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EFFECT OF SEED PRIMING AND PLANTING DATES ON SOME GROWTH CHARACTERISTICS OF TWO CULTIVARS OF SOYBEAN

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ABSTRACT

A field experiment was conducted to investigate the effect of seed priming and planting dates on the growth of two soybean cultivars. This study was conducted during the summer seasons 2022 and 2023 at the fields of the Agricultural Engineering Sciences - University of Baghdad. A Randomized Complete Block Design (RCBD) split-split plot arrangement was employed, with three replicates and three factors. The main factor included planting dates (1/6, 15/6, and 1/7), the second factor included two soybean cultivars (Lee 74 and Shaimaa), and the third factor included seed priming treatments (Gibberellic acid, KCl, and seaweed extract as well as two control treatments (soaking with distilled water and dry seeds). The results showed the superiority of the 15th June planting date, with the highest average plant height and crop growth rate. The Shaimaa cultivar exhibited the highest average in leaf area and crop growth rate, while also outperforming in plant height. The seed priming treatment with seaweed extract excelled in leaf area and crop growth rate, while the KCL treatment excelled in plant height. Overall, 15th June planting date and the Shaimaa cultivar showed superiority, along with the seaweed extract seed priming treatment.

Keywords: Growth regulators, , Seaweed extract, Soybean, wide environmental range
***Part of Ph.D. dissertation of 1st author**

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INTRODUCTION

Soybean (*Glycine max* (L.) is one of the most important economic, protein, and oil crops in the world. Its seeds contain a high percentage of protein (36-40%) and oil (14-26%), which in turn contains a high percentage of unsaturated fatty acids, the most important are linoleic and linolenic. These acids play an important role in reducing the level of harmful cholesterol in the blood, and thus reducing the risk of heart and vascular diseases. As well as, its seeds contain most of the essential amino acids and some important vitamins (Al-Awda *et al*,2009).Soybean seeds are also used as a raw material in many industries. For example, soybean meal is a basic ingredient in animal feed. Soybean cultivation improves soil properties and fertility due to the action of the bacteria root nodule that fix atmospheric nitrogen and provide the plant with the necessary requirements for growth (Awoda, 2015 and Sousa *et al* ,2014). Despite the importance of soybean, its cultivation faces several problems, most notably the issue of germination and field emergence of its seeds, as well as field establishment of the plants, which are among the major challenges encountered by many specialists in soybean cultivation. These challenges contribute to the weakening and reduction of its performance, as well as the low field emergence of seedlings, lack of growth uniformity, and weak seedlings due to factors that could be attributed to genetic factors or environmental stresses during field establishment and the final seeds yield of this strategic crop. This

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negatively impacts growth rates and yields (Al-Baldawi and Hamza,2017, Hamed,2011, Shihab and Hamza, 2019). Therefore, many researchers were directed their efforts towards conducting numerous studies using various methods to develop soybean cultivation. Agricultural techniques, including seed priming before planting, have been utilized. The purpose is to increase the average germination rate, reduce the time between seed sowing and emergence, improve seedling growth, and enhance uniformity. Priming technology enhances the seed's latent energy under a wide range of environmental conditions (Hamd and Hamza,2023). It is cost-effective and highly efficient. This technique could be applied by soaking the seeds in various nutrient solutions. Priming could be apply through different methods, such as hydro priming (water only), hormonal priming (using hormones and plant growth regulators), osmo priming (using solutions containing osmotic substances), thermo priming (treating seeds with high or low temperatures).These techniques stimulate the formation of some digestive enzymes in the aleurone layer, such as amylase, protease, and catalase enzymes (Goudarz *et al*, 2012, Jyoti *et al*,2011). Additionally, they enhance plant tolerance to different environmental stresses by regulating responses to these stresses through controlling various physiological processes, including drought, salinity, heat, and water stress, among others (Al-Karawi, 2022, Kadhim and Hamza,2021). The global trend is now towards reducing the use of synthetic chemical fertilizers because they cause health, environmental, and economic harm. Therefore, it is necessary to find natural alternatives such as using seaweed extracts because they are non-toxic and non-polluting to the environment, in addition to their low cost (Babilie *et al*,2015, Bhattacharyya *et al*,2015). Seaweed extracts are also plant growth stimulants and contribute to most of the important physiological functions of any crop because they are rich in plant hormones such as auxins, gibberellins, and cytokinins, as well as macro- and micronutrients. They alsocontain some essential amino acids and vitamins (Rouphael and Colla,2020). Therefore, seaweed extracts are considered to be a stimulant for the growth of the vegetative and root systems of the plant. Which leads to an increase in the efficiency of photosynthesis and respiration (Al-Maleky,2013, Kadhim and Hamza,2021b, Saudi and Al-Rawi, 2023) This study was aimed to investigate the effect of seed priming and planting dates on some growth of two soybean cultivars**.**

