Effect of Gibberellic Acid and Potassium Applications in Improving Salinity Tolerance of Three Rice Cultivars

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ABSTRACT

Two field experiments were conducted at El-Sirw Agriculture Research Station, Experimental Farm, Damietta governorate, Egypt during 2012 and 2013 summer seasons. The present investigation was designed to study the effect of gibberellic acid and potassium applications in improving salinity tolerance of three rice cultivars, namely; Giza 177, Giza 178 and Sakha 101. Data of both seasons revealed that, the three tested rice cultivars were significantly varied in their growth patterns, as well as, grain yield and its attributes. Giza 178 rice cultivar recorded the maximum values of plant height, number of tillers/m^2, chlorophyll content, leaf area index, the contents of N, P, K and proline, as well as, grain yield and its attributes; viz, panicle weight and number of filled grains/panicle. However, the lowest values of the abovementioned traits were always shown with Giza 177 rice cultivar. Data, also, showed that, potassium and gibberellic acid applications could partially mitigate the harmful effects of salinity stress on growth and productivity of the three tested rice cultivars.

Key words: Rice cultivars, Salinity stress, Gibberellins and Potassium.

INTRODUCTION

Grain yield of rice depends on its genetic potential, agro-climatic conditions and various management practices (Singh and Singh, 1998). Besides, soil salinity is considered one of the most important constrain affecting rice production. In Egypt, the average of rice productivity in saline soils is much lower than that of normal soils which negatively affects the national rice production average (El-Mowafi, 1994).

Soil salinity effects plant growth and development by osmotic stress, toxic effects of Na^+ and Cl^- ions and nutrient imbalance caused by excess of Na^+ and Cl^- ions (Sairam and Tyagi, 2004).

In Egypt rice crop is moderately sensetive to soil salinity. However, rice cultivars discloses a wide variation in their tolerance to soil salinity (Zayed *et al.,* 2007) such varietals variation among rice cultivars were obtained by Khan and Abdallah (2003), Kandil *et al.,* (2010) and Zayed *et al.,* (2012).

Gibberelline (GA_3) is a hormone induced in plants and its chemical formula is $C_{19}H_{22}O_6$. The obtained favorable effect of GA_3 (as growth regulator) in improving rice growth, as well as, grain yield and its components of rice under saline soil conditions might be due to its activation to α-amylase for breakdown of stored starch during germination, enhancing IAA exertion, promoting cell elongation and division particularly, mesocotyle length and internodes of rice plants, reducing Na and Cl uptakes, increasing K, P and N uptakes and chlorophyll content leading to high seedling vigor, reasonable rice growth at early and late stages, improving source-sink relation resulted in high grain yield and its components under salt stress (Chen *et al.,* 2005 and Pan *et al.,* 2013).

Potassium is linked with all phenomena of plant photosynthesis, respiration, metabolism of fats, carbohydrates and nitrogenous compounds, enzyme activation, cell elongation and water efficiency, so, it could be considered as a key element in rice nutrition for improving root growth and plant vigor, helping prevent lodging and enhancing rice resistance to pests and diseases (Krishnakumar *et al.*, 2005).

The present study aimed to investigate the effect of GA_3 and K_2O applications, as well as, their combination treatment in improving salinity tolerance of Giza 177, Giza 178 and Sakha 101 rice cultivars.

MATERIALS AND METHODS

Two field experiments were conducted at El-Sirw Agriculture Research Station, Experimental Farm, Damietta governorate, Egypt, during 2012 and 2013 summer seasons. This investigation aimed to study the performance of three rice cultivars as affected by gibberelline and potassium applications under saline soil conditions.

The three tested rice cultivars used in this study, namely; Giza 177 (salt sensitive), Giza 178 (salt tolerant) and Sakha 101 (salt semi tolerant).

Gibberellic acid and potassium applications used in this investigation were: T_1: control (without GA_3 or K_2O application), T_2: GA_3 (soak rice paddy seeds in gibberellic acid solution at the concentration of 100 ppm and spray rice plants with10 mg/l of gibberelic acid, two times at mid of tillering and panicle initiation growth stages),

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Table 1. Physical and chemical analysis of the experimental sites

Character	2012	2013
Physical analysis:		
Sand (%)	15.5	14.5
Silt (%)	28.3	30.2
Clay (%)	56.2	55.3
Soil texture	Clayey	Clayey
Chemical analysis:		
E.C. (ds/m)	8.32	8.21
Organic matter (%)	1.51	1.53
pH	8.24	8.16
$CaCO_3$ (%)	-	-
Available N (ppm)	96.1	94.6
P (ppm)	17.4	18.0
K (ppm)	296.0	297.0
Fe (ppm)	5.06	5.48
Mn (ppm)	4.29	4.62
Zn (ppm)	0.93	1.07

T_3: K_2O (adding 45 kg K_2O/ha. as basal application and spry rice plants with 2% of K_2O solution, two times at mid of tillering and panicle initiation growth stages) and T_4: mixed treatment (T_2 + T_3).

Soil samples were taken from the experimental site at the depth of 0-30 cm from the soil surface, air-dried, then, ground to pass through a two mm sieve and well mixed. Soil samples were physically analyzed, according to Piper (1950) and Chemically analyzed, according to Black (1983).

The previous winter crops were barley and wheat in 2012 and 2013 seasons, respectively. A strip plot-design with four replications was used. The horizontal plots were randomly devoted to the three tested rice cultivars. While, GA_3 and potassium applications were randomly allocated in the vertical plots. Plot size was 16m^2 (4x4m).

