



RESEARCH ARTICLE

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Investigating the Impact of Planting Date and Different Organic Fertilization on Optimizing Growth Trait, Yield, Yield Components of Borage (*Borago officinalis* L.)

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ABSTRACT

A field study was done at two locations, Grdarasha and Grdmala, during the growing season of 2024-2025. The experiment included factors. The first factor was three planting dates 1st August(D1), 15th August (D2) and 1st September(D3) in 2024, the second factor was five fertilizer types (Control, Pomace 40000 kg ha⁻¹, Rice bio-char 40000 kg ha⁻¹, Seaweed 2 kg ha⁻¹ and Di ammonium phosphate (DAP) 200 kg ha⁻¹. A factorial experiment of (3 x 5) was carried out using a Randomized Complete Block Design (RCBD) using three replications. The mentioned factors showed a positive role in borage growth and yield, it is clear from the results that the highest increment plant height (cm), leaf area (cm²), Leaf thickness (mm) and dry matter plant⁻¹ (g) were recorded on the 1st September (67.41, 299.50, 1.53 and 131.10) and (63.22, 283.48, 1.12 and 144.02) for both locations respectively. While the highest seed yield values for both locations (196.45 and 120.52) kg ha⁻¹ was acquired in 1st August and 15th August the highest value for some of the studied characters at Grdarasha was recorded for pomace treatment in Grdarasha which were leaf thickness 1.28 mm, number of seed flower⁻¹ 3.36, seed index 17.29 g while at Grdmala location the same treatment recorded the highest value for leaf thickness 1.20 mm and seed index 17.70 g. At Grdarasha location Seaweed treatment obtained the highest value for plant height 63.36 cm, chlorophyll 64.70 SPAD, number of flower 664.84 plant⁻¹, dry matter 133.91g and seed yield 213.28 kg ha⁻¹. While in Grdmala caused highest value for chlorophyll content 56.49 SPAD, number of seed flower⁻¹ 3.66 and seed yield 126.22 kg ha⁻¹. The interaction treatments D1*F4 and D1*F4 obtained the highest seed yield values (309.50 and 172.33) kg ha⁻¹ for both locations respectively.

Keywords: Borage Yield, Planting date, Seaweed, Pomace, Rice husk biochar, Dap.

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INTRODUCTION

Borage (*Borago officinalis* L.), Is a member of the Boraginaceae family, named as "starflower" and known "Lisan al-Thawr." in Iraq [1] Mostly prevalent in Europe and the Mediterranean region, it is an upright, spreading, hispid annual plant [2]. During the first century, borage was well-known for its mood-enhancing properties. It was also commercially for its seed oil, which was used in food preparation, medicine, cosmetics, and for dietary supplements [3]. The leaves and blooms can be consumed raw or cooked, and they are used as a food source for beekeepers [4] The an interest Honeybees have in gathering pollen and nectar from borage flowers. While a variety of flower-visiting insects, such as Hymenoptera, Lepidoptera, and Diptera, are drawn to its flowers, honeybees and bumblebees primarily forage for Them, as well as in salads, drinks, meat and vegetable dishes [5]. We cultivated sunflowers (*Helianthus annuus*) around borage (*Borago officinalis* L.) to act as companion plants with high visual and nectar appeal, thereby attracting more pollinators, particularly bees.

Planting dates are crucial for crop germination, growth, and yield. According to [6], the right period to seed borage was in the fall and late winter, as these dates are crucial for crop success.

A [7] showed in his studies that the optimal period to sow for high seed yield and the optimum output in terms of quantity and quality is early August. One crucial management technique is fertilization, which boosts nutrient abundance and increases a plant's resistance to unfavorable environmental circumstances, increasing both the quantity and quality of plant production. Commercial fertilizers generally have a lot of issues, including leaching, hydrolysis, fixation, or precipitation in non-soluble forms, as well as volatilization and decomposition, particularly in calcareous soil.

Rice biochar is one of the organic fertilizers that researchers have recently concentrated on using it, in order to improve soil fertility, reduce fertilizer requirements, reduce nutrient leaching, enhance microbial activity in the soil, improve water holding capacity and efficient water use, and boost soil cation exchange capacity which in turn increase crop production [8] explain

that biochar is a stable type of charcoal generated at a high temperature 350°C or more, using natural organic materials. It is also more chemically and physically stable than the original carbon. According to [9] biochar significantly increased the oil %, yield, and vegetative growth of borage.

Olive pomace (OP), also known as olive cake or olive husk, is the solid that remains after the extraction of olive oil. It is one of the most common by-products of agro-industrial processes in olive waste because it is naturally rich in organic compounds and minerals (except sulfur), it may be a source of nutrients for plant growth and development ([10]Raw pomace was used to improve soil fertility indices [11], whereas composted olive pomace delivers the necessary nutrients for plant growth and improves the physical and chemical characteristics of the soil [12]Olive pomace dramatically increased wheat grain production, according to [13].

One of the fertilizer treatments is seaweed (2 gL⁻¹), Seaweed extracts include hormones like auxin, gibberellin, and cytokinin among, other substances. In comparison to the control treatment, the seaweed fertilizer was successful in considerably raising the plant growth parameters assessed for the borage crop. In other areas, like seed yield, harvest index, and chlorophyll content, the seaweed extract performed better. ([14]One essential water-soluble P fertilizer is di-ammonium phosphate (DAP), a commercial fertilizer that dissolves quickly. including 18% nitrogen and 46% phosphorus [15] [16]This study also showed that cotton seed quality was enhanced by fertilizer sources [17] Since in Kurdistan region has no research on Borage plant, this study intends to determine the effects of various organic and chemical fertilizers, as well as time of sowing, on Borage development, yield component and yield, at two separate locations.

