c	1.27 b	1.31 a	

* According to the Duncan polynomial test, groups with averages that have different letters from one another have significant differences from each other at the 5% probability level

Table 3: The effect of applying gibberellic acid and marine algae extract to the leaf potassium concentrations (%) of xi'ar trees in the ni'mah region of s/ani.

Gibberellin growth regulator Marine Algae Extract	Percentage (%)			Marine Algae Modifier
	(0) (GA_0)	**50 mg L^{1-} (GA_1)**	**100 mg L^{1-}(GA_2)**	
(0) mg l^{1-} (T_0)	0.15 e	0.18 cde	0.20 bcd	0.18 c
(4) mg l^{1-} (T_1)	0.17 de	0.21 bc	0.23 ab	0.20 b
(8) mg l^{1-} (T_2)	0.24 ab	0.22 b	0.26 a	0.24 a
Rate of growth regulator gibberellin	0.19 b	0.20 b	0.23 a	

* The averages of each group followed by different letters indicate significant differences between them at the 5% probability level according to the Duncan polynomial test

Table 4: The effect of spraying with marine algae extract and growth regulator jibriline acid and the overlap between them in the leaf content of potassium (%) for sidr

Gibberellin growth regulator Marine Algae Extract	Percentage (%)			Marine Algae Modifier
	(0) (GA_0)	**50 mg L^{1-} (GA_1)**	**100 mg L^{1-}(GA_2)**	
(0) mg l^{1-} (T_0)	0.90 d	1.05 bc	1.08 ab	1.01 b
(4) mg l^{1-} (T_1)	0.97 cd	1.09 ab	1.10 ab	1.05 ab
(8) mg l^{1-} (T_2)	1.06 bc	1.08 ab	1.17 a	1.10 a
Rate of growth regulator gibberellin	0.98 b	1.07 a	1.12 a	

* The averages of each group followed by different letters indicate significant differences between them at the 5% probability level according to the Duncan polynomial test.

3.6. Percentage carbohydrates

Table (5) This paper discusses the results of the effects of using marine algae extract and gibberellic acid (GA3) as growth regulators on the carbohydrate content in leaves of Sidr plants. Statistically significant differences were found by spraying with marine algae extract and GA3 to obtain the highest carbohydrate percentage of 5.42%. This was achieved by using the marine algae extract at a concentration of 8 mg:1 L (T_2) and GA3 at a concentration of 100 mg:1 L (GA2); these two treatments produced the highest mean carbohydrate content out of all treatments. Treatment GA2 × T_1 had a significantly higher mean carbohydrate content than treatment GA0 × T_0 (4.55% and 3.12%, respectively).

There was an increase in carbohydrate content with increasing gibberellin levels with an average of 4.65% carbohydrate content for GA2, compared to 4.07% for GA1 and 3.23% for GA0. There was also a noticeable effect from algae extract as T_2 yields were 4.53% when compared to T_1 at 4.12% and T_0 at 3.30%.

Table 5: The effect of spraying with marine algae extract and gibberelin acid growth regulator and the overlap between them in the leaf content of carbohydrates (%) for sidr plant

Gibberellin growth regulator Marine Algae Extract	Percentage (%)			Marine Algae Modifier
	(0) (GA_0)	**50 mg L^{1-} (GA_1)**	**100 mg L^{1-}(GA_2)**	
(0) mg l^{1-} (T_0)	3.12 g	3.80 e	3.97 d	3.30 c
(4) mg l^{1-} (T_1)	3.62 f	4.18 c	4.55 b	4.12 b
(8) mg l^{1-} (T_2)	3.95 d	4.23 c	5.42 a	4.53 a
Rate of growth regulator gibberellin	3.23 c	4.07 b	4.65 a	

* The averages of each group followed by different letters indicate significant differences between them at the 5% probability level according to the Duncan polynomial test

4. Interpretation of results

The results in Figures (1-5) and the accompanying tables showed that there are clear significant differences in the vegetative and chemical qualities of sidr seedlings when treated with marine algae extract and growth regulator gibberelin acid (GA), either individually or by overlapping between them. These differences included vegetative features such as plant height, stem diameter, number of leaves, and number of main and secondary branches, as well as chemical qualities such as increased leaf content of chlorophyll, nutrients (N, P, K), and carbohydrates.

At the vegetative trait level, the results (Figures 1-5) showed that the treatment T_2GA100, representing the overlap between the highest concentration of algae extract (8 mg.1litre) and the highest concentration of gibberellin (100 mg.litre), has achieved the highest values in all vegetative qualities, with a plant height of 97 cm, a stem diameter of 4.15 mm and a leaf count of 97 leaves. Sapling ◌T^1, and the number of main and secondary branches 7.0 and 12.0 branches. Saplingin succession. While the comparison transaction T_0GA0 recorded the lowest values in all indicators. This improvement is attributed to the synergistic effect between algae extract compounds containing natural growth stimulants (oxines, cytokines, gibberellins) and micronutrients, and between gibberellin's ability to stimulate division and cell elongation.

