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COMPARISON OF THE ROLE OF GROWTH REGULATORS AND ITS IMPACT ON YIELD AND YIELD COMPONENTS OF RICE UNDER SALINE STRESS

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Abstract

A field experiment was carried out at the research station of the College of Agricultural Engineering Sciences, University of Baghdad, Jadriya in the summer season of 2018, with the aim of comparing the role of growth regulators in reducing the effect of irrigation with salt water on yield and yield component of rice (Anbar 33). A Randomized Complete Block design was used in the arrangement of split plot distribution with three replicates. The main plots occupied the salinity concentrations of irrigation water (irrigation with river water, 4, 6, and 8 dis m^{-1}), which is symbolized by S0, S1, S2, and S3 respectively, while growth regulators operated the sub-plots (Naphthalene acetic acid, kinetin, Abscisic acid, Brassinolide, and distilled water) symbolized as NAA, KIN, ABA, BR, and C respectively). All soil and crop management operations have been performed according to the approved scientific recommendations. Results showed the effects of salinity levels are significantly reduce yield trait and its components. The treatment of saline water at salinity level of 8 dis m^{-1} (S3) did not give the plant any output in the traits of yield and its components, while the salinity level of 6 dis m^{-1} (S2) significantly affect in decrease the number of active tillers by 44.01%, number of grains per panicle by 29.12%, 1000 grains weight by 39.30%, and total yield by 60.61% compared to the control treatment (S0). Application of growth regulators reduced the negative effect of irrigation water salinity of on yield trait and all yields components of the rice crop. Spraying with NAA growth regulator outperformed the number of active tillers, number of grain in panicles, weight of 1000 seeds, and paddy rice yield increased by 56.59%, 27.36%, 35.47% and 42.25%, respectively. The growth regulators however had a significant effect in reducing the damage of saline water on the studied characteristics, especially in the low salinity levels. Thus, it can be recommended to add NAA to the rice subject to salt stress to improve its yield and its components.
***Keywords*:** growth regulators, rice, saline stress

Introduction

The problem of irrigation water salinity increases in the whole lands of the Mesopotamia for several reasons, the most important of which is poor management of water and field, and this has met a great research effort to get rid of the negative impact of worsening salinity.

Salinity affects the growth and development of all plants in all stages of their growth, and salt stress is one of the most important problems facing agricultural expansion as a result of the continuous increase in the proportion of lands affected by salts, including irrigated areas due to the excessive use of irrigation water and the lack of drainage networks performance (Zhang *et al*., 2010).

The effect of saline stress can be reduced by using growth regulators as one of the alternative solutions, despite their difference in the mode of action, as several types of them were used, including cytokinin, where cytokinin is one of the growth regulators that play an important role in plants tolerating various environmental stresses, including salt stress by stimulating roots absorbing water and nutrients from the soil by improving the communication between roots and vegetative system by transmitting food signals, as well as regulating the transpiration process by manipulating opening and closing stomata (Carey, 2008 and Taiz and Zeiger, 2002). As one of the Auxin, naphthalene acetic acid has a clear and effective role in increasing cell division and expansion, as it has a role in many physiological processes leading to plant growth and development as it stimulates cell division and elongation and stimulates apical dominance (Bakhsh *et al*., 2012). Abscisic acid (ABA) is a plant stress hormone and one of the most important Signaling molecules in plants. Increasing the levels of ABA in plant tissues under stress conditions improves the water content by controlling the opening and closing of stomata as well as inducing a number of genes that encode enzymes and help to withstand stresses (Culter *et al*., 2010 and Raghavendra *et al*., 2010). Brassinolide (BR) is one of the naturally occurring steroid plant growth regulators as BR has been found in a wide variety of plants including dicots, monocots, bare seeds and algae and in various plant parts such as pollens, leaves, flowers, seeds, buds, branches and stems (Wang *et al*., 1993). Brassinolide contribute to stress tolerance and affect plant resistance to a biotic stresses through its effect on the reproduction and translation process of the genes responsible for these stresses (Kagalo *et al*. 2007). So this research was conducted to measure the effect of each growth regulator in improving rice yield and yield components grown under saline stress.