2.Materials and Methods

Experimental Design:

The current study was conducted during the summer growing season of 2024-2025 at two different Locations, Grdarasha Field, with GPS reading (latitude 36.10116° N, longitude 44.00925° E), and altitude of 415 m above sea level, and Grdmala Field, with GPS reading (latitude 36.01061° N, longitude 44.05854° E) and elevation of 413.8 m above sea level The experiment had been done under temperate conditions that characterized the Mediterranean climate (Fi

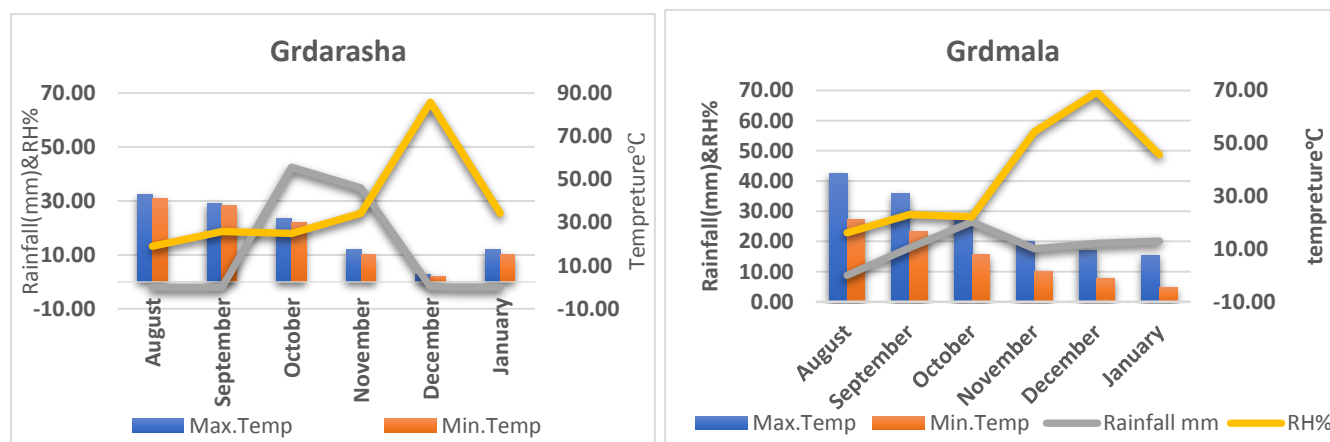


Fig 1. Meteorological data for Grdmala and Grdarasha fields during 2024-2025*

* The meteorological data were conducted at the Directorate of Agriculture Research Center/Erbil.

After the tillage process, representative soil samples were collected from different parts of the field at a depth of (0 to 30) cm. These samples were then allowed to air dry, sieved through a 2 mm sieve, packaged, and stored for soil analysis. The findings of the soil study were displayed in Table 1.

Table 1. Some Physical and Chemical Properties of the Studied Soil Before Planting

Soil properties		Units	Grdarasha	Grdmala
Physical properties	Sand	(g kg ⁻¹)	384.75	118
	Silt		515	432
	Clay		100.25	450
	Soil texture		Silty clay loam	Silty Clay
Chemical properties	Soil Ph	(dS m ⁻¹)	7.53	7.86
	EC		0.38	0.50
	Available N		59.67	80
	Available P	mg kg ⁻¹ soil	2.01	9.3
	K	(g kg ⁻¹ Soil)	94.10	200
	O.M		9.1	9.76
	CaCO ₃ ⁺		269.10	250

The soil properties tests were conducted at the Directorate of Agriculture Research Center

A factorial experiment was used based on randomized complete block design (RCBD), including two factors: The first factor is three sowing dates, which included 1st August 15th August and 1st September during 2024.

The first factor was included planting date which included the following:

1. 1st August 2024
2. 15th August 2024
3. 1st September 2024

The second factor is types of fertilizer, which included the following:

1. Control.
2. Pomace: Olive waste at a rate of 1% soil, which is equivalent to 8 kg per plot (40000 kg ha⁻¹). Which included 71.46% Dry matter, crude protein 3.4%, 43% crude fibre, 18.96% non-fibre carbohydrate, 2.6% ash, and 3.5% fat.
3. Rice biochar: Added at a rate of 1% soil, which is equivalent to 8 kg per plot (40000 kg ha⁻¹).
4. Seaweed 600 (Algae 600): at rate of 2 kg ha⁻¹
5. Diammonium phosphate (DAP) (NH₄)₂HPO₄ (18.18.0) at rate of 200 kg h

The seeds were sown by hand in tool cells on 8 and 26 June and 15 August to prepare the seedlings and be ready at transplanting dates on 1st August, 15th August, and 1st September 2024.

Block shape was made rectangular and perpendicular to the direction of the gradient using three replicates. Each plot area was 1x2 m² with a distance of 0.50 between them, while the distance between plants was 25 cm and row spacing 40 cm in each plot, the number of rows per plot was 5. The number of experimental units per location is 5*3*3 =45 experimental units. Total experimental units =45 * 2 =90 for both locations.

Replanting was done manually using the same seedling of each planting date, hand weeding was practiced as needed, other agricultural practices were performed whenever required, performed, and fungal disease was controlled using Preplant, Pilarstin, Humic acid, Topspin and Reval. The fields were fenced by iron bar and net coverage for security of experiments. the plants were harvested on 15th December and 29th December 2024 and 17th January 2025

Data Collection:

Determination of growth stages:

Five randomly plants were selected in each experimental unit at each location to determine the following traits:

1. Plant height (cm).
2. Leaf area (cm²)

Leaf area was measured at 50% flower formation stages; 15 leaves were randomly selected from the labelled plants, then leaf area was calculated by image J software [18]

3. Chlorophyll Content (SPAD) Index: using the Minolta SPAD chlorophyll meter (Soil Plant Analysis Development) as a hand-held device. from lower, middle, and upper sites of five labeled plants the total number of readings were thirty per experimental unit according to ([19]

4. Leaf thickness (mm) using digital micrometre devices.

5. Number of branch plant: ⁻¹

Determination at maturity stages:

1. Number of Flowers Planted⁻¹

The flowers of five labelled plant were dissected by hand, and total number of flowers were recorded ; then the average was calculated

2. Number of Seeds flower⁻¹

Seeds were collected in each flower for the five labelled plants in each plot, then counted, and the average was calculated.

3. Seed index (g)

Five thousand seeds were weighted, expressed in grams, and multiplied by 2 to measure 1000 seed weight.

