Potential Application of *Glomus Intraradices* (AMF) and Different Isolates of PGPR (Biotol) to Enhance the Yield and Quality of Wheat Grown in The Field in Calcareous Soil Under Different Salinity Levels

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ABSTRACT: Two field experiments were carried out at the farm of Nubaria Agricultural Research Station during the two winter seasons of 2012/2013 and 2013/2014, to study the effect of the arbuscular mycorrhizal fungus, *Glomus intraradices* and the plant growth promoting rhizobacteria (Biotol) on growth, yield parameters and chemical contents of two wheat cultivars (Sakha 93 and Gemmeza 9) grown in calcareous soil under four levels of soil salinity and four rates of NPK mineral fertilizers. Results indicated that, wheat plants inoculated with AMF and Biotol together significantly decreased Na shoot content (mg/kg), increased NPK uptake, proline and salicylic acid contents, chlorophyll and grain protein at all the tested salinity levels compared to un-inoculated plants. Under normal salinity level (≤4 dSm^{-1}), dual inoculation with AMF and Biotol resulted total grain yield to 6.5 and 6.7 t/ha for Sakha 93 and Gemmeza 9, respectively, in the presence of NPK100% with a percentage increases of 41 and 29 more than un-inoculated plants. Results clearly indicated that, proline and Salicylic acid content were significantly increased in dual inoculated plants in Sakha 93 comparing to Gemmeza 9 under soil salinity up to 8 dSm^{-1}. The percentage increases were 38.6 and 37.54 for proline and 192.57 and 135.42 for salicylic acid in case of Sakha 93 and Gemmeza 9, respectively, in the presence of NPK75% and soil salinity 8-12 dSm^{-1}. No significant differences were observed among plants inoculated with *G. intraradices* and PGPR either in the presence of 75 or 100% of the recommended dose of NPK. Summing up it could be concluded that inoculation with AMF and Biotol successfully improve the growth, yield and salt stress tolerance of the tested cultivars in calcareous soil.

Key words: arbuscular mycorrhizal fungus, PGPR, salinity, wheat, proline, salicylic acid

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop in Egypt. Increasing wheat production is an essential national target to fill the gap between production and consumption (Tawfik *et al*. 2006).Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of them are sensitive to salinity caused by high concentrations of salts in the soil (Shrivastava and Kumar, 2015). Salinity affects almost all aspects of plant development including: germination, vegetative growth and reproductive development. Soil salinity imposes ion toxicity, osmotic stress, nutrient (N, Ca, K, P, Fe, and Zn) deficiency and oxidative stress on plants, and thus limits water uptake from soil, some elements, such as sodium, chlorine, and boron besides having specific toxic effects on plants. Excessive accumulation of sodium in cell walls can rapidly lead to osmotic stress and cell death (Munns *et al*. 2002). Salinity and drought stresses inhibit the production of auxins, gibberellins, and zeatin in

the roots and leaves of plants (Sakhabutdinova *et al.* 2003; Figueiredo *et al*. 2008; Perez-Alfocea *et al*., 2010).Calcareous soils occupy wide areas in the North African countries such as Egypt. These soils have a high percentage of calcium carbonate and normally basic in their reaction. Low soil fertility and nutrients deficiency in calcareous soils are very common and could be considered the main constraints for agricultural production in some cases (Hilal *et al*. 1990; Awad *et al*. 1996).Several strategies have been developed in order to decrease the toxic effects caused by high salinity on plant growth, such as mycorrhizal fungi (Cho *et al*. 2006 and Kohler *et al*. 2009) and plant growth-promoting bacteria (PGPB) (Kohler *et al*. 2006 and Dimkpa *et al*. 2009).

Under salt stress conditions, plant tolerance and production are complicated mechanisms. Arbuscular mycorrhizal fungi employ different mechanisms to enhance salt tolerance of host plants such as enhancing nutrient acquisition (P, N, Mg and Ca) (Azcon and El-Atrash 1997; Giri and Mukerji 2004 and Sheng *et al*., 2009), inhibiting high uptake of Na and Cl and their transport to plant shoots (Dai *et al*. 2009), improving water uptake (Ruiz-Lozano and Azcon 2000), accumulating of proline and polyamines (Evelin *et al.* 2009) and increasing some of enzymatic antioxidant defense system (SOD and CAT) (Wu *et al*. 2010). Other arbuscular mycorrhizal mechanisms may include an osmotic adjustment, which assist in maintaining the leaf turgor pressure, and effects on the photosynthesis, transpiration, stomatal conductance and water use efficiency (Juniper and Abbott, 1993).

Tank and Saraf (2010) showed that PGPRs which are able to solubilize phosphate, produce phytohormones and siderophores in salt condition promote growth of tomato plants under 2% NaCl stress. PGPR are able to increase AM fungal development by affecting root colonization as well as by enhancing plant N and P uptake (Artursson *et al*. 2006 and Richardson *et al*. 2009). There are different examples of enhanced associations between different bacterial strains including *Bacillus*, *Paenibacillus*, *Pseudomonas* and *Rhizobia* and different AM species including *G. clarum*, *G. intraradices*, *G. mosseae*, and *G. versiforme* (Artursson *et al*. 2006). These stimulating effects include the growth of fungi and germination of then spores, respectively, root colonization of the host plant by AM fungi, the solubilization of phosphate, and the suppression of pathogens (Artursson *et al*. 2006).

The external hyphae of mycorrhizal fungi, which were about 100 times finer than wheat roots and 10 times finer than root hairs, access sites normally not permeable by roots or root hairs, thus reducing the P diffusion distances and increasing the surface area for nutrient absorption. Also, the length of external hyphae of mycorrhizal fungi can be a good predictor of its relative ability to take up P (Manske *et al*. 2000).Proline levels were found to be increased significantly with salinity stress in mycorrhizal plants when compared to non-mycorrhizal plants. Marked increase in proline occurs in many plants during moderate or severe salt stress and this accumulation, mainly as a result of increased proline biosynthesis, is usually the most outstanding change among free amino acids (Hurkman *et al*. 1989). Salicylic acid (SA), a plant phenolic compound is considered as a hormone

like endogenous regulator, and its role in the defence mechanisms against biotic and abiotic stresses has been well characterized (Szalai *et al*. 2009).The aim of this investigation is to study the effect of inoculation with *Glomus intraradices* and/or with different isolates of plant growth promoting rhizobacteria (Biotol) on growth, yield and chemical contents of two wheat cultivars grown under four levels of soil salinity in calcareous soil.

MATERIALS AND METHODS

Soil physicochemical characteristic

of the surface layers (0-30 cm) of the experimental field were as follows pH: 8.28-8.39, $CaCO_3$ %: 23.29-24.34, O.M. %: 0.30-.045, available N: 50.48-40.36 mg/kg, available P: 3.59-3.00 mg/kg and available K: 107.13-85.96 mg/kg. Soil texture was sandy loam (Page *et al*. 1982 and Klute, 1986).

Wheat seeds:

Two wheat (*Triticum aestivum*, L.) cultivars, Sakha 93 and Gemmeza 9, were provided from the Agricultural Research Center, Ministry of Agriculture, Giza, Egypt.

Isolation of microorganisms and inoculums preparation

1. The mycorrhizal strain *Glomus intraradices*, isolated from the Experimental Station of Alexandria University at Abies, (Aboul- Nasr, 1993), was used in both experiments. The inoculum consists of expanded clay aggregates (2-4 mm in diameter, leca), containing chlamydospores and fungus mycelium, which had been produced on *Tagetes erecta* L. (Aboul-Nasr, 2004). Inoculant was thrown at the rate of 100 g per plot under wheat grains. The control plants received the same amount of heat sterilized expanded clay.

2. Biotol was used as plant growth promoting rhizobacteria (PGPR). Biotol contains a mixture of *Bacillus megaterium, B. thuringiensis, B. mycoides, Paenibacillus graminis and P. borealis*. It was obtained from the Soil, Water and Environment Research Institute – Agricultural Research Center, Giza, Egypt. It has added to the ground with the first irrigation after 25 days from sowing.

NPK fertilizers:

Four different rates of NPK fertilizers were used in this study (NPK_{zero}, $NPK_{50\%}$, $NPK_{75\%}$ and $NPK_{100\%}$ of the recommended dose). The recommended doses of N, P_2O_5 and K_2O fertilizers are 240, 108 and 57.6 kg/ha, respectively. Nitrogen fertilizer (Ammonium nitrate 33.5 % N) was added twice in equal doses, at 25 and 45 days after sowing. Mono-calcium phosphate (15.5 % P_2O_5) was added at the time of soil preparation at one dose. Potassium sulphate (48 % K_2O) was added at 45 days after sowing.

Soil salinity levels:

Four places with different salinity levels (EC dSm^{-1}: average 2.8, 5.3, 7.6 and 10.5) were used in these experiments during the two growing seasons.

Field experiment:

Two field experiments were carried out during two winter seasons of 2012/2013 and 2013/2014 at the Agricultural Research Station of Nubaria. The field experiments were laid out in a split–split –plot design with three replicates.

The following parameters were measured:

The percentage of mycorrhizal root length colonization

was estimated when plants were 45, 90 and 120 days old, according to Koske and Gemma (1989). The percentage of AM root colonization was estimated according to Giovannetti and Mosse (1980).

1000 grains weight (g).

1000-grain weight was expressed as the weight of 1000 clean grains in grams.

Grain yield t/ha.

Grain yield was obtained by harvesting one square meter from each sub-sub plot. Plots were bundled, threshed, and then the grain were cleaned and weighted.

Chemical analysis

Plant samples were taken from each plot, at the suitable age, washed with running tap water, then distilled water. Samples were dried at 65ºC till the weight constant. After dryness, the plant samples were milled well and stored for analysis. 0.5g of plant powder was wet-digested with H_2SO_4 – H_2O_2 digest (Lowther, 1980) and the following determinations were carried out in the digested solution.

1. Shoot Na content

It was carried out according to the method described by (Jackson, 1973) using Beckman flame photometer.

2. Nitrogen uptake (kg/ha) and N % in grains

Total nitrogen was determined in digested wheat leaves colormeterically by Nessler's method (Chapman and Pratt, 1978) using 1 ml of nessler solution (35g KI/100 ml d.w + 20g $HgCl_2$/500 ml d.w) +120g NaOH/250 ml d.w. Reading was achieved using wave length at 420 nm by spectrophotometer (Model 390, Agricultural Microbiology Lab at the Faculty of Agricultural Saba-Basha). The percentage of total nitrogen was calculated as follows:

$\% N = NH_4\% \times 0.7764857$

Nitrogen uptake was calculated by multiplication of the N content × plant dry wt. (g).

The same method was use in case of determination N% in grains.

3. Phosphorus uptake (kg/ha)

It was determined in shoots during both seasons by a mixture of sulphuric, nitric and perchloric acids (1: 10: 40 v: v: v) to determine the total phosphorus in wet ash. Phosphorus was determined by the Vanadomolybdate yellow method

(Jackson, 1958) using Millton Ray spectronic 21 D. Phosphorus uptake was calculated by multiplication the P content × plant dry wt. (g).

4. Potassium uptake (kg/ha)

Total potassium content in plant shoots and grains was determined using a mixture of sulphuric, nitric and perchloric acids (1: 10: 40 v: v: v) according to the method described by (Jackson, 1973) using Beckman flame photometer. Potassium uptake was calculated by multiplication the K content × plant dry wt. (g).