Sowing dates were 3rd and 1st May in 2012 and 2013 seasons, respectively. The rest of culture practices for inbred rice cultivation under saline soil conditions were applied, according to the Recommended cultural practices proposed by of Rice Research and Training Center of Sakha.

Studied characters:

At heading stage, five guarded hills were randomly taken from each plot to determine the following criteria:

1. Growth parameters:

a. Plant height (cm).

b. Number of tillers per hill.

c. Days to heading: Number of days from sowing to 50% heading was recorded in each plot.

d. Leaf chlorophyll content: It was estimated, by using Chlorophyll Analytical Apparantus, Model SPAD-502 Minlota Co. Lted., Japan.

e. Flag leaf area (cm^2).

f. Leaf area index.

2. Plant N,P,K,Na and Proline Contents:

a. Potassium content: It was estimated, by using Flam Photometer, Model E.E.L., according to Jackson (1967).

b. Sodium content: It was measured, by using Flam Photometer, Model E.E.L., according to, Jackson (1967).

c. Sodium/potassium ratio: It was calculated, by using the following formula Na^+/K^+ ratio = $Na^+\%/K^+\%$.

d. Nitrogen content: It was measured, by using Microkieldahl, according to A.O.A.C. (1970).

e. Phosphorus content: It was determined, by using Atomic Absorption Spectrophotometer, according to Jackson (1967).

f. Proline content was measured, according to the method of Bates, *et al.,* (1973).

3. Grain yield attributes:

At harvest time, ten random main panicles from each plot were collected to determine the average values of the following characters:

a. Panicle length (cm): It was estimated, according to IRRI –Standard Evaluation System of Rice (1996).

b. Panicle weight (g).

c. 1000-grain weight (g).

d. Number of filled grains/panicle.

e. Number of unfilled grains/panicle.

f. Sterility percentage: It was calculated, by using the following formula: (Number of filled grains/total number of grains) x 100.

4. Grain yield (t/ha):

Rice plants in the central nine square meters of each plot were manually harvested, then, air-dried for about four days and mechanically threshed. Grain and straw yields were recorded and adjusted into tons per hectare at 14% moisture content and harvest index was calculated.

All collected data were statically analyzed, according to Gomez and Gomez (1984). Differences among treatment means were compared, according to Duncan (1955).

RESULTS AND DISCUSSION

I. Growth patterns:

1. Plant height, number of tillers/hill and days to heading.

Rice cultivars performance:

The results recorded of the three tested rice cultivars under salinity conditions revealed that, Giza 178 rice cultivar produced the tallest plants and the highest tillers number/hill (Table 2). On the other side, the lowest number of tillers/hill and days to heading were obtained by Giza 177 rice cultivar (as sensitive one).

Sakha 101 rice cultivar gave the shortest plants and recorded the longest vegetative period, but, it recorded the intermediate values of tillers number/hill. Such findings could mainly be attributed to genetic variability among rice cultivars. Similar results were reported by Sucharitha and Boopathi (2000), Kandil *et al.,* (2010), Zayed *et al.,* (2012) and Sumontip and Pongthai (2013).

Effect of GA_3 and K_2O applications:

Data in Table (2) clarified that, GA_3 + K_2O treatment significantly recorded the tallest plants and the highest number of tillers/hill, as well as, the longest vegetative period during 2012 and 2013 seasons. While, control (without GA_3 or K_2O application) gave the lowest values of the abovementioned traits. In addition either GA_3 or K_2O treatments recorded the intermediate values in this respect. These findings could mainly be attributed to the positive effect of continuous potassium and GA_3 supply until late season, whereas, K may be relatively increases the uptake of nitrogen, consequently extend the vegetative growth and delay panicle exertion (Hatamifar al., 2013). Beside, the role of potassium as activator of enzymes specific for a modifying internal hormone balancing (reducing ABA and increased Gibberellins and other activators concentrations) (Wang *al.,* 2013). In addition, exogenous GA_3 treatment enhanced the ability of endogenous GA_3 that stimulates α-amylase activity in germination seed by increases in formation ofglucose from starch leading to an improving in synthesis of sucrose used for seedling growth. Also, GA_3 application might be reduced NaCl induced growth inhibition in rice in a concentration dependent manner, including the length of root tissue and influence on the abundance of same salt-regulates proteins (Fu *et al.,* 2009).

Table 2. Effect of GA_3 and K_2O applications on plant height, number of ttillers/hill and days to heading of three rice cultivars under saline soil conditions

Treatments	Plant height (cm)		Number of tillers/hill		Days to heading (Days after sowing)	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	74.86b	76.36b	13.6c	14.0c	83.6c	85.4c
Giza 178	79.62a	78.93a	18.2a	17.4a	91.78b	91.2b
Sakha 101	67.25c	70.98c	15.8b	15.6b	94.03a	94.7a
F. Test	**	**	**	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	65.92d	67.28d	13.1c	12.7c	85.70d	86.23c
T_2:GA_3	74.97b	76.14b	16.9a	16.7ab	91.30b	90.87b
T_3:K_2O	70.18c	71.67c	15.6b	16.0b	89.40c	90.63b
T_4:GA_3 + K_2O	84.56a	86.60a	17.7a	17.3a	92.80a	94.0a
F. Test	**	**	**	**	**	**
CxF Interaction:	**	**	N.S	N.S	**	**

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Similar findings are in harmony with those reported by Meena *et al.* (2003), Sundari and Sureshkumar (2004), Zayed *et al.* (2006), Sivakumar *et al.,* (2007), Manzoor *et al.* (2008), Abd El-Hamed (2013) and Sumontip and Pongthai (2013).