MATERIALS AND METHODS

Field experiment was conducted at the fields of College of Agricultural Engineering Sciences - University of Baghdad during the seasons of 2022 and 2023. It employed a Randomized Complete Block Design (RCBD) with in split-split plot arrangement, with three replicates and three factors. The main factor included planting dates (1/6, 15/6, and 1/7), the second factor included two cultivars of soybeans (Lee 74 and Shaimaa), and the third factor included seed priming treatments, which consisted of gibberellic acid (GA3) at a concentration of 300 mg L^{-1}, potassium chloride (KCl) at a concentration of 30 g L^{-1}, and seaweed extract (*Ascophyllum nodosum*) at a concentration of 3 ml L^{-1}. Additionally, two control treatments were included: soaking in distilled water and dry seeds. The seaweed extract (Ascophyllum) was obtained from Al-Gawad Company, affiliated with the Holy Shrine of Imam Abbas. The seeds were soaked in the solutions of the priming treatments for 24 hours, and then air-dried for 12 hours. The experimental field was prepared by plowing, harrowing, and leveling before planting. It was then divided into three replicates with a distance of 1 meter between each replicate.

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The area of each experimental unit was 6 m^2 with dimensions of 3 m × 2 m. It included four rows with spacing of 75 cm between rows and 20 cm within the row. Urea fertilizer (46% N) was added at a rate of 225 kg ha^{-1} in three equal doses (the first dose at full field emergence, the second dose at the beginning of flowering, and the third dose at the beginning of pod formation). Additionally, triple superphosphate fertilizer (46% P_2O_5) was added at a rate of 120 kg ha^{-1} in a single dose before planting, after preparing the soil and before preparing the rows for planting, by mixing it with the soil (Ali,2012).

Studied traits:

Plant Height (cm): Measured by measuring the height of ten randomly guarded representative plants from the central rows of each experimental unit, from the first node at ground level to the tip of the apex.

Leaf area (cm^2): The leaf area was measured at flowering completion and the beginning of grain formation using the equation by Wiersma and Bailey (Wiersma and Bailey,1975):

LA = 0.624 + (0.723) (L * W)

Where: LA = Leaf area (cm2), L = Length of the leaf (cm), W = Maximum width of the leaf (cm). Then, the total leaf area was calculated by multiplying the leaf area by the number of leaves per plant, and then the values were converted to cm^2 (Al-Jumaili,2014).

Crop growth rate (C.G.R) (g m^{-2} day^{-1}): Five randomly selected plants were taken at the flowering and grain stages from each experimental unit, dried until reaching a stable weight, weighed using a sensitive balance, and the crop growth rate was calculated according to the following equation:

$$\mathrm{CGR} = \frac{\mathrm{W2} - \mathrm{W1}}{\mathrm{T2} - \mathrm{T1}}\ X\ \frac{1}{A}$$

Where: A = Area occupied by the plant sample in m^2 W1 = Dry weight of the plant sample at flowering (T1) W2 = Dry weight of the plant sample at pod stage. T1 = Number of days from planting to flowering T2 = Number of days from planting to the end of the pod stage.