Determination of chlorophyll index (SPAD)

Chlorophyll index was measured by chlorophyll meter device (SPAD 502) Ganji Arjenaki *et al*. (2012).

Determination of protein content in grains (%)

Protein was determined as percentage as follows: protein % = N % x 6.24

Determination of proline (mg/g dry wt.)

The content of proline was determined according to Umbreit *et al*. (1972) using the same extract prepared previously for the determination of total proteins and total soluble carbohydrates. 0.5 ml of extract, 1 ml citrate buffer (pH 5), 0.5 ml ninhydrine and 3.5 ml isopropanol solution were added. The optical density was measured spectrophotometerically at 450nm for proline, 492 nm for phenylalanine and 515 nm for arginine. In addition, 0.5 ml of distilled water was used instead of extract in reference cuvette. The concentration of each amino acid was determined according to the prepared standard curves of each corresponding amino acids.

Determination of salicylic acids (mg/100g root dry wt.)

Determination was implemented according to the method of Iqbal and Vaid (2009) and Malamy *et al*. (1992) as follows;

1. One gram of frozen root tissue is ground in 3.0 ml methanol 90% and centrifuged at 6000 r.p.m. for 15 min.
2. The pellet is re-extracted with 3.0 ml 90% methanol and centrifuged for 10.0 min at 4000 r.p.m.

Assay of salicylic acid was carried out using spectrophotometer according to Iqbal and Vaid (2009).

The supernatant from the both extractions in combined and 2.5 ml of these extractions is diluted to 25.0 ml A.d. in volumetric flask

2.5 ml extraction + 0.5 ml FeCl3 5% + 22.0 ml A.d.

Absorbance of the sample was determined using a spectrophotometer set at 360 nm.

Statistical analysis

Data were statistically analyzed by ANOVA, the analysis of variance to test the treatments effect on different measured parameters. Data were analysed using an ANOVA split split design, the differences between the different treatments

combinations were tested using the Duncan's Multiple range method outlined by (Snedecor and Cochran, 1982).

RESULTS

Mycorrhizal root length colonization

The percentage of AM colonization was estimated after 45, 90 and 120 days old. Records of wheat plants, inoculated either with *G. intraradices* alone or with G. *intraradices* and Biotol significantly increased under all the tested levels of soil salinity, compared to un-inoculated plants. The highest percentages of AM colonization were attained after 90 days under $NPK_{75\%}$ and normal soil salinity being, 65.57 and 65.49 for cv. Sakha 93 and 58.56 and 60.39 for cv. Gemmeza 9, respectively. By increasing soil salinity, the percentage of AM colonization significantly decreased (Tables 1, 2 and 3).

Shoot Na content

Results presented in Table (4) showed that, the lowest values of Na contents (mg/kg) were observed under EC ≤4 dSm^{-1} for plants inoculated with G. *intraradices* and Biotol (9.79 and 18.94 mg/kg) under $NPK_{100\%}$ for Sakha 93 and Gemmeza 9, respectively. Un-inoculated plants recorded 18.75 and 26.86 mg/kg Na for both cultivars, respectively, under the same treatments. The same trends were noticed by increasing soil salinity levels.

Chlorophyll index

Chlorophyll index was significantly affected with soil salinity and levels of mineral fertilizers. Under soil salinity level ≤4 dSm^{-1} the highest values of chlorophyll were 55.75 and 49.96 for plants inoculated with AM+Biotol under $NPK_{100\%}$ for the tested wheat cultivars; representing increase percentages 26.73 and 26.31 % over uninoculated ones. No significant differences were observed between NPK_{75} and $NPK_{100\%}$ of the recommended dose of mineral fertilizers. The same trends were observed with increasing the soil salinity levels. Significant differences in chlorophyll contents were found between the wheat cultivars at soil salinity level 8–12 dSm^{-1}. Sakha 93 recorded higher values of chlorophyll, compared to the Gemmeza 9 (Table 5).

NPK uptake (kg/ha)

Data in Tables (6, 7 and 8) reveal that inoculation with the AM fungus and Biotol, significantly increased NPK uptake (kg/ha) when compared to uninoculated ones. Under salinity level ≤4 dSm^{-1} the highest uptake values of N (Table 6) P (Table 7) K (Table 8) were recorded in case of plants inoculated with AM+Biotol under $NPK_{100\%}$ for both the tested cultivars. No significant differences were observed between NPK_{75} and $NPK_{100\%}$ mineral fertilizers. The same trends were observed with increasing the soil salinity levels. The NPK uptake values decreased under soil salinity level 8-12 dSm^{-1}.

Table (1). Effect of wheat inoculation with *Glomus intraradices* and Biotol on the percentage of mycorrhizal root colonization after 45 days from planting in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014).

Cultivars	NPK Levels	Un-inoc.	AM	Biotol	AM+B	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter		Mycorrhizal root length colonization % EC: average 2.8 dSm^{-1}							L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	0.00	14.94	2.24	16.31	$NPK_{0\%}$	9.42a	NS	2.988*	2.317***	NS
	$NPK_{50\%}$	0.00	15.46	1.10	13.70	7.66 b					
	$NPK_{75\%}$	1.10	21.68	2.19	23.49	$NPK_{50\%}$					
	$NPK_{100\%}$	0.00	17.70	2.09	18.76	8.71 b					
Gemmeza 9	$NPK_{0\%}$	0.00	10.99	0.00	16.77	$NPK_{75\%}$	10.07a				
	$NPK_{50\%}$	1.07	16.38	3.26	18.66	12.73 a					
	$NPK_{75\%}$	0.94	26.40	4.48	21.54	$NPK_{100\%}$					
	$NPK_{100\%}$	1.06	17.06	3.32	19.16	9.89ab					
Mean of Inoc.		0.52b	17.58a	2.35 b	18.55a						
Parameter		Mycorrhizal root length colonization % EC: average 5.3 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.00	5.35	0.95	6.99	$NPK_{0\%}$	7.28 a	NS	1.813***	1.193***	***
	$NPK_{50\%}$	0.19	15.42	0.00	13.68	3.29 c					
	$NPK_{75\%}$	0.00	19.68	2.19	22.96	$NPK_{50\%}$					
	$NPK_{100\%}$	1.08	11.98	1.71	14.25	6.57 b					
Gemmeza 9	$NPK_{0\%}$	0.00	6.06	0.00	6.96	$NPK_{75\%}$	6.91a				
	$NPK_{50\%}$	1.10	9.18	0.00	13.00	11.24 a					
	$NPK_{75\%}$	1.07	19.24	2.19	22.57	$NPK_{100\%}$					
	$NPK_{100\%}$	1.05	12.85	1.07	14.16	7.27 b					
Mean of Inoc.		0.56c	12.47b	1.01c	14.32a						
Parameter		Mycorrhizal root length colonization % EC: average 7.6 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.00	0.88	0.00	2.22	$NPK_{0\%}$	1.93a	NS	0.941***	0.604***	***
	$NPK_{50\%}$	0.22	1.26	0.67	2.57	0.80 b					
	$NPK_{75\%}$	0.00	4.05	2.01	5.56	$NPK_{50\%}$					
	$NPK_{100\%}$	1.11	4.33	1.60	4.43	1.49 b					
Gemmeza 9	$NPK_{0\%}$	0.00	1.11	0.00	2.23	$NPK_{75\%}$	2.11a				
	$NPK_{50\%}$	0.00	1.67	1.61	3.95	3.21 a					
	$NPK_{75\%}$	0.00	6.37	1.67	6.05	$NPK_{100\%}$					
	$NPK_{100\%}$	0.51	2.15	2.22	4.31	2.58 a					
Mean of Inoc.		0.23d	2.73b	1.22c	3.91a						
Parameter		Mycorrhizal root length colonization % EC: average 10.5 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.00	0.58	0.00	1.18	$NPK_{0\%}$	1.70a	NS	0.683**	0.564***	NS
	$NPK_{50\%}$	0.22	1.19	0.59	2.99	0.59 c					
	$NPK_{75\%}$	0.28	3.61	1.18	5.16	$NPK_{50\%}$					
	$NPK_{100\%}$	0.61	3.60	1.23	4.82	1.22 bc					
Gemmeza 9	$NPK_{0\%}$	0.00	1.17	0.00	1.78	$NPK_{75\%}$	1.08a				
	$NPK_{50\%}$	0.00	1.77	0.59	2.37	2.1a					
	$NPK_{75\%}$	0.00	2.98	0.59	3.00	$NPK_{100\%}$					
	$NPK_{100\%}$	0.00	1.20	0.00	1.79	1.66ab					
Mean of Inoc.		0.14c	2.01b	0.522c	2.89a						

Table (2). Effect of wheat inoculation with *Glomus intraradices* and Biotol the percentage of mycorrhizal root colonization after 90 days from planting in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014).

Cultivars	NPK Levels	Un-inoc.	AM	Biotol	AM+B	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter		Mycorrhizal root length colonization % EC: average 2.8 dSm^{-1}							L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	0.71	27.45	2.24	31.57	$NPK_{0\%}$	23.97a	NS	4.623***	3.018***	***
	$NPK_{50\%}$	0.61	39.74	1.63	44.30	15.34 d					
	$NPK_{75\%}$	4.48	65.57	6.52	65.49	$NPK_{50\%}$					
	$NPK_{100\%}$	3.25	42.01	3.85	44.25	20.98 c					
Gemmeza 9	$NPK_{0\%}$	0.00	28.57	1.62	30.52	$NPK_{75\%}$	23.99a				
	$NPK_{50\%}$	2.19	34.89	3.82	40.67	33.88 a					
	$NPK_{75\%}$	3.23	58.56	6.81	60.39	$NPK_{100\%}$					
	$NPK_{100\%}$	3.38	51.40	1.63	56.28	25.75 b					
Mean of Inoc.		2.23 c	43.52b	3.52c	46.68a						
Parameter		Mycorrhizal root length colonization % EC: average 5.3 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.33	16.06	0.93	18.11	$NPK_{0\%}$	18.56a	NS	1.906***	1.910***	***
	$NPK_{50\%}$	0.28	35.22	0.80	36.62	11.65 c					
	$NPK_{75\%}$	2.14	47.00	4.38	51.42	$NPK_{50\%}$					
	$NPK_{100\%}$	2.17	38.21	1.65	41.69	17.69 b					
Gemmeza 9	$NPK_{0\%}$	1.08	22.11	2.10	32.48	$NPK_{75\%}$	18.09a				
	$NPK_{50\%}$	1.09	30.61	2.17	34.71	24.74 a					
	$NPK_{75\%}$	1.63	41.83	2.18	47.39	$NPK_{100\%}$					
	$NPK_{100\%}$	1.36	31.05	2.68	35.87	19.23 b					
Mean of Inoc.		1.15 c	32.76	2.11c	37.29a						
Parameter		Mycorrhizal root length colonization % EC: average 7.6 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.33	10.66	1.30	11.29	$NPK_{0\%}$	11.02a	NS	1.571***	0.985***	***
	$NPK_{50\%}$	1.32	14.06	0.61	16.30	6.23 c					
	$NPK_{75\%}$	1.20	25.78	2.64	30.79	$NPK_{50\%}$					
	$NPK_{100\%}$	0.64	24.87	1.39	33.09	8.39 b					
Gemmeza 9	$NPK_{0\%}$	0.00	10.00	1.24	15.04	$NPK_{75\%}$	10.33a				
	$NPK_{50\%}$	0.00	15.95	1.18	17.74	13.85 a					
	$NPK_{75\%}$	0.00	21.43	2.65	26.31	$NPK_{100\%}$					
	$NPK_{100\%}$	0.00	23.56	3.27	26.93	14.22 a					
Mean of Inoc.		0.44 d	18.29b	1.79	22.19a						
Parameter		Mycorrhizal root length colonization % EC: average 10.5 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.28	7.84	1.12	10.55	$NPK_{0\%}$	9.32a	NS	1.289***	0.867***	***
	$NPK_{50\%}$	0.86	11.02	0.56	13.96	5.35 c					
	$NPK_{75\%}$	1.06	21.57	1.67	26.08	$NPK_{50\%}$					
	$NPK_{100\%}$	0.56	20.58	1.40	30.01	7.13 b					
Gemmeza 9	$NPK_{0\%}$	0.00	8.89	1.07	13.09	$NPK_{75\%}$	9.04a				
	$NPK_{50\%}$	0.00	13.44	0.81	16.41	11.71 a					
	$NPK_{75\%}$	0.00	18.87	2.50	21.90	$NPK_{100\%}$					
	$NPK_{100\%}$	0.22	20.53	3.05	23.98	12.54 a					
Mean of Inoc.		0.37 d	15.34b	1.52c	19.49a						