Materials and Methods

This experiment was carried out at research station at College of Agricultural Engineering Sciences, University of Baghdad, Al- Jadriya during the summer season 2018, in order to compare the negative effect of saline stress on Rice crop (Amber-33). A randomized complete block design in Split-plot arrangement with three replicates was used. The main plots occupied with salinity concentrations of irrigation water (4, 6, and 8 dis m^{-1}) stated as S1,S2 and S3 as well as the control treatment (0.65 dis m^{-1}) (Tigris river water)(S0), while the sub-plots were occupied with the plant growth regulators (ABA, BR, KIN, and NAA) in concentrations of (3, 3, 5 and 200) mg l^{-1} respectively as well as the control treatment which were sprayed with distilled water (C). All soil and crop management processes were carried out according to the recommendations; the field was divided into experimental units spaced by 80 cm, and 40 cm between each sub plot, with area of (2*2) m^2 for each experimental unit.

The field was planted at 16/6/2018, each line spaced by 20 cm, and each experimental unit occupied with 10 lines. The DAP fertilizer was applied before planting (120 kg ha^{-1}), and potassium sulfate (96 kg ha^{-1}) in three batches, after a month of planting and after two months of planting and during the flowering stag. Urea fertilizer was applied (280 kg ha^{-1}) in three batches, after a month of planting and after two months from sawing dates planting and during the flowering stage. All agricultural operations have been carried out until maturity.

Results

Number of fertile tillers (per m^{-2})

The factors of saline stress and growth regulators and their interaction had a significant effect on the average number of fertile tillers (FT) of rice plant and their interaction (Table 1). Irrigation with salt water at all applied levels (except for S1) reduced the number of FT significantly compared to control treatment (S0), where the number of fertile tillers become 537.8 per m^{-2}, while the treatment of irrigation with 6 dis m^{-1} salinity (S2) gave the lowest average of the attribute amounted to 312.5 FT per m^{-2}. Spraying growth regulators resulted in an increase in the number of FT (except for ABA) and there was a significant effect among regulators in this trait. NAA gave the highest average number of fertile tillers amounting to 560.3 tiller per m^{-2}, while ABA treatment gave the lowest average reached 357.7 tillers (Table 1). The two factors of the study had a significant interaction in the number of fertile tillers when spraying with NAA at S1 level of salinity, as it gave the highest average reach 694.7 FT per m^{-2} compared to the irrigation combination of S2 salinity level sprayed with pure water (C) which gave the lowest average of the trait of 288.7 FT per m^{-2}.

Table 1 : Effect of salinity levels and plant growth regulators and their interaction on the number of fertile tillers per m^{-2} of rice.

Salinity levels	Plant growth regulators					Average
	BR	KIN	ABA	NAA	C	
S_0	605.1	573.4	400.5	672.2	541.5	**558.6**
S_1	552.8	556.3	376.3	694.7	508.8	**537.8**
S_2	334.5	330.6	295.0	313.9	288.7	**312.5**
L.S.D $_{0.05}$	69.8					**65.2**
Average	497.5	486.8	357.8	560.3	446.4	
L.S.D $_{0.05}$	**40.3**					

Number of grains per Panicle

The salinity levels of irrigation water and plant growth regulators and their interaction significantly affected the number of grains in panicle (Table 2), as the salinity levels of irrigation water decreased the number of grains per panicle increase, S2 treatment (6 dis m^{-1}) gave the lowest average (60.85 grain) in comparison with S0 treatment which gave the highest average of 85.85 grains, which did not differ significantly from salinity level of S1, it gave an average of 79.53 grains per panicles. It was clear from the use of growth regulators that they have an effective role in increasing the number of grains per panicle, as the NAA treatment outperformed and gave the highest average of 84.47 grains compared to control treatment (C) which gave the lowest average of the trait (66.32 grains). The interaction of salinity levels and growth regulators had a significant effect on the number of grains per panicle, as spraying with NAA under the S0 salinity level gave the highest average reaches 99.75 grains, while the treatment of distilled water under the salinity of S2 gave the lowest average attain 46.82grains per panicle.

Table 2 : Effect of salinity levels and plant growth regulators and their interaction on the number of grains per panicle.

Average	Plant growth regulators					Salinity levels
	BR	KIN	ABA	NAA	C	
85.85	91.40	88.08	70.28	99.75	79.75	**S_0**
79.53	84.43	81.00	64.62	95.17	72.41	**S_1**
60.85	61.45	69.36	68.15	58.49	46.82	**S_2**
9.74	12.11					**L.S.D $_{0.05}$**
	79.09	79.48	67.68	84.47	66.32	**Average**
6.99						**L.S.D $_{0.05}$**

Weight of 1000 grain (g)

