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المجلة العراقية لبحوث السوق
وحماية المستهلك

EFFECT OF SEEDS PRIMING AND SOWING DATES ON VIABILITY AND VIGOUR OF TWO SOYBEAN (GLYCINE MAX L.) SEEDS CULTIVARS

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ABSTRACT

A laboratory experiment was conducted during the seasons of 2023 and 2024 in the Seed Technology Laboratory, Department of Field Crops- College of Agricultural Engineering Sciences - University of Baghdad, using a Completely Randomized Design (CRD) according to factorial experiments with four replicates and three factors. The first factor was planting dates (1 june , 15 june and 1 july), the second factor was two soybean cultivars (Lee 74 and Shaimaa), and the third was seed priming treatments (GA3 300 mg L-1 , KCl 30 g L-1, and seaweed extract 3 ml L-1, in addition to two control treatments: soaking in distilled water and dry seeds). The results showed the superiority of the June 15th planting date and achieved the highest average radicle length, plumule length, seedling dry weight, and seedling vigor index. The Shaimaa cultivar exhibited the highest average in all the mentioned traits above. The seed priming treatment with seaweed extract excelled in radicle length and seedling vigor index, while the KCl treatment outperformed in seedling dry weight and plumule length. Overall, the planting date of June 15th and the Shaimaa cultivar showed superiority, along with the seed priming treatment with seaweed extract.

Key words: Wide environmental range, seed quality, seed priming, germination characteristics.

تأثير تنشيط البذور ومواعيد الزراعة في حيوية وقوة البذور الناتجة لصنفين من فول الصويا

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الخلاصة

تم تنفيذ تجربة مختبرية خلال الموسمين 2023 و 2024 في مختبر تكنولوجيا البذور التابع الى قسم المحاصيل الحقلية- كلية علوم الهندسة الزراعية- جامعة بغداد، باستعمال تصميم CRD وفق التجارب العاملية بأربعة مكررات بثلاثة عوامل، العامل الرئيسي مواعيد الزراعة (1/ حزيران و 15/ حزيران و 1/ تموز) والعامل الثانوي صنفين من فول الصويا (Lee 74 و الشيماء) والعامل تحت الثانوي معاملات تنشيط البذور (حامض الجبرلين بتركيز 300 ملغم لتر-1،

[*] **This article is taken from the doctoral dissertation of the first researcher.**

KCl بتركيز 30غم لتر-1، ومستخلص الطحالب البحرية بتركيز 3 مل لتر-1، فضلا عن معاملتي المقارنة نقع بالماء المقطر والبذور الجافة). أظهرت النتائج تفوق موعد الزراعة 15 حزيران حيث حقق أعلى متوسط لطول الجذير والرويشة والوزن الجاف للبادرة ودليل قوة البادرة. أظهر صنف الشيماء أعلى متوسط في جميع الصفات المذكورة في أعلاه. تفوقت معاملة تنشيط البذور بمستخلص الطحالب البحرية في طول الجذير ودليل قوة البادرة، بينما تفوقت معاملة KCL في الوزن الجاف للبادرة وطول الرويشة. وبشكل عام، أظهر موعد زراعة 15 حزيران وصنف الشيماء تفوقاً، بالإضافة إلى معاملة تحفيز البذور بمستخلص الطحالب البحرية.

الكلمات المفتاحية: المدى البيئي الواسع، جودة البذور، نقع البذور، خصائص الإنبات.

INTRODUCTION

Soybean (*Glycine max* L.) is considered a complete source of proteins needed by the body for those who wish to eliminate animal meats. It is the only crop among all field crops that contains the eight essential amino acids necessary for human and animal growth, excluding sulfur-containing amino acids such as cysteine and methionine. Its seeds contain a high percentage of protein (36-40%) and oil (14-26%), rich in folic acid, vitamin K, calcium, magnesium, iron, and fiber. Moreover, its seeds contain about 400% of the amino acids, especially lysine, which has equal value and quality to proteins found in milk and meat. They also have a high percentage of beneficial fats, reaching up to 19%, particularly omega-3 and linolenic acids, which are heart-friendly unsaturated fatty acids that do not cause obesity or arterial sclerosis. Additionally, soybeans contain nutrients, phenols, antioxidants, and flavonoids **(Hossain *et al.*, 2019).** Furthermore, its seeds are utilized as a raw material in many food industries such as vegetable oil production, dyes, and solid fats. Additionally, soybean meal serves as a fundamental ingredient in animal feed formulations. Moreover, soybean cultivation contributes to improving soil properties and fertility due to the presence of root nodules bacteria that fix atmospheric nitrogen and supply plants with the necessary nutrients for growth **(Naseralla *et al.*, 2002; Abass, 2003; Sousa *et al*., 2014; Awoda, 2015).**