Statistical Analysis

The data for the studied traits were statistically analyzed using analysis of variance (ANOVA). The means of the treatments compared using LSD 5% (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

Plant height (cm)

The results in Tables (1) and (2) indicate a significant effects among seed priming treatments as well as interactions between planting dates and seed priming treatments for this trait, except for the interaction between dates and cultivars in the first season. The second planting date, 15^{th} June achieved significant superiority with the highest average, at 128.333 cm and 129.758 cm for both seasons, respectively. While, the third planting date recorded the lowest average of 96.401 cm and 98.103 cm for both seasons, respectively. The reason for the superiority of the second date could be attributed to the longer period from planting to full maturity, which provided the longest possible opportunity for cell division and elongation, leading to increased height. These results are consistent with those found by (Bin Shuaib and Omar Mahfouz,2004) which aligns with (Al-Jumaili, 2007), who observed significant differences in plant height. The mid-June planting date significantly outperformed when compared to the end of June and mid-July planting dates. The results in Tables (1) and (2) also indicate a significant differences among cultivars in their effect on that trait. The Lee 74 cultivar achieved significant superiority with the highest average of 115.095 cm, while the Shaimaa cultivar achieved the lowest average of 114.574 cm in the first season. In the second season, the Shaimaa cultivar achieved the highest average,

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at 116.825 cm, while the Lee 74 cultivar recorded the lowest average of 114.641 cm. The increases in plant height could be attributed to the genetic nature of the cultivars, which positively responded to environmental conditions, leading to increased cell division and elongation, resulting in height increase. These results are consistent with those found by (Dawood and Jaddoa,2023). The results of the priming treatments indicate a highly significant effect, as the potassium chloride seed priming treatment achieved the highest mean values of 130.073 and 127.607 for both seasons, respectively, while the dry seed and distilled water priming seed treatments recorded the lowest mean values of 101.765 and 105.088 cm and 102.957 and 105.003 cm for both seasons, respectively. The reason for this could be attributed to the role of potassium chloride and its positive effect on increasing cell division and elongation, which led to the production of strong seedlings that grow and develop better, leading to an increases in the accumulation of nutrients in the seedling tissues, which had a positive impact on their vegetative growth. These results are consistent with those found by (Goudarz et al,2019), who confirmed that soybean seeds priming with potassium chloride solution achieved the highest mean values for plant height. The results of Tables (1) and (2) show significant interaction between cultivars and priming treatments. The potassium chloride priming treatment for the Shaimaa cultivar, excelled with the highest average at 132.627 and 128.823 cm, respectively, which did not differed significantly from the seaweed extract priming treatment for the same cultivar in the second season, where the average for this trait reached 127.650 cm. Whereas, the control treatments, including soaking in distilled water and dry seeds for the Shaimaa cultivar, recorded the lowest average at 100.017 and 99.560 cm for the first season, respectively. For the second season, the control treatments for dry seeds for both the Shaimaa and Lee 74 cultivars recorded the lowest average at 104.643 and 101.940 cm, respectively. The results of Tables (1) and (2) indicate non-significant interaction between planting dates and cultivars in the first season, while the interaction was significant in the second season. The second planting date, 15th June for the Shaimaa cultivar, achieved the highest average of 132.960 cm, while the third planting date, July 1st, recorded the lowest average at 99.624 and 96.582 cm, respectively, for both cultivars. The results also demonstrated that the interaction between planting dates and cultivars had a highly significant effect. The potassium chloride and seaweed extract priming treatments excelled significantly for the second planting date, 15th June as well as the potassium chloride priming treatment for the first planting date, June 1st, by providing the highest averages, of 138.815, 142.325, 140.480, 142.280, 138.390, and 138.615 cm, respectively, for both seasons. This is compared to the control treatments (dry seeds and seeds soaked in distilled water), which recorded the lowest averages at 87.885, 89.855, 93.700, and 91.850 cm, respectively, for both seasons. The results indicate a significant three-way interaction between planting dates, and cultivars, and different priming treatments, significant differences were observed at a 1% level of significance. From the results of Tables (1) and (2) the potassium chloride priming treatment excelled in both the first and second planting dates with the highest average at 144.440 and 147.470 cm, respectively. While, in the second season, both the seaweed extract and potassium chloride priming treatments outperformed providing the highest average at 142.950 and 147.050 cm, respectively.