4. Dry Weight (g):

Borage plant was dried (at maturity Stage) at 60°C for 48 hours in the oven, then, the dry weight was measured to constant weight.

5. Seed yield (kg ha⁻¹)

The seeds were collected from borage plants in each plot, then weighed separately in gram per plot and converted to kg ha⁻¹.



Fig2. The borage acts as an attractant for bees and other beneficial insect, cultivated sunflower surrounded by borage plants

Data analysis

The data were statistically analyzed according to the technique of analysis of variance (ANOVA) for randomized complete block design (RCBD) the IBM SPSS program version (27). The difference among means of treatments was tested using Duncan's multiple range test at level of significance of 5% [20]. The charts were drawn, and Pearson's correlation coefficient was calculated between the seed yield and other traits, and among the traits themselves using Excel.

3.RESULTS and DISCUSSION:

3.1. Effect of planting dates on some growth characteristics of borage plant.

The data presented in Table 3 revealed that sowing dates had a significant impact on specific borage plant growth parameters in both locations, Grdarasha and Grdmala. It is clear from the results that the highest increment in plant height (cm), leaf area (cm²), leaf thickness (mm) were recorded on the 3rd sowing dates (D₃) with the values 67.41, 65.90, 299.50 and 1.53 at Grdarasha and 63.22, 283.48 and 1.12 at Grdmala, respectively, compared to the lowest means values of 52.95, 248.11 and 0.73 and 38.54, 234.22 and 0.93, respectively, resulted from plants grown on (D₁) in both locations.

This may be attributed to the fact that plants germinating and grew with an appropriate average of temperatures and sun shine hours (Table.1). this result was in agreement with the findings of [21], they reported that the date of planting significantly affects vegetative growth, and the first of September recorded the highest values compared with 15th of September and 1st of October.

This may be due to differences in soil fertility ,climate conditions, between locations or crop.the results indicated that number of branch plant⁻¹ and chlorophyll content (SPAD) affected significantly by sowing date at both locations, the highest values (6.93 and 65.90) and (6.47 and 54.83) were obtained on (D₁, D₃ and D₂, D₂) at Grdarasha and Grdmala, respectively, while their lowest values (5.28,58.89) and (5.60, 48.1) were presented in (D₃ and D₁) at both locations ,respectively.

Table 3. Effect of planting dates on some growth characteristics of borage

Grdarasha location					
Sowing dates	Plant height cm	No. branch plant ⁻¹	Chlorophyll SPAD	Leaf area cm ²	Leaf thickness mm
D ₁	52.95 ^c	6.93 ^a	58.89 ^b	248.11 ^c	0.73 ^c
D ₂	60.04 ^b	6.59 ^a	63.69 ^a	263.27 ^b	0.93 ^b
D ₃	67.41 ^a	5.28 ^b	65.90 ^a	299.50 ^a	1.53 ^a
Grdmala location					
D ₁	38.54 ^c	6.12 ^{ab}	48.1 ^b	234.22 ^b	0.93 ^b
D ₂	53.07 ^b	6.47 ^a	54.83 ^a	247.14 ^{ab}	1.10 ^a
D ₃	63.22 ^a	5.60 ^b	54.14 ^a	283.48 ^a	1.12 ^a

D₁=1stAugust, D₂=15thAugust, D₃=1stSeptember

Values with different letters indicate significant differences at 5% according to Duncan's multiple- range test

3.2. Effect of fertilizer types on some growth characters of the borage plant.

Table 4 illustrated that growth characters affected significantly by different fertilizer types.The highest value for some of the growth characters was recorded for F₅,except plant height, chlorophyll content ,and leaf thickness.The highest values for these characters was 63.36cm ,64.70 SPAD and 1.28mm, which were recorded from F₄ ,F₄ and F₂. These results was in line with [22] This may due to contributing nitrogen in chlorophyll formation and the role of phosphorus in root growth, then an increase in nutrients absorption[23] .. Furthermore, the highest value for no. branch plant⁻¹ and Leaf area (cm²) was recorded for DAP fertilizer (F₅), with values of 6.97and 335.77, respectively. Finally, it was noticed that the lowest value for

all growth characters was recorded for control treatment; the values was 53.76, 5.74, 58.70, 222.18 and 0.96, respectively, at Grdarasha.

In Grdmala, type of fertilizer had a major impact on growth characteristics. Rice biochar had the highest plant height value (55.89 cm), as seen in Table 4. This could be due to the role of biochar in improving the chemical, physical, and biological characteristics of the soil, which in turn promotes plant growth [24], while the lowest value, 49.42 cm, was recorded in pomace treatment.

The highest value of chlorophyll content (SPAD) and leaf thickness was noted in F₄ and F₂ (56.49 and 1.20), which increase by 14.38 and 42.86 % comparing with control treatments, respectively, whilst the control treatment noted the lowest obtained value (49.39 SPAD and 0.84 mm), the results was in agreement with [25]. Additionally, the findings showed that DAP had a substantial impact on the number of branch plants, leaf area (cm²), with the highest values (7.16 and 286.05); these findings were consistent with [26] and [27]. However, the control treatments show the lowest values (5.07, 221.62, respectively)

Table 4. Effect of different fertilizer types on some growth characteristics of Borage.

Grdarash location					
Treatments	Plant height cm	No. branch plant ⁻¹	Chlorophyll SPAD	Leaf area cm ²	Leaf thickness mm
F ₁	53.76 ^b	5.74 ^b	58.70 ^b	222.18 ^c	0.96 ^b
F ₂	60.92 ^{ab}	6.16 ^b	63.79 ^a	272.49 ^b	1.28 ^a
F ₃	59.89 ^{ab}	6.07 ^b	62.44 ^{ab}	282.56 ^b	1.02 ^b
F ₄	63.76 ^a	6.40 ^{ab}	64.70 ^a	238.47 ^c	0.97 ^b
F ₅	62.36 ^a	6.97 ^a	64.50 ^a	335.77 ^a	1.07 ^b
Grdmala location					
F ₁	51.18 ^{ab}	5.07 ^c	49.39 ^b	221.62 ^b	0.84 ^b
F ₂	49.42 ^b	5.81 ^{bc}	54.52 ^a	231.02 ^{ab}	1.20 ^a
F ₃	55.89 ^a	5.80 ^{bc}	50.64 ^b	256.41 ^{ab}	1.08 ^a
F ₄	51.33 ^{ab}	6.49 ^{ab}	56.49 ^a	279.63 ^a	1.04 ^a
F ₅	50.22 ^b	7.16 ^a	50.81 ^b	286.05 ^a	1.09 ^a

F₁: Control, F₂: Pomace, F₃: Biochar, F₄: Seaweed, F₅: DAP.