Despite the importance of this crop, its cultivation faces several challenges, especially in arid and semi-arid regions (including Iraq). One of the main challenges is the decrease in seed germination capability, which hinders seedling emergence and uniformity of growth and development. All of these factors negatively impact the field establishment of the plant and the final yield of this strategic crop **(Al-Baldawi & Hamza, 2017; Saudi, 2017a; Shihab & Hamza, 2019).** Therefore, many researchers have directed numerous studies and utilized various methods to develop soybean cultivation. One of the more economical agricultural techniques employed is seed priming, which is a common practice aimed at reducing the time between seed sowing and seedling emergence. This technique accelerates and enhances seed germination and field emergence, positively impacting field establishment (achieving optimal plant density) under a wide range of environmental conditions **(Al-Haidary *et al.*, 2018; AL-Rawi & Cheyed, 2018; Mustafa *et al.*, 2020; Kadhim & Hamza, 2021a).** These techniques are cost-effective and highly efficient. They can be implemented by soaking the seeds in various nutrient solutions **(Hamza & Ali, 2017).** There are several methods for seed priming, including priming with water only (Hydro priming), hormonal and plant growth regulator priming (Hormonal priming), priming with solutions containing osmotic agents (Osmo priming), or treating seeds with high or low-temperature conditions (Thermo priming), among other methods of seed pre-treatment. Most of these techniques aim to increase both germination and field establishment rates under natural environmental conditions and stress conditions. Additionally, they are important for promoting uniform seedling emergence, growth, and crop harvest simultaneously **(Hamza *et al*., 2019; Kadhim & Hamza, 2021b).**

In recent years, various plant growth regulators have been widely used to narrow the gap between laboratory germination rates and field emergence (**Jadoua & Najm, 2017).** These regulators also enhance plant tolerance to different environmental stresses by regulating responses to such stresses through control of various physiological processes, including drought, salinity, heat, and water stress, among others. Additionally, they can accelerate or delay germination, growth, flowering, and ripening, which positively impacts growth rates and yields **(Saudi, 2012; Saudi, 2017c; Al-Jaf, 2022).**

The modern trend worldwide is to reduce the use of synthetic chemical fertilizers due to their health, environmental, and economic hazards. Therefore, it is essential to find natural alternatives, such as using seaweed extracts in seed priming technology. Seaweed extracts are characterized by their non-toxicity, environmental friendliness, and low cost. They contribute to most important physiological functions of any crop, promoting growth, as they are rich in plant hormones such as auxins, gibberellins, and cytokinins, as well as macro and micro nutrients, essential amino acids, and vitamins. They also play a crucial role in regulating cell components and enhancing resistance to biotic and abiotic stresses. Additionally, they increase the chlorophyll content in leaves, leading to improved efficiency of both carbon assimilation and respiration processes **(Al-Maleky, 2013; Hussain & AL-Rawi, 2023; Saudi & Al-Rawi, 2023).**

The suitable planting date is a significant factor affecting various stages of plant growth and development, as well as improving crop components. This is due to the increased efficiency of the crop in utilizing available climatic conditions during the season, including temperature, relative humidity, light intensity, and others, which positively impacts seed quality and yield. Moreover, the selection of cultivars is equally important as determining the most suitable planting dates for crop growth. It forms one of the foundations for the success of soybean cultivation, especially when some farmers, under certain conditions, opt to either advance or delay the planting date due to its association with suitable temperatures for successful germination, seedling growth, and development, as well as its effects on plant growth stages and yield **(Al-Muaini & Al-Obaidi, 2018)**. This experiment was conducted to understand the impact of seed priming and planting dates on some laboratory traits of the resulting seeds from the field experiment of two soybean cultivars.

MATERIALS AND METHODS

The laboratory experiment was conducted at the Seed Technology Laboratory, Department of Field Crops- College of Agricultural Engineering Sciences - University of Baghdad, during the seasons of 2023 and 2024. The purpose was to conduct seed viability tests on seeds resulting from the field experiment for the seasons of 2022 and 2023. The experimental design used was a Completely Randomized Design (CRD) following factorial experiments with four replications and three factors. The first factor was planting dates (1june, 15 june and 1july), the second factor was two cultivars of soybeans (Lee 74 and Shaimaa), and the third factor was seed priming treatments, which included 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 at a concentration of 3 ml L^{-1}, in addition to two control treatments (soaking in distilled water and dry seeds). Two hundred seeds were randomly selected from each treatment of the resulting seeds. Then, the seed samples were sterilized with a 1% sodium hypochlorite solution for three minutes, followed by rinsing with distilled water to eliminate the chlorine effect. Subsequently, the sterilized seeds were divided into four replicates, with 50 seeds for each replicate. Both the germinating medium and all tools used for germination were sterilized with alcohol to protect the seeds from fungal and bacterial infections. The laboratory experiment was conducted using a germination apparatus, which was set and maintained at a temperature of (25±2°C) and a humidity level of 80%. The seeds were sown using the paper towel roll method for a duration of 8 days (**ISTA, 2021**).

1. The standard laboratory germination rate in the final count (%):

Natural prodromes were calculated only after the end of the examination period (eight days), then the results were converted into a percentage (ISTA, 2021) according to the following law: Germination percentage in the final count (%) = (number of natural seedlings after 8 days/ number of total seeds) x 100

2. Radicle and plumule length (cm), **in the standard laboratory germination test**:

Ten natural seedlings were selected after the examination period (eight days). The radicle and plumule were then separated from their attachment point to the seed. The length of the radicle and plumule was measured individually using a ruler, and the average lengths were calculated for each. (**ISTA, 2021**).

