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THE ROLE OF GIBBERELLIC ACID IN ALLEVIATING THE ADVERSE EFFECT OF SALINE IRRIGATION WATER ON GROWTH AND YIELD COMPONENTS OF BARLEY PLANT.

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ABSTRACT

A pot experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the growth season of 2005/2006 to investigate the effectiveness of Gibberellin (GA_3) in improving the salt irrigation water tolerance of barley (*Hordeum vulgare* L.) and its effect on barley plant growth and yield components.GA_3 significantly improve in shoot weight of barley plant by 30- 39 %, shoot fresh weight by 23-34 %, shoot dry weight by 22- 31 % and leaf area by 7- 26 % compared to unsprayed treatment. Also, spike length increased by 31 %, 100-grain weights by 8- 16 %, number of grains per spike by 22- 35 % and weight of grains per spike by 22 % compared to unsprayed treatment.

Keywords:Irrigation water salinity, salt tolerance, barley plants and Gibberellin (GA_3).

INTRODUCTION

Salinity is one of the major ecological limiting factors to food production because it limits crop yield and restrict use of uncultivated land. Cereal cultivation have occupy an important location among the agricultural crops all over the world. Wheat and barley are considered the two main grain crops, especially in the arid and semi-arid zones, that depend on rains in cultivation. Barley *Hordeum vulgare* L.) is the fourth largest cereal crop in the world and, is one of the most salt tolerance crop species. However, salinity limits barley yield and it is one of the major a biotic stresses, especially in arid and semi-arid regions (Ashraf and Harris (2004)) and (Munns, 2005). Barley is mostly grown as landraces by subsistence farmers without application of fertilizers, pesticides and herbicides. Barley grain is used for human consumption and animal feed (Dakir *et al*., 2002).

Farhad and Salehi (2008) studied the effect of different concentrations of salinity (0, 37.5, 75, 150 and 225 mmol / L NaCl + $CaCl_2$) on 12 barley varieties. He found that, the growth parameters (leaf area, dry weight of shoot, shoot length and fresh weight of stem) were significantly decreased with increasing salinity levels.

Different types of phytohormones are being extensively used to alleviate the adverse effects of salinity stress on crop growth. For example, Gibberellic acid (GA_3) application has been reported to be helpful in enhancing wheat growth under saline conditions. Final seed germination, growth and grain yield of wheat were decreased with increasing salinity levels but were relatively increased by seed treatment with GA_3 (Hisamatsu *et al*., 2000).

GA_3 is known to be involved in the regulation of plant response to salinity stress and counteract the adverse effect of stress conditions (Hamdia and El Kamy,1998; Hamdia and Brakat, 1999; Cassin *et al*., 2001, a and b).

The spraying of GA_3, showed a significant effect on plant, in the extent of reducing the hurt effect of salinity on the vegetative measurements and some components of plant (Gherroucha *et al*., 2011). The application method of GA_3 had a stimulated effect on the adverse effect of salinity stress on the growth parameters and survival percentage for acclimatization stage (Darwesh and Mohamed, 2009).

Plant growth regulators have gained much importance due to their consistent effects on germination and growth of various plant species (Iqbal and Ashraf, 2005, 2006, 2007; Atia *et al.*, 2009; Gurmani *et al*., 2009; Perez-Garcia, 2009).

Gibberellins are generally involved in growth and development, they control seed germination, leaf expansion, stem elongation and flowering (Magome *et al*., 2004).

GA_3 enhances, elongation of cell, formation of partinocarpy fruits and combial activity and building of protein.

Ghoniem (2004) studied the effect of GA_3 at the rates of (0, 50, 100, 150, 200 and 400 ppm) on flax at 45 days after sowing. He reported that, there was an increase in vegetative growth characters (plant height) compared to control plants. The best results were obtained with the lowest rates of GA_3 (50 and 100 ppm) in plant height of flax plant.

Sastry and Shekhawat (2001) studied the effect of salinity levels (0, 1.0 and 1.5 %) and GA_3 (0, 5, 10 and 15 ppm) treatments on wheat plants. They found that GA_3 improved the growth parameters of salinized plants.