Values with different letters indicate significant differences at 5% according to the Duncan's multiple-range test



Pomace Fertilizer Seaweed Fertilizer Control*DAP fertilizers
Fig 3. Effect Organic Fertilization on number seed per flowers of Borage

Table5. Interaction effect of sowing dates and fertilizer types on some growth traits

Fertilizer	Date of sowing	Grdarasha location				
		Plant height cm	No. branch plant ⁻¹	Chlorophyll SPAD	Leaf area cm ²	Leaf thickness mm
F ₁	D ₁	47.20 ^d	6.37 ^{bc}	58.71 ^{cde}	173.76 ^f	1.01 ^{de}
	D ₂	51.80 ^{cd}	6.33 ^{bc}	54.03 ^e	226.89 ^e	0.65 ^{fg}
	D ₃	62.27 ^{bc}	4.53 ^{de}	63.36 ^{bcd}	265.90 ^{cd}	1.24 ^{cd}
F ₂	D ₁	71.93 ^{ab}	6.13 ^{bc}	63.20 ^{bcd}	303.12 ^{ab}	1.93 ^a
	D ₂	52.40 ^{cd}	6.60 ^{bc}	62.34 ^{b-e}	248.31 ^{cde}	0.97 ^{def}
	D ₃	58.42 ^{bcd}	5.73 ^{cde}	65.83 ^{a-d}	266.04 ^{cd}	0.96 ^{def}
F ₃	D ₁	51.60 ^{cd}	7.80 ^{ab}	57.32 ^{de}	274.90 ^{bc}	0.53 ^g
	D ₂	64.13 ^{abc}	6.00 ^{bc}	69.02 ^{ab}	245.01 ^{cde}	1.06 ^d
	D ₃	63.93 ^{abc}	4.40 ^e	60.97 ^{b-e}	327.75 ^a	1.48 ^{bc}
F ₄	D ₁	58.93 ^{bcd}	7.13 ^{abc}	57.94 ^{de}	240.39 ^{cde}	0.60 ^{efg}
	D ₂	70.27 ^{ab}	6.53 ^{bc}	67.26 ^{abc}	240.37 ^{cde}	1.00 ^{de}
	D ₃	62.07 ^{bc}	5.53 ^{cde}	68.90 ^{ab}	234.66 ^{de}	1.23 ^{cd}
F ₅	D ₁	54.60 ^{cd}	6.73 ^{bc}	58.13 ^{de}	303.21 ^{ab}	0.49 ^g
	D ₂	55.60 ^{cd}	8.37 ^a	62.33 ^{b-e}	338.02 ^{ab}	0.98 ^{def}
	D ₃	76.87 ^a	5.80 ^{cde}	73.06 ^a	366.07 ^a	1.75 ^{ab}
Grdmala location						
F ₁	D ₁	35.80 ^d	5.27 ^{def}	44.63 ^d	237.97 ^{bcd}	1.02 ^{a-f}
	D ₂	52.07 ^b	5.27 ^{def}	52.35 ^{cd}	171.79 ^d	0.84 ^{def}
	D ₃	64.57 ^a	4.67 ^{ef}	49.60 ^{cde}	244.21 ^{bcd}	0.66 ^f
F ₂	D ₁	53.33 ^b	5.67 ^{def}	53.50 ^c	248.51 ^{a-d}	1.46 ^a
	D ₂	41.07 ^{cd}	5.33 ^{def}	55.51 ^{bc}	235.14 ^{bcd}	1.03 ^{abc}
	D ₃	53.8 ^b	6.43 ^{a-d}	54.56 ^{bc}	209.40 ^{cd}	1.12 ^{a-e}
F ₃	D ₁	42.20 ^{cd}	5.93 ^{b-e}	50.69 ^{cde}	287.08 ^{abc}	0.90 ^{def}
	D ₂	58.00 ^{ab}	7.27 ^{ab}	52.24 ^{cd}	219.99 ^{bcd}	1.40 ^{ab}
	D ₃	67.47 ^a	4.20 ^f	48.99 ^{cde}	262.14 ^{a-d}	0.93 ^{c-f}
F ₄	D ₁	36.73 ^d	6.33 ^{a-d}	45.66 ^{de}	182.67 ^d	0.72 ^{ef}
	D ₂	52.27 ^b	6.80 ^{a-d}	60.84 ^{ab}	319.24 ^{ab}	1.07 ^{c-f}
	D ₃	65.00 ^a	6.33 ^{a-d}	62.97 ^a	347.87 ^a	1.34 ^{abc}
F ₅	D ₁	36.90 ^d	7.73 ^a	46.21 ^{de}	239.11 ^{bcd}	0.98 ^{b-f}
	D ₂	49.13 ^{bc}	6.60 ^{ab}	53.20 ^c	304.39 ^{abc}	1.08 ^{a-f}
	D ₃	65.73 ^a	7.13 ^{abc}	54.59 ^{bc}	314.64 ^{ab}	1.20 ^{a-d}

D₁:1stAugust, D₂:15th August, D₃:1st September and F₁: Control, F₂: Pomace

F₃: Biochar, F₄: Seaweed

Values with different letters indicate significant differences at 5% according the Duncan's multiple-rang test

3.3. Interaction effect of planting dates and fertilizer types on some growth characters of borage.

Table 5 illustrates how the interaction treatments had a significant impact on plant growth at Grdarasha. The interaction treatments D₃ * F₅ produced the highest values (76.87, 73.06, and 366.07 cm) for plant height (cm), chlorophyll content (SPAD), and leaf area (cm²) at Grdarasha, while the interaction treatments D₁* F₁, D₂*F₁, and D₁* F₁ obtained the lowest values (47.20, 54.03, and 173.76), respectively. These outcomes are consistent with those noted by [28]. [29] stated that when chemical fertilizers were utilized exclusively, the microbial activity of the cropping system was low. Continuous use of chemical fertilizers can alter the pH of the soil, decrease the amount of organic matter, humus, and beneficial organisms, impede plant growth, and increase pests, acidity, and soil crust. [30]

The two interaction treatments, D₂*F₅ and D₃*F₃, obtained the highest and lowest numbers of branches (8.37 and 4.40) branch plant⁻¹. The interaction treatments D₁*F₂ and D₁*F₅ recorded the highest and lowest leaf thickness (1.93 and 0.49) mm. These results support the conclusion that has been arrived at by [31].

