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Minimizing Salt Stress Influence on Growth and Yield of Soybean Cultivars Through Foliar Application of Kinetin

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ABSTRACT

To minimize salt stress effect on soybean growth and yield using foliar application of kinetin, an experiment applied in Field Crops Research Station, Tikrit University. Two type of water (river and well), two application of kinetin (kinetin and without kinetin), and four soybean cultivars (Shaima, Laura, Dee and Lee) were used. The Randomize Complete Block Design (RCBD) arranged with spilt plot. The leaf area and leaf area index were calculated 80 days after planting (DAP). At the end of the season, the plant height, dry weight, and yield were calculated. The results showed that the effect of type of water, kinetin, and cultivars and the interaction among those factors were significantly affected the soybean traits. Watering soybean with river water increased leaf area and leaf area index 17%, plant height 12%, dry weight 30%, 100 seed weight 16%, and yield 17% comparison with soybean irrigated with well water. Soybean treated with kinetin increased leaf area and leaf area index 18%, plant height 14%, dry weight 12%, 100 seeds weight 10%, and yield 19% compared without kinetin. Shaima cultivar was higher in most of measured traits. The outcome of this study might be beneficial for the soybean farmers in Tikrit city area.

تقليل تأثير إجهاد الملح على نمو وإنتاجية أصناف فول الصويا من خلال التطبيق الورقي للكينيتين

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الخلاصة

لتقليل تأثير إجهاد الملح على نمو وحاصل فول الصويا باستخدام الرش الورقي للكينيتين، أجريت تجربة في محطة أبحاث المحاصيل الحقلية، جامعة تكريت. تم استخدام نوعين من ماء السقي (النهر والبئر)، واثنين من مستويات الكينيتين (كينيتين وبدون كينيتين)، وأربعة أصناف فول الصويا (شيماء ولورا ودي ولي). استخدم تصميم القطعات العشوائية بنظام المنشقة مرتين. تم حساب مساحة الأوراق ودليل المساحة الورقية بعد ٨٠ يوما من الزراعة. في نهاية الموسم ، تم حساب الوزن الجاف والحاصل أظهرت النتائج أن تأثير نوع الماء والكينيتين والأصناف والتفاعل بين هذه العوامل قد أثر بشكل كبير على صفات فول الصويا. أدى سقي فول الصويا بمياه النهر إلى زيادة مساحة الأوراق ودليل مساحة الأوراق بنسبة ١٧ ٪ ، والوزن الجاف ٣٠ ٪ ،والحاصل بنسبة ١٧ ٪ مع فول الصويا المروي بمياه الآبار. زاد فول الصويا المعالج بالكينيتين من مساحة الأوراق ودليل مساحة الأوراق بنسبة ١٨ ٪ ، والوزن الجاف بنسبة ١٢ ٪ ،والحاصل بنسبة ١٩ ٪ مقارنة بدون كينيتن. كان صنف شيماء أعلى

في معظم الصفات المقاسة. قد تكون نتائج هذه الدراسة مفيدة لمزارعي فول الصويا في منطقة مدينة تكريت.
الكلمات المفتاحية : فول الصويا، كينيتين، المياه المالحة، الإجهاد، الأصناف.

INTRODUCTION

Soybean yield Glycine max L. is one of the most important industrial summers cultivated legume crops rich in amino acids, fatty acids, carbohydrates and mineral nutrients (Pagano, 2016). The soybean crop is used to improve soil fertility through the biological fixation of nitrogen due to the symbiotic relationship with Rhizobium bacteria (Hasanuzzaman et al., 2016). Its seeds contain a high oil content ranging from 14-24 %, with a high nutritional value because it contains most of the unsaturated fatty acids such as linolenic, oleic, and linoleic. Soybean seeds also contain a high protein content of 30-50% (Carbor and Wilson, 1998). The cultivation of soybeans in Iraq in terms of cultivated area and productivity is considered compared to neighboring countries such as Iran, Turkey and Syria, the area planted with soybeans amounted to only 40 hectares with a productivity .(rate of 0.78 tons ha-1 (Arab Organization for agricultural development, 2022