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Table 1. Effect of seed priming, cultivars, planting dates, and their interactions on plant height (cm) for 2022 growing season

Cultivars	Priming treatments	Planting season June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	112.930	129.520	97.880	113.443
	Dist. water	100.270	111.850	87.930	100.017
	Seaweed	141.280	140.250	100.140	127.223
	KCL	144.440	147.470	105.970	132.627
	Dry	98.350	109.920	90.410	99.560
Lee	GA3	116.870	129.580	96.900	114.450
	Dist. water	109.530	120.320	87.840	105.897
	Seaweed	134.750	137.380	98.780	123.637
	KCL	136.520	137.180	108.860	127.520
	Dry	102.750	119.860	89.300	103.970
LSD 5%			5.147**		2.971**
Cultivars		planting dates * cultivars			Mean cultivars
Shaimaa		119.454	127.802	96.466	114.574
lee		120.084	128.864	96.336	115.095
LSD 5%			ns		0.782**
Treatments		planting dates * priming treatments			Mean priming
GA3		114.900	129.550	97.390	113.947
Dist. water		104.900	116.085	87.885	102.957
Seaweed		138.015	138.815	99.460	125.430
KCL		140.480	142.325	107.415	130.073
Dry		100.550	114.890	89.855	101.765
LSD 5%			3.639**		2.101**
Mean planting dates		119.769	128.333	96.401	
LSD 5%			1.528**		

Table 2. Effect of seed priming, cultivars, planting dates, and their interactions on plant height (cm) for 2023 growing season

Cultivars	Priming treatments	Planting season June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	111.750	134.400	98.680	114.943
	Dist. water	107.080	121.540	95.580	108.067
	Seaweed	130.780	142.950	109.220	127.650
	KCL	139.970	147.050	99.450	128.823
	Dry	99.880	118.860	95.190	104.643
Lee	GA3	126.300	126.860	98.800	117.320
	Dist. water	101.130	112.870	91.820	101.940
	Seaweed	132.850	133.830	99.380	122.020
	KCL	137.260	137.510	104.400	126.390
	Dry	106.380	121.710	88.510	105.533
5% LSD			4.912**		2.836**
Cultivars		planting dates * cultivars			Mean cultivars
Shaimaa		117.892	132.960	99.624	116.825
lee		120.784	126.556	96.582	114.641
5% LSD			2.934**		1.582*
Treatments		planting dates * priming treatments			Mean priming
GA3		119.025	130.630	98.740	116.132
Dist. water		104.105	117.205	93.700	105.003
Seaweed		131.815	138.390	104.300	124.835
KCL		138.615	142.280	101.925	127.607
Dry		103.130	120.285	91.850	105.088
5% LSD			3.474**		2.005**
Mean planting dates		119.338	129.758	98.103	
5% LSD			2.797**		

Leaf area (cm2 plant^{-1})

The results of Tables (3) and (4) showe a significant effects among different seed priming treatments, planting dates, cultivars, and their interactions on leaf area. The first and second planting dates significantly outperformed with the highest average at 81.333 and 80.472, and 83.792 and 83.787 cm^2

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plant^{-1} for both seasons, respectively. While, the third planting date, July 1st, recorded the lowest average at 71.700 and 73.323 cm^2 plant^{-1} for both seasons, respectively. The reason for this could be attributed to the availability of favorable environmental conditions, especially light and temperature, which helped stimulate cell division in the leaves, increasing their size and consequently leading to an increase in total leaf area (Al-Jubouri *et al*,2002). As shown in Tables (3) and (4), there is a significant difference between the cultivars. The Shaima cultivar outperformed with the highest mean value at of 81.371 and 83.546 cm^2 plant^{-1} for both seasons, respectively, while the Lee 74 cultivar recorded the lowest mean of 74.299 and 77.055 cm^2 plant^{-1} for both seasons, respectively. The reason for this could be attributed to the different responses of soybean cultivars to different growth factors, which in turn depends on the genetic potential of each cultivar. In addition, the morphological traits of the plant are directly related to the plant's ability to absorb nutrients and its efficiency in photosynthesis, as well as the process of transporting nutrients from the source to the sink (Elsahooki,2006). This is consistent with what (Al-Jumaili,2014) found, who obtained an increase in leaf area when comparing soybean cultivars. The results show a highly significant differences the priming treatments. The seaweed extract seed priming treatment achieved the highest mean at 100.557 and 103.087 cm^2 plant^{-1} for both seasons, respectively, compared to the control treatment of non-priming seeds (dry seeds), which recorded the lowest mean of 53.060 and 56.273 cm^2 plant^{-1} for both seasons, respectively. The superiority of the seaweed extract priming treatment could be attributed to its essential role in increasing cellular metabolic activity due to the presence of some growth-stimulating substances in its composition, such as indoleacetic acid, as well as the presence of gibberellins, cytokinins, and some micronutrients, vitamins, and amino acids (Pacholczak, 2016).