The interaction between fertilizer types and sowing date in Grdamala, as indicated in Table 5, had a significant impact on the majority of the study traits. The interaction treatments of biochar fertilizer and 1st September (D₃* F₃) and (D₁* F₁) produced the highest and lowest values of plant height (67.47 and 35.80) cm. Furthermore, the results indicated that the number of branches plant⁻¹ and chlorophyll content (SPAD) were affected significantly, the highest and lowest values recorded for the interactions (D₁* F₅ and D₃*F₄) and (D₃*F₃) and (D₁* F₁) with values (7.73 and 62.97) and (4.20 and 44.63) respectively,

These may be due to creating distinct growth circumstances that produced distinct outcomes respectively where, biochar changes the biological communities' makeup and other soil characteristics [32]. In contrast, the interaction treatments of $D_3 \times F_4$ and $D_2 \times F_1$ produced the highest and lowest values (347.87, 171.79) cm^2 of leaf area.

In addition to providing macro- and micronutrients, seaweed possesses liming properties, enhances phosphorus availability, and contains phycocolloids that enhance soil structure, water retention, and cation-exchange capabilities. Additionally, they promote plants' tolerance to detrimental biotic and abiotic agents, bind metals, and boost biological activity [33]. Furthermore, a significant difference was observed in leaf thickness (mm), the highest and lowest values (1.46 and 0.66) recorded due to the interaction between $D_1 \times F_2$ and $D_3 \times F_1$. These results were in line with [34] who showed that, as long as all the nutrients are balanced, a moderate dosage and timely fertilizer application can increase plant development and improve crop output

3.4. Effect of planting dates on some yield characters of borage.

Based on the information shown in Table 6, planting date had a major impact on the yield and yield components of Borage., the highest values (641.78 and 3.21) and (739.05 and 3.76) of number of flowers plant⁻¹, number of seeds flower⁻¹ was due to second planting dates 15th August at both locations, whilst the lowest values (457.19 and 2.94) and (457.91 and 3.16) acquired in D1 and D3 for both locations.

The same table showed that D1 and D2 had the highest seed index values (18.49 and 17.40) g, while the lowest value was (12.01 and 12.16) g noted in D3 for both locations respectively. It is evident result that dry matter gained the highest values (131.10 and 144.02) g by D3 at both locations whilst D_2 recorded the lowest value (100.38 and 97.73) g for both locations respectively. The findings once again showed how a postponed sowing date drastically lowered borage output [35]

The best period to sow Borage was in early August at both locations, when the highest seed yield, as reported in the same table, was (196.45 and 114.24) kg ha^{-1} . A considerable positive association between seed yields and the seed index is seen in Figure 1. It was revealed from our results that delayed planting significantly reduces borage seed yield at (< 0.05). This may be due to both high and low temperatures can cause problems for seed development, especially during flowering and seed-filling. This conclusion was similar to [36], who claimed that a considerable decrease in seed yield was regularly linked to delayed planting. **Fig.4** demonstrates a highly significant correlation between seed yield and seed index with a correlation coefficient value of (1) for both locations.

Table 6. Effect of planting dates on Borage yield and its component

Sowing dates	No. flower Plant ⁻¹	No. seed flower ⁻¹	Seed index g	Dry matter g	Seed yield kg ha ⁻¹
D ₁	457.19 ^b	3.13 ^{ab}	18.49 ^a	115.37 ^{ab}	196.45 ^a
D ₂	641.78 ^a	3.21 ^a	17.08 ^b	100.38 ^b	186.35 ^a
D ₃	600.57 ^a	2.94 ^b	12.01 ^c	131.10 ^a	57.60 ^b
Grdmala location					
D ₁	457.91 ^c	3.27 ^b	15.16 ^{ab}	105.65 ^b	114.24 ^a
D ₂	739.05 ^a	3.76 ^a	17.40 ^a	97.73 ^b	120.52 ^a
D ₃	623.45 ^b	3.16 ^b	12.16 ^b	144.02 ^a	47.61 ^b

D1:1st August, D2:15th August, D3:1st September

Values with different letters indicate significant differences at 5% according Duncan's multiple-range test