Effect of the interaction:

The interaction between GA_3 and K_2O applications ,as well as, rice cultivars had highly significant effect on plant height and number of days to heading. At the application of T_4 treatment Giza 178 rice cultivar produced the tallest plants followed by Giza 177 and Sakha 101 rice cultivars. Moreover, all tested rice cultivars recorded the tallest plants when the mixed treatment (GA_3 + K_2O) was applied (Table, 3).In addition, the longest vegetative period during both seasons was recorded by Sakha 101 rice cultivar with GA_3 + K_2O treatment (T_4), while, Giza 177 rice cultivar without potassium or gibberellic acid application recorded the shortest vegetative period (Table, 4). On the other hand, number of tillers/hill was not significantly affected by the interaction.

2. Leaf chlorophyll content, flag leaf area and leaf area index.

Rice cultivars performance:

It is clear from data tabulated in Table (5) that, there were significant differences among the tested rice cultivars for leaf chlorophyll content and flag leaf area, whereas, the differences among three tested rice cultivars in leaf area index were insignificant. During both seasons the maximum values of leaf chlorophyll content and flag leaf area were produced by Giza 178 and Sakha 101 rice cultivars, respectively. On the contrary, Giza 177 rice cultivar gave the lowest values in the abovementioned traits. This variation in leaf chlorophyll content and flag leaf area of the three tested rice cultivars could be mainly due to their genetic make up. Such varietals' differences among rice cultivars under saline soil conditions have been pointed out by Zayed *et al.* (2006), Farooq *et al.,* (2008), Okasha,Amira (2011) and Sumontip and Pongthai (2013).

Effect of GA_3 and K_2O applications:

Results in Table (5) indicated a positive effect on leaf chlorophyll content and flag leaf area in both seasons of study. The maximum values of leaf chlorophyll content, as well as, the largest flag leaf and the highest leaf area index were obtained when GA_3 and K_2O were applied (T_4). On the other hand, control (T_1) recorded the lowest values. Both GA_3(T_2) and K_2O (T_3) treatments gave intermediate values in this respect. Enhancing leaf growth of rice grown under saline soil conditions by GA_3 + K_2O treatment could be mainly due to the superiority of the integration between soil and foliar potassium and gibberellic acid application

Table 3. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on plant height (cm) under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	66.53ef	67.82e	63.41g	67.94f	68.18f	65.72g
T_2:GA_3	75.89c	84.06b	64.97fg	77.25d	82.74c	68.43f
T_3:K_2O	72.24d	75.12c	63.18g	73.86e	74.23e	66.93fg
T_4:GA_3 + K_2O	84.77b	91.48a	77.43c	86.37b	90.57a	82.86c

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 4. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on number of days to heading (days after sowing) under saline soil conditions.

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	80.9j	87.2f	89.0e	81.2j	88.1g	89.4f
T_2:GA_3	83.3i	93.8c	96.8b	84.9i	92.2d	95.5b
T_3:K_2O	84.5h	91.6d	92.1d	92.2d	91.0e	94.1c
T_4:GA_3 + K_2O	85.7g	94.5c	98.2a	95.5b	93.5c	99.8a

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 5. Effect of GA_3 and K_2O applications on leaf chlorophyll content, flag leaf area and leaf area index of three rice cultivars under saline soil conditions

Treatments	Leaf chlorophyll content (SPAD value)		Flag leaf area (cm^2)		Leaf area index	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	32.72b	31.55c	17.46c	18.24c	5.78	5.62
Giza 178	36.53a	34.92a	24.83b	24.97b	5.86	5.69
Sakha 101	34.95b	33.47b	32.17a	33.36a	5.51	5.35
F. Test	**	**	**	**	N.S	N.S
GA_3 and K_2O applications (F):						
T_1:Control	29.66d	28.56c	22.51d	23.37d	5.38c	5.29b
T_2:GA_3	36.08b	34.35b	23.14c	24.11c	5.84ab	5.67a
T_3:K_2O	35.22c	33.81b	26.45b	26.53b	5.65bc	5.53ab
T_4:GA_3 + K_2O	37.97a	36.52a	27.18a	28.08a	5.99a	5.72a
F. Test	*	**	**	**	*	*
CxF Interaction:	**	**	**	**	N.S	N.S

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

during critical crop growth stages resulted in increasing plant K content, which considered co-activator of enzymes related to chlorophyll biosynthesis formation.Also, K might be relatively increased the uptake of nitrogen, consequently extend the vegetative growth. Moreover, GA_3 application encouraged growth of rice leaves due to its role in cell elongation and division which increase photosynthetic activity (Wang *et al.,* 2013). These findings are in line with those reported by Wang *et al.* (2002), Dong *et al.* (2008) and Hagras *et al.*, (2011).

Effect of the interaction:

Tables (6 and 7) showed that, when potassium fertilizer and gibberellic acid were added (the mixed treatment), Giza 178 rice cultivar produced its maximum values of leaf chlorophyll content and Sakha 101 rice cultivar gave its largest flag leaves ,while the narrowest flag leaf and the lowest values of leaf chlorophyll content were obtained by Giza 177 rice cultivar with the control.

II.Plant N, P, K, Na, and Proline contents:

1. **potassium (%), sodium (%) and sodium / potassium ratio.**

Rice cultivars performance:

Data of table (8) indicated that, the three tested rice cultivars were significantly varied in their K and Na percentages, as well as, Na^+/K^+ ratio during 2012 and 2013 seasons. The maximum potassium percentage was obtained by Giza 178 rice cultivar. The differences between Sakha 101 and Giza 177 rice cultivars in potassium percentage during two seasons were insignificant. Meanwhile, Giza 177 rice gave the maximum sodium percentage with no significant differences with Sakha 101. On the contrast, Giza 177 rice cultivar recorded the maximum Na^+/K^+ ratio. These varietals' variation among these tested rice cultivars could mainly be due to their genetic background and their variation in ions selectivity. In addition Giza 178 rice cultivar had high affinity for ion selectivity, which reduces sodium uptake and increases uptake leading to a low Na^+/K^+ ratio (Zayed *et al.,* 2007). Such findings were reported by Khan and Abdallah (2003) and Abd El-Hamed (2013).