Table (3). Effect of wheat inoculation with *Glomus intraradices* and Biotol on the percentage of mycorrhizal root colonization after 120 days from planting in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	Biotol	AM+B	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter		Mycorrhizal root length colonization % EC: average 2.8 dSm^{-1}							L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	1.41	31.80	5.55	33.41	$NPK_{0\%}$	31.65a	NS	4.486***	2.555***	***
	$NPK_{50\%}$	2.31	54.02	3.28	56.04	18.36 d					
	$NPK_{75\%}$	5.58	78.31	10.91	82.09	$NPK_{50\%}$					
	$NPK_{100\%}$	4.34	62.06	7.68	67.64	27.04 c					
Gemmeza 9	$NPK_{0\%}$	0.55	34.06	5.32	34.75	$NPK_{75\%}$	28.64a				
	$NPK_{50\%}$	3.27	43.63	5.46	48.33	41.57 a					
	$NPK_{75\%}$	5.35	69.93	10.21	70.17	$NPK_{100\%}$					
	$NPK_{100\%}$	2.28	55.90	7.14	61.93	33.62 b					
Mean of Inoc.		3.14d	53.71b	6.95c	56.79a						
Parameter		Mycorrhizal root length colonization % EC: average 5.3 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	1.09	22.48	1.84	26.01	$NPK_{0\%}$	22.48a	NS	4.529***	3.463***	***
	$NPK_{50\%}$	1.72	40.71	3.24	47.96	14.99 c					
	$NPK_{75\%}$	3.18	55.75	7.67	60.16	$NPK_{50\%}$					
	$NPK_{100\%}$	1.91	35.04	2.76	48.28	21.74 b					
Gemmeza 9	$NPK_{0\%}$	3.04	27.01	2.87	35.57	$NPK_{75\%}$	21.47a				
	$NPK_{50\%}$	2.16	33.66	4.29	40.22	28.74 a					
	$NPK_{75\%}$	4.32	46.06	5.44	47.36	$NPK_{100\%}$					
	$NPK_{100\%}$	2.94	33.19	5.34	50.04	22.43 b					
Mean of Inoc.		2.55 c	36.74b	4.18c	44.45a						
Parameter		Mycorrhizal root length colonization % EC: average 7.6 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.39	13.64	0.89	17.76	$NPK_{0\%}$	13.07a	NS	1.340***	1.308***	***
	$NPK_{50\%}$	0.44	18.21	0.89	21.11	8.96 c					
	$NPK_{75\%}$	1.29	29.29	1.82	36.17	$NPK_{50\%}$					
	$NPK_{100\%}$	0.67	28.68	2.28	35.61	11.06 b					
Gemmeza 9	$NPK_{0\%}$	0.81	16.56	1.64	20.04	$NPK_{75\%}$	13.41a				
	$NPK_{50\%}$	0.56	22.17	1.03	24.04	16.57 a					
	$NPK_{75\%}$	1.69	27.66	4.44	30.18	$NPK_{100\%}$					
	$NPK_{100\%}$	1.91	26.09	2.55	33.16	16.37 a					
Mean of Inoc.		0.97c	22.78b	1.94c	27.26a						
Parameter		Mycorrhizal root length colonization % EC: average 10.5 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	0.83	11.46	2.28	14.24	$NPK_{0\%}$	12.18a	NS	1.583***	1.110***	***
	$NPK_{50\%}$	1.20	14.95	0.59	18.56	7.76 b					
	$NPK_{75\%}$	0.82	31.35	2.04	31.23	$NPK_{50\%}$					
	$NPK_{100\%}$	1.10	27.97	2.40	33.91	9.31 b					
Gemmeza 9	$NPK_{0\%}$	0.22	15.30	1.24	16.50	$NPK_{75\%}$	11.63a				
	$NPK_{50\%}$	0.58	17.81	0.59	20.17	15.15 a					
	$NPK_{75\%}$	1.18	25.09	2.38	27.13	$NPK_{100\%}$					
	$NPK_{100\%}$	1.35	26.08	2.42	28.57	15.42 a					
Mean of Inoc.		0.91c	21.25b	1.69c	23.79a						

Table (4). Effect of wheat inoculation with *Glomus intraradices* and Biotol on Shoot Na content (mg/kg) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter												L.S.D.$_{0.05}$		
					Shoot Na content (mg/kg) EC: average 2.8 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	45.94	34.19	25.56	41.16	10.40	27.08	41.05	$NPK_{0\%}$	25.46b	3.34*	4.22***	3.46***	NS
	$NPK_{50\%}$	41.27	26.77	35.13	31.20	24.40	21.26	48.48	35.53 a					
	$NPK_{75\%}$	24.07	21.79	9.47	21.59	10.31	20.62	14.34	$NPK_{50\%}$					
	$NPK_{100\%}$	18.75	10.39	44.60	11.54	38.44	9.79	47.78	31.14 b					
Gemmeza9	$NPK_{0\%}$	37.62	33.80	10.14	36.69	2.46	27.76	26.20	$NPK_{75\%}$	29.21a				
	$NPK_{50\%}$	34.78	30.78	11.51	33.07	4.91	29.96	13.86	25.74 c					
	$NPK_{75\%}$	31.36	29.14	7.08	29.54	5.82	27.82	11.29	$NPK_{100\%}$					
	$NPK_{100\%}$	26.86	18.89	29.67	20.30	24.42	18.94	29.47	16.93 d					
Mean of Inoc.		32.58a	25.72 bc		28.14 b		22.90 c							
Parameter					**Shoot Na content (mg/kg) EC: average 5.3 dSm^{-1}**									
Sakha 93	$NPK_{0\%}$	59.37	45.87	22.74	50.55	14.86	40.19	32.30	$NPK_{0\%}$	35.45a	NS	3.53***	2.58***	NS
	$NPK_{50\%}$	41.36	36.94	10.69	40.51	2.07	31.57	23.68	47.19 a					
	$NPK_{75\%}$	36.86	30.99	15.92	34.81	5.56	18.65	49.40	$NPK_{50\%}$					
	$NPK_{100\%}$	30.53	22.75	25.47	30.12	1.34	16.16	47.08	39.64 b					
Gemmeza9	$NPK_{0\%}$	52.67	42.91	18.53	47.41	9.99	38.64	26.64	$NPK_{75\%}$	36.14a				
	$NPK_{50\%}$	48.84	38.35	21.49	46.11	5.58	33.40	31.61	30.83 c					
	$NPK_{75\%}$	39.24	28.41	27.59	33.17	15.48	24.51	37.53	$NPK_{100\%}$					
	$NPK_{100\%}$	31.51	22.88	27.39	28.12	10.75	22.11	29.82	25.52 d					
Mean of Inoc.		42.55a	33.64 c		38.85 b		28.15 d							
Parameter					**Shoot Na content (mg/kg) EC: average 7.6 dSm^{-1}**									
Sakha 93	$NPK_{0\%}$	69.17	49.42	28.55	57.78	16.46	44.77	35.27	$NPK_{0\%}$	46.34a	NS	4.09***	3.00***	NS
	$NPK_{50\%}$	59.96	45.75	23.70	48.90	18.45	38.44	35.89	55.11 a					
	$NPK_{75\%}$	58.35	41.90	28.19	44.45	23.83	35.83	38.60	$NPK_{50\%}$					
	$NPK_{100\%}$	39.29	36.47	7.19	40.20	2.31	30.78	21.65	48.89 b					
Gemmeza9	$NPK_{0\%}$	65.95	53.92	18.25	57.07	13.46	42.81	35.09	$NPK_{75\%}$	42.93a				
	$NPK_{50\%}$	57.29	45.61	20.38	53.15	7.23	42.05	26.61	42.18 c					
	$NPK_{75\%}$	45.68	36.55	19.97	42.72	6.47	32.03	29.87	$NPK_{100\%}$					
	$NPK_{100\%}$	32.73	25.14	23.20	29.24	10.66	24.92	23.88	32.34 d					
Mean of Inoc.		53.55a	41.84 c		46.68 b		36.45 d							
Parameter					**Shoot Na content (mg/kg) EC: average 10.5 dSm^{-1}**									
Sakha 93	$NPK_{0\%}$	75.44	62.62	17.00	70.63	6.38	57.90	23.25	$NPK_{0\%}$	60.89a	6.61*	4.11***	3.69***	NS
	$NPK_{50\%}$	64.30	51.17	20.42	55.26	14.07	45.67	28.99	67.27 a					
	$NPK_{75\%}$	58.59	53.74	8.28	55.08	5.98	38.58	34.14	$NPK_{50\%}$					
	$NPK_{100\%}$	50.20	41.27	17.80	43.96	12.44	33.97	32.23	57.14 b					
Gemmeza9	$NPK_{0\%}$	78.96	65.78	16.69	72.06	8.73	54.79	30.60	$NPK_{75\%}$	49.57b				
	$NPK_{50\%}$	71.40	55.64	22.07	64.57	9.56	49.12	31.20	53.93 b					
	$NPK_{75\%}$	63.98	51.97	18.77	63.19	1.23	40.61	36.25	$NPK_{100\%}$					
	$NPK_{100\%}$	51.03	41.91	17.88	44.54	12.73	33.96	33.45	42.60 c					
Mean of Inoc.		64.34a	53.73 b		58.66 c		44.33 d							