Iqbal *et al.* (2008) stated that application of GA_3 at (150 mg/l) led to an increase in shoot length of wheat plants under salinity (15 dS/m NaCl).

Iqbal and Ashraf (2010) reported that 100-grain weight decreased in wheat plants under salt stress (15 dS/m NaCl) when compared with control, however lower concentrations of GA_3 (100-150 mg/l) were effective in increasing grain weight in wheat plant.

The aim of the current study is to investigate the effect of gibberellin on alleviating the adverse and hurt effect of salinity on growth and yield components of barley plants.

MATERIALS AND METHODS

A pot experiment was carried out at Sakha Agricultural Research Station Kafr El-Sheikh Governorate, during the growth season of 2005/ 2006 to study the effect of salinity of irrigation water on growth, yield components of barley plants and to investigate the effectiveness of Gibberellin (GA_3) in improving the salt tolerance of barley plants (*Hordeum vulgara* L.). Planting was done in pottary pots; each was filled with 20 kg sandy soil. The physical and chemical properties of the soil are present in Table (1).

Table 1. Physical and Chemical properties of the used soil .

Physical properties				Chemical properties									
T. sand	Silt	clay	Texture	PH*	EC** dS/m	Cations m.e/L				Anions m.e/L			
						Mg^{++}	Ca^{++}	K^+	Na^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^-
90	1.2	8.8	Sandy	8.15	2.60	3.70	10.3	1.36	9.84	- -	2.51	6.13	1.86

*** 1: 2.5 ** soil paste**

Soil was prepared before sowing and fertilized with NPK at 80 kg N/Fed. as urea, 30 kg P_2O_5 / Fed., and 15 kg K_2O / Fed. Barley variety Giza 125 was cultivated. The plants were irrigated twice every week till the end of experimental period with salinized solution of sodium chloride and calcium chloride four concentrations; tap water (control), 4, 8 and 12 dS/m. The salinized pots were washed with tap water once every two weeks to prevent salt accumulation in the adopted soil. Gibberellic acid (as Barelex tablets) was used at 100 ppm concentration for spraying plants of two stages: 35 and 65 days after sowing. GA_3 treatment where control treatment was sprayed with distilled water.

Samples were taken after 45 (tillering stage) and 75 days (heading stage) after sowing for each treatment then, four plants per each pot were left for yield estimation. The plants were harvested (about 150 days from planting) to investigate the yield components .

Shoot height, fresh and dry weights of shoots and leaf area were determined. In addition, the following yield components were carried out at the harvesting time: 100 -grain weight, spike length, number of grains/spike and weight of grains/spike

Statistical analysis was conducted as described by Cochran and Cox (1960).

RESULTS AND DISCUSSION

I. Growth Parameters :

1. Shoot Height :

Data in Table (2) indicated that GA_3 significantly improved shoot height of plants compared to salinized unsprayed plants. This improvement depended upon spraying GA_3 and salinity levels. Plants irrigated with EC 4 dS/m (saline water) and treated with 100 ppm GA_3 recorded an increment in shoot height represented by 31.2 and 39.7 % for the first and second samples, respectively compared to unsprayed salinized plants. Moreover , the increment of shoot height for plants grown under EC 8 dS/m saline water and sprayed with GA_3 was 29.2 % and 34.5 % for the first and second one, respectively compared to unsprayed salinized plants. Regarding plants irrigated with EC12 dS/m saline water, GA_3 treatment increased shoot height by 26.9 and 34.5 % for the first and second samples, respectively compared to unsprayed plants. The above results indicated that the effect of GA_3 was effective for increasing the shoot height.

2. Shoot Fresh Weight :

Shoot fresh weight of barley plants grown under salinity levels and sprayed with GA_3 was significantly increased compared to salinized unsprayed plants (Table 2). For instance, the increment of shoot fresh weight for plants grown under EC 8 dS/m saline water and sprayed with GA_3 was 27.1 and 22.6 % for the first and second samples, respectively compared to salinized control plants. Similar response was detected for plants grown under EC 12 dS/m saline water and sprayed with GA_3, the increment being 34.2 and 23.2 % for the first and second one, respectively compared to control plants.