Effect of GA_3 and K_2O applications:

Gibberellic acid and potassium applications significantly affected plant K, Na and Na^+/K^+ ratio during both seasons of study (Table 8). The mixed treatment of GA_3 + K_2O significantly gave the highest percentages of K and Na. On the other side, the lowest contents K and Na were obtained by control (without GA_3 or K_2O application). While, both GA_3 or K_2O treatments came in between. The highest potassium/sodium ratio was recorded with control treatment (T_1). In addition, growth regulator treatment (T_2) and nutrient treatment (T_3) or their combination treatment (T_4) significantly decreased Na^+/K^+ ratio. The Superiority of GA_3 + K_2O treatment (T_4) in increasing K and Na ,as well as, reducing Na^+/K^+ ratio under salinity stress could be mainly attributed to the positive effect of GA_3 and K_2O in enhancing nutrients absorption and translocation by rice plants(Wang *et al.,* 2013). The current findings are in coincidence with those reported by Baskar *et al.,*(2000),Hong and Wang

(2004), Pandey *et al.,* (2007), Reddy *et al.,* (2009), Bassiouni *et al.,* (2011), and Zayed (2012).

Table 6. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on leaf chlorophyll content (SPAD value) under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	27.04f	31.18e	30.76e	26.87h	30.39fg	28.43gh
T_2:GA_3	34.23d	37.24b	36.17c	33.03de	35.73bc	34.29cd
T_3:K_2O	33.54d	37.96b	34.16d	31.83ef	35.49bc	34.11cd
T_4:GA_3 + K_2O	36.07c	39.13a	38.71ab	34.45cd	38.08a	37.03ab

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 7. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on flag leaf area (cm^2) of three rice cultivars under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza177	Giza178	Sakha 101
T_1:Control	15.89h	22.82f	28.81d	16.66i	22.79g	30.67d
T_2:GA_3	16.40h	23.27f	29.74c	16.96i	23.65g	31.72c
T_3:K_2O	18.58g	26.32e	34.45b	19.32h	26.06f	34.21b
T_4:GA_3 + K_2O	18.95g	26.91e	35.68a	20.03h	27.38e	36.84a

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 8. Effect of GA_3 and K_2O applications on K(%), Na(%) and Na^+/K^+ ratio of three rice cultivars under saline soil conditions

Treatments	K (%)		Na (%)		Na^+/K^+ ratio	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	1.62b	1.85b	0.559a	0.545a	0.368a	0.313a
Giza 178	2.03a	2.21a	0.520b	0.519b	0.263c	0.238c
Sakha 101	1.79b	1.92b	0.545a	0.533ab	0.316b	0.293b
F. Test	**	**	**	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	1.34c	1.42d	0.518c	0.516b	0.409a	0.378a
T_2:GA_3	1.81b	2.06c	0.548ab	0.539a	0.307b	0.263b
T_3:K_2O	1.97ab	2.18b	0.529bc	0.529ab	0.273bc	0.247c
T_4:GA_3 + K_2O	2.12a	2.31a	0.570a	0.545a	0.271c	0.236c
F. Test	**	**	**	**	**	**
CxF Interaction:	*	**	N.S	N.S	*	**

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Effect of the interaction:

Table (8) showed that, both potassium content and sodium/potassium ratio were significantly affected by the interaction between GA_3 and K_2O applications ,as well as, rice cultivars in both seasons of study. The maximum potassium percentage were produced by Giza 178 rice cultivar when it treated with K_2O or with the mixed treatment of (GA_3 + K_2O) without any significant difference between them. In contrast, the lowest potassium content was obtained by Giza 177 rice cultivar with control (without GA_3 or K_2O application) (Table 9).It is clear from data presented in Table (10) that, the lowest Na^+/K^+ ratio was recorded by Giza 178 rice cultivar when it treated with the mixed treatment (GA_3 + K_2O) or with K_2O alone, while, the highest

Na^+/K^+ ratio was recorded by Giza 177 rice cultivar with the control (without GA_3 and K_2O application).

2. Nitrogen, phosphorus and proline percentages.

Rice cultivars performance:

Data of table (11) indicated that, the three tested rice cultivars were significantly varied in their N, P and Proline percentages during 2012 and 2013 seasons. Giza 178 rice cultivar gave the maximum phosphorus, and proline percentage. Meanwhile, Sakha 101 rice cultivar recorded the highest nitrogen percentage without any significant difference with Giza 178 rice cultivar. In addition, the lowest percentages of nitrogen ,phosphorus and proline were obtained by Giza 177 rice cultivar. This variation in plant N, P and proline contents of the three tested rice cultivars under saline soil conditions could mainly be due to their genetic background. Furthermore, .this increasing in proline content with Giza 178 rice cultivar could be indicator for salinity tolerance. These varietals' differences had, also, been pointed out by several researchers, such as Bassiouni *et al.,* (2011) and Zayed *et al.* (2012).