± % Increase or decrease to uninoculated (control) plants

Table (5). Effect of wheat inoculation with *Glomus intraradices* and Biotol on chlorophyll index (SPAD) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean Of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter			**Chlorophyll index (SPAD) EC: average 2.8 dSm^{-1}**									L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	32.72	42.09	28.64	39.73	21.43	44.52	36.07	$NPK_{0\%}$ 36.72 c	45.94a	3.332*	4.179***	2.159***	NS
	$NPK_{50\%}$	38.28	49.20	28.54	45.41	18.63	46.82	22.30						
	$NPK_{75\%}$	41.35	52.34	26.57	47.20	14.14	55.57	34.38	$NPK_{50\%}$ 41.30 b					
	$NPK_{100\%}$	43.56	50.49	15.92	50.53	16.00	55.75	26.73						
Gemmeza9	$NPK_{0\%}$	26.20	36.32	35.76	34.20	27.83	37.45	40.01	$NPK_{75\%}$ 44.85ab	38.99b				
	$NPK_{50\%}$	32.87	39.71	20.80	35.46	7.87	42.66	29.78						
	$NPK_{75\%}$	33.15	44.17	33.24	39.47	19.08	45.57	37.47	$NPK_{100\%}$ 46.98 a					
	$NPK_{100\%}$	39.55	45.61	15.31	40.98	3.60	49.96	26.31						
Mean of Inoc.		36.03d	44.99 b		41.62 c		47.22 a							
Parameter			**Chlorophyll index (SPAD) EC: average 5.3 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	28.16	31.32	11.24	29.28	4.01	32.91	16.90	$NPK_{0\%}$ 28.73 c	37.45a	NS	2.962***	1.128***	NS
	$NPK_{50\%}$	29.99	38.24	27.50	34.89	16.33	37.60	25.36						
	$NPK_{75\%}$	35.74	45.51	27.35	40.09	12.17	44.62	24.86	$NPK_{50\%}$ 36.73 b					
	$NPK_{100\%}$	37.92	43.85	15.64	43.80	15.50	45.25	19.33						
Gemmeza9	$NPK_{0\%}$	22.23	31.60	41.53	26.81	20.05	27.44	22.87	$NPK_{75\%}$ 41.33 a	37.05a				
	$NPK_{50\%}$	32.04	39.47	23.18	39.51	23.31	42.14	31.52						
	$NPK_{75\%}$	36.27	43.22	19.17	40.89	12.74	44.32	22.20	$NPK_{100\%}$ 42.21 a					
	$NPK_{100\%}$	36.97	44.39	20.06	41.01	10.93	44.46	20.26						
Mean of Inoc.		32.43c	39.7 a		37.03 b		39.84 a							
Parameter			**Chlorophyll index (SPAD) EC: average 7.6 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	18.10	23.49	29.74	24.94	37.74	29.25	61.54	$NPK_{0\%}$ 23.7 d	31.54a	NS	2.833***	2.095***	NS
	$NPK_{50\%}$	23.10	28.65	24.03	28.22	22.16	30.05	30.10						
	$NPK_{75\%}$	28.05	37.37	33.25	32.05	14.26	39.41	40.49	$NPK_{50\%}$ 26.63 c					
	$NPK_{100\%}$	36.16	40.63	12.36	40.89	13.09	44.25	22.37						
Gemmeza9	$NPK_{0\%}$	13.52	27.62	104.22	23.76	75.65	28.93	113.88	$NPK_{75\%}$ 33.12 b	29.28a				
	$NPK_{50\%}$	17.79	28.66	61.13	26.76	50.45	29.78	67.45						
	$NPK_{75\%}$	23.50	38.08	62.05	31.15	32.58	35.40	50.66	$NPK_{100\%}$ 38.18 a					
	$NPK_{100\%}$	29.11	39.83	36.84	35.13	20.71	39.42	35.45						
Mean of Inoc.		23.66c	33.04 a		30.36 b		34.56 a							
Parameter			**Chlorophyll index (SPAD) EC: average 10.5 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	13.38	21.07	57.53	21.02	57.16	22.59	68.90	$NPK_{0\%}$ 18.49 c	27.3a	1.233*	2.015***	1.108***	*
	$NPK_{50\%}$	19.96	28.23	41.46	27.13	35.92	28.82	44.41						
	$NPK_{75\%}$	24.23	35.63	47.05	29.75	22.81	34.42	42.06	$NPK_{50\%}$ 25.59 b					
	$NPK_{100\%}$	29.10	33.43	14.89	32.91	13.12	35.19	20.95						
Gemmeza9	$NPK_{0\%}$	10.36	18.73	80.78	17.49	68.86	23.28	124.79	$NPK_{75\%}$ 29.36 a	24.93b				
	$NPK_{50\%}$	20.19	26.28	30.15	24.75	22.58	29.45	45.88						
	$NPK_{75\%}$	24.41	29.47	20.74	27.58	12.99	29.44	20.60	$NPK_{100\%}$ 31.01 a					
	$NPK_{100\%}$	26.36	31.25	18.57	28.41	7.79	31.44	19.29						
Mean of Inoc.		20.99d	28.01 b		26.13 c		29.33 a							

± % Increase or decrease to uninoculated (control) plants

Table (6). Effect of wheat inoculation with *Glomus intraradices* and Biotol on N uptake (kg/ha) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter												L.S.D.$_{0.05}$		
					N Uptake (kg/ha) EC: average 2.8 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	14.908	37.525	151.71	30.492	104.53	43.428	191.30	$NPK_{0\%}$	65.49a	NS	5.519***	7.09***	**
	$NPK_{50\%}$	20.692	58.805	184.19	48.179	132.84	61.231	195.92	29.47 d					
	$NPK_{75\%}$	41.419	99.613	140.50	77.232	86.47	105.178	153.94	$NPK_{50\%}$					
	$NPK_{100\%}$	64.175	126.311	96.82	92.478	44.10	116.433	81.43	54.41 c					
Gemmeza9	$NPK_{0\%}$	13.72	41.813	204.72	28.380	106.82	32.982	140.36	$NPK_{75\%}$	65.08a				
	$NPK_{50\%}$	23.570	62.426	164.85	66.095	180.42	77.786	230.02	77.8 b					
	$NPK_{75\%}$	34.903	90.744	159.99	65.977	89.03	107.354	207.58	$NPK_{100\%}$					
	$NPK_{100\%}$	59.886	118.167	97.32	95.000	58.63	130.015	117.10	99.47 a					
Mean of Inoc.		32.39c	81.49 a		62.98 b		84.3 a							
Parameter														
					N Uptake (kg/ha) EC: average 5.3 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	6.384	11.980	87.67	16.987	166.10	22.145	246.90	$NPK_{0\%}$	35.35a	NS	4.945***	3.414***	***
	$NPK_{50\%}$	11.705	33.575	186.84	31.677	170.62	41.977	258.61	12.04 d					
	$NPK_{75\%}$	19.429	52.407	169.74	38.678	99.07	50.151	158.12	$NPK_{50\%}$					
	$NPK_{100\%}$	40.466	70.250	73.60	52.723	30.29	75.119	85.63	24.52 c					
Gemmeza9	$NPK_{0\%}$	5.092	9.626	89.02	8.129	59.64	15.963	213.46	$NPK_{75\%}$	28.08a				
	$NPK_{50\%}$	10.202	24.933	144.39	17.944	75.88	24.176	136.96	38.07 b					
	$NPK_{75\%}$	16.960	43.089	154.05	29.901	76.30	53.973	218.23	$NPK_{100\%}$					
	$NPK_{100\%}$	25.615	53.581	109.18	46.544	81.70	63.513	147.95	52.22 a					
Mean of Inoc.		15.73d	37.43 b		30.32 c		43.38 a							
Parameter														
					N Uptake (kg/ha) EC: average 7.6 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	2.208	6.735	205.04	4.630	109.72	8.020	263.27	$NPK_{0\%}$	16.32a	NS	2.716***	1.863***	***
	$NPK_{50\%}$	5.323	14.505	172.48	13.915	161.39	15.887	198.44	5.06 d					
	$NPK_{75\%}$	10.791	23.131	114.34	17.576	62.87	27.374	153.66	$NPK_{50\%}$					
	$NPK_{100\%}$	16.238	39.148	141.09	24.454	50.60	41.956	158.38	10.49 c					
Gemmeza9	$NPK_{0\%}$	2.549	5.950	133.45	4.715	84.98	7.835	207.42	$NPK_{75\%}$	14.83a				
	$NPK_{50\%}$	3.874	12.526	223.30	7.124	83.87	13.756	255.04	19.21 b					
	$NPK_{75\%}$	9.804	28.953	195.31	16.953	72.92	28.802	193.77	$NPK_{100\%}$					
	$NPK_{100\%}$	14.817	32.122	116.79	20.687	39.61	36.504	146.36	27.53 a					
Mean of Inoc.		5.64 d	20.38 b		13.76 c		22.52 a							
Parameter														
					N Uptake (kg/ha) EC: average 10.5 dSm^{-1}									
Sakha 93	$NPK_{0\%}$	1.464	2.025	38.34	1.890	29.14	4.703	221.33	$NPK_{0\%}$	8.92a	NS	2.695***	1.599***	**
	$NPK_{50\%}$	2.600	5.565	114.05	6.596	153.71	8.907	242.58	2.35 d					
	$NPK_{75\%}$	3.570	13.680	283.16	9.593	168.67	18.917	429.81	$NPK_{50\%}$					
	$NPK_{100\%}$	6.827	19.416	184.00	14.510	112.24	23.396	242.21	6.95 c					
Gemmeza9	$NPK_{0\%}$	1.517	2.972	95.93	1.832	20.77	4.381	188.87	$NPK_{75\%}$	8.41a				
	$NPK_{50\%}$	2.494	10.724	330.02	5.658	126.88	13.075	424.27	10.76 b					
	$NPK_{75\%}$	4.290	13.974	225.73	8.622	100.97	13.423	212.88	$NPK_{100\%}$					
	$NPK_{100\%}$	6.065	16.226	167.53	12.288	102.61	18.056	197.69	14.59 a					
Mean of Inoc.		3.35 d	10.57 b		7.62 c		13.11 a							