This is consistent with what (Begum *et al*,2018) found about the physiological and important role of marine extracts in plants is to improve crop performance and productivity. The reason could be attributed to the role of seaweed extracts in increasing membrane permeability, which in turn improves growth traits (Al-Fahdawi and Mustafa,2023). The interference between cultivars and treatments can be observed from the results of Tables (3 and 4), as the interference is significant. This is evident as the treatment of seed priming with seaweed extract for the Shaimaa cultivar achieved the highest average of 105.883 and 108.330 cm^2 plant^{-1} for both seasons, respectively, compared to the control treatments of dry seeds and seeds priming with distilled water for the Lee 74 cultivar in the first season. The latter showed the lowest average at 51.570 and 52.703 cm^2 plant^{-1}. As for the second season, the control treatments for both cultivars and the treatment of seeds priming with distilled water for the Lee 74 cultivar recorded the lowest averages at 55.823, 56.723, and 54.580 cm^2 plant^{-1}, respectively. The results indicate a significant interaction between planting dates and cultivars. The second date, 15th June for Shaimaa cultivar, achieved a significant superiority with highest average at 86.662 and 88.824 cm^{2}plant^{-1} for both seasons, respectively, while the third date, July 1st, for the Lee 74 cultivar recorded the lowest average of 70.612 and 72.004 cm^2 plant^{-1}, respectively, for both seasons. Data in Tables (3) and (4) indicates a significant interaction between the dates and priming treatments. The first and second planting dates for the seaweed extract seed priming treatment and the potassium chloride priming treatment were

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superior, with the highest mean of 104.810, 104.920, 102.465, 101.385, 107.645, 107.440, 105.780, and 104.170 cm^2 plant^{-1}, respectively, compared to the control treatment of non-priming seeds (dry seeds) for the second and third planting dates of the first season and the third date of the second season, which gave the lowest mean of 51.900, 50.300, and 51.750 cm^2 plant^{-1} for both seasons, respectively. The results also indicate that the three-way interaction between dates, cultivar, and different priming treatments was significant. The seaweed extract and potassium chloride seed priming treatments for the second date in the first season for the Shaima cultivar were significantly superior, with the highest mean values of 116.480 and 110.510 cm^2 plant^{-1}, respectively. The seaweed extract seed priming treatment for the second date in the second season for the Shaima cultivar also achieved the highest mean of 118.030 cm^2 plant^{-1}. The following treatments recorded the lowest mean: the dry seeds treatment for the Shaima cultivar for the second and third planting dates and the distilled water seed priming treatment for the Lee 74 cultivar for the first and third planting dates 52.690, 50.610, 55.520, 52.860, 52.280, 50.120, 54.130, and 52.100 cm^2 plant^{-1} for both seasons, respectively. The dry seeds treatment for the Lee 74 cultivar for three dates in the first season recorded the lowest mean values of 53.610, 51.110, and 49.990 cm^2 plant^{-1}, while the dry seed treatment for the same cultivar for the third date in the second season recorded the lowest mean of 50.640 cm^2 plant^{-1}.