Salt stress or soil salinity is one of the main environmental (non-biological) factors that impact plant growth, causing poor growth and productivity, and the problem of salt stresses increases in dry and semi-dry areas due to high temperatures (Munns and Gilliham, 2015). Due to climatic changes and the decline in the amount of fresh water suitable for agricultural uses, the problem of soil salinity is expected to worsen even more in the future and is also expected to become the main factor in reducing the productivity of field crops (Negrao et al., 2017). More than 25% of the world's arable land, in general, is affected by salt stress, and an estimated 5.1 million hectares of productive land are lost annually as a result of salt stress (Parihar et al., 2014). Salt stress generally reduces the ability of plants root system, including soybeans, which are sensitive to salinity, to absorb water and minerals, as well as reducing physiological activities such as deterioration of carbon metabolism due to excessive toxic and Ionic effects that lead to oxidative damage (Li et al., 2006). Growth regulators play a key role in increasing yield of soybean crop due to their active role in the division (growth) and differentiation (development) of plant cells, which contributes to raising their physiological effectiveness (absorption, photosynthesis, carbon metabolism, respiration and transpiration) (Shafique et al., 2023), and one of these organizations is the growth regulator kinetin of the cytokines group, which some studies have proven its importance in increasing the growth and production of soybeans (Soares et al., 2017) and its contribution to reducing the harm of about some environmental stresses (Hamayun et al., 2015). The study of the effect of kinetin in mitigating the damage caused by abiotic stresses of soybean plants is of great importance in helping the spread of crop cultivation in areas with high temperatures. It is irrigated through the use of relatively salty well water. The idea of using growth regulators to reduce non-biological stresses is not new, but it has not been studied on soybeans in the Saladin regions. Therefore, this study aimed to test the effect of irrigation water quality (well water and river water) on the growth and yield of soybean cultivars and to test the possibility of reducing the effect of salinity resulting from irrigation water on the growth and yield of these cultivars using the growth regulator kinetin.

MATERIALS AND METHODS

A field experiment was carried out at the Research Station located at the Field Crops Department, Agriculture College, Tikrit University throughout the summer season 2023 in gypsum soil (table 1). The experiment was applied using RCBD design with siplt-split plot arrangement (three factors) with three replications. The experiment included type of irrigation water (river water and well water), spraying kinetin (kinetin and without kinetin), and soybean cultivars (Shaima, Laura, Dee and Lee). The experiment soil was plowed two times using a plow to insure not to flip the gypsum soil from the top surface to the bottom, the water type was in main plot, kinetin was in sub-plot, and the cultivars were in sub-sub-plots. The area of the experimental unit was 9 m2 (3×3 m), the number of experimental units was 48 experimental units. The volume of fertilizers was applied before and after planting according to the recommendations. Urea as source of N was 50% of recommendation before planting and the other 50% when plant reach V4, and total amount was 120 kg ha -1. Triple superphosphate as source of P (46% P2O5) was add (80 kg per ha-1) at once before

planting. Soybean seeds were planted using 3-4 seeds per hole at a depth of 3 cm. The plants were thinned to one plant per spot after reaching the third true leaf stage (V3). The planting was done in longitudinal rows with a distance of 0.75 m between rows and 0.10 m between holes, on the date of 05-06-2023.

Irrigation was carried out using a drip irrigation method, with water lines isolated according to their source, river or well, each on its side. The experimental area was irrigated immediately after planting, and irrigation continued based on the plants' needs until the end of the season. The experimental area was manually weeded three times during the growing season.

At the end of the season, an analysis of soil electrical conductivity was conducted to assess the impact of the irrigation water by taking three random samples from different areas of the experiment (table 2).

Table 1. Analysis of the chemical, physical, and qualities of the experiment soil and irrigation water used in the experiment.

Soil traits	The value	Measurement units
pH	7.04*	
EC	2.61	Desi Sims meter^{-1}
CEC	10	Senti mol kg soil $^{-1}$
O.M	9.3	g Kg^{-1}
$CaCO_3$	120	g Kg^{-1}
$CaSO_4.2H_2O$	56.62	g Kg^{-1}
Dissolved ions in the soil, both positive and negative		
Ca^{++}	35.55	mm L^{-1}
Mg^{++}	26.25	
Na^{+}	6.956	
K^{+}	0.470	
SO_4^{-2}	19	
Cl^{-1}	5.2	
HCO_3^{-1}	7.2	
CO_3^{-2}	1.7	
Soil Texture	Sandy Clay Loam	
Clay	288	g Kg^{-1}
Loam	168	
Sand	544	
pH and electrical conductivity of the two types of irrigation water		
River water	pH	6.55
	EC	2.78
Well water	pH	7.16
	EC	0.47

*Soil and water analyses were conducted at the Department of Soil Science and Water resources at the Faculty of Agriculture, Tikrit University

Table 2. Sample rate showing the electrical conductivity of the experiment soil after the end of the season.

