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COMPARISON OF THE ROLE OF PLANT GROWTH REGULATORS IMPACT ON GROWTH CHARACTERISTICS AND YIELD OF RICE UNDER SALINE STRESS CONDITION

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Abstract

A field experiment was conducted at College of agricultural engineering Sciences research station, University of Baghdad, Al-Jadriya in 2018 summer season, in order to compare the role of several plant growth regulators in reducing the effect of irrigation with salty water on growth and yield characteristics of Rice (Amber-33). A randomized complete block design in Split-plot distribution with 3 replicates was used. The main plots occupied by salinity levels of irrigation water (River water, 4, 6 and 8 dis m^{-1}) which were symbolized as S_0, S_1, S_2 and S_3 respectively, while the sub-plots were occupied with plant growth regulators (pgrs) (Naphthalene acetic acid, Kinetin, Abscisic acid, Brassinolide and distilled water) symbolized as NAA, KIN, ABA, BR and C respectively. All soil and crop management processes were carried out according to the scientific recommendations. Results revealed that salinity have significantly decreased all studied traits. The treatment of salt stress 8 dis m^{-1} (S_3) has significantly decreased the plant height, leaf area, growth rate, total chlorophyll content, dry weight and total tillers number by (48.59%), (50.57%), (44.97%), (50.32%), (53.84%) and (54.73%) respectively in comparison with S_0, plant did not give any yield at 8 dis.m^{-1} salinity level. Application of plant growth regulators has decreased the negative effect of salinity in all studied traits. The foliar spray of NAA has increased plant height, leaf area, growth rate and dry weight by (12.35%), (27.34%), (18.57%) and (13.09%) respectively. However, spraying KIN has significantly increased the total chlorophyll content (32.65%) and total tiller number (34.74%) in comparison with (C). It can be stated that plant growth regulators have a significant role in reducing salinity effect on the studied traits, especially at low salinity levels. Thus, it can be concluded that application of NAA to the rice plant under salt stress can be recommended to improve its growth and yield.

Key words: plant growth, rice, saline stress condition.

Introduction

Water salinity is a growing problem in Iraq because of mainly poor management of water and soil. This has been a major research effort to eliminate the negative impact of salinity. It affects the growth and development of all plants at all growth stages and the salt stress was considered as one of the most important problems that impedes the agricultural expansion as a result of the continuous increment in the proportion of land affected by salts, including irrigated areas due to excessive use of irrigation water and the lack of regulation of drainage networks (Zhang *et al*., 2010). The effect of salt stress can be reduced by applying plant growth regulators as an alternative solution in spite of their variable mode of action. Cytokinin (CK) is one of the growth regulators which play an important role in sustaining the plant to various environmental stresses, by stimulating water and nutrients absorption from soil and through improving transmission of nutritional signals between roots and vegetative growth, as well as regulating the transpiration through control the mechanism of opening stomata and stimulating the lateral buds growth (Carey, 2008 and Taiz and Zeiger, 2008). NAA is one of the important auxins that play a substantial role in cells division and enlargement, as well as many physiological processes which effect plant growth and development by stimulating apical dominance (Bakhsh *et al*., 2012). ABA is a plant stress hormone and one of the most important signaling molecules in plants, the increment of ABA levels in plant tissues under stress conditions can improve water content through control the opening and closing of stomata as well as in inducing specific genes that encode enzymes and help to undertake stress (Culter *et al*., 2010 and Raghavendra *et al*., 2010). However it has a role in formation of membrane protein. The Brassinosetroids

(BR) are naturally occurring steroidal plant growth regulator, BR has been found in a wide variety of plants including dicots, monocots, gymnosperms, algae and in various plant tissues such as pollen, leaves, flowers, seeds, buds, tillers and stems. BRs contribute in sustaining the biotic stresses and affect plant resistance to abiotic stresses through its effect on the process of *Transcription* of genes responsible for these stresses. Therefore, this research was aimed to identify the effect of each plant growth regulator on growth characteristics and yield of rice 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}) as well as the control treatment (0.65 dis.m^{-1}), 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 (0). 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.