± % Increase or decrease to uninoculated (control) plants

Table (7). Effect of wheat inoculation with *Glomus intraradices* and Biotol on P uptake (kg/ha) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter												L.S.D.$_{0.05}$		
						P Uptake (kg/ha) EC: average 2.8 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	1.388	4.457	221.02	2.875	107.07	5.087	266.46	$NPK_{0\%}$	8.60 a	NS	1.789***	1.292***	NS
	$NPK_{50\%}$	2.346	9.555	307.22	6.161	162.58	7.578	222.96	3.08 c					
	$NPK_{75\%}$	4.136	16.468	298.12	9.934	140.17	19.158	363.16	$NPK_{50\%}$					
	$NPK_{100\%}$	6.191	16.867	172.46	12.121	95.79	13.342	115.52	6.72 b					
Gemmeza 9	$NPK_{0\%}$	1.557	4.748	204.98	2.246	44.25	3.258	109.27	$NPK_{75\%}$	8.69 a				
	$NPK_{50\%}$	2.378	8.582	260.92	7.109	198.99	10.032	321.91	12.04 a					
	$NPK_{75\%}$	4.575	15.334	235.13	10.959	139.52	16.884	269.00	$NPK_{100\%}$					
	$NPK_{100\%}$	9.974	15.673	57.14	12.899	29.33	17.720	77.67	12.76 a					
Mean of Inoc.		3.46 c	11.46 a		8.04 b		11.63 a							
						P Uptake (kg/ha) EC: average 5.3 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	0.427	0.934	118.72	1.114	160.89	1.988	365.77	$NPK_{0\%}$	3.43 a	NS	0.749***	0.368***	***
	$NPK_{50\%}$	0.863	3.272	278.96	2.617	203.12	3.332	286.00	0.95 d					
	$NPK_{75\%}$	1.655	5.343	222.88	4.044	144.39	5.812	251.19	$NPK_{50\%}$					
	$NPK_{100\%}$	2.418	7.898	226.59	5.416	123.97	7.748	220.42	2.29 c					
Gemmeza 9	$NPK_{0\%}$	0.333	0.679	103.86	0.616	84.97	1.481	344.72	$NPK_{75\%}$	2.96 a				
	$NPK_{50\%}$	0.974	2.797	187.03	1.735	78.08	2.694	176.41	4.14 b					
	$NPK_{75\%}$	1.785	4.729	164.98	3.188	78.61	6.579	268.60	$NPK_{100\%}$					
	$NPK_{100\%}$	2.131	5.894	176.54	4.871	128.55	6.926	224.99	5.41 a					
Mean of Inoc.		1.32 d	3.94 b		2.95 c		4.57 a							
						P Uptake (kg/ha) EC: average 7.6 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	0.210	0.447	112.84	0.320	52.52	0.754	259.31	$NPK_{0\%}$	1.49 a	NS	0.434***	0.245***	***
	$NPK_{50\%}$	0.368	0.895	143.08	0.686	86.27	1.335	262.57	0.43 c					
	$NPK_{75\%}$	0.523	1.973	277.11	1.351	158.18	2.599	396.76	$NPK_{50\%}$					
	$NPK_{100\%}$	1.440	3.368	133.93	2.621	82.02	5.229	263.19	0.78 c					
Gemmeza 9	$NPK_{0\%}$	0.218	0.517	136.60	0.367	68.00	0.793	263.16	$NPK_{75\%}$	1.55 a				
	$NPK_{50\%}$	0.350	1.061	203.41	0.608	73.80	1.183	238.19	1.83 b					
	$NPK_{75\%}$	1.199	2.872	139.55	1.886	57.36	2.927	144.19	$NPK_{100\%}$					
	$NPK_{100\%}$	1.975	3.932	99.08	2.522	27.71	4.312	118.34	3.04 a					
Mean of Inoc.		0.52 d	1.88 b		1.29 c		2.39 a							
						P Uptake (kg/ha) EC: average 10.5 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	0.074	0.118	59.69	0.101	37.25	0.254	244.17	$NPK_{0\%}$	0.76 a	NS	0.189***	0.171***	***
	$NPK_{50\%}$	0.197	0.541	175.02	0.411	108.77	0.612	211.18	0.16 d					
	$NPK_{75\%}$	0.433	1.262	191.45	0.647	49.41	2.012	364.76	$NPK_{50\%}$					
	$NPK_{100\%}$	0.649	1.753	170.26	1.077	66.02	2.242	245.65	0.58 c					
Gemmeza 9	$NPK_{0\%}$	0.081	0.269	233.48	0.137	70.18	0.323	300.20	$NPK_{75\%}$	0.79 a				
	$NPK_{50\%}$	0.288	0.921	219.95	0.464	61.22	1.299	351.36	1.05 b					
	$NPK_{75\%}$	0.415	1.462	252.18	0.799	92.50	1.661	300.35	$NPK_{100\%}$					
	$NPK_{100\%}$	0.646	1.479	128.87	0.998	54.38	1.757	171.88	1.29 a					
Mean of Inoc.		0.26 d	0.98 b		0.58 c		1.27 a							

± % Increase or decrease to uninoculated (control) plants

Table (8). Effect of wheat inoculation with *Glomus intraradices* and Biotol on K uptake (kg/ha) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter												L.S.D.$_{0.05}$		
						K Uptake (kg/ha) EC: average 2.8 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	10.890	19.583	79.82	16.520	51.70	34.139	213.49	$NPK_{0\%}$	38.01 a	NS	11.407***	5.325***	***
	$NPK_{50\%}$	23.339	49.610	112.56	33.063	41.67	47.506	103.55	13.95 c					
	$NPK_{75\%}$	26.200	52.899	101.90	36.377	38.84	75.957	189.91	$NPK_{50\%}$					
	$NPK_{100\%}$	31.698	58.118	83.35	48.186	52.02	80.725	154.67	36.47 b					
Gemmeza 9	$NPK_{0\%}$	3.759	11.308	200.86	6.193	64.75	15.092	301.51	$NPK_{75\%}$	36.57 a				
	$NPK_{50\%}$	17.644	45.705	159.04	26.124	48.06	72.081	308.53	44.88ab					
	$NPK_{75\%}$	26.053	48.271	85.28	36.580	40.40	78.374	200.82	$NPK_{100\%}$					
	$NPK_{100\%}$	43.115	75.603	75.35	47.945	47.945	75.458	75.02	53.86 a					
Mean of Inoc.		12.61 d	45.14 b		31.37 c		60.04 a							
						K Uptake (kg/ha) EC: average 5.3 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	2.140	3.866	80.67	2.879	34.57	8.242	285.19	$NPK_{0\%}$	8.99 a	NS	2.161***	1.421***	***
	$NPK_{50\%}$	5.187	11.707	125.69	7.974	53.73	11.795	127.39	3.00 d					
	$NPK_{75\%}$	6.183	11.238	81.76	8.280	33.92	17.382	181.14	$NPK_{50\%}$					
	$NPK_{100\%}$	8.932	14.925	67.10	11.488	28.61	20.732	132.10	7.47 c					
Gemmeza 9	$NPK_{0\%}$	0.882	1.531	73.57	0.999	13.19	2.302	160.88	$NPK_{75\%}$	8.63 a				
	$NPK_{50\%}$	2.641	8.261	212.84	3.994	51.27	11.569	338.13	10.92 b					
	$NPK_{75\%}$	5.774	12.106	109.66	8.335	44.35	19.075	230.34	$NPK_{100\%}$					
	$NPK_{100\%}$	10.229	20.165	97.14	13.590	32.86	19.742	93.00	13.85 a					
Mean of Inoc.		3.06 d	10.35 b		7.32 c		14.52 a							
						K Uptake (kg/ha) EC: average 7.6 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	0.746	1.937	159.52	1.122	50.34	2.306	208.92	$NPK_{0\%}$	4.64 a	NS	1.272***	0.658***	***
	$NPK_{50\%}$	2.581	5.113	98.12	3.643	41.17	4.754	84.20	1.39 d					
	$NPK_{75\%}$	3.301	5.637	70.78	4.515	36.79	8.927	170.45	$NPK_{50\%}$					
	$NPK_{100\%}$	5.283	9.396	77.85	7.121	34.79	13.799	161.19	3.52 c					
Gemmeza 9	$NPK_{0\%}$	0.466	1.032	121.27	0.726	55.61	1.100	135.91	$NPK_{75\%}$	5.49 a				
	$NPK_{50\%}$	1.491	4.724	216.85	1.972	32.26	4.556	205.60	6.29 b					
	$NPK_{75\%}$	3.428	9.446	175.52	5.781	68.62	13.148	283.52	$NPK_{100\%}$					
	$NPK_{100\%}$	6.293	14.651	132.79	7.705	22.43	14.413	129.02	9.08 a					
Mean of Inoc.		1.30 d	6.49 b		4.07 c		8.42 a							
						K Uptake (kg/ha) EC: average 10.5 dSm^{-1}								
Sakha 93	$NPK_{0\%}$	0.318	0.509	59.70	0.398	27.98	0.792	148.65	$NPK_{0\%}$	2.19 a	NS	0.673***	0.497***	***
	$NPK_{50\%}$	1.072	2.075	93.65	1.602	49.53	2.164	101.99	0.57 d					
	$NPK_{75\%}$	1.739	2.962	70.36	2.024	16.41	5.563	219.93	$NPK_{50\%}$					
	$NPK_{100\%}$	2.133	4.124	93.29	3.036	42.30	6.655	211.92	1.89 c					
Gemmeza 9	$NPK_{0\%}$	0.260	0.532	104.31	0.281	7.83	0.730	180.65	$NPK_{75\%}$	2.44 a				
	$NPK_{50\%}$	0.784	2.551	225.24	1.297	65.34	2.607	232.36	2.85 b					
	$NPK_{75\%}$	1.622	3.846	137.14	2.151	32.62	4.452	174.53	$NPK_{100\%}$					
	$NPK_{100\%}$	2.663	5.929	122.66	3.307	24.19	6.138	130.50	3.95 a					
Mean of Inoc.		0.66 d	2.82 b		1.76 c		4.03 a							

± % Increase or decrease to uninoculated (control) plants

1000 grain weight

Results presented in Table (9) showed that the highest value of 1000 grain weight (g) was obtained from Gemmeza 9 plants inoculated with G. *intraradices* (54.59 g) under soil salinity level ≤4 dSm^{-1} and $NPK_{75\%}$. No significant differences were observed between NPK_{75} and $NPK_{100\%}$ mineral fertilizers. At soil salinity 8 – 12 dSm^{-1}, the 1000 grain weight were 40.92 and 35.98 g for plants inoculated with AM+Biotol under $NPK_{100\%}$ for Sakha 93 and Gemmeza 9, respectively.

Grain yield (t/ha)

Results presented in Table (10) indicated that, grain yield due to dual inoculation with *Glomus intraradices* and Biotol resulted the maximum yield of grain (6.723 t/ha) under soil salinity level ≤4 dSm^{-1} and $NPK_{100\%}$ in case of Gemmeza 9. No significant differences were observed between NPK_{75} and $NPK_{100\%}$ mineral fertilizers. When the soil salinity level increased to 8-12 dSm^{-1}, the wheat grain yield decreased. The grain yield was 1.991 t/ha in plants inoculated with AM+Biotol under $NPK_{100\%}$ for Sakha 93, while it was 1.710 t/ha for Gemmeza 9. Significant differences in the grain yield (t/ha) were found between the two wheat cultivars. Sakha 93 recorded highest value of grain yield, compared to Gemmeza 9 under high level of soil salinity.

Grain protein

Wheat plants Inoculated with *G. intraradices* alone or *G. intraradices* + Biotol resulted high values of protein content of wheat grains for both cultivars. Under normal salinity levels ≤4 dSm^{-1}, the highest grain protein content was obtained in case of plants inoculated with mycorrhizal fungus and Biotol (1.39 %) for Gemmeza variety at $NPK_{75\%}$. Under salinity level 8-12 dSm^{-1} the highest protein content was obtained from both cultivars in the presence of $NPK_{100\%}$ with percentage increases 36.31 and 43.96% more than un-inoculated plants, for Sakha 93 and Gemmeza 9, respectively. Significant differences in protein contents were found between the two cultivars, Gemmeza 9 recorded the highest value compared to Sakha 93 (Table 11).

Proline content

Significant differences in shoot proline contents among the two wheat cultivars were recorded by increasing soil salinity levels. Sakha 93 recorded higher values of proline than Gemmeza 9 (Table 12). Data clearly show positive effect of AM inoculation on proline content under the tested levels of soil salinity.