The samples	The EC
The soil irrigated with well water	7.74
The soil irrigated with river water	5.03

For preparation of kinetin, kinetin by mixing 400 mg per 7 L-1 to maintain concentration of 50 ppm, the mixer was sprayed twice when the plants reach the stage of the third true Leaf (V3), then spray when the plants reach the sixth true leaf (V6), and it was spraying the plants before sunset using a 16-liter back spray until the leaves of the plant are completely wet.

The leaf area and leaf area index were calculated 80 days after planting (DAP). At the end of the season, the plant height, dry weight, and yield were calculated.

RESULT AND DISCUSSION

1. Soybean Leaf Area

Leaf area is a one of crucial indicators of plant health, particularly in soybeans, as leaves are the primary surfaces for light absorption. This directly influences the plant's carbon metabolism. Therefore, leaf area is essential for maximizing the profits of soybean cultivation. As shown in table 3, the quality of irrigation water significantly affected the leaf area of soybean plants, with river water irrigation outperforming well water by up to 17%. The salinity levels in the irrigation water (Tables 1 and 2) increased soil salinity, negatively impacting the growth of soybean plants irrigated with well water, which led to a reduced. Thus, salinity from irrigation water caused water stress, hampering root absorption of water and nutrients and diminishing carbon metabolism, resulting in reduced leaf area. Similar findings were reported by Peña-Calzada et al. (2023) and Gobade et al. (2024). Spraying with kinetin significantly increased the leaf area of soybean plants by 8% compared to unsprayed soybean (table 3). This application plays a dynamic role in enhancing total chlorophyll content in the leaves and improves carbon metabolism (photosynthesis) efficiency (Yadav and Yadav, 2016), which further contributes to increased leaf area (Muthu et al., 2023). The Shaima cultivar exhibited a significant advantage over other cultivars, producing 12%, 17%, and 18% more leaf area than the Laura, Dee, and Lee, respectively, while the other cultivars did not show significant differences among themselves (table 4). Some cultivars, like Shaima, exhibit a greater capacity for chlorophyll production, enhancing light absorption and carbon metabolism efficiency, this characteristic leads to an increased relative growth rate, and subsequently a larger leaf area (Burroughs et al., 2023.(

Table 3. Evaluation of the effect of saline stretching formed by irrigation water using kinetin on the leaf area (cm2) of soybean cultivars.

Water type	Kinetin	Cultivars				Kinetin×water	Water type
		Shaima	Laura	Dee	Lee		
River	With out Kinetin	1953.8 ab	1685.4 cde	1564.9 def	1575.0 def	1694.8 b	1788.8 a
	Kinetin	2166.1 a	1885.5 bc	1742.8 bcd	1737.1 bcd	1882.9 a	
Well	With out Kinetin	1609.7 def	1378.6 fg	1305.9 g	1477.4 efg	1442.9 c	1486.9 b
	Kinetin	1697.1 b-e	1579.6 def	1464.8 efg	1382.1 fg	1530.9 c	
Without kinetin×cultivar		1781.7 ab	1532.0 d	1435.4 d	1526.2 d	Kinetin	
Kinetin×cultivar		1931.6 a	1732.5 bc	1603.8 bc	1559.6 cd	Without kinetin	Kinetin
Cultivar×river water		2059.9 a	1785.5 b	1653.8 bc	1656.0 bc	1568.8 b	1706.9 a
Cultivar×well water		1653.4 bc	1479.1 cd	1385.4 d	1429.8 d		
Cultivar		1856.6 a	1632.3 b	1542.9 b	1519.6 b		

* Similar characters mean no significant difference according to the Duncan polynomial test at probability level 0.05