Table 9. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on potassium percentage under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	2.77f	3.34de	3.16e	2.92f	3.56e	3.03f
T_2:GA_3	3.56cd	3.74bc	3.38de	3.88d	3.94cd	3.61e
T_3:K_2O	3.42de	3.96ab	3.78bc	3.62e	4.18a	3.99bcd
T_4:GA_3 + K_2O	3.71bc	4.08a	3.85ab	3.98cd	4.15ab	4.05abc

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 10. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on sodium/potassium ratio of three rice cultivars under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	0.522a	0.317cde	0.387b	0.451a	0.280cd	0.405b
T_2:GA_3	0.311cde	0.266ef	0.345bc	0.259de	0.238ef	0.292c
T_3:K_2O	0.329bcd	0.233f	0.258ef	0.292c	0.213f	0.236ef
T_4:GA_3 + K_2O	0.308cde	0.234f	0.272def	0.251e	0.221f	0.237ef

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 11. Effect of GA_3 and K_2O applications on nitrogen, phosphorus and proline percentages of three rice cultivars under saline soil conditions

Treatments	N (%)		P (%)		Free Proline µ moles/g/ fresh wight	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	2.29b	2.33b	0.317a	0.323a	0.49c	0.50c
Giza 178	2.43a	2.52a	0.309ab	0.317a	0.62a	0.64a
Sakha 101	2.49a	2.57a	0.283b	0.274b	0.57b	0.59b
F. Test	**	**	*	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	2.09c	2.12c	0.294b	0.281c	0.44d	0.46d
T_2:GA_3	2.56a	2.59ab	0.291b	0.298b	0.52c	0.49c
T_3:K_2O	2.36b	2.45b	0.304b	0.309b	0.62b	0.64b
T_4:GA_3 + K_2O	2.61a	2.73a	0.322a	0.330a	0.65a	0.71a
F. Test	**	*	*	**	**	**
CxF Interaction:	N.S	N.S	N.S	N.S	**	**

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.

Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Effect of GA_3 and K_2O applications:

Gibberellic acid and potassium applications significantly affected plant N, P, and proline contents during both seasons of study (Table 11). The mixed treatment of GA_3 + K_2O (T_4) significantly gave the highest percentages of N, P and proline. On the other side, the lowest contents N, P and proline were obtained by control (without GA_3 or K_2O application). While, both GA_3 or K_2O treatments came in between. The Superiority of GA_3 + K_2O treatment in increasing N, P and proline percentages could be mainly attributed to the positive effect of GA_3 and K_2O in enhancing nutrients absorption and translocation by rice plants(Wang *et al.,* 2013). This trend is in harmony with those observed by Reddy *et al.,* (2009) and Zayed (2012).

Effect of the interaction:

It is clear from data presented in Table (12) that, the highest proline content was recorded by Giza 178 rice cultivar when it treated with the mixed treatment (GA_3 + K_2O), while, the lowest percentage of proline was recorded by Giza 177 rice cultivar with the control (without GA_3 and K_2O application). While, the interaction between GA_3 and K_2O applications, as well as, rice cultivars failed to exert any significant effect on both nitrogen and phosphorus percentages in both seasons.

III.Grain yield attributes:

1. panicle length, panicle weight and 1000-grain weight.

Rice cultivars performance:

The three tested rice cultivars under saline soil conditions were significantly differed in their panicle length and weight ,as well as, 1000-grain weight (Table, 13). Giza 178 rice cultivar produced the heaviest panicles however its recorded intermediate values of panicle length and 1000-grain weight. On the other hand, Sakha 101 rice cultivar gave the heaviest 1000-grain, as well as, tallest panicles compared to the other tested two cultivars. It, also, gave intermediate values of panicle weight. In general, the lowest values of the abovementioned traits were obtained by Giza 177 rice cultivar. These results are in a parallel line with the findings of Bhowmik *et al.,* (2007), Dong *et al.,*(2009), Kandil *et al.,* (2010) and Zayed *et al.,* (2012).

Effect of GA_3 and K_2O applications:

Panicle length was not significantly affected by GA_3 and K_2O applications. While, GA_3 and K_2O applications exhibited significant differences in panicle weight and 1000-grain weight. Generally, the application of GA_3 + K_2O (T_4) gave the maximum panicle weight and 1000-grain weight, descending follow by K_2O (T_3), GA_3 (T_2) and control (T_1) treatments. Such effects of potassium and GA_3 applications under saline soil conditions could be mainly attributed to improving grain filling process, especially with late GA_3 and K_2O applications(Hatamifar al., 2013 and Misratia *et.al.,* 2013). The obtained data are in a good agreement with those reported by Meengoen *et.al.,*(2004), Gobi *et al.* (2006), Awan *etal.*(2007), Nagarathna and Prakasha (2007), Gavino *et al.,* (2008), Geetha andVelayutham (2009), Mashmann *et al,.* (2010) and Wang *et al.,* (2013) .

Effect of the interaction:

Panicle weight and 1000-grain weight were significantly affected by the interaction between (GA_3 and K_2O applications) and rice cultivars as shown in Table (13).When Giza 178 rice cultivar was treated with the mixed treatment of GA_3 + K_2O (T_4) the heaviest panicle was recorded. Also, Sakha 101 rice cultivar produced the heaviest 1000-grain when it treated with GA_3 + K_2O (mixed treatment). Generally, the lowest values in this respect were found by Giza 177 rice cultivar with control (without GA_3 or K_2O application). Tables (14 and 15).

Table 12. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on proline percentage under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	0.41h	0.48g	0.43h	0.42j	0.50g	0.46i
T_2:GA_3	0.46g	0.59d	0.51f	0.45i	0.54f	0.48h
T_3:K_2O	0.53ef	0.67bc	0.66c	0.57e	0.69c	0.66d
T_4:GA_3 + K_2O	0.55e	0.72a	0.69b	0.56e	0.81a	0.76b

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.

Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 13. Effect of GA_3 and K_2O applications on panicle length, panicle weight and 1000-grain weight of three rice cultivars under saline soil conditions

Treatments	Panicle length (cm)		Panicle weight (g)		1000-grain weight (g)	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	17.45c	17.29c	1.64c	1.75c	16.32c	16.68c
Giza 178	18.38b	18.55b	2.33a	2.48a	21.73b	21.22b
Sakha 101	19.63a	19.71a	1.97b	2.04b	25.08a	25.54a
F. Test	**	**	**	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	18.15	18.23	1.68d	1.76d	19.63d	19.78d
T_2:GA_3	18.37	18.49	2.06b	2.17b	20.78c	21.62b
T_3:K_2O	18.68	18.52	1.94c	2.08c	21.41b	21.12c
T_4:GA_3 + K_2O	18.76	18.83	2.23a	2.35a	22.35a	22.07a
F. Test	N.S	N.S	**	**	**	**
CxF Interaction:	N.S	N.S	**	**	**	**

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Table 14. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on panicle weight (g) under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	1.32i	1.94de	1.78g	1.48i	2.11de	1.69h
T_2:GA_3	1.83fg	2.46b	1.89ef	2.01ef	2.58b	1.93fg
T_3:K_2O	1.57h	2.23c	2.02d	1.66h	2.42c	2.17d
T_4:GA_3 + K_2O	1.83fg	2.69a	2.17c	1.86g	2.81a	2.38c

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 15. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on 1000-grain weight (g) under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	15.33j	19.74g	23.81d	15.44j	20.03g	23.86c
T_2:GA_3	16.58i	21.12f	24.65c	16.82i	21.63e	26.41a
T_3:K_2O	16.30i	22.38e	25.56b	17.11hi	21.04f	25.22b
T_4:GA_3 + K_2O	17.07h	23.69d	26.28a	17.35h	22.18d	26.67a

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

2. Number of filled grains/panicle, number of unfilled grains/panicle and sterility percentage.

Rice cultivars performance:

The three tested rice cultivars showed a wide variation in its number of filled and unfilled grains/panicle, as well as, sterility percentage (Table, 16). Giza 178 rice cultivar gave the highest number of filled grains/panicle and the lowest sterility percentage, while, the maximum number of unfilled grains/panicle and sterility percentage were obtained by Giza 177 rice cultivar in both seasons. Moreover, Sakha 101 rice cultivar came in between in this respect. These detected variation among the tested rice cultivars could mainly be attributed to their genetic background. The present findings are in agreement with those obtained by Bhowmik *et al.,* (2007), Dong *et al.,*(2009), Kandil *et al.,* (2010), Hagras *et al.*, (2011) Abd El-

Hamed (2013), Misratia *et.al.,* (2013) and Shafiee *et al.*, (2013).

Table 16. Effect of GA_3 and K_2O applications on number of filled grains/panicles, number of unfilled grains/panicle and sterility percentage of three rice cultivars under saline soil conditions

Treatments	Number of filled grains/panicles		Number of unfilled grains/panicle		Sterility (%)	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	93.4c	92.6c	30.3a	29.2a	24.58a	24.01a
Giza 178	114.0a	112.9a	16.9c	17.3c	13.04c	13.49c
Sakha 101	102.8b	104.5b	23.7b	22.5b	18.89b	17.86b
F. Test	**	**	**	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	91.2d	89.4c	29.4a	27.5a	24.24a	23.65a
T_2:GA_3	107.8b	105.9b	22.6c	21.8c	17.45c	17.12c
T_3:K_2O	103.1c	104.8b	24.1b	24.7b	19.02b	19.19b
T_4:$GA_3 + K_2O$	111.5a	113.2a	18.5d	18.0d	14.38d	13.84d
F. Test	**	**	**	**	**	**
CxF Interaction:	**	**	**	**	**	**

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Effect of GA_3 and K_2O applications:

GA_3 and K_2O applications used in this study exhibited significant differences in panicle weight, number of filled and unfilled grains/panicle, as well as, sterility percentage., The application of GA_3 + K_2O gave the maximum number of filled grains/panicle, as well as, the lowest number of unfilled grains/panicle and sterility percentage (Table,16). On contrast, the lowest number of filled grains/panicle, as well as, the highest number of unfilled grains/panicle and sterility percentage where recorded with control(without GA_3 or K_2O application). Such effects of potassium and GA_3 applications in improving rice grain filling under saline soil conditions could be mainly attributed to encourage faster and earlier growth and improve the photosynthesis rate, which consequently increase stored carbohydrates at pre-heading which relatively translocated to the panicles, consequently increased filling of spikelets (Gobi *et al.*, 2008 and Pan *et al.,* 2013). The obtained data are in a good agreement with those reported by Meengoen *et.al.,*(2004), Gobi *et al.*, (2006), Awan *etal.*(2007), Nagarathna and Prakasha (2007), Gavino *et al.,* (2008), Geetha andVelayutham (2009), Mashmann *et al.*, (2010) and Hatamifar al., (2013).

Effect of the interaction:

With respect to the interaction between rice cultivars, as well as, GA_3 and K_2O applications, Tables (17, 18 and 19) indicated that, Giza 178 rice cultivar gave the highest number of filled grains/panicle ,as well as, the lowest number of unfilled grains/panicle and sterility percentage in both 2012 and 2013 seasons when it treated with GA_3 + K_2O (T_4), while, Giza 177 rice cultivar with the control (T_1) gave the highest number of unfilled grains/panicle and sterility percentage, as well as, the lowest number of filled grains/panicle.