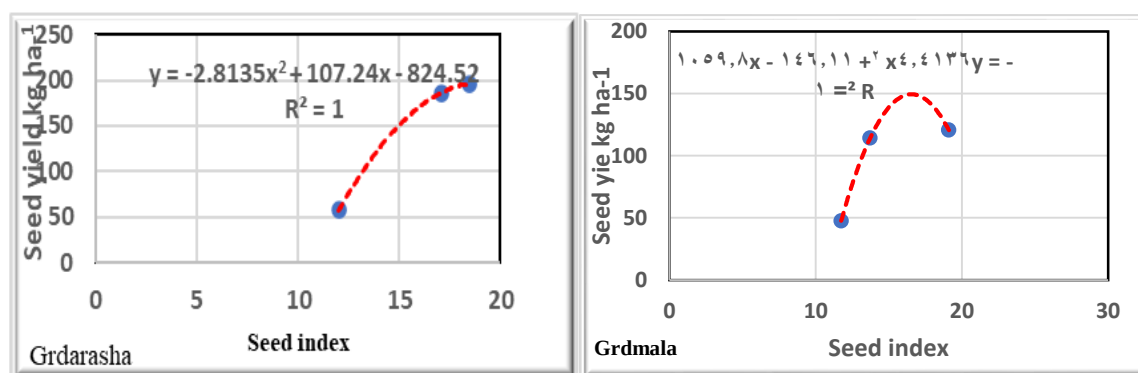


Fig 4. Correlation between seed index and seed yield at both locations

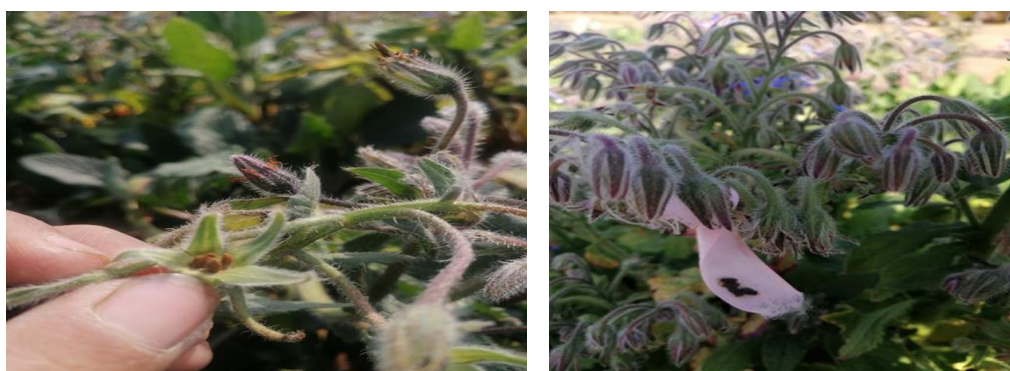


Fig5. Effect of delayed planting date and seed shattering on yield losses in Borage.

3.5 Effect of fertilizer types on some yield characters of borage plant.

The information in Table 7 illustrates how fertilizer types have a major impact on yield and its constituent parts. F_4 and F_5 had the maximum number of flowers per plant 664.84 and 723.27 whilst F_1 had the lowest value (452.50 and 533.84) flowers per plant at both locations respectively. These findings were consistent with [37] and [38], who claimed that both chemical and biological fertilizers increase the number of flower plants per plant

Pomace treatment led to a significant increase in no seed flower⁻¹ and seed index (g) at Grdarasha ($P \leq 0.05$), with the highest values being 3.36 and 17.29, respectively, similar to Grdarasha Pomace treatment increase seed index in Grdmala with the highest value 17.70 g while the lowest value (14.07 and 11.41) g obtained in control treatment at both locations. When seaweed was applied to Grdmala, the studied characters of no. seed flower⁻¹ increased with a value of 3.66. The result demonstrates the synergistic role of seaweed in increasing crop yield component, as evidenced by the findings of [39]. The number of seeds flower⁻¹ and seed index, on the other hand, were significantly lower for the control treatment at both locations (2.91, 14.07) and (2.96, 11.41), respectively. Fig.3 shows evidence to clarify the different number of seeds per flower among the organic fertilizer types.

The dry matter was greatly impacted by different fertilizers applied; at Grdarasha, the highest value, 133.91 g, was noted in F_4 , whereas at Grdmala, the highest value was 143.40 g, recorded from F_3 . The optimal circumstances for plant development and productivity were apparently offered biochar [40], while the lowest values for dry matter (96.48 and 83.72) g resulted in control treatment.

Better yield performance can be attributed to the combined improvement of seed production and flowering. It is noteworthy that the F_4 treatments resulted in an increase in seed yield at both locations. When different types of fertilizers were applied, it was observed that the fertilizer treatments in term of seed yield were assorted as: $F_4 > F_5 > F_3 > F_2 > F_1$, in Grdarasha, whereas Grdmala's were $F_4 > F_3 > F_5 > F_2 > F_1$. This suggests that the algae treatment increased seed yield. The seed yield in Grdarasha was increased 69 % compared with Grdmala may be due to environmental factors, as shown in Fig 1. which led to a greater number of flowers and seed in flower.

Table 7. Effect of fertilizer types on Borage yield and its components

Treat.	No. flower plant ⁻¹	No. seed flower ⁻¹	Grdarash location		
			Seed index	Dry matter g	Seed yield kg ha ⁻¹
F_1	452.50 ^c	2.91 ^b	14.07 ^b	96.48 ^b	116.67 ^c
F_2	661.49 ^a	3.36 ^a	17.29 ^a	121.29 ^{ab}	119.17 ^c
F_3	468.62 ^{bc}	3.09 ^{ab}	14.84 ^b	103.45 ^{ab}	129.28 ^{bc}
F_4	664.84 ^a	3.13 ^{ab}	16.51 ^a	133.91 ^a	213.28 ^a
F_5	585.11 ^{ab}	2.94 ^b	16.60 ^{aa}	122.94 ^{ab}	155.61 ^b
Treat.	No. flower plant ⁻¹	No. seed flower ⁻¹	Grdmala location		
			Seed index	Dry matter g	Seed yield kg ha ⁻¹
F_1	533.84 ^b	2.96 ^b	11.41 ^b	83.72 ^b	79.02 ^b
F_2	538.80 ^b	3.34 ^{ab}	17.70 ^a	124.04 ^{ab}	80.33 ^b
F_3	570.81 ^b	3.46 ^{ab}	15.73 ^{ab}	143.40 ^a	100.94 ^b
F_4	667.30 ^{ab}	3.66 ^a	16.71 ^a	102.06 ^{ab}	126.22 ^a
F_5	723.27 ^a	3.57 ^{ab}	12.98 ^{ab}	125.78 ^{ab}	84.11 ^b

F_1 : Control, F_2 : Pomace, F_3 : Biochar, F_4 : Seaweed, F_5 : DAP

Values with different letters indicate significant differences at 5% according the Duncan's multiple-range test

3.8 Interaction effect of sowing dates and fertilizer types on yield characters of Borage

Table 8 demonstrates that interaction between sowing date and fertilizer types had a considerable impact on yield and yield components of Borage plant. In both locations number of flower gained the highest value (928.53 and 812.67) from the interaction treatments ($D_2 \times F_4$) had the most blooms per plant, whereas ($D_1 \times F_1$) had the lowest values (422.00 and 224.80) for both locations. Number of seed per plant recorded the highest value 3.58 and 4.23 from the interaction treatments $D_2 \times F_5$ and $D_2 \times F_4$ for both locations while the lowest values 2.28 and 2.72 acquire for $D_3 \times F_1$ respectively. In Grdarasha location $D_1 \times F_4$ obtained the highest values for the seed index (g) and seed yield (kg ha^{-1}) 21.00 and 309.50, respectively, while $D_3 \times F_1$ and $D_3 \times F_2$ had the lowest values for the two characters at 8.33g and 45.50 (kg ha^{-1}).