Table 4 showed that the effect of bilateral interference of two kinetin × cultivars was significant in the leaf area, as the bilateral interference exceeded two kinetin × Shaima by giving the highest leaf area of the plant reached 1931.6 cm2, and did not differ significantly from the bilateral interference without kinetin × Shaima, which gave a leaf area of 1781.7 cm2, while the bilateral interferences without kinetin × Laura (1532.0 cm2) and without kinetin × dee (1435.4 cm2) and without kinetin ×Lee (1526.2 cm2) were the least significant in comparison with interferons of the same class and did not differ from each other. It is clear the influence of single factors in the bilateral overlap, as the distinction of the Shaima cultivars and its adaptation to the environment in comparison with the rest of the cultivars with its ability to benefit from kinetin may have contributed to the fact that the bilateral overlap of kinetin × Shaima is the highest significant for the quality of paper space.

In the same direction, it was found that the bilateral interference of kinetin × irrigation water significantly affected the average leaf area of soybean plants, as the bilateral interference of kinetin × river water was significantly higher than the rest of the interferences from the same category by

giving the highest leaf area (1882.9 cm2) while the bilateral interference without kinetin × well water was the least significant than the rest of the bilateral interferences of the same category (1442.9 cm2), and it is clear that the type of irrigation water (river) played a major role with the help of the growth regulator kinetin this helped to increase carbon representation, which made a difference in leaf area.

The impact of bilateral interference of cultivar × irrigation water significantly on the leaf area of soybean plants (table 3), as the bilateral interference of Shaima × river water significantly exceeded the rest of the bilateral interferences of the same category in the leaf area of soybean plants and amounted to 2059.9 cm2, while the bilateral interferences of Laura × well water (1479.1 cm2), Dee × well water (1385.4 cm2) and Lee × well water (1429.8 cm2) were the least morally they did not differ with each other (table 3). It seems that the influence of single significant factors (cultivars and irrigation water) contributed to the manifestation of significant bilateral overlaps of the leaf area attribute.

Triple interventions of kinetin × cultivar × irrigation water showed a significant effect on the leaf area of soybean plants. The triple interference of kinetin × Shaimaa × river water morally exceeded the rest of the triple interferences and amounted to 2166.1 cm2, and did not differ significantly from the triple interference without kinetin × Shaimaa × river water, which amounted to 1953.8 cm2, whereas the triple interferences without kinetin × Laura × well water (1378.6 cm2) and without kinetin × dee × well water (1305.9 cm2) and without kinetin × dee × river water (1477.4 cm2), Kinetin × dee × well water (1464.8 cm2) and kinetin × Lee × well water (1382.1 cm2) significantly differ from the rest of the triple interferences. The influence of individual factors (spraying with kinetin, cultivars, irrigation water quality) contributed to raising the relative growth rate, crop growth rate, and the rate of net photosynthesis, which led to an increase in the leaf area of the plant.

Leaf area index

The leaf area and its index are one of the most important qualities that depend on it in determining the health of plants and the extent to which the plant benefits from the planted area, as the leaf area index represents the extent to which the plant benefits from the leaf area to receive and absorb light in the specified area of the plant. Table 4 showed that the quality of irrigation water had a significant impact on the leaf area index of soybean plants, as irrigation with river water (2.38) significantly exceeded irrigation with well water (1.98) by up to 17%. The percentage of salinity in irrigation water (table 1 and 2) caused an increase in soil salinity, which reflected on the growth of soybean plants irrigated with well water and contributed to reducing their relative growth rate, and the rate of their net photosynthesis, which contributed to reducing the leaf area index of soybean plants irrigated with well water. The changes that occurred between plants irrigated with river water and well water and the resulting difference in leaf area (table 3) affected in the same direction as evidence of the correlation of the two qualities between them. Similar results were reported by Wen et al. (2023).

Table 4. Evaluation of the effect of saline stretching formed by irrigation water using kinetin on the leaf area index of soybean cultivars.