Table 1: Effect of salty irrigation water levels and plant growth regulators on plant's height (cm) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	100.6	122.7	89.9	105.4	113.3	106.4
S_1	92.7	117.0	80.7	97.3	104.5	98.5
S_2	67.0	74.7	75.4	83.7	78.1	75.8
S_3	53.3	57.5	48.7	54.5	59.5	54.7
$L.S.D_{0.05}$	15					9
Average	78.4	93.0	73.7	85.2	88.8	
$L.S.D_{0.05}$	7					

Table 2: Effect of salty irrigation water levels and plant growth regulators on leaf area (cm^2) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	22.00	25.33	22.01	24.33	23.67	23.47
S_1	20.00	22.67	20.33	22.33	23.00	21.67
S_2	13.67	17.00	14.67	16.00	17.33	15.73
S_3	9.33	12.67	12.33	11.67	12.00	11.60
$L.S.D_{0.05}$	N.S					0.80
Average	15.25	19.42	17.34	18.58	19.00	
$L.S.D_{0.05}$	0.92					

Results

Plant Height (cm)

Salinity stress treatments growth regulators and their interaction had a significant effect on rice plant height (Table 1). Irrigation with saline water with all its applied levels (except S_1) reduced plant height significantly compared to control (river water, S_0), where plant height reached 106.4cm. While irrigation field with salinity level S_3 gave the lowest average trait of 54cm. Growth regulators led to an increase in plant height (except ABA) and there was a significant differences among plant growth regulators in this trait. NAA gave the highest average height of plant reading 93cm, while spraying ABA gave the lowest average of 73.7cm (Table 1). Looking at the interaction between the tested factors, they showed an increase in plant height when spraying rice with NAA with salinity S0, giving the highest plant 122.7cm compared to the combination of S_3 salinity may ABA application which gave the shortest plants (48.7cm).

Leaf area (cm^2)

Salinity levels of irrigation water and plant growth regulators significantly affected the flag leaf area (Table 2). Increasing irrigation water salinity caused continues redaction in flag leaf area. S_3 gave the lowest area (11.60cm^2) with redaction parentage of 50.57%, 46.47% and 26.26% as S_3, S_2 and S_1 respectively comparing to control. The application of plant growth regulators has an effective role in increasing the leaves area. Application

Table 3: Effect of salty irrigation water levels and plant growth regulators on crop growth rate (gm m^{-2} day^{-1}) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	31.29	34.30	25.10	32.85	32.20	31.15
S_1	24.70	37.34	24.56	30.87	23.85	30.06
S_2	20.70	24.11	28.01	26.24	23.38	24.51
S_3	15.07	17.08	18.94	18.35	16.25	17.14
$L.S.D_{0.05}$	4.41					3.48
Average	22.97	28.21	24.15	27.07	26.17	
$L.S.D_{0.05}$	1.81					

of NAA gave the highest value reached 19.42 cm^2 in comparison with control (C) which gave the lowest value reached 15.25 cm^2. Also results revealed that there is no significant effect among the interaction treatments on leaf area.

Crop Growth rate (CGR) (gm m^{-2} day^{-1})

Salinity levels and plant growth regulators and their interaction has a significant effect on (CGR) which represent the amount of material manufactured by the plant in a specified area and time (Table 3). River water treatment (S_0) has significantly gave the highest value reached 31.15 gm m^{-2} day^{-1}, which were not significantly different from S_1 which gave 30.06 gm m^{-2} day^{-1}, while the treatment S_3 gave the lowest value (17.14 gm m^{-2} day^{-1}) in a significant difference among all the salinity levels. However results showed a significant effect for the application of plant growth regulators, the foliar spraying of NAA gave the highest values reached 28.21 gm m^{-2} day^{-1}, while the foliar application of distilled water (C) gave the lowest value (22.97 gm m^{-2} day^{-1}). The interaction between river water (S_1) and NAA gave the highest value reached 34.30 gm m^{-2} day^{-1}, comparing with S_3 and distilled water (C) which gave the lowest value approaching 15.07 gm m^{-2} day^{-1}.

Total chlorophyll content (µg gm^{-1})

Salinity levels, growth regulators and their interactions had a significant effect on plant chlorophyll content (Table 4). River water (S_0) gave the highest values reached 21.42 µg gm^{-1}, while the salt stress treatment (S_3) has significantly decrease total chlorophyll content by giving the lowest value (10.64 µg gm^{-1}). However, results revealed that applying KIN as provide highest values reached 19.81µg gm^{-1}, while distilled water treatment gave the lowest amount of chlorophyll reached 13.54 µg gm^{-1}, with no significant differences among BR, ABA and NAA on the studied trait. Data however, results revealed that there is no significant effect of interaction between tested treatments on plant chlorophyll content.