The irrigation water salinity levels, growth regulators and their interaction had a significant effect on the weight of 1000 rice grains (Table 3), as it was shown that the irrigation treatment in river water (S0) was significantly superior by giving it the highest average trait amounting to 11.27 gm, while it did not differ from the irrigation treatment at S1 salinity level of which gave an average of 10.44 g, while the lowest mean average for the trait was 6.84 g, for S2 stress treatment, which was significantly decreased for all treatments. The results also showed that there was a significant effect of growth regulators on the weight of 1000 grains, as spray treatment excelled with NAA and gave the highest average reaching of 10.73 g, while ABA spray treatment gave the lowest average of 7.92 g. The results indicate that there is a significant interaction of regulators with salt concentrations, as the irrigation combination in river water (S0) with the NAA growth regulator gave the highest average trait of 13.28 g compared to the irrigation combination with S2 level of salinity and spraying with distilled water (C) which gave the lowest average trait of 5.21g.

Table 3 : Effect of salinity levels and plant growth regulators and their interaction on weight of 1000 rice grains (g).

Average	Plant growth regulators					Salinity levels
	BR	**KIN**	**ABA**	**NAA**	**C**	
11.27	11.90	12.09	8.06	13.28	10.99	**S_0**
10.44	10.94	10.70	7.89	12.65	9.98	**S_1**
6.84	6.72	8.21	7.78	6.26	5.21	**S_2**
1.35	1.49					**L.S.D $_{0.05}$**
	9.86	10.33	7.92	10.73	8.73	**Average**
0.86						**L.S.D $_{0.05}$**

Paddy rice yield (Kg ha^{-1})

Results revealed that irrigating with river water (S_0) gave the highest production average of paddy rice yield (1072 Kg ha^{-1}), which is not significantly different from 4 dis m^{-1} (S_1) (1020 Kg ha^{-1}), while the treatment S_2 gave the lowest value reached 422.2 Kg ha^{-1}(table 4). Also plant growth regulator NAA gave the highest rice yield reached (1010 Kg ha^{-1}), with non-significant difference from KIN which gave 899 Kg ha^{-1}, while the foliar application of ABA gave the lowest value reached 710 Kg ha^{-1}. The interaction between S_0 and NAA gave the highest value peaked at 1319 Kg ha^{-1}, while the interaction between S_2 and spraying with distilled water gave the lowest value reached 298 Kg ha^{-1}.

Table 4 : Effect of salinity levels and plant growth regulators and their interaction on paddy rice yield (kg ha^{-1}).

Salt Level	Plant growth regulators					Average
	C	**NAA**	**ABA**	**KIN**	**BR**	
S_0	956.1	1319.4	838.5	1135.3	1111.7	1072.4
S_1	885.6	1312.2	733.7	1021.9	1048.3	1020.5
S_2	298.3	400.6	458.1	541.4	414.9	422.4
L.S.D $_{0.05}$	237.3					185.2
Average	713.3	1010.7	710.5	899.5	857.3	
L.S.D $_{0.05}$	123.6					

Biological yield (g m^{-2})

Irrigation water salinity levels, plant growth regulators and their interference had a significant effect on the biological yield (Table 5). Salinity levels significantly affected in reducing biological yield, as the irrigation treatment in river water (S0) gave higher average of 1581.0 g m^{-2}, and did not differ Significantly from treatment salinity level S1, which gave an average of 66.1517 kg m^{-1}. Whereas, the S3 treatment gave the lowest mean value to 813.0 g m^{-2}. Growth regulators, however have a significant effect on most characteristics of growth and yield, which has been reflected in the biological yield trait. The NAA treatment have the superiority effect and gave the highest average of 1338.4 g m^{-2} and did not differ significantly from KIN effect which gave an average of 1292.4 g m^{-2} compared to the control treatment that gave the lowest average of 1146.2 g m^{-2}. The results also show a significant interaction between salt stress treatments and growth regulators as the S1 combined with NAA provide the highest average of trait (1809.5 g m^{-2}), while S3 combination and spraying with distilled water gave the lowest average of the trait of 725 g m^{-2}.

Table 5 : Effect of salinity levels and plant growth regulators and their interaction in biological yield (g m^{-2}) for rice plant.

Average	Plant growth regulators					Salinity levels
	BR	**KIN**	**ABA**	**NAA**	**C**	
1584.0	1694.0	1633.5	1281.5	1694.0	1617.0	S_0
1517.66	1807.0	1485.0	1241.9	1809.5	1241.9	S_1
1183.6	1221.0	1221.0	1375.0	1100.0	1001.0	S_2
813.0	830.0	830.0	930.0	750.0	725.0	S_3
177.0	247.0					L.S.D $_{0.05}$
	1388.7	1292.4	1207.100	1338.4	1146.2	Average
110.0						L.S.D $_{0.05}$

Harvest index (%):

The salinity levels of irrigation water had a significant effect in the harvest index, whereas plant growth regulators and their interaction with salinity did not have a significant effect (Table 6). Salinity of 4 dis m^{-1} (S1) treatment gave a higher average of harvest index of 6.98%, S0 treatment gave an average of 6.78%,which did not differ significantly. Whereas, S2 treatment gave the lowest harvest index of 3.65% meaning that salinity reduce the seed weight among the whole plant weight.