IV. Grain yield, straw yield and harvest index.

Rice cultivars performance:

It could be easily observed from data presented in Table (20) that, the three tested rice cultivars were statistically varied in their grain and straw yields, as well as, harvest index. Giza 178 rice cultivar produced the maximum grain yield and harvest index during both seasons of investigation. The lowest harvest index was obtained by Giza 177 rice cultivar as a result to produce the lowest grain and straw yields. On the other side, the maximum straw yield was belonged with Sakha 101 rice cultivar. Such variation probably due to the differences among the tested rice cultivars in their vegetative growth behavior and genetic variability. The superiority of Giza 178 rice cultivar in grain yield could be mainly attributed to it recorded the maximum values of panicle weight and number of filled grains/panicle, as well as, the lowest number of unfilled grains/panicle and sterility percentage. In addition Giza 178 rice cultivar could be considered salt-tolerant cultivar (Zayed *et al.,* 2007).

The obtained results are in accordance with the findings of Bhowmik *et al.,* (2007),Bassiouni (2011), Okasha,Amira(2011),Zayed *et al.,* (2012) and Abd El-Hamed (2013).

Effect of GA_3 and K_2O applications:

It was clear from Table (20) that, during both seasons of investigation potassium and gibberellic acid treatments significantly affected grain yield, straw yield and harvest index. The application of GA_3 + K_2O (T_4) recorded the maximum grain and straw yields ,as well as, harvest index. On the other side, the lowest grain and straw yields were recorded with the control (T_1). Growth regulator treatment (T_2) which was statistically at par with the nutrient treatment (T_3) recorded intermediate values. Furthermore, such effect of potassium and gibberellic acid application in improving rice productivity under salinity conditions were caused by increased grain yield attributes; i.e, , panicle length and weight, 1000-grain weight and number of filled grains/panicle. Data in Tables (13 and 16) supported these findings. Superiority of (T_4) treatment might be due to partitioning potassium and gibberellic acid through several integrated soil and foliar application doses during vegetative period, which increase dry matter contents, consequently promote growth patterns and delay plant senescence, as well as, improve the photosynthesis rate and which increase stored carbohydrates at pre-heading which relatively translocated to the panicles, consequently increased filling of spikelets (Gobi *et al.*, 2008 and Pan *et al.,* 2013). Such results are in line with those recorded by Gavino *et al.,* (2008), Geetha and Velayutham (2009), Mashmann *et al.* (2010), Bassiouni (2011), Zayed *et al.,* (2012), Abd El-Hamed (2013), Shafiee *et al.*, (2011). and Wang *al.,* (2013).

Effect of the interaction:

Table (20) reveals that, grain and straw yields of all tested rice cultivars were significantly affected by the interaction between rice cultivars, as well as, GA_3 and K_2O applications during two investigation seasons. Interestingly, Giza 178 rice cultivar with GA_3 + K_2O (T_4) produced the maximum grain yield and harvest index, while, the maximum straw yield was obtained by Sakha 101 rice cultivar with GA_3 + K_2O (T_4).

On contrary, the minimum grain and straw yields, as well as, harvest index were recorded by Giza 177 rice cultivar with the control (T_1)(Tables, 21,22 and 23).

This study concluded that, rice growers were advised to soak rice paddy grains in gibberellic acid solution at the concentration of 100 ppm, adding 45 kg K_2O/ha. as basal application and spry rice plants with 10 mg/l and 2% of gibberellic acid and, K_2O solution, respectively , two times at mid of tillering and panicle initiation growth stages to mitigate salinity harmful, improve growth and enhance grain yield.

Table 17. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on number of filled grains/panicle under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	81.6k	100.2g	91.7j	77.1h	98.4e	92.6g
T_2:GA_3	97.3h	119.8b	106.4e	96.2f	116.5b	104.9c
T_3:K_2O	93.1i	113.6c	102.5f	94.5fg	115.7b	104.2cd
T_4:GA_3 + K_2O	101.4fg	122.3a	110.7d	102.6d	120.8a	116.3b

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 18. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on number of unfilled grains/panicle under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	36.7a	22.8f	28.6c	32.7a	23.5f	26.3cd
T_2:GA_3	28.9c	17.0i	21.9g	27.3c	17.0h	21.2g
T_3:K_2O	31.4b	15.6j	25.3d	31.4b	18.2h	24.5ef
T_4:GA_3 + K_2O	24.2e	12.3k	19.0h	25.3de	10.6i	18.1h

E.C.=8.32 and 8.21 ds/m in 2012 and 2013, respectively.

Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 19. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars number of sterility (%) under saline soil conditions

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	30.98a	18.53f	23.97c	29.56a	19.28d	22.12c
T_2:GA_3	22.89d	12.42i	17.05g	21.82c	12.73f	16.81e
T_3:K_2O	25.21b	12.06i	19.79e	24.93b	13.59f	19.04d
T_4:GA_3 + K_2O	19.25e	9.13j	14.76h	19.73d	8.34g	13.46f

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table20. Effect of GA_3 and K_2O applications on grain yield, straw yield and harvest index of three rice cultivars under saline soil conditions

Treatments	Grain yield (t/ha.)		Straw yield (t/ha.)		Harvest index (HI)	
	2012	2013	2012	2013	2012	2013
Rice cultivar (C):						
Giza 177	4.98c	5.03c	7.93c	7.88c	38.55c	38.92c
Giza 178	6.45a	6.38a	8.68b	8.37b	42.43a	43.06a
Sakha 101	6.05b	5.94b	9.16a	8.83a	39.72b	39.84b
F. Test	**	**	**	**	**	**
GA_3 and K_2O applications (F):						
T_1:Control	5.17d	5.29d	7.68c	7.59d	40.16b	40.91b
T_2:GA_3	5.91b	5.72b	8.85b	8.53b	39.70c	39.76c
T_3:K_2O	5.69c	5.48c	8.69b	8.27c	39.42c	39.32c
T_4:GA_3 + K_2O	6.53a	6.64a	9.13a	9.04a	41.64a	42.43a
F. Test	**	**	**	**	**	**
CxF Interaction:	**	**	**	**	**	*

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.
*,** and N.S.: Significant at 0.05 and 0.01 levels and not significant, respectively.