Table 4: Effect of salty irrigation water levels and plant growth regulators on Plant total chlorophyll content (µg gm^{-1}) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	17.65	23.47	22.80	24.76	18.45	21.42
S_1	15.02	19.88	14.98	19.95	20.45	18.06
S_2	12.36	13.70	17.95	22.91	16.55	16.69
S_3	9.12	10.94	10.22	11.62	11.28	10.64
$L.S.D_{0.05}$	N.S					1.90
Average	13.54	17.00	16.49	19.81	16.68	
$L.S.D_{0.05}$	2.47					

Table 5: Effect of salty irrigation water levels and plant growth regulators on Dry weight yield (gm m^{-2}) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	272.2	354.5	322.5	298.1	314.1	312.3
S_1	259.9	297.2	276.7	334.3	268.2	287.2
S_2	216.9	196.2	207.5	214.9	250.6	217.2
S_3	126.1	160.6	144.6	143.0	146.2	144.1
$L.S.D_{0.05}$	21.0					28.0
Average	218.8	252.1	237.7	247.6	245.8	
$L.S.D_{0.05}$	44.0					

Total dry matter (TDM) (gm m^{-2})

According to the data in table 5, salinity levels, plant growth regulators and their interactions significantly affected the total dry matter of rice plant treatment (S_0) gave the highest values approaching (312 gm m^{-2}) which were not significantly different from S1 (287 gm m^{-2}), while S_3 gave the lowest value approaching (144 gm m^{-2}). Data however shows that applying growth regulator improves significantly plant TDM. NAA gave the highest values approaching (252 gm m^{-2}) with non-significant difference with KIN, ABA and BR, while the treatment of distilled water (C) gave the lowest value approaching 219 gm m^{-2}. The interaction between salinity levels and growth regulator gave the highest values at (S_0 and NAA) approaching 355 gm m^{-2}, while (S_3 and distilled water) gave the lowest TDM value reached 126 gm m^{-2}.

Total tillers number (tiller m^{-2})

Results in table 6, revealed that the application of river water gave the highest number of tillers 888 tiller m^{-2}, while high salty water (8 dis m^2) (S_3) gave the lowest value reached 402 tiller m^{-2}, with non-significant differences between S_0 and S_1. Also the foliar application of KIN providing the highest number of tiller (733 tillers m^{-2}) while the foliar application of distilled water (control) gave the lowest value reached 471 tiller m^{-2}. The interaction between S_0 (river water) and KIN gave the highest value approaching 959 tiller m^{-2}, in comparison with the interaction between distilled water and salinity

Table 6: Effect of salty irrigation water levels and plant growth regulators on Total branches number (branch m^{-2}) of Rice.

Salt level	Plant growth regulators					Average
	C	NAA	ABA	KIN	BR	
S_0	852.4	948.6	747.2	958.8	931.2	887.6
S_1	729.9	894.2	729.9	1018.2	858.0	846.0
S_2	394.1	509.0	575.0	532.2	504.2	502.9
S_3	307.3	433.1	424.9	424.5	420.9	402.1
$L.S.D_{0.05}$	104.2					66.1
Average	570.9	696.2	619.2	733.4	678.6	
$L.S.D_{0.05}$	49.6					

Table 7: Effect of salty irrigation water levels and plant growth regulators on Paddy yield (Kg ha^{-1}) of Rice.

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					

level S_3 which gave the lowest value tiller (307 tiller m^{-2}).

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

Results revealed that the treatment S_0 gave the highest value paddy rice yield (1072 Kg ha^{-1}), which is not significantly different from S_1 (1020 Kg ha^{-1}), while the treatment S_2 gave the lowest value reached (422 Kg ha^{-1} (Table 7). Also plant growth regulator NAA gave the highest value reached (1010 Kg ha^{-1}), with non-significant difference from KIN which gave 899 Kgha^{-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 distilled water gave the lowest value reached 298 Kg ha^{-1}.