Furthermore, at Grdmala, the interaction treatments showed notable changes in yield and its components characteristics; the interaction treatments ($D_2 \times F_4$) and ($D_3 \times F_2$) produced the highest and lowest values (172.33 and 22.00) seed yield kg ha^{-1} . This is supported by the fact that this interaction treatment outperformed the other interactions in every way when it came to enhancing yield parameters while there are no significant differences between the two studied factors for seed index. At Grdarasha, $D_1 \times F_2$ and $D_1 \times F_1$ had the highest and lowest dry matter values (177.93 and 83.08) g, respectively, whereas $D_3 \times F_3$ and $D_2 \times F_3$ had the highest and lowest values (240.14 and 63.27) g at Grdmala.

Table8. Interaction effect of sowing dates and fertilizer types on Borage yield component

Grdarasha Location						
Fertilizer Types	Date of sowing	No. flower plant ⁻¹	No. seed flower ⁻¹	Seed index g	Dry matter g	Seed yield kg ha ⁻¹
F ₁	D ₁	422.00 ^c	3.22 ^a	17.67 ^b	83.08 ^b	98.9 ^{de}
	D ₂	454.43 ^{cd}	3.33 ^{a-d}	16.20 ^{bc}	87.83 ^b	186.25 ^c
	D ₃	481.07 ^{cd}	2.28 ^e	8.33 ^e	118.54 ⁰	64.83 ^e
F ₂	D ₁	671.20 ^{bc}	3.55 ^{ab}	18.40 ^{ab}	177.93 ^a	151.33 ^{cd}
	D ₂	422.47 ^c	3.28 ^{a-d}	17.07 ^b	96.16 ^b	160.67 ^c
	D ₃	890.80 ^a	3.23 ^{a-d}	16.40 ^{bc}	89.78 ^b	45.50 ^e
F ₃	D ₁	356.07 ^c	2.98 ^{bcd}	17.20 ^b	87.46 ^b	175.50 ^c
	D ₂	510.67 ^{cd}	2.85 ^d	16.60 ^{bc}	122.67 ^{ab}	160.83 ^c
	D ₃	539.13 ^{bc}	3.45 ^{abc}	10.73 ^{de}	100.21 ^b	51.50 ^e
F ₄	D ₁	563.60 ^{cd}	3.23 ^{a-d}	21.00 ^a	176.83 ^a	309.50 ^a
	D ₂	928.53 ^a	3.03 ^{a-d}	17.53 ^b	108.84 ^{ab}	258.83 ^{ab}
	D ₃	502.40 ^{bc}	3.12 ^{a-d}	11.00 ^{de}	116.07 ^{ab}	71.50 ^e
F ₅	D ₁	521.80 ^{bc}	2.93 ^{cd}	18.20 ^{ab}	133.30 ^{ab}	247.00 ^b
	D ₂	424.47 ^c	3.58 ^a	18.00 ^{ab}	92.79 ^b	165.17 ^c
	D ₃	809.07 ^{ab}	2.32 ^e	13.60 ^{cd}	142.74 ^{ab}	54.67 ^e
Grdmala Location						
F ₁	D ₁	224.8 ^e	3.18 ^{abc}	12.67 ^a	81.81 ^c	75.33 ^{cde}
	D ₂	689.00 ^{abc}	2.98 ^{bc}	9.67 ^a	103.56 ^{bc}	82.50 ^{b-e}
	D ₃	687.67 ^{abc}	2.72 ^c	11.90 ^a	65.79 ^c	79.23 ^{b-e}
F ₂	D ₁	615.13 ^{abc}	3.18 ^{abc}	19.80 ^a	181.68 ^{ab}	101.33 ^{bcd}
	D ₂	335.07 ^{de}	2.82 ^c	20.20 ^a	78.44 ^c	117.67 ^{bc}
	D ₃	666.20 ^{abc}	4.02 ^{ab}	13.10 ^a	111.99 ^{bc}	22.00 ^f
F ₃	D ₁	454.09 ^{cde}	3.35 ^{abc}	14.33 ^a	126.78 ^{bc}	98.73 ^{bcd}
	D ₂	743.67 ^{abc}	3.85 ^{abc}	21.33 ^a	63.27 ^c	162.58 ^a
	D ₃	514.67 ^{bcd}	3.18 ^{abc}	11.53 ^a	240.14 ^a	41.50 ^{ef}
F ₄	D ₁	563.43 ^{a-d}	3.50 ^{abc}	14.47 ^a	103.98 ^{bc}	168.98 ^a
	D ₂	812.67 ^a	4.23 ^a	21.86 ^a	88.57 ^{bc}	172.33 ^a
	D ₃	625.80 ^{abc}	3.25 ^{abc}	13.80 ^a	113.63 ^{bc}	37.33 ^{ef}
F ₅	D ₁	712.07 ^{abc}	3.52 ^{abc}	14.53 ^a	137.23 ^{bc}	126.83 ^{ab}
	D ₂	783.73 ^{ab}	3.70 ^{abc}	13.93 ^a	121.27 ^{bc}	67.50 ^{def}
	D ₃	674.00 ^{abc}	3.48 ^{abc}	10.47 ^a	118.86 ^{bc}	58.00 ^{def}

D₁: 1st August, D₂: 15th August, D₃: 1st September and F₁: Control, F₂: Pomace,

F₃: Bio-charF₄: Seaweed, F₅: DAP

Values with different letters indicate significant differences at 5% according to Duncan's multiple-range test

Table 9 indicates that there is a positive significant correlation between seed yield and the number of branches and seed index, and a negative correlation with leaf thickness ($r=0.796$, 0.860 , and -0.769). Additionally, there is a significant positive correlation between leaf thickness and plant height and chlorophyll content ($r=0.785$ and 0.782).