3. Dry weight of seedlings (mg): The same natural seedlings used to measure radicle and plumule length were used for the purpose of conducting the dry weight test. The cotyledons and seed coat were removed from the natural seedlings resulting from the standard laboratory germination test. The seedlings were then placed in perforated paper bags and dried in an electric oven at 75°C for 24 hours. After cooling for half an hour, they were weighed using a sensitive electronic balance, and the average dry weight of the seedlings was extracted. (**ISTA, 2021**).

4.Seedling vigor index: The seedling vigor index was calculated using the following equation:

Seedling vigor index = % germination × [radicle length (cm) + plumule length (cm)]. (**ISTA, 2021**).

Statistical Analysis: The data were statistically analyzed for the studied traits using analysis of variance (ANOVA) to compare the means of treatments at a significance level of 5%. (**Steel & Torrie, 1981**).

RESULTS AND DISCUSSION

The standard laboratory germination rate in the final count (%)

The results of tables 1 and 2 indicate a significant effect of seed priming treatments, planting dates, cultivars, and the interaction between cultivars, seed priming treatments, and the interaction between planting dates and cultivars, as well as the interaction between planting dates and seed priming treatments, and the three-way interaction between planting dates, cultivars, and seed priming treatments on the standard laboratory germination rate in the final count (%).

The second planting date, June 15th, showed a significant superiority, as it achieved the highest consecutive averages of 82.900% and 83.425% for both seasons, respectively. Meanwhile, the third planting date, July 1st, recorded the lowest consecutive averages of 75.975% and 74.750% for both seasons, respectively. The superiority of the June 15th planting date may be attributed to the optimal utilization of ideal environmental conditions and its positive reflection on the physiological potential of the resulting seeds **(Bornhofen *et al.*, 2015).**

The results of tables 1and 2 showed the significant superiority of the cultivar "Shaimaa", as it achieved the highest consecutive averages of 82.167% and 80.533% for both seasons, respectively. Meanwhile, the cultivar "Lee 74" achieved the lowest consecutive averages of 77.150% and 77.500% for both seasons, respectively. The variation between cultivars may be attributed to genetic control or differences in the rates of metabolic compounds and other raw materials transferred from the mother plant to the resulting seeds **(Elsahooki & Chiyad, 2023).**

Seed priming treatments had a significant impact, as the treatment with marine algae extract achieved the highest consecutive averages of 89.000% and 89.500% for both seasons, respectively. Meanwhile, the dry seed treatment recorded the lowest consecutive averages of 65.000% and 65.667% for both seasons, respectively. The reason may be attributed to the role of marine algae extracts containing compounds capable of stimulating the proteinase enzyme, which in turn breaks down proteins during germination initiation **(Saudi & Al-Rawi, 2023).**

The interaction between cultivars and seed priming treatments had a significant superiority for the "Shaimaa" cultivar treated with marine algae extract, achieving the highest consecutive averages of 92.667% and 91.833% for both seasons, respectively. This did not differ significantly from seeds of the same cultivar treated with potassium chloride, which recorded averages of 91.500% and 90.333% for both seasons, respectively. Compared to the dry seed treatment for the "Lee 74" cultivar, which recorded the lowest average of 64.417% for the first season only, the dry seed treatment for the "Shaimaa" cultivar recorded the lowest average of 65.000% for the second season only. This did not differ significantly from the dry seed treatment and distilled water-treated seeds for the "Lee 74" cultivar, which recorded consecutive lowest averages of 66.333% and 67.667% for the second season only.

The interaction between planting dates and cultivars had a significant impact, as the second planting date, June 15th, for the "Shaimaa" cultivar achieved the highest average of 86.150% for the first season only. Meanwhile, the third planting date, July 1st, for the "Lee 74" cultivar recorded the lowest average of 74.950% for the first season only. This did not differ significantly from the first planting date for the same cultivar, which recorded an average of 76.850% for the first season only.

Regarding the interaction between planting dates and seed priming treatments, it was observed that seeds primed with marine algae extract and planted on the second date, June 15th, achieved the highest average of 92.750% for the first season only. This did not differ significantly from seeds primed with marine algae extract and planted on the first date, June 1st, as well as seeds treated with potassium chloride and gibberellic acid, and planted on the second date, June 15th, which recorded averages of 90.000%, 91.750%, and 90.250%, respectively, for the first season only. On the other hand, seeds treated with potassium chloride and planted on the second date, June 15th, outperformed, achieving an average of 93.500% for the second season only. This did not differ significantly from seeds primed with marine algae extract and planted on both the first and second dates, as well as seeds treated with gibberellic acid and planted on the second date, June 15th, which recorded averages of 92.750%, 90.750%, and 89.750%, respectively, for the second season only. Comparing to the dry seed treatment planted on the third date, July 1st, which gave the lowest averages of 62.375% and 63.625% for both seasons respectively, it did not differ significantly from the dry seed treatment planted on the first date, June 1st, which gave 65.250% for the second season only.