3. Shoot Dry Weight :

The data recorded in Table (2) indicated that GA_3 application interestingly increased the shoot dry weight of salinized plants, especially for the samples taken after the first application. For instance, the increments of shoot dry weight for plants grown under EC 4 dS/m saline water and sprayed with 100 ppm GA_3 were 34.3 % for the first sample and 22.5% for the second one compared to salinized control plants. Additionally, at EC 8 dS/m and EC 12 dS/m saline water the shoot dry weight was increased by 41.8 and 51.1 %, respectively at first sample compared to salinized untreated plants. Similar trend of these results was also detected for the second sample.

4. Leaf Area :

Data in Table (2) clearly showed that leaf area of barley plants grown under salinity levels and sprayed with GA_3 were markedly greater than salinized unsprayed plants. The second sample of GA_3 increased leaf area of barley plants more effectively than the first one. The leaf area of plants grown under EC 8 dS/m saline water and treated with GA_3 was increased by 10.6 and 18.4 % for the first and second samples, respectively compared to salinized control plants. Regarding plants grown under EC 12 dS/m saline water and sprayed with 100 ppm GA_3, the leaf area increased by 7.2 and 26.4 % for the first and second samples, respectively compared to unsprayed plants.

It could be concluded from the above results that application of GA_3 ameliorated the harmful effect of salinity concentrations on plant growth parameters. These results were true during the studied samples and agreement with those obtained by Asmaeel (1997) on *Casuarina equisetifolia*; Gherroucha *et al*. (2003) on wheat plants; Abbas (2005) on flax plant and El-Ziat (2011) on *Conocarpus erectus* plants.

In this respect, Lin and Kao (1995) found that gibberellic acid had high affinity to reduce NaCl inhibition of rice growth and photosynthesis rate, resulted in enhancing dry matter production.

Basra *et al*. (2004) reported that GA_3 might be accelerated the starch analysis by increasing amount of α-amylase content and resulted desirable improvement in seed emergence, germination and growth also, elevated gibberellic acid content in cell might encouraged cell division and metabolism process resulted in growth improvement. Moreover, starch analysis to simple sugar might enhance osmotic pressure resulted in rice salinity tolerance promotion.

Additionally, GA_3 promoted cell division and elongation and enhanced nutrient uptake and content as well as mitigated the harmful effect of salt stress resulted in large and big leaf in the terms of leaf area / seedlings (Chen *et al*., 2005).

Table (2). Effect of GA_3 on some growth parameters in shoots of barley plants under salinity levels of irrigation water during growth stages.

Growth Parameters	Shoot height (cm)		Shoot fresh weight (g/plant)		Shoot dry weight (g/plant)		Leaf area (cm^2/plant)	
Samples / Treatments	45 days	75 days	45 days	75 days	45 days	75 days	45 days	75 days
S_1	20.5	23.0	0.73	1.01	0.44	0.69	15.32	22.06
$S_1 + GA_3$	29.8	38.16	0.95	1.21	0.67	0.89	17.6	24.1
S_2	17.7	19.8	0.62	0.82	0.32	0.54	12.88	15.6
$S_2 + GA_3$	25.0	30.23	0.85	1.06	0.55	0.77	14.4	19.12
S_3	16.6	18.86	0.52	0.73	0.23	0.42	12.16	12.7
$S_3 + GA_3$	22.73	28.8	0.79	0.95	0.47	0.65	13.1	17.25
LSD at 5 %	0.72	0.94	0.018	0.05	0.02	0.03	0.09	0.25

S_1, S_2 and S_3 = EC 4, 8 and 12 dS/m . GA3 = 100 ppm foile

II -Yield Components:

Yield components involved spike length, 100-grains weight, number of grains per spike and weight of grains per spike. It can be noticed that using GA_3 application for plants irrigated with salinity levels increased the yield components of the tested plants.