Discussions

Results revealed negative effect of salinity on all studied traits. The salinity negative effects on vegetative growth traits (plant height and leaf area) can be due to the physiological stress on cells through decrease the osmotic pressure, as well as increasing the ionic toxicity stress which can make a poisonous effects on plant, that can resulted in decreasing water and nutrients availability in plant as amounts of salts increased. However, salinity reduce cells volume which resulted in shrinking leaves area (Hakim *et al*., 2014 and Amirjani, 2011), these results are in agreement with Jamil *et al.,* (2012) and Jini and Joseph, (2017). The reason of chlorophyll destruction in the plant under salt stress may due to the production of Chlorophylase enzyme which naturally produced in the plants under abiotic stresses, as well as the effect of salinity on destroying the plastids protein and therefore the chlorophyll (Fisarakis *et al*., 2001), Researches mentioned that the high amounts of sodium and chloride ions in leaf cells cytoplasm can directly affected the photosynthesis enzymes and pigments formation (Ghanem *et al*., 2008; Karpe *et al*., 2012; Nahar, 2018). The dry weight might be affected by the decrement in all vegetative growth traits including plant height, leaves area and chlorophyll content (Tables 1, 2 and 4 respectively) which affect the producing efficiency of plant tissues and roots absorption ability, these results are in agreement with Nahar, (2018) and Garcia morals *et al*., (2012). Also the salinity has an effect on the total tillers number decrement because the high levels of salt prevented the new tillers ability to carry the salts to the vacuoles, which lead to increase the salts concentration in cytoplasm to the toxic level and desiccate the tillers, Also it decrease the accumulation of nitrogen in plant which is important in vegetative growth (Yongguang *et al*., 2015). These results are in agreement with Alwagaa, (2018) and Rad *et al*., (2012). The yield decrement can be due to the negative effect of salt stress on all growth characteristics which lead to decrease grains yield which reflected on the total yield, these results are in agreement with Araf and Rad, (2012) and Muhammad, (2000) and Hakim *et al.,* (2014).

The foliar application of plant growth regulators (pgrs) has increased plant resistance to saline stress which is affected all growth and yield traits. Spraying NAA has increased plant height, leaf area and total dry matter (TDM) which may be due to the role of growth regulators in increasing the water and nutrients absorption which is positively reflected on the photosynthesis process and contribute in cells division and enlargement and stimulate the lateral roots (Azad *et al*., 2004 and Woodward and Bartel, 2005) also it has a role in genetic decoding against plant shortage (Hayat and Ahmed, 2011 and Sharma, 2011). The plant growth regulators have an important role in improving the distribution process between source and sink in plant (Nataraj, 2016) these results are in agreement with Jahn and golam, (2011) and Khan *et al*., (2016). KIN also play an important role increasing total chlorophyll content because it has a positive effect in reducing the effects of environmental stresses, including moisture, salt and its effect on the accumulation of ions by reducing Na and Cl ions in plant tissue which lead to decrease the saline potential by increasing root cells division and enlargement (Kaya *et al.,* 2010). Also KIN has an important role in increasing tillers number by stimulating the differentiation of buds vascular tissues, as well as inhabiting the apical dominance and stimulating lateral root growth, also It prevents the nutrient deficiency by promoting their absorption and transport and reduces plant sensitivity to abiotic stresses (Carey, 2008 and Taiz and zeiger, 2002). NAA however has a positive role in increasing the total yield by stimulating the transport of photosynthesis products and increasing the hydrolysis enzyme activities, which has a positive effect on the total yield (Elankavi *et al*., 2009) by observing the interaction treatments, it can be concluded that growth regulators have a role in increasing most growth traits at low salinity levels, but as salinity levels increase, they become less effective.

Conclusions

1. Saline irrigation has a negative effect on growth, yield and qualitative characteristics

2. The irrigation under salinity level 4 ds m^{-1} didn't have a negative effect in most traits, which makes it the upper limit (threshold) in the economic impact of salinity in the yield and quality of rice, the irrigation at level 6 and 8 ds M^{-1} had an adverse effects on the studied traits

3. The application of plant growth regulators has reduced the negative effect of salinity in most studied traits and NAA has the most significant effect among the growth regulators in reducing the impact of salt stress on most growth traits.

4. The effect of salinity levels and plant growth regulators have been interacted in most of the studied traits and the growth regulators have a better influence under the lower salinity levels.

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