Table 21. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on grain yield (t/ha.) under saline soil conditions.

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101
T_1:Control	4.56k	5.63g	5.32h	4.71j	5.76f	5.40h
T_2:GA_3	4.92i	6.58c	6.23e	5.05i	6.13d	5.97e
T_3:K_2O	4.76j	6.47d	5.84f	4.62j	6.28c	5.54g
T_4:GA_3 + K_2O	5.68g	7.12a	6.79b	5.73f	7.35a	6.84b

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.
Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 22. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on straw yield (t/ha.) under saline soil conditions.

GA_3 and K_2O applications (F)	Rice cultivars (C)					
	2012			2013		
	Giza 177	Giza 178	Sakha 101	Giza 177	Giza 178	Sakha 101

T_1:Control	7.07h	7.48g	8.49de	7.19e	7.43e	8.14d
T_2:GA_3	8.04f	9.18bc	9.33bc	8.23d	8.67c	8.69c
T_3:K_2O	8.39de	8.65d	9.04c	7.94d	8.09d	8.78c
T_4:GA_3 + K_2O	8.23ef	9.41b	9.76a	8.15d	9.28b	9.71a

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.

Means: followed by the same litter (s) are not significantly different, according to DMRT.

Table 23. Effect of the interaction between GA_3 and K_2O applications, as well as, rice cultivars on harvest index under saline soil conditions

GA_3 and K_2O applications (F)	**Rice cultivars (C)**					
	2012			**2013**		
	Giza 177	**Giza 178**	**Sakha 101**	**Giza 177**	**Giza 178**	**Sakha 101**
T_1:Control	39.20a	42.75a	38.54de	39.58d	43.67ab	39.49d
T_2:GA_3	37.95e	41.11b	40.04c	38.03ef	41.41c	39.84d
T_3:K_2O	36.21i	42.79a	39.26cd	36.78f	42.50bc	38.68de
T_4:GA_3 + K_2O	4.83b	43.08a	41.02b	41.29c	44.66a	41.35c

E.C.=8.32 and 8.21 ds/m in 2012 and 2013 seasons, respectively.

Means: followed by the same litter (s) are not significantly different, according to DMRT.

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الملخص العربي

تأثير المعاملة بحمض الجبرلين والبوتاسيوم على تحسين تحمل ثلاثة أصناف من الأرز للملوحة

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أجريت تجربتين حقليتين بالمزرعة البحثية لمحطة البحوث الزراعية بالسرو، بمحافظة دمياط خلال موسمي صيف ٢٠١٢، ٢٠١٣م وذلك لدراسة تأثير المعاملة بالجبرلين والبوتاسيوم على تحسين تحمل ملوحة التربة لثلاثة أصناف من الأرز وهى: جيزة ١٧٧(حساس لملوحة التربة)، جيزة ١٧٨(متحمل لملوحة التربة)، سخا ١٠١ (متوسط التحمل لملوحة التربة). شملت الدراسة أربعة معاملات من إضافات البوتاسيوم والجبرلين وهى:(١): الكنترول (بدون إضافة أى من البوتاسيوم أو حمض الجبريليك)، (٢): المعاملة بالبوتاسيوم فقط(إضافة ٤٥كجم بو٢أ/هكتار على الشراقى+ رش ٢% من محلول البوتاسيوم مرتين، عند منتصف مرحلة التفريع وعند مرحله بدأ نشوء الدالية)، (٣): المعاملة بحمض الجبريليك فقط (نقع تقاوى الأرز فى محلول حمض الجبريليك بتركيز ١٠٠ جزء فى المليون+ رش النباتات بحمض الجبريليك بتركيز ١٠ مليجرام/اللتر مرتين، عند منتصف مرحلة التفريع وعند مرحلة بدأ نشوء الداليه)، (٤): المعاملة بكل من البوتاسيوم وحمض الجبريليك كما فى المعاملتين (٢+٣). وقد أظهرت نتائج كل من موسمي الدراسة تباين أصناف الأرز المختبرة معنويا فيما بينها من حيث مقاييس النمو الخضري ومحصول الحبوب ومكوناته. أعطى الصنف جيزة ١٧٨ أفضل نمو خضري وأعلى نسب مئوية من النيتروجين والفسفور والبوتاسيوم والبرولين كما أنتج أثقل الداليات وأعلى عدد من الحبوب الممتلئة فى الدالية وكذلك أعلى محصولا من الحبوب، فى حين كانت أقل القيم المتحصل عليها فى معظم الصفات المدروسة من نصيب الصنف جيزه ١٧٧. أوضحت نتائج الدراسة أيضا أن المعاملة الرابعة(الجبرليين + البوتاسيوم) أدت إلى تقليل تأثير الإجهاد الملحي وأيضا تحسين النمو الخضري وزيادة محتوى عناصر النيتروجين والفسفور والبوتاسيوم إلى جانب البرولين فى النباتات ومحصول الحبوب ومكوناته لأصناف الأرز المختبرة تحت ظروف الأراضي الملحية.