Water type	Kinetin	Cultivars				Kinetin×water	Water type
		Shaima	Laura	Dee	Lee		
River	With out Kinetin	2.60 ab	2.24 cde	2.08 dg	2.10 def	2.26 b	2.38 a
	Kinetin	2.89 a	2.51 bc	2.32 bcd	2.32 bcd	2.51 a	
Well	With out Kinetin	2.14 def	1.84 fg	1.74 g	1.97 efg	1.92 c	1.98 b
	Kinetin	2.26 b-e	2.11 def	1.95 efg	1.84 fg	2.04 c	
Without kinetin×cultivar		2.37 ab	2.04 d	1.91 d	2.03 d	Kinetin	
Kinetin×cultivar		2.58 a	2.31 bc	2.14 bcd	2.08 cd	Without kinetin	Kinetin
Cultivar×river water		2.75 a	2.38 b	2.20 bc	2.21bc	2.09 b	2.28 a
Cultivar×well water		2.20 bc	1.97 cd	1.85 d	1.91 d		
Cultivar		2.47 a	2.18 b	2.03 b	2.06 b		

* Similar characters mean no significant difference according to the Duncan polynomial test at probability level 0.05

Spraying soybean with kinetin significantly improved the leaf area index of soybean plants by 8% compared to plants that were not sprayed (Table 4). The process of spraying soybean plants with kinetin is important and has a vital and catalytic role in enhancing the chlorophyll content of leaves, as kinetin contributes to improving the efficiency of carbon metabolism (Yadav and Yadav, 2016), which contributes to increasing the leaf area (Muthu et al., 2023), which is reflected in the final result on its evidence.

The Shaima cultivar was significantly superior to the rest of the cultivars in the leaf area index by 12, 17 and 18% compared to Laura, Dee and Lee cultivars respectively, while the rest of the cultivars did not differ significantly from each other (table 4). Studies show that some cultivars have the ability to produce larger amounts of chlorophyll than others, so the Shaima cultivar, increasing the Leaf area and that might be enhances the plant's ability to absorb light and improve the efficiency of carbon metabolism, so these cultivars are distinguished from others by an increase in the relative growth rate, which contributes to an increase in their leaf area index (Burroughs et al., 2023). It is clear from table 4 that the effect of bilateral interference of kinetin × cultivars was significant in the leaf area index, as the bilateral interference exceeded kinetin × Shaima by giving the highest leaf area index of the plant at 2.58, and did not differ significantly from the bilateral interference without kinetin × Shaima, which gave a leaf area index of 2.37, while the bilateral interferences without kinetin × Laura (2.04), without kinetin × Dee (1.91), without kinetin × Lee (2.03) and without kinetin × Dee (2.14), and kinetin × Lee (2.08) were the least significant in comparison with interferons of the same category and did not differ from each other. The influence of single factors in the bilateral overlap was obvious, as the distinction of the Shaima cultivar and its adaptation to the environment compared to the rest of the cultivars with its ability to benefit from kinetin may have contributed to the fact that the bilateral overlap kinetin × Shaima is the highest moral of the leaf area index attribute .

Table 4 showed that the bilateral interference of two kinetin × irrigation water had a significant impact on the average leaf area index for soybean plants, as the bilateral interference of kinetin × river water was significantly higher than the rest of the interferences for the same category by giving the highest leaf area index (2.51), while the bilateral interference without two kinetin × well water (1.92) and without kinetin × well water (2.04) was the least significant. The water from river played a key role with the help of the growth regulator kinetin, which helped to increase carbon representation and leaf area, which made a difference in the leaf area index .

The effect of bilateral interference of irrigation water × cultivars was significant in the soybean plant leaf area index (table 4), as the bilateral interference of Shaima × river water was significantly higher than the rest of the bilateral interferences of the same category in the soybean plant leaf area index and amounted to 2.75, while the bilateral interferences of Laura × well water (1.97), Dee × well water (1.85) and Lee × well water (1.91) were the least significant and did not differ with each other (table 4). It seems that the influence of the single-semantic factors (cultivars and irrigation water) contributed to the manifestation of the significance of bilateral overlaps of the leaf area index attribute .

The triple interventions of kinetin × cultivars × irrigation water showed a significant effect in the leaf area index of soybean plants. The triple interference of kinetin × Shaima × river water morally exceeded the rest of the triple interferences and amounted to 2.89, and it did not differ morally from the triple interference without kinetin × Shaima × well water, which amounted to 2.60, while the triple interferences without kinetin × Laura × well water (1.84), without kinetin × Dee ×well water (1.74), without kinetin × Lee × water (1.97), and kinetin × Dee × well water (1.95), kinetin × Lee × well water (1.84) and without kinetin × Dee × river water (2.08) significantly differ from the rest of the triple interferences. The influence of individual factors

(spraying with kinetin, cultivars, and irrigation water quality) contributed to raising leaf area (table 3) which led to an increase in the leaf area index.