The three-way interaction between planting dates, cultivars, and seed priming treatments had a significant effect on the standard laboratory germination rate in the final count (%). Seeds of the "Shaimaa" cultivar primed with marine algae extract and planted on the second date, June 15th, achieved the highest average of 97.000% for the first season only. This did not differ significantly from seeds of the same cultivar primed with marine algae extract and planted on the first date, June 1st, as well as seeds treated with potassium chloride and planted on both the first and second dates, recording averages of 95.000%, 96.000%, and 94.500%, respectively. Comparing to the dry seed treatment for the "Shaimaa" cultivar planted on the third date, July 1st, which gave the lowest average of 60.500%, it did not differ significantly from the dry seed treatment for the "Lee 74" cultivar planted on the second and third dates, which recorded consecutive averages of 62.750% and 64.250% for the first season only.

Table (1): Effect of seed priming, planting dates, and their interaction on the standard laboratory germination rate in the final count (%) of soybean seeds produced for the season 2023.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	85.000	94.000	77.250	85.417
	Dist. water	74.000	75.750	77.250	75.667
	seaweed	95.000	97.000	86.000	92.667
	KCL	94.500	96.000	84.000	91.500
	Dry	68.250	68.000	60.500	65.583
Lee 74	Gibberellin	81.500	86.500	79.000	82.333
	Dist. water	72.000	73.000	70.500	71.833
	seaweed	85.000	88.500	82.500	85.333
	KCL	79.500	87.500	78.500	81.833
	Dry	66.250	62.750	64.250	64.417
Lsd 5%		0.440*			0.254*
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		83.350	86.150	77.000	82.167
Lee 74		76.850	79.650	74.950	77.150
Lsd 5%		1.903**			1.099**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		83.250	90.250	78.125	83.875
Dist. water		73.000	74.375	73.875	73.750
seaweed		90.000	92.750	84.250	89.000
KCL		87.000	91.750	81.250	86.667
Dry		67.250	65.375	62.375	65.000
Lsd 5%		2.775**			1.602**
Planting date mean		80.100	82.900	75.975	
Lsd 5%		1.233**			

Table (2): Effect of seed priming, planting dates, and their interaction on the standard laboratory germination rate in the final count (%) of soybean seeds produced for the season 2024.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	85.000	90.000	76.500	83.833
	Dist. water	72.000	75.000	68.000	71.667
	seaweed	95.000	94.000	86.500	91.833
	KCL	91.500	96.500	83.000	90.333
	Dry	65.500	66.750	62.750	65.000
Lee 74	Gibberellin	83.000	89.500	79.000	83.833
	Dist. water	63.750	71.000	68.250	67.667
	seaweed	86.500	91.500	83.500	87.167
	KCL	81.500	90.500	75.500	82.500
	Dry	65.000	69.500	64.500	66.333
Lsd 5%		N.S			3.229**
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		81.800	84.450	75.350	80.533
Lee 74		75.950	82.400	74.150	77.500
Lsd 5%		N.S			1.756**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		84.000	89.750	77.750	83.833
Dist. water		67.875	73.000	68.125	69.667
seaweed		90.750	92.750	85.000	89.500
KCL		86.500	93.500	79.250	86.417
Dry		65.250	68.125	63.625	65.667
83.425		74.750			2.283**
Planting date mean		78.875	83.425	74.750	
Lsd 5%		2.397**			

Radicle length (cm)

The results of tables (3, 4) indicated a significant effect among different seed priming treatments, planting dates, soybean cultivars, and their interactions on radicle length of the resulting seeds, except for the interaction between planting dates and cultivars, which was not significant for both seasons. The second planting date, June 15th, showed a significant superiority, with average lengths of 4.998 and 5.003 cm for both seasons, respectively. While, the first planting date for the first season recorded the lowest average length of 4.749 cm, which was not significantly different from the third planting date, July 1st, for the second season, at 4.770 cm. The superiority of the second planting date, June 15th, could be attributed to the longer period from planting to full maturity, providing ample opportunity for cell division and elongation, which positively affected the physiological potentials of the produced seeds, leading to the superiority of most laboratory traits, including radicle length **(Bin Shuaib, 2004; Al-Jumaili, 2007; Bornhofen *et al.*, 2015).**

The data in tables (3 and 4) also indicated a significant difference among soybean cultivars in their effect on radicle length. The Shaimaa cultivar achieved a significant superiority with the highest average length of 4.860 and 4.993 cm for both seasons, respectively. While, the Lee 74 cultivar achieved the lowest average length of 4.728 and 4.784 cm for both seasons, respectively. The increase in radicle length of the resulting seeds can be attributed to the genetic nature of the cultivars, which positively responded to environmental conditions and led to increased cell division and elongation rates, consequently enhancing this trait. These results are consistent with findings by **Mahmoud *et al*., (2017)**, who found significant differences for most traits among soybean cultivars. Furthermore, these results align with those of **Saudi (2013), Awoke (2022), Dawood & Jaddoa (2023).**

The results of seed priming treatments had a significant effect. The treatment with seaweed extract seed priming achieved the highest averages of 6.071 and 6.079 cm for both seasons, respectively. These averages were not significantly different from the treatment with potassium chloride seed priming (5.995 and 5.941) cm for both seasons, respectively. While, the dry seed treatment recorded the lowest averages at 3.568 and 3.582 cm for both seasons, respectively. The superiority of seaweed extract seed priming treatments in this trait may be attributed to its fundamental role in enhancing cellular metabolic activity due to the presence of some growth-promoting substances within its composition, such as indole acetic acid, along with gibberellins, cytokinins, micronutrients, vitamins, and amino acids **(Mathur *et al.*, 2015; Pacholczak *et al.*, 2016).** These results align with findings by **Begum *et al.* (2018),** highlighting the physiological and significant role of marine extracts in improving crop performance and productivity **(Al-Fahdawi & Mustafa, 2023).**