Data indicated that GA_3 treatment significantly increased spike length of salinized plants for the tested sample of barley plants. For instance, the increment of spike length for plants grown under EC 4 dS/m saline water and sprayed with GA_3 at 100 ppm was 31.1% compared to control treatments.

The same observation was detected for plants grown under EC 8 and EC 12 dS/m saline water and sprayed with GA_3 treatment (Table (3) and Fig. (1)).

A markedly increase in weight of 100 grains of barley plants for salinized plants was detected when plants sprayed with GA_3 compared to control plants. The increment in weight of 100 grains for plants grown under EC 8 and EC 12 dS/m saline water and sprayed with GA_3 at 100 ppm was 16.8 and 8.12 %, respectively compared to control plants (Table (3) and Fig. (2) .

It is clearly observed that application of GA_3 significantly improved number of grains per spike of plants grown under saline concentrations compared to salinized unsprayed plants. For example, plants irrigated with EC 4 dS/m saline water and treated with 100 ppm GA_3 recorded an increment in number of grains per spike represented by 35.4 % compared to unsprayed salinized plants. Additionally, at EC 8 and EC 12 dS/m the number of grains per spike was increased by 22.3 and 23.8 %, respectively compared to unsprayed salinized plants (Table (3) and Fig. (3)) .

Regarding weight of grains per spike, results show that weight of grains per spike of barley plants was significantly increased in salinized plants treated with GA_3 treatment. For instance, the increment in weight of grains per spike for plants grown under EC 12 dS/m saline water and sprayed with GA_3 at 100 ppm was 22.14 % compared to unsprayed salinized plants (Table (3) and Fig. (4) .

It is worthy to mentioned that application of GA_3 partially ameliorated the depressive effect of salinity on yield and its components. Similar finding was reported by Prakash and Prathapasenan (1990 a) on rice plant; Lin and Kao (1995) on rice seedling and Ashraf *et al*. (2000) on wheat plants.

The increase in grain yield in the salt tolerant (Inqlab-91) was probably due to the increased rate of translocation of photosynthates from leaves to grains caused by GA_3 pre-treatment through increased concentrations of ABA (Iqbal *et al.*, 2006 b).

Reduction in fertile tillers production in the salt tolerant (Inqlab-91) also supports this speculation.

GA_3-mediated increase in grain yield in the salt intolerant (MH-97) was due to the increased number of fertile tillers per plant and grain weight rather than number of grains per ear particularly when under salt stress. In contrast, the increase in grain number per ear on main stem observed with tiller reduction in the salt tolerant (Inqlab-91) may be attributed to the increase in grain yield when under salt stress (Iqbal and Ashraf, 2010).

Thus it can be concluded that GA_3 can play an important role in alleviating the adverse effect of salinity on growth (shoot height, fresh weight, dry weight and leaf area) and yield components (spike length, 100-grain weights, number of grains per spike and weight of grains per spike).

Table (3). The interaction effect between different salinity levels and GA_3 application on different yield components of barley plants .

Yield components / Treatments	Spike length (cm / spike)	100-grain weight (gm)	Number of grains / spike	Weight of grains / spike (gm / spike)
S_1	7.1	3.41	23.4	1.22
$S_1 + GA_3$	10.3	4.03	36.2	1.9
S_2	6.0	3.08	19.9	1.10
$S_2 + GA_3$	8.06	3.7	25.6	1.5
S_3	5.7	2.94	18.6	1.09
$S_3 + GA_3$	6.8	3.2	24.4	1.4
LSD at 5 %	0.27	0.054	0.82	0.048

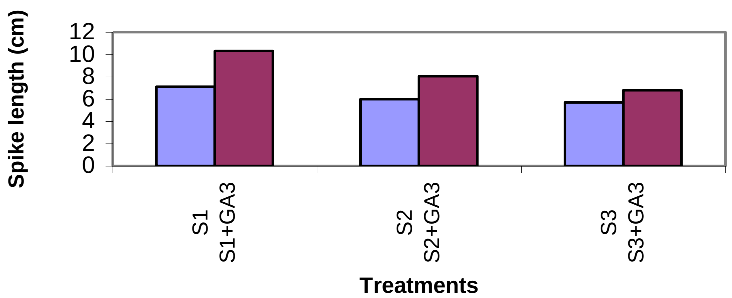

Fig. (1). The interaction effect between salinity levels and GA_3 application on spike length of barley plant.