Plant dry weight

Dry weight is one of the important indicators in evaluating the performance of soybean plants and an effective indicator to determine the health of the plant and its productive capacity, as dry weight is used to estimate the biomass of the plant, and is also known as an important measure to understand the success of the growth process, and therefore the biomass formed reflects the ability of the plant to absorb nutrients and water and also reflects the efficiency of the carbon metabolism process .

Table 5 showed that the quality of irrigation water had a significant impact on the dry weight of soybean plants, as irrigation with river water morally exceeds irrigation with well water by up to 30%. The percentage of salinity in irrigation water (table 1 and 2) caused an increase in soil salinity, which was reflected in the growth of soybean plants. High salinity levels reduce the dry weight of plants due to water stress, impair the ability of roots to absorb water and nutrients, reduce carbon metabolism and reduce leaf area (table 3) and then reduced the dry weight. Similar results were reported by Munns and tester (2008), Xu and Zhou (2008), Raza and Wali (2015 .(

Spraying with a growth regulator (kinetin) had a significant effect on the dry weight of soybean plants by up to 12% compared to plants that were not sprayed (table 5). The process of spraying soybean plants with kinetin is important and has a vital and catalytic role in enhancing the content of leaves of the chlorophyll pigment of soybean plants, as kinetin contributes to improving the efficiency of carbon metabolism (Yadav and Yadav, 2016), which contributes to the dry weight of the plant (Ahmad and Jaleel, 2009 .(

Table 4. Evaluation of the effect of saline stretching formed by irrigation water using kinetin on the dry weight (g plant-1) of soybean cultivars.

Water type	Kinetin	Cultivars				Kinetin×water	Water type
		Shaima	Laura	Dee	Lee		
River	With out Kinetin	23.53 b	21.30 c	20.46 c	21.13 c	21.61 b	23.21 a
	Kinetin	28.61 a	24.15 b	22.36 bc	24.12 b	24.81 a	
Well	With out Kinetin	15.63 d	15.07 d	15.14 d	15.26 d	15.28 d	16.27 b
	Kinetin	20.89 c	15.80 d	15.67 d	16.69 d	17.26 c	
Without kinetin×cultivar		19.58 bc	18.19 cd	17.80 d	18.19 cd	Kinetin	
Kinetin×cultivar		24.75 a	19.98 b	19.58 bc	20.41 b	Without kinetin	Kinetin
Cultivar×river water		26.07 a	22.73 b	21.41 d	22.63 b	18.44 b	21.04 a
Cultivar×well water		18.26 c	15.44 d	15.41 d	15.97 d		
Cultivar		22.16 a	19.08 b	18.41 b	19.30 b		

* Similar characters mean no significant difference according to the Duncan polynomial test at probability level 0.05

The Shaimaa cultivar was significantly superior in giving the highest dry weight by 14, 17 and 13% over the Laura, Dee and Lee cultivars, respectively, whereas the rest of the cultivars did not differ significantly from each other (table 5). Studies showed that some cultivars have the ability to produce larger amounts of chlorophyll than others, which enhances their ability to absorb light and improve the efficiency of carbon metabolism, so these cultivars are distinguished from others by adding dry weight during their life cycle compared to others (Bheemanahalli et al., 2022).

Table 5 exhibited that the effect of bilateral interference of kinetin × cultivars was significant in the dry weight for soybean plant, as the bilateral interference exceeded kinetin × Shaima by giving the highest dry weight, which was 24.75 g plant-1, while the bilateral interference without kinetin × Dee (17.80 g plant-1) was the least significant and did not differ from the bilateral interferences without kinetin × Lee and without kinetin × Laura, which amounted to 18.19 G plant-1 compared to the rest of the bilateral interferences of the same category. The distinction of the Shaima cultivar and its adaptation to the environment compared to other cultivars with its ability to benefit from kinetin may have contributed to the fact that the double overlap of kinetin × Shaima is the highest significant for the dry weight of the plant.