Table 3. Effect of seed priming, cultivars, planting dates, and their interactions on leaf area (cm^2 plant^{-1}) for 2022 growing season

Cultivars	Priming treatments	Planting season June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	85.130	93.710	71.230	83.357
	Dist. water	64.080	59.920	60.700	61.567
	Seaweed	109.150	116.480	92.020	105.883
	KCL	104.610	110.510	89.380	101.500
	Dry	60.350	52.690	50.610	54.550
Lee	GA3	83.330	78.970	70.350	77.550
	Dist. water	52.280	55.710	50.120	52.703
	Seaweed	100.470	93.360	91.860	95.230
	KCL	100.320	92.260	90.740	94.440
	Dry	53.610	51.110	49.990	51.570
LSD 5%			5.362**		3.096**
Cultivars			planting dates * cultivars		Mean cultivars
Shaimaa		84.664	86.662	72.788	81.371
lee		78.002	74.282	70.612	74.299
LSD 5%			1.601**		1.046**
Treatments			planting dates * priming treatments		Mean priming
GA3		84.230	86.340	70.790	80.453
Dist. water		58.180	57.815	55.410	57.135
Seaweed		104.810	104.920	91.940	100.557
KCL		102.465	101.385	90.060	97.970
Dry		56.980	51.900	50.300	53.060
LSD 5%			3.792*		2.189**
Mean planting dates		81.333	80.472	71.700	
LSD 5%			1.359**		

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Table 4. Effect of seed priming, cultivars, planting dates, and their interactions on leaf area (cm^2 $plant^{-1}$) for 2023 growing season

Cultivars	Priming treatments	Planting season June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	87.110	96.760	72.570	85.480
	Dist. water	65.890	61.500	62.020	63.137
	Seaweed	112.410	118.030	94.550	108.330
	KCL	108.660	112.310	91.210	104.060
	Dry	61.790	55.520	52.860	56.723
Lee	GA3	85.970	82.710	71.970	80.217
	Dist. water	54.130	57.510	52.100	54.580
	Seaweed	102.880	96.850	93.800	97.843
	KCL	102.900	96.030	91.510	96.813
	Dry	56.180	60.650	50.640	55.823
LSD 5%			5.244**		3.028**
Cultivars			planting dates * cultivars		Mean cultivars
Shaimaa		87.172	88.824	74.642	83.546
lee		80.412	78.750	72.004	77.055
LSD 5%			1.669**		1.323**
Treatments			planting dates * priming treatments		Mean priming
GA3		86.540	89.735	72.270	82.848
Dist. water		60.010	59.505	57.060	58.858
Seaweed		107.645	107.440	94.175	103.087
KCL		105.780	104.170	91.360	100.437
Dry		58.985	58.085	51.750	56.273
LSD 5%			3.708**		2.141**
Mean planting dates		83.792	83.787	73.323	
LSD 5%			0.835**		

Crop Growth Rate (CGR) (g m^{-2} day^{-1})

The results of Tables (5) and (6) indicate a significant effect among different seed priming treatments, dates, cultivars, and two-way interactions, and non-significant three-way interaction for both seasons. The second date, 15th June achieved a significant superiority with highest average of 19.238 and 19.606 g m^{-2} $day^{-1}$for both seasons, respectively, which did not differed significantly from the first date, 1st June for the second season, as it achieved an average of 19.491 19.606 g m^{-2} day^{-1}, While, the third date, 1st July yielded the lowest average at 15.573 and 16.182 g m^{-2} day^{-1} for both seasons, respectively. The superiority of the second date, which did not differed significantly from the first date, could be attributed to an increases in leaf area resulting from the plant's tendency toward vegetative growth, i.e., an increases in net dry matter. Conversely, the last date resulted in a decreases in leaf area as the plant tends toward fruiting, where the number of leaves decreases (Muhammad,2008). The results indicate significant differences among cultivars in crop growth rate (Tables 5 and 6). Shimaa cultivar significantly outperformed by providing the highest average for that trait at 17.799 and 19.000 g m^{-2} day^{-1}, while the Lee 74 cultivar recorded the lowest average at 17.389 and 17.853 g m^{-2} day^{-1} for both seasons respectively. The reason for this could be attributed to the variability among cultivars in their response to photoperiod and temperature, leading to the accumulation of dry matter, which caused an increase in crop growth rate (Khan,2004). Alternatively, the superiority of the Shimaa cultivar for this trait may be due to its superiority in leaf area (Tables 3 and 4). Seed priming treatments differed in the crop growth rate, as shown in (Tables 5 and 6). The seed priming treatment with seaweed extract