Table (3): Effect of seed priming, planting dates, and their interaction on radicle length (cm) of soybean seeds produced for the season 2023.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	4.422	5.020	4.113	4.518
	Dist. water	3.875	4.118	3.968	3.987
	seaweed	5.871	6.562	5.873	6.102
	KCL	5.950	6.078	5.998	6.009
	Dry	3.396	3.603	4.055	3.685
Lee 74	Gibberellin	4.373	4.718	4.748	4.613
	Dist. water	4.398	4.120	4.153	4.224
	seaweed	5.893	6.135	6.093	6.040
	KCL	5.955	5.945	6.045	5.982
	Dry	3.355	3.685	3.313	3.451
Lsd 5%		0.440*			0.254*
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		4.703	5.076	4.801	4.860
Lee 74		4.695	4.721	4.770	4.728
Lsd 5%		NS			0.102
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		4.398	4.869	4.431	4.566
Dist. water		4.137	4.119	4.061	4.105
seaweed		5.882	6.349	5.983	6.071
KCL		5.953	6.012	6.022	5.995
Dry		3.376	3.644	3.684	3.568
Lsd 5%		0.243			0.180
Planting date mean		4.749	4.998	4.836	
Lsd 5%		0.154			

Table (4): Effect of seed priming, planting dates, and their interaction on radicle length (cm) of soybean seeds produced for the season 2024.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	4.757	5.167	4.718	4.881
	Dist. water	3.980	4.152	4.115	4.082
	seaweed	6.325	6.151	5.875	6.117
	KCL	5.919	5.947	5.978	5.948
	Dry	4.050	4.080	3.688	3.939
Lee 74	Gibberellin	4.434	5.035	4.406	4.625
	Dist. water	3.964	4.268	4.050	4.094
	seaweed	6.382	5.850	5.888	6.040
	KCL	6.065	5.873	5.863	5.934
	Dry	3.044	3.508	3.123	3.225
Lsd 5%		NS			0.214**
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		5.006	5.099	4.875	4.993

Lee 74	4.778	4.907	4.666	4.784
Lsd 5%	NS			0.097**
Treatments	Treatments x planting dates			Treatments mean
Gibberellin	4.596	5.101	4.562	4.753
Dist. water	3.972	4.210	4.083	4.088
seaweed	6.354	6.001	5.882	6.079
KCL	5.992	5.910	5.921	5.941
Dry	3.547	3.794	3.406	3.582
lsd5%	0.262**			0.151**
Planting date mean	4.892	5.003	4.770	
Lsd 5%	0.096*			

Plumule Length (cm)

The results in Tables (5 and 6) indicated a significant effect of different seed priming treatments, planting dates, soybean cultivars, and some of their interactions on plumule length of the resulting seeds. However, the three-way interaction was not significant for the first season only. Additionally, the two-way interaction between cultivars and treatments, as well as the two-way interaction between planting dates and cultivars, was also not significant. The second planting date, June, 15th achieved a significant superiority with the highest average of 4.216 and 4.176 cm for both seasons, respectively. While, the third planting date recorded the lowest average at 3.901 and 3.803 cm for both seasons, respectively. This difference was not statistically significant compared to the first planting date in the first season, which yielded an average of 3.913 cm. The superiority of the second planting date in this trait may be attributed to the increased efficiency of the crop to utilize the available climatic conditions during that period, such as temperature, relative humidity, light intensity, duration, and other factors, which positively reflected on the superiority in that trait **(Al-Muaini & Al-Obaidi, 2018).**

The results indicated a significant difference among cultivars in their effect on this trait (Tables 5 and 6). The Shaimaa cultivar achieved a significant superiority, providing the highest average of 4.094 and 4.055 cm for both seasons, respectively. In contrast, the Lee 74 cultivar obtained the lowest average at 3.926 and 3.889 cm for both seasons, respectively. The superiority of the Shaimaa cultivar may mainly be attributed to the rates of metabolic compounds and other raw materials transferred from the mother plant to the seed, which control this genetic trait. Additionally, there might be genetic dominance within the seed itself **(Ngalamu *et al.*, 2013; Al-Jumaili, 2014; Elsahooki & Chiyad, 2023).**

The results indicate that seed priming treatments had a significant effect. The treatment with potassium chloride achieved the highest average at 4.582 cm, which was not significantly different from the treatment with seaweed extract, as it provided an average of 4.484 cm in the first season. However, in the second season, the seaweed extract seed priming treatment outperformed by providing the highest average at 4.443 cm, which was not significantly different from the potassium chloride seed priming treatment (4.378 cm), compared to the dry seed treatment, which recorded the lowest average of 3.115 and 3.242 cm for both seasons, respectively. The superiority in this trait in the first season may be attributed to the role of potassium chloride and its positive effect on increasing cell division and elongation, leading to strong seedlings that grow and develop better, resulting in increased accumulation of nutrients in the seedling tissues, and positively affecting plumule length **(Saudi, 2017a**). These results are consistent with findings from **Goudarz *et al.*, (2012), Sadeghi *et al,*. (2011),** who affirmed that soybean seeds primed with potassium chloride solution achieved the highest average for this trait. Furthermore, the superiority of seaweed extract-primed seeds in the second season can be attributed to their nutritional content, such as iron, copper, zinc, cobalt, molybdenum, manganese, nickel, as well as growth regulators like auxins, gibberellins, cytokinins, and various vitamins and amino acids **(Cheyed & AL-Rawi, 2018; Okasha *et al.*, 2019).** These results align with **Saudi (2017b),** indicating the significant role of the components within seaweed extract in efficiently receiving solar radiation and converting it into nutrients, ultimately contributing positively to the superiority in this trait.