Similarly, it was found that the bilateral interference of kinetin × irrigation water had a significant impact on the dry weight of soybean, as the bilateral interference of kinetin × river water was significantly higher than the rest of the interventions and for the same category by giving the highest dry weight rate (24.81 g plant-1) while the bilateral interference without kinetin × well water decreased significantly from the rest of the bilateral interventions of the same category (15.28 g plant-1) (table 5), and it is clear that the type of irrigation water (river) plays a major role with the help of the growth regulator, kinetin had contributed to an increase in carbon metabolism, which made a difference in the dry weight of the plant. Also, the effect of bilateral interference of cultivars × irrigation water had a significant impact on the dry weight of the plant (table 5), as the bilateral interference of Shaima × river water was significantly higher than the rest of the bilateral interferences of the same category in the dry weight of soybean and amounted to 26.07 g plant-1, while the bilateral interference of Dee × well water (15.41 g plant-1) and did not differ significantly from the bilateral interferences of Laura × well water (15.44 g plant-1) and Lee × well water (15.97 g plant-1) (table 5). It seems that the influence of single significant factors (cultivars and irrigation water) contributed to the appearance of the significance of bilateral connections.

Triple interventions of kinetin × cultivars × irrigation water showed a significant effect on the dry weight of the plant for the soybean crop. The triple interference of kinetin × Shaima × river water significantly topped the rest of the triple interference by dry weight and amounted to 28.61 g plant-1, while the triple interference without kinetin × Shaima × well water decreased (15.63 g plant-1) and without kinetin × Laura × well water (15.07 g plant-1) and without kinetin × Dee × well water (15.14 g plant-1) and without kinetin × Lee × well water (15.26 g plant-1), kinetin × Laura × well water (15.80 g plant-1), kinetin × Dee × well water (15.67 g plant-1) and kinetin × Lee × well water (16.96 g plant-1) significantly differ from the rest of the triple interventions. The influence of individual factors (spraying with kinetin, cultivars, irrigation water quality) contributed to raising leaf area, which led to the above results.

Yield

The yield of soybean plants is influenced by biological and abiotic factors related to the quality of genetic structures and the environmental conditions in which it grows, therefore, table 6 showed that irrigation water has significantly affected the yield of soybean plants, as the plants irrigated with river water gave a seed yield of 2040 kg ha-1, morally superior to the plants irrigated with well water, which gave a seed yield of 1690 kg ha-1, with a percentage of more than 17 %. The quality of irrigation water affected the relative growth rate, leaf area (table 3) and leaf area index (table 4), and dry weight (table 5), so that reflected to the yield of soybean. Similar results were reported by Han et al. (2023) and Welshaboury et al. (2024 .(

Table 4. Evaluation of the effect of saline stretching formed by irrigation water using kinetin on the yield (kg ha-1) of soybean cultivars.

Water type	Kinetin	Cultivars				Kinetin×water	Water type
		Shaima	Laura	Dee	Lee		
River	With out Kinetin	2220 a-d	1820 c-g	1750 c-g	1480 f-i	1820 b	2040 a
	Kinetin	2640 a	2250 abc	2090 b-e	2100 b-e	2270 a	
Well	With out Kinetin	1920 c-f	1170 hi	1690 d-h	1320 ghi	1520 c	1690 b
	Kinetin	2570 ab	1580 e-i	1090 i	2180 a-d	1860 b	
Without kinetin×cultivar		2070 bc	1490 e	1720 cde	1400 e	Kinetin	
Kinetin×cultivar		2600 a	1920 bcd	1590 de	2140 b	Without kinetin	Kinetin
Cultivar×river water		2430 a	2030 bc	1920 bc	1790 c	1670 b	2060 a
Cultivar×well water		2240 ab	1380 d	1390 d	1750 cd		
Cultivar		2340 a	1700 b	1650 b	1770 b		

* Similar characters mean no significant difference according to the Duncan polynomial test at probability level 0.05

Spraying soybean plants with a growth regulator (kinetin) resulted in a significant impact on the yield, as the plants sprayed with kinetin produced a yield of 2060 kg ha-1, morally superior to the plants that were not sprayed with a growth regulator, which gave a yield of 1670 kg ha-1, an increase of 19 % (table 6). The effect of kinetin was apparent on the growth qualities (leaf area, leaf area index, and dry weight), which contributed to led an increase in yield. Similar results were reported by Passos et al. (2001) and Soares et al. (2017).