Table 10 displays the considerable positive association between seed yield and seed index ($r = 0.734$) as well as the positive correlation between no seed and no branch or flower ($r = 0.857$ and 0.727).

Table 9. Correlation Coefficients Between Borage characters at Grdarasha.

Characters	Seed yield	Plant Height	No branch	Chl. Content	Leaf area	Leaf thickness	No. flower	No. Seed	Seed index	Dry matter
Seed yield	1									
Plant height	-.467	1								
No branch	.364	-.189	1							
Chl.	-.137	.484	.199	1						
Leaf area	-.264	.410	.197	.621*	1					
Leaf thickness	-.080	.278	.415	.523*	.386	1				
No flower	.145	.428	.518*	.376	.184	.168	1			
No. seed	.232	.003	.735**	.276	.224	.357	.528*	1		
Seed index	.539*	-.064	.473	.391	.260	.188	.446	.749**	1	
Dry matter	-.364	.246	-.270	-.114	.144	.117	-.034	-.066	-.318	1

Table10. Correlation Coefficients Between Borage characters at Grdmala

Characters	Seed yield	Plant Height	No branch	Chl. Content	Leaf area	Leaf thickness	No. flower	No. Seed	Seed index	Dry matter
Seed yield	1									
Plant height	-.467	1								
No branch	.364	-.189	1							
Chl.	-.137	.484	.199	1						
Leaf area	-.264	.410	.197	.621*	1					
Leaf thickness	-.080	.278	.415	.523*	.386	1				
No flower	.145	.428	.518*	.376	.184	.168	1			
No. seed	.232	.003	.735**	.276	.224	.357	.528*	1		
Seed index	.539*	-.064	.473	.391	.260	.188	.446	.749**	1	
Dry matter	-.364	.246	-.270	-.114	.144	.117	-.034	-.066	-.318	1

Conclusion

The most notable findings summed up the fact that significant impact of Borage planting dates and different fertilizer types application and their interactions on growth traits, yield and its components in comparison with control treatments. it appears comparing the early planting dates 1st August, compared to late date 1st September, leads to failure of seed development. Applying seaweed and pomace organic fertilizer can greatly enhance the crop performance, also provides a dependable and sustainable method for farmer and growers looking to boost borage productivity and preserve the soil quality, and a reliable and environment friendly approach. The best treatments and their interactions were the 1st August and Seaweed application for highest seed yield were improved in both locations. control treatments obtained the lowest values .in both locations for most fertilizer types applications. Further studies on the long-term impacts of these treatments and their interaction with other environmental factors are recommended.

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Conflict of Interest

The authors declare no conflict of interest

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دراسة تأثير موعد الزراعة والتسميد العضوي المختلف على تحسين صفة النمو والمحصول ومكونات المحصول في نبات لسان الثور (*Borago officinalis* L.)

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قسم المحاصيل الحقلية والنباتات الطبية، كلية علوم الهندسة الزراعية، جامعة صلاح الدين - أربيل، إقليم كردستان، العراق.

الخلاصة

أجريت دراسة ميدانية في موقعين، جرداراشا وجردمالا، خلال موسم النمو 2024-2025. شملت التجربة عاملين، العامل الأول كان ثلاثة مواعيد للزراعة في 1 أغسطس (*D1*) و 15 أغسطس (*D2*) و 1 سبتمبر *D3* في عام 2024، والعامل الثاني كان خمسة أنواع من الأسمدة (الشاهد، ثقل الذرة 40000 كجم هكتار-1، الفحم الحيوي للأرز 40000 كجم هكتار-1، الأعشاب البحرية 2 كجم هكتار-1 وفوسفات ثنائي الأمونيوم *DAP* 200 كجم هكتار-1. أجريت تجربة عاملية (5×3) باستخدام تصميم القطاعات الكاملة العشوائية (*RCBD*) باستخدام ثلاثة مكررات. تمت دراسة العديد من المعلمات الكمية. أظهرت العوامل المذكورة دورًا إيجابيًا في نمو لسان الثور والغلة، ويتضح من النتائج أن أعلى زيادة في ارتفاع النبات (سم) ومساحة الورقة (سم²) وسمك الورقة (مم) والمادة الجافة للنبات-1 (جم) تم تسجيلها في 1 سبتمبر (67.41 و 299.50 و 1.53 و 131.10) و (63.22، 283.48 و 1.12 و 144.02) لكلا الموقعين على التوالي. في حين تم الحصول على أعلى قيم لإنتاج البذور لكلا الموقعين (196.45 و 120.52) كجم هكتار-1 في 1 أغسطس و 15 أغسطس، تم تسجيل أعلى قيمة لبعض الصفات المدروسة في *Grdarasha* لمعاملة ثقل الذرة في *Grdarasha* والتي كانت سمك الورقة 1.28 مم، وعدد البذور الزهرة-1 3.36، ومؤشر البذور 17.29 جم بينما في موقع *Grdmala* سجلت نفس المعاملة أعلى قيمة لسمك الورقة 1.20 مم ومؤشر البذور 17.70 جم. في موقع *Grdarasha* حصلت معاملة الأعشاب البحرية على أعلى قيمة لارتفاع النبات 63.36 سم، والكوروفيل 64.70 *SPAD*، وعدد الزهور 664.84 نبات-1، والمادة الجافة 133.91 جم، وإنتاج البذور 213.28 كجم/هكتار. بينما في منطقة جردمالا، سُجلت أعلى قيمة لمحتوى الكلوروفيل (56.49 *SPAD*)، وعدد البذور الزهرية (3.66)، وإنتاجية البذور (126.22 كجم/هكتار). وقد حققت معاملات التفاعل *D1*F4* و *D1*F4* أعلى قيم لإنتاجية البذور (309.50 و 172.33) كجم/هكتار لكلا الموقعين على التوالي.

الكلمات المفتاحية: محصول لسان الثور، موعد الزراعة، الأعشاب البحرية، ثقل الأرز، الفحم الحيوي لقشر الأرز، داب.