Salicylic acid

Dual inoculation with G. *intraradices* and Biotol significantly increased the salicylic acid concentration at all the tested levels of soil salinity. The percentage increases, as compared to uninoculated control was reached 192.57 and 135.42 for Sakha 93 and Gemmeza 9, respectively, in the presence of $NPK_{75\%}$ and soil salinity 8-12 dSm^{-1} (Table 13).

DISCUSSION

Salinity represents one of the most important environmental stresses since it limits crop plant production which is contrary to the increased demand for food all over the world. Therefore, the studies of salinity tolerance in plants consider a special importance. From the above results we concluded that, wheat inoculated with AM fungus showed significant increases in the percentage of AMF colonization and growth yield parameters compared to un-inoculated plants under different levels of soil salinity. It was clear that, by increasing soil salinity, the percentage of AMF colonization and growth yield parameters significantly decreased. Aroca *et al*. (2013) found that, increasing soil salinity levels lowered the percentage of mycorrhizal root colonization in lettuce plants. Miransari *et al*. (2007) observed that, Zea mays plant inoculated with AM fungi (*Glomus mosseae* and *Glomus etunicatum*)

Table (9). Effect of wheat inoculation with *Glomus intraradices* and Biotol on 1000 grains weight (g) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM		Biotol		AM+B		Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
				± %		± %		± %						
Parameter			**1000 Grain Weight (g) EC: average 2.8 dSm^{-1}**									L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	36.39	42.83	17.70	44.33	21.83	46.91	28.92	$NPK_{0\%}$	47.14a	NS	3.363***	1.049***	NS
	$NPK_{50\%}$	41.03	48.34	17.83	48.03	17.08	48.97	19.36	42.54 c					
	$NPK_{75\%}$	43.89	50.21	14.40	48.22	9.85	53.35	21.54	$NPK_{50\%}$					
	$NPK_{100\%}$	46.14	51.54	11.70	50.16	8.70	53.85	16.72	46.61 b					
Gemmeza 9	$NPK_{0\%}$	38.46	44.37	15.35	42.65	10.88	44.45	15.56	$NPK_{75\%}$	47.99a				
	$NPK_{50\%}$	43.73	48.42	10.73	45.23	3.44	49.18	12.46	49.96ab					
	$NPK_{75\%}$	45.28	54.59	20.58	51.88	14.59	52.26	15.44	$NPK_{100\%}$					
	$NPK_{100\%}$	48.46	53.12	9.61	49.85	2.87	54.27	11.98	51.13 a					
Mean of Inoc.		43.13 d	47.54 c		49.17 b		50.40 a							
Parameter			**1000 Grain Weight (g) EC: average 5.3 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	34.75	37.08	6.70	36.29	4.44	39.40	13.38	$NPK_{0\%}$	44.69a	NS	1.646***	1.196***	NS
	$NPK_{50\%}$	38.81	44.74	15.28	41.79	7.67	47.81	23.18	36.44 d					
	$NPK_{75\%}$	42.50	49.41	16.27	46.13	8.55	52.01	22.38	$NPK_{50\%}$					
	$NPK_{100\%}$	46.17	52.92	14.62	50.51	9.39	54.73	18.53	44.51 c					
Gemmeza 9	$NPK_{0\%}$	33.33	36.18	8.56	37.03	11.10	37.50	12.50	$NPK_{75\%}$	45.32a				
	$NPK_{50\%}$	42.24	45.37	7.42	46.50	10.09	48.82	15.60	48.622b					
	$NPK_{75\%}$	47.39	50.24	6.00	49.86	5.20	51.45	8.55	$NPK_{100\%}$					
	$NPK_{100\%}$	46.72	50.57	8.24	48.81	4.47	53.14	13.74	50.45 a					
Mean of Inoc.		41.49d	45.81 b		44.61 c		48.11 a							
Parameter			**1000 Grain Weight (g) EC: average 7.6 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	26.56	32.42	22.07	30.18	13.65	34.67	30.52	$NPK_{0\%}$	37.17a	NS	1.661***	1.428***	NS
	$NPK_{50\%}$	29.09	34.32	20.04	33.32	14.56	39.16	34.62	30.65 d					
	$NPK_{75\%}$	33.44	40.91	22.37	39.40	17.85	42.29	26.49	$NPK_{50\%}$					
	$NPK_{100\%}$	39.74	42.54	7.04	47.47	19.44	48.61	22.31	33.81 c					
Gemmeza 9	$NPK_{0\%}$	26.46	30.73	16.17	31.35	18.49	32.82	24.06	$NPK_{75\%}$	35.71a				
	$NPK_{50\%}$	28.12	34.94	24.27	32.89	16.95	38.02	35.19	38.06 b					
	$NPK_{75\%}$	32.12	39.02	25.05	38.40	23.04	39.84	27.67	$NPK_{100\%}$					
	$NPK_{100\%}$	35.49	42.24	19.01	44.58	25.62	45.31	27.66	43.25 a					
Mean of Inoc.		31.26c	37.22 b		37.19 b		40.09 a							
Parameter			**1000 Grain Weight (g) EC: average 10.5 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	22.60	27.09	19.84	26.20	15.91	28.97	28.19	$NPK_{0\%}$	32.92a	NS	2.171***	1.098***	*
	$NPK_{50\%}$	23.39	35.03	49.76	32.61	39.39	35.83	53.18	26.43 c					
	$NPK_{75\%}$	30.37	37.42	23.21	36.02	18.59	39.33	29.50	$NPK_{50\%}$					
	$NPK_{100\%}$	33.08	39.71	20.03	38.13	15.24	40.92	23.67	30.82 b					
Gemmeza 9	$NPK_{0\%}$	21.87	28.67	31.12	26.28	20.18	29.77	36.15	$NPK_{75\%}$	30.80a				
	$NPK_{50\%}$	24.16	33.27	37.74	27.62	14.36	34.62	43.31	34.09 a					
	$NPK_{75\%}$	28.02	33.69	20.23	31.40	12.04	36.48	30.16	$NPK_{100\%}$					
	$NPK_{100\%}$	31.99	35.76	11.81	33.26	3.96	35.98	12.47	36.10 a					
Mean of Inoc.		26.94d	33.83 b		31.44 c		35.24 a							

± % Increase or decrease to uninoculated (control) plants

Table (10). Effect of wheat inoculation with *Glomus intraradices* and Biotol on grains yield (t/ha) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM		Biotol		AM+B		Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
			± %		± %		± %							
Parameter			**Grains Yield (t/ha) EC: average 2.8 dSm^{-1}**									L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	2.248	3.013	34.03	3.183	41.59	3.263	45.15	$NPK_{0\%}$					
	$NPK_{50\%}$	3.391	4.704	38.72	4.379	29.14	5.159	52.14	2.74 c					
	$NPK_{75\%}$	4.235	6.132	44.79	4.858	14.71	6.309	48.97	$NPK_{50\%}$	4.66a				
	$NPK_{100\%}$	4.644	6.583	41.75	5.082	9.43	6.543	40.89	4.11 b					
Gemmeza 9	$NPK_{0\%}$	1.731	2.849	64.59	2.468	42.57	3.127	80.65	$NPK_{75\%}$		NS	0.559***	0.299***	**
	$NPK_{50\%}$	2.981	4.474	50.08	3.735	25.29	4.062	36.26	5.69 a					
	$NPK_{75\%}$	4.736	6.304	33.11	5.633	18.94	6.095	28.69	$NPK_{100\%}$	4.50a				
	$NPK_{100\%}$	5.216	6.468	24.00	6.209	19.04	6.723	28.89	5.79 a					
Mean of Inoc.		3.374 c	5.165 a		4.505 b		5.285 a							
Parameter			**Grains Yield (t/ha) EC: average 5.3 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	1.570	2.722	73.37	2.483	58.15	2.517	60.32	$NPK_{0\%}$					
	$NPK_{50\%}$	2.537	3.455	36.18	3.194	25.89	3.517	38.63	2.36 c					
	$NPK_{75\%}$	3.412	5.358	57.03	3.859	13.10	5.723	67.73	$NPK_{50\%}$	3.62a				
	$NPK_{100\%}$	3.865	5.101	31.98	4.661	20.59	5.593	44.71	3.22 b					
Gemmeza 9	$NPK_{0\%}$	1.729	2.596	50.14	2.554	47.72	2.780	60.78	$NPK_{75\%}$		NS	0.624***	0.269***	**
	$NPK_{50\%}$	2.747	3.754	36.66	3.160	15.03	4.140	50.71	4.43 a					
	$NPK_{75\%}$	3.252	5.303	63.07	3.941	21.18	5.156	58.55	$NPK_{100\%}$	3.73a				
	$NPK_{100\%}$	3.966	5.200	31.11	4.276	7.82	5.749	44.95	4.70 a					
Mean of Inoc.		2.64 c	4.18 a		3.15 b		4.39 a							
Parameter			**Grains Yield (t/ha) EC: average 7.6 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	0.888	1.340	50.90	10.92	22.97	1.457	64.08	$NPK_{0\%}$					
	$NPK_{50\%}$	1.144	1.629	42.39	1.307	14.25	1.759	53.75	1.19 c					
	$NPK_{75\%}$	١.688	1.935	14.63	1.823	7.99	1.808	7.11	$NPK_{50\%}$	1.79a				
	$NPK_{100\%}$	2.300	2.830	23.04	2.425	5.43	2.940	27.83	1.51 b					
Gemmeza 9	$NPK_{0\%}$	0.771	1.055	36.84	1.266	64.20	1.316	70.68	$NPK_{75\%}$		NS	0.337***	0.149***	***
	$NPK_{50\%}$	1.094	1.686	54.11	1.362	24.49	1.755	60.42	1.64 b					
	$NPK_{75\%}$	1.375	1.744	26.84	1.732	25.96	1.777	29.34	$NPK_{100\%}$	1.71a				
	$NPK_{100\%}$	1.885	2.195	16.45	2.095	11.14	2.285	21.22	2.67 a					
Mean of Inoc.		1.15 c	1.92 b		1.78 b		2.15 a							
Parameter			**Grains Yield (t/ha) EC: average 10.5 dSm^{-1}**											
Sakha 93	$NPK_{0\%}$	0.601	0.907	50.92	0.877	45.92	1.054	75.37	$NPK_{0\%}$					
	$NPK_{50\%}$	0.930	1.268	36.34	1.059	13.87	1.210	30.11	0.832 b					
	$NPK_{75\%}$	1.266	1.886	48.97	1.887	49.05	1.950	54.03	$NPK_{50\%}$	1.39a				
	$NPK_{100\%}$	1.354	1.828	35.01	1.824	34.71	1.991	47.05	1.08 b					
Gemmeza 9	$NPK_{0\%}$	0.541	0.764	41.22	0.818	51.20	0.853	57.67	$NPK_{75\%}$		0.231*	0.253***	0.089***	*
	$NPK_{50\%}$	0.852	1.149	34.86	0.907	6.45	1.262	48.12	1.43 a					
	$NPK_{75\%}$	0.941	1.246	32.41	0.958	1.81	1.383	46.97	$NPK_{100\%}$	1.08b				
	$NPK_{100\%}$	1.223	1.684	37.69	1.488	21.67	1.710	39.82	1.64 a					
Mean of Inoc.		0.899 d	1.37 b		1.21 c		1.49 a							