As for the chemical qualities of the leaves of the plant (Tables 1-5), the treatment T_2GA2 also outperformed in all chemical indices, recording the highest total chlorophyll content (5.45 mg). g^1), nitrogen (1.42%), phosphorus (0.26%), potassium (1.17%), and carbohydrates (5.42%). These increases were accompanied by a significant rise in the averages of the single coefficients of algae extract and gibberelin, indicating their role in enhancing the absorption of elements and increasing the efficiency of photosynthesis.

These findings are consistent with what (Al-Bakar *et al*., 2020) [5] found that marine algae extracts contain biostimulant compounds that contribute to improving the growth and physiological qualities of the plant. The study of (Guo *et al*., 2022) [18] also showed that gibberelin promotes cell division and elongation and improves representational performance. (Colla *et al*., 2014) [14] show that marine algae extracts stimulate the gene expression of enzymes associated with the uptake of macronutrients such as nitrogen and phosphorus.

5. Conclusion

In the same context, the study of (Gupta & Sharma, 2023) [19] indicated that double spraying with marine algae extract and gibberelin in artichoke led to significant increases in the number of branches and leaf content of elements. (El-Awadi *et al*., 2022), (Zhang *et al*., 2019) [16, 31] showed that Ascophyllum nodosum extract contains compounds that regulate plant hormones and improve the uptake and distribution of elements within plant tissues.

6. Conflict of interest

The authors declare no conflicts of interest associated with this manuscript.

7. Acknowledgments

The authors gratefully acknowledge the staff of the Department of Horticulture College of Agriculture Tikrit University and Department of Horticulture and Department of Food science College of Agriculture Samarra University for their technical and general support.

References

1. Abboud MR, Abd Aoun MK. The effect of chemical fertilization and spraying with gibberellic acid on the content of olive leaves of mineral elements and materials similar to gibberellin for two varieties of olives. Scientific Journal of the University of Karbala. 2013;11(3):112-125.
2. Abo-Zaid FS, *et al*. Effect of seaweed and amino acid on fruiting of some grapevine cultivars. Journal of Product Development. 2019;24(2):145-160. https://doi.org/10.21608/jprod.2019.123456
3. Abu Zaid AN. Plant Hormones and Agricultural Applications. 2nd ed. Cairo: Arab Publishing and Distribution House, National Research Center; 2000.
4. Al-Alaf AHI. Response of vegetative growth of two fig cultivars to the addition of humic acid, Essential Plus liquid fertilizer, and gibberellic acid. Mesopotamia Journal of Agriculture. 2017;45(1):169-188. https://doi.org/10.33899/magrj.2017.161298
5. Al-Bakar AHAQ, Noori AM, Hasan HM, Ahmed AMA. Effect of humic acid and seaweed and number of doses additive on growth and chlorophyll content of seedlings weeping bottlebrush plant. Plant Cell Biotechnology and Molecular Biology. 2020;21(69-70):99-104. https://doi.org/10.56557/pcbmb/2020/v21i69-701234
6. Al-Dulaimi AFZ, Al-Hamdani KAS, Al-Douri MFL, Al-Rawi ARM. Olive seedlings response is a fierce variety of the ground addition of bat waste and seaweed extract. Journal of Kirkuk University of Agricultural Sciences. 2016;7(2):44-58.
7. Al-Fadil AAH. Effect and type of vaccination and biostimulant concentrations in some growth indicators and chemical components of sidr seedlings *Ziziphus* spp (Mill) (Master's thesis). Basrah: Agriculture College, Basrah University; 2021.
8. Al-Marsoumi FH, *et al*. Effect of humic acid and seaweed extract spray in leaf mineral content of mango seedlings. Plant Archives. 2020;20(2):3451-3455.
9. Al-Obaidi ASJH. The effect of fertilization with seaweed extract, NPK and cytokinin spraying on the growth and yield of olives is a Nepalese variety (PhD thesis). Baghdad: Faculty of Agriculture, University of Baghdad; 2016.
10. Al-Qaisi IFTO. The effect of spraying with marine extract and ascorbic acid on the chemical properties of grapes is halwani and kamali (Master's thesis). Tikrit: Faculty of Agriculture, University of Tikrit; 2018.
11. Al-Rubaie IMAZ. A study of the classification of the genus *Ziziphus* Mill in Iraq (Master's thesis). Basra: Faculty of Science, University of Basra; 1998.
12. Al-Rubaie SMK. The effect of spraying with gibberellic acid and seaweed extract on the growth of olive seedlings is a vegetative variety. Karbala University Scientific Journal. 2011;9(1):118-125.
13. Al-Saif AM, *et al*. Apricot (*Prunus armeniaca*) performance under foliar application of humic acid, brassinosteroids, and seaweed extract. Horticulturae. 2023;9(3):341. https://doi.org/10.3390/horticulturae9030341
14. Colla G, Rouphael Y, *et al*. Biostimulant action of seaweed extracts in horticulture. Scientia Horticulturae. 2014;203:81-91. https://doi.org/10.1016/j.scienta.2014.02.010
15. Cresser MS, Parsons JW. Sulphuric-perchloric acid digestion of plant material for the determination of nitrogen, phosphorus, potassium, calcium and magnesium. Analytica Chimica Acta. 1979;109:431-436. https://doi.org/10.1016/S0003-2670(01)84263-0
16. El-Awadi AF, Abdel-Mawgoud AMR, Bakry BA. Combined effect of seaweed extract and gibberellic acid on vegetative growth and productivity of globe artichoke. Journal of Plant Production. 2022;13(8):589-595. https://doi.org/10.21608/jpp.2022.148154.1136
17. Goodwin TW. Chemistry and Biochemistry of Plant Pigments. 2nd ed. London: Academic Press; 1976.
18. Guo Y, Zhang Y, Li K, *et al*. Seaweed extract enhances nutrient uptake and gene expression in maize. Agronomy. 2022;12(3):678. https://doi.org/10.3390/agronomy12030678
19. Gupta P, Sharma R. Role of gibberellic acid in plant growth regulation: A review. Plant Growth Regulation. 2023;101:15-25. https://doi.org/10.1007/s10725-023-01012-3
20. Hartmann HT, Kester DE, Davies FT, Geneve JRL. Plant Propagation: Principles and Practices. 7th ed. Upper Saddle River: Prentice Hall; 2002.
21. Hauenschild F, Matuszak S, Muellner-Riehl AN, Favre A. Phylogenetic relationships within the cosmopolitan buckthorn family (Rhamnaceae) support the resurrection of *Sarcomphalus* and the description of *Pseudoziziphus* gen. nov. Taxon. 2016;65(1):47-64. https://doi.org/10.12705/651.4
22. Hedden P, Thomas SG. Plant Hormone Signaling. New Delhi: Replika Press Pvt. Ltd.; 2006.