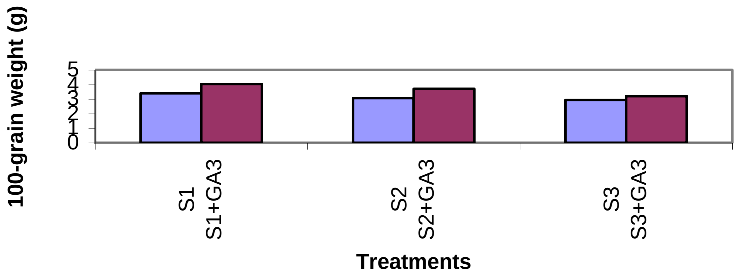

Fig. (2). The interaction Efffect between salinity levels and GA_3 application on 100-grain weight of barley plant.

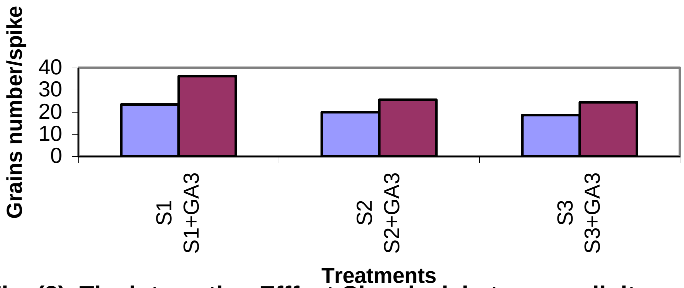

Fig. (3). The interaction Efffect Chemical between salinity levels and GA_3 application on grains number/spike of barley plant.

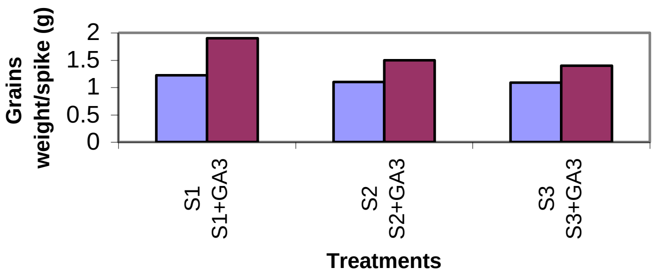

Fig. (4). The interaction effect between salinity levels and GA_3 application on grains weight/spike of barley plant.

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دور حمض الجبريليك في تقليل الآثار العكسية لمياه الري المالحة علي نمو ومكونات محصول نبات الشعير

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**** معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية.**

أقيمت تجربة في أصص في مزرعة محطة البحوث الزراعية بسخا – كفر الشيخ في الموسم الزراعي 2006/2005 لدراسة دور حمض الجبريليك في تحسين مقاومة نبات الشعير لملوحة مياه الري وأثره علي نمو ومكونات محصول الشعير . ويمكن تلخيص أهم النتائج التي أمكن الحصول عليها فيما يلي:
- أدى الرش بحمض الجبر يليك إلي تحسن معنوي في طول نبات الشعير بنسبه 30 إلي 39 % ، وزن الاشطار الرطبة بمقدار 23-34 % ، وزن الاشطار الجافة بمقدار22-31 % ومساحه الورقة بمقدار 7-26 % مقارنه بالمعاملة الغير مرشوشة. أيضا طول السنبلة زاد بحوالي 31 % ، وزن المائة حبة بمقدار 8-16 % ، عدد الحبوب في السنبلة بمقدار 22-35 % ووزن الحبوب لكل سنبلة بمقدار 12 % عن المعاملة الغير مرشوشة .

قام بتحكيم البحث

أ.د / أحمد عبد القادر طه	**كلية الزراعة – جامعة المنصورة**
أ.د / محمد مصطفى صالح رجب	**مركز البحوث الزراعية**