± % Increase or decrease to uninoculated (control) plants

Table (11). Effect of wheat inoculation with *Glomus intraradices* and Biotol on Protein (%) in the presence of different levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM		Biotol		AM+B		Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
				± %		± %		± %						
Parameter			Grain Protein (%) EC: average 2.8 dSm^{-1}									L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	0.47	0.81	72.50	0.71	51.67	0.84	78.62	$NPK_{0\%}$	0.95 a	NS	0.125***	0.056***	NS
	$NPK_{50\%}$	0.65	0.95	44.69	0.89	35.64	0.99	50.94	0.73c					
	$NPK_{75\%}$	0.78	1.25	59.73	1.06	34.88	1.25	59.73	$NPK_{50\%}$					
	$NPK_{100\%}$	0.92	1.23	33.12	1.16	25.86	1.27	37.38	0.92b					
Gemmeza 9	$NPK_{0\%}$	0.59	0.84	41.53	0.71	20.03	0.85	44.18	$NPK_{75\%}$	1.04 a				
	$NPK_{50\%}$	0.79	1.03	29.38	0.98	23.77	1.08	36.54	1.15a					
	$NPK_{75\%}$	1.04	1.30	25.22	1.16	11.70	1.39	34.17	$NPK_{100\%}$					
	$NPK_{100\%}$	1.03	1.33	29.60	1.18	14.47	1.38	33.86	1.18a					
Mean of Inoc.		0.78 c	1.09 a		0.98 b		1.13 a							
Parameter			Grain Protein (%) EC: average 5.3 dSm^{-1}											
Sakha 93	$NPK_{0\%}$	0.31	0.52	68.93	0.47	53.28	0.75	140.96	$NPK_{0\%}$	0.79 b	0.089*	0.112***	0.065***	NS
	$NPK_{50\%}$	0.50	0.89	77.35	0.79	57.50	0.83	65.57	0.57c					
	$NPK_{75\%}$	0.70	1.02	46.47	0.83	18.47	1.03	47.89	$NPK_{50\%}$					
	$NPK_{100\%}$	0.87	1.07	23.66	1.02	17.80	1.12	29.57	0.79b					
Gemmeza 9	$NPK_{0\%}$	0.38	0.67	74.60	0.64	66.20	0.81	113.15	$NPK_{75\%}$	0.92 a				
	$NPK_{50\%}$	0.64	0.94	46.22	0.79	23.20	1.01	57.90	0.97a					
	$NPK_{75\%}$	0.88	1.15	31.25	1.09	24.58	1.12	28.03	$NPK_{100\%}$					
	$NPK_{100\%}$	0.91	1.30	43.09	1.08	18.80	1.27	39.46	1.07a					
Mean of Inoc.		0.65 c	0.94 a		0.84 b		0.99 a							
Parameter			Grain Protein (%) EC: average 7.6 dSm^{-1}											
Sakha 93	$NPK_{0\%}$	0.24	0.46	95.97	0.37	55.96	0.59	150.22	$NPK_{0\%}$	0.65 a	NS	0.043***	0.042***	NS
	$NPK_{50\%}$	0.39	0.59	49.35	0.49	24.49	0.68	72.42	0.49d					
	$NPK_{75\%}$	0.56	0.89	58.35	0.73	30.89	0.89	58.73	$NPK_{50\%}$					
	$NPK_{100\%}$	0.71	0.96	36.03	0.84	19.33	1.03	45.80	0.57c					
Gemmeza 9	$NPK_{0\%}$	0.42	0.65	56.73	0.55	32.64	0.69	64.86	$NPK_{75\%}$	0.72 a				
	$NPK_{50\%}$	0.49	0.73	48.94	0.55	11.29	0.69	41.52	0.79b					
	$NPK_{75\%}$	0.66	0.88	32.39	0.82	23.29	0.96	44.17	$NPK_{100\%}$					
	$NPK_{100\%}$	0.73	0.92	25.50	0.84	15.23	0.95	30.76	0.87a					
Mean of Inoc.		0.52 d	0.76 b		0.65 c		0.81 a							
Parameter			Grain Protein (%) EC: average 10.5 dSm^{-1}											
Sakha 93	$NPK_{0\%}$	0.18	0.31	68.17	0.26	42.00	0.31	68.17	$NPK_{0\%}$	0.38 a	NS	0.044***	0.022***	NS
	$NPK_{50\%}$	0.28	0.40	45.91	0.37	34.91	0.40	45.52	0.28c					
	$NPK_{75\%}$	0.36	0.45	25.30	0.37	3.56	0.47	31.83	$NPK_{50\%}$					
	$NPK_{100\%}$	0.40	0.53	34.93	0.45	14.51	0.54	36.31	0.36b					
Gemmeza 9	$NPK_{0\%}$	0.22	0.32	45.74	0.30	35.83	0.35	60.90	$NPK_{75\%}$	0.39 a				
	$NPK_{50\%}$	0.27	0.38	39.19	0.34	27.40	0.42	54.47	0.40b					
	$NPK_{75\%}$	0.37	0.40	9.60	0.37	1.55	0.42	15.46	$NPK_{100\%}$					
	$NPK_{100\%}$	0.44	0.60	36.51	0.50	14.22	0.63	43.96	0.51a					
Mean of Inoc.		0.31c	0.42a		0.37b		0.44a							

± % Increase or decrease to uninoculated (control) plants

Table (12). Effect of wheat inoculation with *Glomus intraradices* and Biotol on proline (mg/100 g shoot dry wt.) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM	± %	Biotol	± %	AM+B	± %	Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
Parameter		Proline content (mg/100 g shoot dry wt.) EC: average 2.8 dSm^{-1}										L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	42.73	59.65	39.60	59.07	38.24	64.92	51.93	$NPK_{0\%}$	85.54a	NS	9.167***	4.981***	*
	$NPK_{50\%}$	63.68	83.15	30.58	73.31	15.13	89.04	39.82	57.47d					
	$NPK_{75\%}$	74.76	109.86	46.95	89.15	19.24	111.76	49.49	$NPK_{50\%}$					
	$NPK_{100\%}$	86.17	123.43	43.23	108.70	26.14	129.39	50.15	84.16c					
Gemmeza 9	$NPK_{0\%}$	47.98	60.37	25.84	62.24	29.74	62.75	30.79	$NPK_{75\%}$	92.12a				
	$NPK_{50\%}$	68.35	103.67	51.67	84.02	22.93	108.07	58.11	101.77b					
	$NPK_{75\%}$	77.11	117.44	52.29	107.48	39.37	126.63	64.21	$NPK_{100\%}$					
	$NPK_{100\%}$	98.42	121.09	23.03	109.26	11.01	119.05	20.96	111.94a					
Mean of Inoc.		69.90c	97.33 a		86.65 b		101.45 a							
Parameter		Proline content (mg/100 g shoot dry wt.) EC: average 5.3 dSm-1												
Sakha 93	$NPK_{0\%}$	36.81	53.70	45.90	47.72	29.64	58.63	59.28	$NPK_{0\%}$	82.78 a	NS	8.613***	3.055***	NS
	$NPK_{50\%}$	56.92	74.18	30.33	72.08	26.64	87.90	54.42	49.41 c					
	$NPK_{75\%}$	78.48	111.27	41.77	92.79	18.23	125.87	60.38	$NPK_{50\%}$					
	$NPK_{100\%}$	85.32	113.50	33.03	99.66	16.81	129.69	52.01	69.89 b					
Gemmeza 9	$NPK_{0\%}$	38.66	53.39	38.10	49.08	26.94	57.29	48.18	$NPK_{75\%}$	76.65 a				
	$NPK_{50\%}$	45.56	79.14	73.71	66.53	46.05	76.82	68.62	96.44 a					
	$NPK_{75\%}$	80.10	94.62	18.13	88.92	11.01	99.49	24.21	$NPK_{100\%}$					
	$NPK_{100\%}$	89.89	99.91	11.14	100.48	11.78	106.52	18.50	103.12 a					
Mean of Inoc.		63.97d	84.96 b		77.16 c		92.78 d							
Parameter		Proline content (mg/100 g shoot dry wt.) EC: average 7.6 dSm^{-1}												
Sakha 93	$NPK_{0\%}$	29.05	38.85	33.70	32.51	11.88	40.24	38.50	$NPK_{0\%}$	49.75 a	10.863*	7.424***	2.644***	NS
	$NPK_{50\%}$	28.86	40.46	40.22	38.72	34.19	43.12	49.44	30.33 b					
	$NPK_{75\%}$	46.26	65.57	41.72	59.14	27.83	69.08	49.31	$NPK_{50\%}$					
	$NPK_{100\%}$	55.05	73.04	32.67	62.00	12.62	74.07	34.54	34.53 b					
Gemmeza 9	$NPK_{0\%}$	17.90	28.00	56.44	25.34	41.55	30.72	71.65	$NPK_{75\%}$	37.49 b				
	$NPK_{50\%}$	21.00	35.50	69.02	31.46	49.81	37.09	76.59	52.13 a					
	$NPK_{75\%}$	31.90	50.61	58.69	42.60	33.57	51.86	62.60	$NPK_{100\%}$					
	$NPK_{100\%}$	43.79	52.03	18.81	46.55	6.29	53.59	22.36	57.52 a					
Mean of Inoc.		34.23c	48.01 a		42.29 b		49.97 a							
Parameter		Proline content (mg/100 g shoot dry wt.) EC: average 10.5 dSm^{-1}												
Sakha 93	$NPK_{0\%}$	25.36	28.44	12.13	28.06	10.64	31.23	23.13	$NPK_{0\%}$	37.83 a	10.852*	2.652***	0.997***	*
	$NPK_{50\%}$	28.26	37.30	32.01	36.95	30.76	40.87	44.61	24.25 d					
	$NPK_{75\%}$	34.44	45.85	33.13	39.76	15.43	47.74	38.60	$NPK_{50\%}$					
	$NPK_{100\%}$	36.81	49.34	34.04	45.29	23.05	49.65	34.90	29.72 c					
Gemmeza 9	$NPK_{0\%}$	16.23	21.08	29.88	19.29	18.85	24.32	49.79	$NPK_{75\%}$	25.50 b				
	$NPK_{50\%}$	19.40	25.01	28.93	22.51	16.08	27.50	41.76	34.39 b					
	$NPK_{75\%}$	22.34	28.60	28.03	25.70	15.06	30.72	37.54	$NPK_{100\%}$					
	$NPK_{100\%}$	27.12	33.00	21.68	30.46	12.34	34.75	28.13	38.30 a					
Mean of Inoc.		26.24d	33.58 b		31.00 c		35.85 a							

± % Increase or decrease to uninoculated (control) plants

Table (13). Effect of wheat inoculation with *Glomus intraradices* and Biotol on salicylic acid (mg/100g root fresh wt.) in the presence of four levels of soil salinity (averages of the two seasons 2012/2013 and 2013/2014)