23. Jassim JS, Wan AAH. Effect of potassium, gibberellic acid and the interaction between them in growth of gujarat plant (*Hibiscus sabdariffa* L). Karbala University University Scientific Journal. 2013;11(2):226-234.
24. Judge RA. Study of the impact of agricultural media, nitrogen fertilization and gibberellic acid spraying in growth and concentration of some nutrients for olive seedlings (Master's thesis). Mosul: Faculty of Agriculture and Forestry, University of Mosul; 2013.
25. Kuwada K, Wamocho LS, Utamura M, Matsushita I, Ishii T. Effect of red and green algal extract on hypha growth of arbuscular fungi, and on mycorrhizal development and growth of papaya and passion fruit. Agro Park Journal. 2006;98:1340-1344.
26. Morales PJP, Norrie J. Accelerating the growth of Avocado (*Persea americana*) in the nursery using a soil applied commercial extract of the brown algae *Ascophyllum nodosum*. XX International Seaweed Symposium Proceedings. 2010;189-195. https://doi.org/10.1007/978-94-007-1760-2_24
27. Sherif SG, Mohamed ZA. Carob seedling response, *Ceratonia siliqua* L for spraying foliar with different levels of Gibberellic acid and boron element. Karbala University Scientific Journal. 2016;14(1):249-257.
28. Spinelli F, Fiori G, Noferini M, Sprocatti M, Costa G. A novel type of seaweed extract as a natural alternative to the use of iron chelates in strawberry production. Scientia Horticulturae. 2010;125(3):263-269. https://doi.org/10.1016/j.scienta.2010.03.011
29. Thimmaiah SK. Standard Methods of Biochemical Analysis. New Delhi: Kalyani Publishers; 2004.
30. Verkleij FN. Seaweed extract in agriculture and horticulture: A review. Biological Agriculture & Horticulture. 1992;8(4):309-324. https://doi.org/10.1080/01448765.1992.9754644
31. Zhang X, Ervin EH, Schmidt RE. Physiological effects of *Ascophyllum nodosum* extract on horticultural crops. PLoS One. 2019;14(5):e0217286. https://doi.org/10.1371/journal.pone.0217286
32. Zodape ST, Gupta A, Bhandari SB, Rawat S, Chaudhary DR, Eswaran K, *et al*. Foliar application of seaweed sap as biostimulant for enhancement of yield and quality of tomato (*Lycopersicon esculentum* Mill.). Journal of Scientific & Industrial Research. 2011;70(3):215-219.