Table (5): Effect of seed priming, planting dates, and their interaction on plumule length (cm) of soybean seeds produced for the season 2023.

Cultivar	**Treatments**	**Planting dates**			**Cultivar x Treatments**
		June 1st	**June 15th**	**July 1st**	
AL-Shaimaa	Gibberellin	4.460	4.550	3.848	4.286
	Dist. water	3.650	3.748	3.698	3.699
	seaweed	4.342	4.910	4.695	4.649
	KCL	4.697	4.887	4.580	4.721
	Dry	3.091	2.990	3.265	3.115
Lee 74	Gibberellin	3.977	4.360	3.855	4.064
	Dist. water	3.626	3.785	3.660	3.690
	seaweed	4.135	4.748	4.071	4.318
	KCL	4.033	4.915	4.380	4.443
	Dry	3.117	3.266	2.960	3.114
lsd5%		NS			0.171
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		4.048	4.217	4.017	4.094
Lee 74		3.778	4.215	3.785	3.926
lsd5%		0.137*			0.079**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		4.219	4.455	3.852	4.175
Dist. water		3.638	3.767	3.679	3.695
seaweed		4.239	4.829	4.383	4.484
KCL		4.365	4.901	4.480	4.582
Dry		3.104	3.128	3.113	3.115
lsd5%		0.274**			0.158**
Planting date mean		3.913	4.216	3.901	
lsd5%		0.155**			

Table (6): Effect of seed priming, planting dates, and their interaction on plumule length (cm) of soybean seeds produced for the season 2024.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	4.080	4.738	3.800	4.206
	Dist. water	3.939	3.603	3.866	3.803
	seaweed	4.636	5.015	4.067	4.573
	KCL	4.060	4.933	4.122	4.372
	Dry	3.350	3.139	3.474	3.321
Lee 74	Gibberellin	3.938	3.993	3.920	3.950
	Dist. water	3.638	3.523	3.738	3.633
	seaweed	3.953	4.898	4.090	4.314
	KCL	4.788	4.410	3.955	4.384
	Dry	2.983	3.503	3.000	3.162
Lsd 5%		0.323			ns
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		4.013	4.286	3.866	4.055
Lee 74		3.860	4.065	3.741	3.889
Lsd 5%		NS			0.097**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		4.009	4.366	3.860	4.078
Dist. water		3.789	3.563	3.802	3.718
seaweed		4.295	4.957	4.079	4.443
KCL		4.424	4.672	4.039	4.378
Dry		3.167	3.321	3.237	3.242
Lsd 5%		0.228**			0.132**
Planting date mean		3.937	4.176	3.803	
Lsd 5%		0.092**			

Seedling dry weight (mg)

The results from tables 7 and 8 indicate a highly significant effect among different seed priming treatments, sowing dates, cultivars, and their interactions on the dry weight of the seedling (mg) for the resulting seeds. With the exception of the interaction between sowing dates and treatments, which was not significant for the first season only, the second sowing date on June 15 showed a significant superiority with the highest average weight of 0.476 and 0.489 mg for both seasons, respectively. While, the third sowing date on July 1 recorded the lowest average weight of 0.432 and 0.452 mg for both seasons, respectively, which did not significantly differ from the first sowing date for the second season only, as it yielded an average weight of 0.446 mg. The superiority of the second sowing date on June 15 for this trait can be attributed to the early dates' optimal utilization of prevailing environmental conditions during seed maturity stages, leading to improved growth and yield components. This positively reflected on enhancing most germination traits of the resulting seeds, including the dry weight of the seedling **(Muhammd, 2008; Umburanas *et al.*, 2019).**

The results also indicated a significant difference among cultivars in their effect, where the Shaimaa cultivar achieved a significant superiority with the highest average weight of 0.463 and 0.492 mg for both seasons, respectively. While, the Lee 74 cultivar recorded the lowest average weight of 0.439 and 0.433 mg for both seasons, respectively. The superiority of the Shaimaa cultivar in the dry weight of the seedling can be attributed to structural differences in the genes controlling this trait, which positively manifested in the phenotypic behavior of this trait **(Saudi, 2017c).** These results align with findings by **Latique *et al.* (2014).**

The results also indicated that seed priming treatments had a significant effect, with the potassium chloride seed priming treatment achieving the highest averages of 0.571 mg. This was not significantly different from the seaweed extract seed priming treatment, which recorded an average of 0.558 mg for the first season. However, in the second season, the seaweed extract seed priming treatment outperformed, achieving the highest average of 0.600 mg, which was not significantly different from the potassium chloride seed priming treatment, recording an average of 0.592 mg. When compared to the dry seed treatment, which recorded the lowest average for at 0.296 and 0.311 mg for both seasons, respectively, there were no significant differences with the control treatment (distilled water priming) for the second season only, as it gave the lowest average of 0.317 mg.