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excelled by providing the highest average at 20.715 and 21.486 g m^{-2} day^{-1} for both seasons, respectively, which did not differed significantly from the seed priming treatment with potassium chloride, as it reached 20.283 and 21.365 g m^{-2} day^{-1}for both seasons, respectively. Compared to the non-primed seeds (dry seeds), it recorded the lowest average for this trait at 13.141 and 14.740 g m^{-2} day^{-1} for both seasons, respectively. The superiority could be attributed to the role of seaweed extracts in accelerating biochemical processes in plants due to their content of numerous nutrients, hormones, and vitamins, which improve the plant's efficiency in tolerating biotic and abiotic stresses, leading to an increase in crop growth rate (Al-Ubaidi,2009, Pramanick *et al*,2020). The results demonstrate the response of the crop growth rate trait to the interaction between cultivars and different seed priming treatments (Tables 5 and 6). The seed priming treatments with seaweed extract and potassium chloride outperformed significantly for the Shimaa cultivar by providing the highest average at 21.452 and 20.929, and 22.758 and 22.268 g m^{-2} day^{-1} respectively. This is in comparison to the dry seed treatment for both cultivars in the first season, which yielded the lowest average at 13.112 and 13.170 g m^{-2} day^{-1} respectively. Additionally, the dry seed treatment for the Lee 74 cultivar in the second season yielded the lowest average at 14.305 g m^{-2} day^{-1}. The results indicate the significance interaction between planting dates and cultivars of (Tables 5 and 6). The second date, 15th June for the Shimaa cultivar achieved a significant superiority with highest average at 19.669 g m^{-2} day^{-1} for the first season. While, the third date, July 1st, resulted in the lowest average for both cultivars at 15.791 and 15.355 g m^{-2} day^{-1}, respectively. In the second season, the Shimaa cultivar achieved a significant superiority in the first and second planting dates by providing the highest average at 20.246 and 20.375 g m^{-2}day^{-1} , respectively. This is in comparison to the third date for the Lee 74 variety, which recorded the lowest average at 15.985 g m^{-2}day^{-1}. The results also indicates the significance of the interaction between planting dates, and priming treatments for the first season only (Tables 5 and 6). The first date, June 1st, excelled for both seaweed extract and potassium chloride seed priming treatments, achieving the highest average at 22.295 and 21.814 g m^{-2} day^{-1}. respectively. While, the non-primed seed treatment (dry seeds) for the third date, July 1st, yielded the lowest average at 11.547 g m^{-2}day^{-1}.The results also indicate that the three-way interaction between dates, cultivar, and different priming treatments did not significant for both seasons.

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Table 5. Effect of seed priming, cultivars, planting dates, and their interactions on crop growth rate (CGR) (g m^{-2} day^{-1}) for 2022 growing season

Cultivars	Priming treatments	Planting season June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	17.977	18.700	15.423	17.367
	Dist. water	15.960	18.087	14.357	16.135
	Seaweed	21.610	23.700	19.047	21.452
	KCL	21.260	22.617	18.910	20.929
	Dry	12.877	15.243	11.217	13.112
Lee	GA3	18.417	18.427	14.677	17.174
	Dist. water	18.070	18.797	14.093	16.987
	Seaweed	20.647	20.890	18.393	19.977
	KCL	20.170	21.010	17.733	19.638
	Dry	12.723	14.910	11.877	13.170
LSD 5%			N.S		0.659**
Cultivars			planting dates * cultivars		Mean cultivars
Shaimaa		17.937	19.669	15.791	17.799
lee		18.005	18.807	15.355	17.389
LSD 5%			0.793**		0.362**
Treatments			planting dates * priming treatments		Mean priming
GA3		18.197	18.564	15.050	17.270
Dist. water		17.015	18.442	14.225	16.561
Seaweed		21.129	22.295	18.720	20.715
KCL		20.715	21.814	18.322	20.283
Dry		12.800	15.077	11.547	13.141
LSD 5%			0.808*		0.466**
Mean planting dates		17.971	19.238	15.573	
LSD 5%			0.788**		