Table 6 : Effect of salinity levels and plant growth regulators and their interaction in rice harvesting index%.

Average	Plant growth regulators					Salinity levels
	BR	KIN	ABA	NAA	C	
6.78	6.73	6.50	6.50	7.81	5.89	S_0
6.98	6.48	7.09	6.65	7.33	7.37	S_1
3.65	3.68	4.42	3.36	3.69	3.11	S_2
2.12	N.S					L.S.D $_{0.05}$
	5.63	6.15	5.50	6.28	5.46	Average
N.S						L.S.D $_{0.05}$

Discussion

This study exhibits the harmful effects of saline stress on rice yield and all of the yield components. It has an effect in reducing the studded traits including number of active tillers, as it causes a decrease in the growth of cells and the ability to divide them due to the stress.Because the food needed for growth does not reach them properly ,this leads to a reduction in the number of effective branches (Zhao *et al.*, 2013). As well as the direct impact of salts on the emergence of the flower inflorescence, as it is one of the most rice plant stages sensitive to salinity (Rad *et al.*, 2012). Number of grains have reduced by salinity due to the damage caused by salinity in pollen grains vitality and reduction in their number, causing a reduction in fertility rate, which leads to the failure of a large percentage of eggs and the formation of grains or weakening the ability of the stigma to receive pollens (Abdullah and others, 2001 and Mohammed, 2000). Also salinity has a role in reducing the weight of 1000 grains by reducing the amount of carbohydrates formation as a result of reducing photosynthesis, which reduces The amount of accumulated material and its transference to seeds (Hasega wa *et al.*, 2000). This finding was consistent with the findings of Muhammad, (2000), and Hakim *et al.* (2014). The reason for yield reduction may due to the effect of saline stress all of growth characteristics and its effect on reducing yield components, which ultimately led to a decrease in the cereal yield, which represents the summary of the treatment effects on plant growth and its dynamic interactions, and thus reflected on the properties. This finding is consistent with the findings of (Al-Wakaa, 2018, Araf, Rad (2012), Muhammad (2000), Hakim, and others (2014).

Spraying growth regulators increased the plant's resistance to saline stress, which is represented by an increase in all growth characteristics and incidence, despite the variation in mode of affects. Spraying with NAA had a role in increasing the number of fertile tillers, number of grains, and the weight of 1000 grains, which was subsequently reflected in the total yield of the plant, and this may be due to the role of apical dominance stimulation when treating plant with NAA, as one of the Auxin inhibiting the growth of lateral buds, especially the ineffective ones. Allowing the distribution of photosynthates from source to sink adequately and uniformly (Liu *et al.*, 2011 and Ao *et al.*, 2010), this finding is consistent with Nataraj *et al.* (2016). The reason for this increment can be attributed to the role of growth regulators in improving the dry matter construction sources deposited in the photosynthesis process and increasing the efficacy of sink by storing those representations (Davies, 2010), this result is consistent with the findings of Khan and others (2016). And Narajis Jahan (2011) who found a significant decrease in this trait as NAA concentration increased. The NAA had a positive effect in increasing total grain yield as it stimulates the transport processes of photosynthesis products and their transformation into sink, by increasing the activities of the hydrolysis enzyme which positively reflected on grain yield (Elankavi *et al.*, 2009). From observing the interaction process, we conclude that growth regulators have a role in increasing most of the yield indicators especially in low salt stresses.

Conclusions

1. Irrigation with salt water had a negative effect on yield and yield characteristics of rice plant.
2. Irrigation with salinity of 4 dis m^{-1} did not have a negative effect on most of the yield characteristics, which makes it the upper limit (threshold) for the economical effect of salinity in the yield and quality of rice. While irrigation with 6 and 8 dis m^{-1} had adverse effects in all studied traits.
3. Spraying with growth regulators reduced the negative effect of salinity on most of the studied traits. NAA, among other regulators, excelled in reducing the effect of saline stress on most traits of yield and its components.
4. Growth regulators had a greater impact on lower salinity levels.

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