The reason for the superiority of the potassium chloride seed priming treatment in the first season may be attributed to the increased rates of cellular metabolism in seeds primed with this solution, which is responsible for the activity of hydrolytic enzymes breaking down stored materials in the cotyledons. This led to an increase in seed vigor and subsequently produced strong seedlings with high dry matter content. Additionally, the superiority of this treatment can be attributed to its inherent superiority in the plumule length trait (Table 5 and 6), which is consistent with findings by **Sadeghi (2011); Saudi (2017a)**. Similarly, the reason for the superiority of the seaweed extract seed priming treatment in the second season may be due to its high levels of growth regulators, amino acids, and various macro and micronutrients that stimulate cell division and expansion. This leads to balanced physiological and vital processes, reflecting positively on the superiority of this trait. These results are consistent with the findings of **Amabika & Sujatha (2015)**; **Saudi (2017b)**

Table (7): Effect of seed priming, planting dates, and their interaction on seedling dry weight (mg) of soybean seeds produced for the season 2023.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	0.431	0.507	0.438	0.459
	Dist. water	0.393	0.369	0.336	0.366
	seaweed	0.548	0.620	0.578	0.582
	KCL	0.580	0.635	0.551	0.589
	Dry	0.314	0.320	0.328	0.321
Lee 74	Gibberellin	0.479	0.501	0.437	0.472
	Dist. water	0.344	0.368	0.373	0.362
	seaweed	0.545	0.561	0.499	0.535
	KCL	0.545	0.579	0.538	0.554
	Dry	0.278	0.301	0.237	0.272
Lsd 5%		0.048*			0.027**
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		0.453	0.490	0.446	0.463
Lee 74		0.438	0.462	0.417	0.439
Lsd 5%		0.023*			0.014**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		0.455	0.504	0.438	0.466
Dist. water		0.368	0.368	0.355	0.364
seaweed		0.546	0.590	0.538	0.558
KCL		0.563	0.607	0.545	0.571
Dry		0.296	0.311	0.282	0.296
Lsd 5%		NS			0.019**
Planting date mean		0.446	0.476	0.432	
Lsd 5%		0.018**			

Table (8): Effect of seed priming, planting dates, and their interaction on seedling dry weight (mg) of soybean seeds produced for the season 2024.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	0.504	0.560	0.496	0.520
	Dist. water	0.376	0.414	0.364	0.385
	seaweed	0.567	0.715	0.566	0.616
	KCL	0.564	0.593	0.605	0.588
	Dry	0.337	0.353	0.364	0.351
Lee 74	Gibberellin	0.464	0.488	0.446	0.466
	Dist. water	0.267	0.236	0.248	0.250
	seaweed	0.568	0.602	0.579	0.583
	KCL	0.581	0.639	0.569	0.597
	Dry	0.236	0.290	0.286	0.270
Lsd 5%		0.052*			0.030**
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		0.470	0.527	0.479	0.492
Lee 74		0.423	0.451	0.425	0.433

Lsd 5%	0.013*			0.008**
Treatments	Treatments x planting dates			Treatments mean
Gibberellin	0.484	0.524	0.471	0.493
Dist. water	0.321	0.325	0.306	0.317
seaweed	0.568	0.659	0.573	0.600
KCL	0.573	0.616	0.587	0.592
Dry	0.286	0.322	0.325	0.311
Lsd 5%	0.037*			0.021**
Planting date mean	0.446	0.489	0.452	
Lsd 5%	0.016**			

Seedling vigor index

The results from Tables 9 and 10 indicate a significant high effect between different seed priming treatments, sowing dates, cultivars, and their interactions on the seedling vigor index for the resulting seeds. The second sowing date, June15th, showed significant superiority by providing the highest mean at 701.510 and 707.010, for both seasons respectively. These values did not significantly differ from the first sowing date's mean value for the first season only, which were 699.860. On the other hand, the third sowing date, July1st, recorded the lowest mean values at 643.570 and 613.620, for both seasons respectively. The reason for the superiority of the second sowing date, June15th, could be attributed to the early sowing dates from the beginning of May to mid-June, which excelled in most growth traits and yields, positively influencing the improvement of most germination traits for the resulting seeds, including the seedling vigor index trait. These results align with previous findings by **Muhammd (2008); Umburanas *et al*. (2019).**

The results also indicated a significant difference among cultivars in their effect on this trait. The cultivar Shaimaa showed significant superiority with the highest mean of 716.647 and 677.973 for both seasons respectively. In contrast, the cultivar "Lee 74" achieved the lowest mean at 646.647 and 637.933 for both seasons respectively. The reason for the superiority of the Shaimaa cultivar in this trait could be attributed to its higher seed content of stored materials, allowing the seeds to absorb water more quickly and efficiently during the early stages of germination. Consequently, its performance was better than that of the "Lee 74" cultivar, which positively influenced the seed vigor index **Saudi (2017c)**. These results are consistent with the findings of **Latique *et al.*, (2014).**