Table 6. Effect of seed priming, cultivars, planting dates, and their interactions on crop growth rate (CGR) (g m^{-2} day^{-1}) for 2023 growing season

Cultivars	Priming treatments	Planting date June 1st	June 15th	July 1st	Cultivars * priming
Shaimaa	GA3	19.053	19.910	15.393	18.119
	Dist. water	17.377	18.020	14.647	16.681
	Seaweed	24.710	24.253	19.310	22.758
	KCL	24.033	23.240	19.530	22.268
	Dry	16.057	16.450	13.017	15.175
Lee	GA3	18.027	18.860	15.050	17.312
	Dist. water	18.067	17.787	15.060	16.971
	Seaweed	20.793	20.973	18.877	20.214
	KCL	21.577	20.890	18.920	20.462
	Dry	15.220	15.677	12.017	14.305
LSD 5%			N.S		0.780**
Cultivars			planting dates * cultivars		Mean cultivars
Shaimaa		20.246	20.375	16.379	19.000
lee		18.737	18.837	15.985	17.853
LSD 5%			0.342**		0.249**
Treatments			planting dates * priming treatments		Mean priming
GA3		18.540	19.385	15.222	17.716
Dist. water		17.722	17.904	14.854	16.826
Seaweed		22.752	22.613	19.094	21.486
KCL		22.805	22.065	19.225	21.365
Dry		15.639	16.064	12.517	14.740
LSD 5%			12.517		14.740
Mean planting dates		19.491	19.606	16.182	
16.182			0.249**		

CONCLUSION

The field experiment conducted over two summer seasons was aimed to assess the impact of seed priming and planting dates on the growth of two soybean cultivars. Results revealed that the 15th June planting date yielded the highest average for plant height and crop growth rate. The Shaimaa cultivar exhibited superior performance in leaf area and crop growth rate, surpassing even in plant

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height. Among the seed priming treatments, seaweed extract demonstrated excellence in leaf area and crop growth rate, while KCl treatment excelled in plant height. In conclusion, the June 15th planting date, coupled with the Shaimaa cultivar and seaweed extract seed priming treatment, emerged as the optimal combination for enhancing soybean growth

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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تأثير تنشيط البذور ومواعيد الزراعة في بعض صفات النمو لصنفين من فول الصويا

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المستخلص

أجريت تجربة حقلية لمعرفة تأثير تحضير البذور ومواعيد الزراعة في نمو صنفين من فول الصويا . أجريت الدراسة خلال الموسمين الصيفيين 2022 و 2023 في حقول علوم الهندسة الزراعية – جامعة بغداد ، باستعمال تصميم RCBD بترتيب الألواح المنشقة – المنشقة بثلاثة مكررات و بثلاثة عوامل تضمن العامل الرئيسي مواعيد الزراعة (1 / 6 و 15 /6 و 7/1) والعامل الثانوي صنفين من فول الصويا (Lee 74 و شيماء) والعامل تحت الثانوي معاملات تنشيط البذور ، والعامل الثالث معاملات تنشيط البذور (حامض الجبرلين ، KCl ، ومستخلص الطحالب البحرية فضلا عن معاملتي المقارنة (نقع بالماء المقطر والبذور الجافة). أظهرت النتائج تفوق موعد الزراعة 15 حزيران حيث حقق أعلى متوسط لارتفاع النبات ومعدل نمو المحصول. أظهر صنف الشيماء أعلى متوسط في مساحة الأوراق ومعدل نمو المحصول، في حين تفوق أيضًا في ارتفاع النبات. تفوقت معاملة تنشيط البذور بمستخلص الأعشاب البحرية في مساحة الورقة ومعدل نمو المحصول، بينما تفوقت معاملة KCL في ارتفاع النبات. وبشكل عام، أظهر موعد زراعة 15 حزيران وصنف الشيماء تفوقاً، بالإضافة إلى معاملة تحفيز البذور بمستخلص الأعشاب البحرية.

الكلمات المفتاحية: المدى البيئي الواسع، فول الصويا ،منظمات النمو، مستخلص الطحالب البحرية

***جزء من اطروحة دكتوراه للباحث الأول**