Cultivars	NPK Levels	Un-inoc.	AM		Biotol		AM+B		Mean of NPK	Mean of Cultiv.	Cultiv.	NPK	Inoc.	Inoc.* NPK
			± %		± %		± %							
Parameter		Salicylic Acid (mg/100g root fresh wt.) EC: average 2.8 dSm^{-1}										L.S.D.$_{0.05}$		
Sakha 93	$NPK_{0\%}$	35.75	72.64	103.21	65.64	84.22	74.38	108.07	$NPK_{0\%}$	97.11a	NS	35.014***	13.003**	NS
	$NPK_{50\%}$	54.92	82.10	49.49	72.47	31.96	82.50	50.21	58.00 c					
	$NPK_{75\%}$	57.13	108.62	90.14	84.44	47.81	130.32	128.11	$NPK_{50\%}$					
	$NPK_{100\%}$	106.39	174.74	64.25	154.61	45.33	196.84	85.03	80.37 bc					
Gemmeza 9	$NPK_{0\%}$	32.62	63.88	95.81	52.28	60.24	66.69	104.13	$NPK_{75\%}$	97.84a				
	$NPK_{50\%}$	58.05	105.97	82.56	73.14	26.00	113.79	96.03	106.39 b					
	$NPK_{75\%}$	61.83	141.96	129.61	98.83	59.85	168.01	171.74	$NPK_{100\%}$					
	$NPK_{100\%}$	88.61	150.16	69.46	123.57	39.46	166.19	87.55	145.14 a					
Mean of Inoc.		61.91 c	112.51 a		90.65 b		124.83 a							
Parameter		Salicylic Acid (mg/100g root fresh wt.) EC: average 5.3 dSm^{-1}												
Sakha 93	$NPK_{0\%}$	33.10	48.91	47.74	42.87	29.51	55.36	67.22	$NPK_{0\%}$	91.42a	NS	23.330***	12.128***	***
	$NPK_{50\%}$	45.56	79.45	74.40	59.44	30.47	99.69	118.84	42.14 c					
	$NPK_{75\%}$	59.25	134.68	127.32	107.42	81.31	160.75	171.33	$NPK_{50\%}$					
	$NPK_{100\%}$	74.91	153.53	104.96	119.63	59.70	188.15	151.17	77.22 b					
Gemmeza 9	$NPK_{0\%}$	32.97	38.26	16.05	39.48	19.73	46.17	40.04	$NPK_{75\%}$	99.76a				
	$NPK_{50\%}$	44.85	114.91	156.22	60.41	34.69	113.44	152.94	123.41 a					
	$NPK_{75\%}$	76.89	159.55	107.50	114.46	48.85	174.30	126.68	$NPK_{100\%}$					
	$NPK_{100\%}$	90.23	162.42	80.01	144.60	60.26	183.26	103.11	139.59 a					
Mean of Inoc.		57.22 d	111.46 b		86.04 c		127.64 a							
Parameter		Salicylic Acid (mg/100g root fresh wt.) EC: average 7.6 dSm^{-1}												
Sakha 93	$NPK_{0\%}$	22.50	41.18	83.03	32.74	45.53	41.27	83.43	$NPK_{0\%}$	66.53 a	NS	13.41***	11.041***	NS
	$NPK_{50\%}$	26.62	86.62	225.39	58.16	118.50	102.01	283.19	34.48 c					
	$NPK_{75\%}$	40.10	93.54	133.27	73.48	83.26	102.87	156.54	$NPK_{50\%}$					
	$NPK_{100\%}$	62.08	100.06	61.17	72.02	16.01	109.29	76.05	59.54 b					
Gemmeza 9	$NPK_{0\%}$	19.32	40.05	107.26	29.31	51.67	49.46	155.94	$NPK_{75\%}$	64.32a				
	$NPK_{50\%}$	28.43	68.32	140.34	38.82	36.56	67.37	136.99	80.84 a					
	$NPK_{75\%}$	43.23	100.32	132.05	65.72	52.00	127.44	194.76	$NPK_{100\%}$					
	$NPK_{100\%}$	67.87	108.53	59.91	71.93	5.98	138.23	103.66	86.84 a					
Mean of Inoc.		38.77 c	78.49 a		55.27 b		89.16 a							
Parameter		Salicylic Acid (mg/100g root fresh wt.) EC: average 10.5 dSm^{-1}												
Sakha 93	$NPK_{0\%}$	14.05	36.06	55.88	25.34	43.68	39.46	120.07	$NPK_{0\%}$	54.93a	5.640*	9.861***	5.916***	*
	$NPK_{50\%}$	22.95	51.32	86.05	42.08	29.71	51.70	99.60	24.39 d					
	$NPK_{75\%}$	39.70	81.47	120.61	58.20	51.32	93.46	192.57	$NPK_{50\%}$					
	$NPK_{100\%}$	55.87	90.49	90.01	91.17	45.29	90.57	116.21	35.55 c					
Gemmeza 9	$NPK_{0\%}$	14.18	22.11	156.74	20.38	80.37	32.22	180.95	$NPK_{75\%}$	42.75b				
	$NPK_{50\%}$	18.91	35.18	123.63	24.53	83.36	37.75	125.29	60.88 b					
	$NPK_{75\%}$	28.02	61.83	105.21	42.41	46.60	81.99	135.42	$NPK_{100\%}$					
	$NPK_{100\%}$	41.18	78.24	61.97	59.83	63.19	89.03	62.11	74.54 a					
Mean of Inoc.		28.39 d	57.09 b		45.49 c		64.39 a							

± % Increase or decrease to uninoculated (control) plants

Showed significant increases in shoot and root dry weights and root length compared to uninoculated plants under field conditions. The results also show that, the lowest values of Na contents (mg/kg) were observed under EC ≤4 dSm-1 for plants inoculated with *G. intraradices* and Biotol under NPK100% for Sakha 93 and Gemmeza 9. The increased photosynthetic pigments by mycorrhizal colonization in plants is due to the inhibition of Na+ transport, which leads to better functioning of photosynthetic machinery (Borde *et al*. 2010; García-Garrido and Ocampo, 2002). Ragab *et al*. (2008) reported that, when irrigation wheat plants with different levels of salinity led to an increase in the concentration of the sodium component of wheat plants, and decrease NPK uptake, 1000 grain wt. and grain yield compared to wheat plants growing in low salinity. Daughtry *et al*. (2000) and Bojović and Markovic (2009), indicated that, inoculated wheat plant *Triticum aestivum* with AM fungi significantly increased chlorophyll content compared to un-inoculated plants. Since mycorrhization increases the absorption of Mg++ in plants, the synthesis of chlorophyll increases in mycorrhizal plants. Increasing chlorophyll activity in AM-inoculated plants decreases Na+ level under salt stress. The results also show that, inoculation with the AM fungus and Biotol, significantly increased proline and salicylic acid content when compared to uninoculated ones under different levels of soil salinity. Proline accumulation is one of the natural means to adapt to environmental stress conditions. Proline is a non-toxic and good osmolyte and maintains the osmoregulation under salt stress (Rasool *et al*. 2013a, b). Kumar *et al*. (2011) reported that, wheat plant inoculated with *Glomus mosseae* contained increased proline levels compared to non inoculated plants. Salicylic acid (SA), a plant phenolic, is considered as a hormone like endogenous regulator, and its role in the defence mechanisms against biotic and abiotic stresses has been well characterized, (Szalai *et al*. 2009). It also plays an important role in plant growth and plant defense responses to pathogen attack local (hypersensitive response) and systemic acquired resistance, (Durner and Klessig 1996). Zhang *et al*. (2013) reported that, inoculated wheat plants with AM fungi significantly increased salicylic acid contents compared to non AM-inoculated plants. Wheat plants Inoculated with *G. intraradices* alone or *G. intraradices* + Biotol resulted high values of NPK uptake, grain yield and protein contents of wheat grains for both cultivars. Zhu *et al*. (2010) and Mardukhi *et al*. (2011) reported that, wheat plant inoculated with AM fungi significantly increased NPK uptake compared to non AM-inoculated wheat plants. Sari, *et al.* (2002) reported similar results in garlic plants. Douds *et al.* (2005) and Ortas *et al.* (2001) confirmed that the AM hyphae increase the total absorption surface in infected plants which improve its access of immobile elements such as P, Cu, Zn. Kumar *et al.* (2011) and Bojović and Marković (2009) showed that, inoculated wheat plant with AM fungi showed significant increase in 1000 grain weight and grain yield compared to un-inoculated plants. Mycorrhizal colonization can enhance K+ absorption under saline conditions (Sharifi *et al.* 2007; Zuccarini and Okurowska, 2008). Nia *et al.* (2012) reported that, wheat plants inoculated with two *Azospirillum* isolates increased salinity tolerance, the saline-adapted isolate significantly increased grain yield. Afzal and Bano (2008), indicated that, wheat plant *Triticum aestivum* inoculated with *Rhizobium* strains significantly increased in grain yield, P content and protein content compared to uninoculated plants. Richardson *et al.* (2009),

showed that, plants inoculated of with Bacillus and Paenibacillus increased plant growth parameters compared to un-inoculated plants.

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الملخص العربي

امكانية استخدام فطر *Glomus intraradices* وعزلات مختلفة من البكتيريا المنشطة للجذور النباتية (Biotol) لتحسين محصول وجودة القمح النامي في الحقل تحت مستويات مختلفة من ملوحة التربة الجيرية

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تم إجراء تجربتان حقليتان خلال الموسمين الشتويين ٢٠١٢/٢٠١٣ و٢٠١٣/٢٠١٤ بالمزرعة البحثية لمحطة البحوث الزراعية بالنوبارية (الأراضي الجيرية). بهدف دراسة تأثير التلقيح بفطر الميكوريزا الداخلية وبكتريا الجذور المحفزة لنمو النبات (مستحضر البيوتول) تحت أربعة مستويات من ملوحة التربة وأربعة معدلات من التسميد المعدني بعناصر النيتروجين والفوسفور والبوتاسيوم علي النمو ، الصفات المحصولية ، المحتوي الكيميائي لصنفين من القمح (سخا ٩٣ وجميزة ٩) تحت ظروف التربة الجيرية. اشارت النتائج الي ان تلقيح نباتات القمح بفطر الميكوريزا ومستحضر البيوتول معا ادي الي تقليل تركيز عنصر الصوديوم في النباتات لدرجة معنوية وزيادة امتصاص عناصر النيتروجين والفوسفور والبوتاسيوم وايضا محتوي النباتات من البرولين ، حمض السليسليك ، الكلوروفيل ومحتوي الحبوب من البروتين تحت المستويات المختلفة من ملوحة التربة بالمقارنة بالنباتات غير الملقحة. تحت مستوي ملوحة التربة العادي ($\leq$4 dSm^{-}) [1] أدي التلقيح بفطر الميكوريزا و البيوتول معا الي الحصول علي أعلي قيم لمحصول حبوب القمح (٦.٥ و ٦.٧ طن/هكتار) للأصناف سخا ٩٣ وجميزة ٩ علي التوالي عند مستوي تسميد معدني $NPK_{100\%}$ الموصي به في منطقة النوبارية بزيادة قدرها ٤١ و ٢٩ % عن النباتات غير الملقحة. أظهرت النتائج ايضا عدم وجود اختلافات معنوية بين النباتات الملقحة بالميكوريزا والبكتيريا المنشطة لنمو النبات عند مستوي تسميد معدني ٧٥ أو١٠٠% من المعدلات الموصي بها من الأسمدة المعدنية NPK . ويمكن استخلاص أن التلقيح بفطر الميكوريزا ومخصب البيوتول يحسن من النمو وانتاجية نباتات القمح تحت تأثير الإجهاد الملحي.