The results also indicated that seed priming treatments had a significant effect, with the treatment of priming seeds with seaweed extract achieving the highest means of 837.550 and 809.233 for both seasons respectively. These means did not significantly differ from the treatment of seed priming with potassium chloride, which recorded a mean of 833.017 for the first season only.Comparatively, the dry seed treatment recorded the lowest mean for this trait, reaching 439.683 and 446.683 for both seasons sequentially. The reason for this could be attributed to the role of seaweed extract in regulating and accelerating the transfer of carbon metabolism products from the source (leaves) to the sink (seeds) during seed formation and development stages. This increased the content of manufactured materials in the seeds, resulting in the production of high-vigor and high-performance seeds, which in turn led to superiority in this trait (Saudi, 2017). These findings are consistent with those of **Amabika & Sujatha (2015).**

The results also indicated that the activation treatments had a significant effect, as the seaweed extract seed activation treatment achieved the highest averages average of 837.550 and 809.233 for the two seasons, respectively, which did not differ significantly from the potassium chloride seed activation treatment, which recorded an average of 833.017 for the first season only, when compared to the dry seed treatment, which recorded the lowest average at 439.683 and 446.683 for the two seasons, respectively. The reason for this may be attributed to the role of seaweed extract in regulating and accelerating the transfer of photosynthetic products from the leaves (source) to the seeds (sink) during the stages of seed formation and development, which increased the seed content of manufactured materials and thus produced high-quality seeds. The performance and vigor, which in turn led to the superiority of that trait **Saudi (2017 b)**. These results agree with those found by **Amabika & Sujatha, (2015).**

Table (9): Effect of seed priming, planting dates, and their interaction on seedling vigor index of soybean seeds produced for the season 2023.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	749.100	773.600	676.400	733.033
	Dist. water	764.800	549.200	550.100	621.367
	seaweed	939.600	965.600	790.200	898.467
	KCL	864.100	948.600	804.500	872.400
	Dry	474.700	469.200	430.000	457.967
Lee 74	Gibberellin	699.600	750.900	655.600	702.033
	Dist. water	535.300	539.200	544.100	539.533
	seaweed	760.600	783.900	785.400	776.633
	KCL	772.300	814.300	794.300	793.633
	Dry	438.500	420.600	405.100	421.400
lsd5%		62.130**			35.870**
Cultivar		Cultivar x date			Cultivar mean
AL-Shaimaa		758.460	741.240	650.240	716.647
Lee 74		641.260	661.780	636.900	646.647
Lsd 5%		39.590**			22.860**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		724.350	762.250	666.000	717.533
Dist. water		650.050	544.200	547.100	580.450
seaweed		850.100	874.750	787.800	837.550
KCL		818.200	881.450	799.400	833.017
Dry		456.600	444.900	417.550	439.683
Lsd 5%		43.930**			25.360**
Planting date mean		699.860	701.510	643.570	
lsd5%		22.970**			

Table (10): Effect of seed priming, planting dates, and their interaction on Seedling vigor index of soybean seeds produced for the season 2024.

Cultivar	Treatments	Planting dates			Cultivar x Treatments
		June 1st	June 15th	July 1st	
AL-Shaimaa	Gibberellin	733.300	773.800	627.500	711.533
	Dist. water	547.000	555.900	539.400	547.433
	seaweed	870.300	918.500	745.900	844.900
	KCL	829.500	887.400	750.700	822.533
	Dry	440.700	483.500	466.200	463.467
Lee 74	Gibberellin	733.400	725.200	699.300	719.300
	Dist. water	471.000	539.100	538.900	516.333
	seaweed	806.600	850.800	663.300	773.567
	KCL	700.900	853.500	697.300	750.567
	Dry	399.600	482.400	407.700	429.900
Lsd 5%		34.300**			19.800**
Cultivar		Cultivar x date			Cultivar mean
Shaimaa		684.160	723.820	625.940	677.973
lee		622.300	690.200	601.300	637.933
Lsd 5%		18.610*			10.740**
Treatments		Treatments x planting dates			Treatments mean
Gibberellin		733.350	749.500	663.400	715.417
Dist. water		509.000	547.500	539.150	531.883
seaweed		838.450	884.650	704.600	809.233
KCL		765.200	870.450	724.000	786.550
Dry		420.150	482.950	436.950	446.683
Lsd 5%		24.250**			14.000**
Planting date mean		653.230	707.010	613.620	
Lsd 5%		11.890**			

CONCLUSION

From the aforentione results, it can be concluded that the planting date from June 15th to July 1st achieved significant superiority in all studied traits. Also, seed priming of soybean seeds with seaweed extract at a concentration of 3 ml L^{-1} improved the standard laboratory germination traits of the resulting seeds. Based on this, it is suggested to consider planting the Shaimaa cultivar with primed seeds using seaweed extract before planting. Furthermore, conducting further studies to evaluate the effect of priming soybean seeds using different concentrations of seaweed extract is recommended. Additionally, analytical studies should be conducted on the resulting plants to understand the physiological and biochemical changes occurring in the plant as a result of seed priming with seaweed extract, and its impact on the nature of plant growth and increasing seed yield.

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