Table 6 showed that the Shaima cultivar was decently greater to the rest of the cultivars and gave the peak yield of 2340 kg ha-1, while the rest of the cultivars decreased morally from the Shaima cultivar, but did not differ among themselves, as the Laura cultivar gave a yield of 1700 kg ha-1, the Dee Cultivar had a yield of 1650 kg ha-1 and the Lee Cultivar had a yield of 1770 kg ha-1 (table 6). Cultivars differ among themselves in terms of their chlorophyll content (Reddy et al., 2000 and pirdashti et al., 2010), their susceptibility to carbon metabolism (Li et al., 2017) and, consequently, on the production of pods (Burroughs et al., 2023) and the final result is the difference in the yield (Bheemanahalli et al., 2022).

The effect of bilateral interference of kinetin × cultivars significantly affected the yield of soybean plants (table 6), as bilateral interference exceeded kinrtin × Shaima by producing the highest seed yield of 2060 kg ha-1, while bilateral interference without kinetin ×Lee (1400 kg ha-1) was the least significant and did not differ from bilateral interferences without kinetin × Laura (1490 kg ha-1) and without kinetin ×Dee (1720 kg ha-1) and kinetin × Dee (1590 kg ha-1). The dissimilarity of the Shaima cultivar and its adaptation to the environment in comparison with the rest of the cultivars with its ability to benefit from kinetin may have contributed to the fact that the bilateral overlap of kinetin × Shaima was the highest moral characteristic of the final product.

Similarly, it was found that the bilateral interference of kinetin × irrigation water had a significant impact on the final plant yield, as the bilateral interference of kinetin × river water was significantly higher than the rest of the interventions and for the same category by giving the highest yield rate (2270 kg ha-1) while the bilateral interference without kinetin × well water decreased significantly from the rest of the bilateral interventions of the same category (1520 kg ha-1), and it was clear that the type of irrigation water (river) plays a major role with the help of the growth regulator it contributed to an increase in carbon representation, which made a difference in the weight of the final result .

Table 6 showed that the effect of bilateral interference of cultivars × irrigation water had a significant impact on the yield of soybean plants, as the bilateral interference of Shaima × river water significantly exceeded the rest of the bilateral interferences of the same category in the content of the seed yield and amounted to 2430 kg ha-1, and did not differ significantly from the bilateral interference of Shaima × well water, which gave a yield of 2240 kg ha-1, while the bilateral interference of Laura × well water (1380 kg ha-1) was the least significant in the amount of the quotient did not differ significantly from the two interferences Dee × well water (1390 kg ha-1) and Lee × well water (1750 kg ha-1) (table 6). It seems that the influence of single significant factors (cultivars and irrigation water) contributed to the indicator of the significance of bilateral overlaps .

Table 16 showed that the triple interactions of kinetin × cultivars × irrigation water had a significant effect on the yield of soybean plants. The triple interference of kinetin × Shaima × river water morally exceeded the rest of the triple interferences with the final result and amounted to 2640 kg ha-1, and it did not differ morally from the triple interferences without kinetin × Shaimaa × river water (2220 kg ha-1), kinetin × Shaimaa × well water (2570 kg ha-1) and kinetin × Lee × well water (2180 kg ha-1), while the triple interference recorded a well with a lower yield of 1090 kg ha-

1 and did not differ significantly from triple overlaps and without kinetin × Lee × river water (1480 kg ha-1) and without kinetin × Laura × well water (1170 kg ha-1) and without kinetin × Lee × well water (1320 kg ha-1), and kinetin × Laura × well water (1580 kg ha-1). The influence of individual factors (spraying with kinetin, cultivars, irrigation water quality) contributed to raising leaf area (table 3), leaf area index (table 4), and dry weight for soybean plants (table 5), which led to the above results.

CONCLUSIONS

This study compared the effects of a type of irrigation water and growth regulator, kinetin, on some soybean cultivars to enhance their salinity resistance and growth. Experiments showed that kinetin application improved soybean growth traits, such as leaf area, leaf area index, dry weight, and yield even under saline conditions. Additionally, kinetin assisted mitigate salinity stress by enhancing metabolic activities of plants. These outcomes indicate that kinetin was an effective tool for refining soybean adaptability to salinity, thereby enhancing productivity in salinity-affected areas. This underscores the need for mixing water management strategies with growth regulators to boost agricultural production in challenging environments.

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