Response of Barley to Nitrogen Fertilizer Sources, Sulphur Application, Inoculation with Mycorrhizae and Phosphate Slubilizing Bacteria in Salt Affected Soil

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ABSTRACT: This investigation aimed to increase barley grain yield. In this respect, two field experiments were carried out at the Experimental Farm, Faculty of Agriculture (Saba Basha), Alexandria University, Alexandria, Egypt, in a split- split plot design with three replications during 2013/2014 and 2014/2015 growing seasons. Main plot treatments were sulphur rates (0, 200 and 400 kg/ha), however nitrogen fertilizer sources (urea, nitrate ammonium and ammonium sulphate) were allocated in sub-plots and biofertilizers inoculation (control, mycorrhizae and phosphorein inoculation) were distributed in sub- sub plots. The obtained results indicated that increasing sulphur application up to 400 kg/ha., significantly increased all studied yield, yield components and grain composition traits, i.e. number and weight of spikes/m^2, number of spikelets and grains/spike, 1000-kernel weight, biological, straw and grain yield/ha, harvest index, grain protein, nitrogen, phosphorus and potassium content in the two studied seasons. Also, ammonium sulphate (as nitrogen source) produced the highest values of the previous trait. However, inoculated barley grains with phosphorein biofertilizers showed the highest of the studied traits except phosphorus grains content in the two seasons, where inoculation with mycorrhizae showed the highest grains phosphorus content (0.273 and 0.287%) in the two successive seasons. Sulphur application at 400 kg/ha., combined with ammonium sulphate or phosphorein inoculation interaction produced the highest values of all studied traits, except P and K contents in grains, meanwhile 400 kg S/ha application combined with mycorrhizal inoculation had the highest P and K content in two seasons. Ammonium sulphate X phosphorein inoculation interaction had the same trend in the two seasons. Regarding the three factors of interaction effects, sowing inoculated grains with phosphorein under 400 kg S/ha and ammonium sulphate application produced the highest values of the studied traits, except P and K grains content in both seasons. Conversely, any of two and three factors of interaction did not reach significant level effect on 1000- grains weight in the two seasons.
Keywords: Sulphur rate, Nitrogen sources, Biofertilizers, Barley, Yield, attributes, Grain quality.

INTRODUCTION

Barley (*Hordeum vulgare*, L.) is grown as a commercial crop in one hundred countries around the world and it assumes the fourth rank in total cereal production in the world after wheat, rice and maize (FAO, 2004). Barley is considered as one of the most important cereal crops in Egypt. It is the major food source in many North African countries, because it tolerates the adverse environments compared to other cereal crops (Hayes *et al*., 2003). Nitrogen is the most important factor affecting crop morphology (Amanullah *et al*., 2008), increased grains yield with increasing nitrogen level (Singh and Uttam, 2000).

Plant growth is enhanced through conversion of nutritionally important elements as nitrogen and phosphorus by biological processes as nitrogen fixation and solubilization of rock phosphate (Mohammadi and Sohrabi, 2012).

Sulphur is considered as soil amendment. Oxidation of sulphur to H_2SO_4 is beneficial in alkaline soil to reduce pH, supply SO^-_4 to plants, makes phosphorus and micronutrients more available in reclaim soils (Lindemann *et al*., 1991). Ghani *et al.* (1997) reported that microbial population in soil is not a limiting factor in elemental sulphur oxidation. Now days, biofertilizers inoculation is considered to limit the use of mineral fertilizers and supports an effective tool for desert development under less polluted environment, decreasing production costs, maximizing crop yield due to providing them with an available nutritive clement (Metin *et al*., 2012). Soil micro- organisms bind soil particles into stable aggregates, which improve soil structure and reduce erosion potential (Shetty *et al*., 1994).

Biofertilizer can be used as fertilizer or as soil amendment, depending on its effect on the plant nutrition.Hence, a fertilizer is a source of quickly available nutrients that have a direct and short-term effect on plant growth, while a soil amendment can influence plant growth indirectly by improving the physical and biological properties of the soil (Angelova *et al*., 2013).

A- Mycorrihzal fungi have been shown to promote plant growth and salinity tolerance by many researchers. They promote salinity tolerance by utilizing various mechanisms, such as enhancing nutrient uptake, producing plant growth hormones, improving rhizospheric and soil conditions, improvement in photosynthetic activity or water use efficiency, accumulation of compatible solutes, and production of higher antioxidant enzymes. As a result, AM fungi are considered suitable for bioamelioration of saline soils (Asghari *et al*. 2005, Hajiboland *et al.,* 2010, Manchanda and Garg 2011, and Evelin *et al*., 2012 and 2013).

The present investigation was carried out to study the effect of sulphur application rates, nitrogen sources and biofertilizers inoculation on growth, grains yield and its components of barley crop.

MATERIALS AND METHODS

Two filed experiments were carried out at the Experimental Farm, Faculty of Agriculture (Saba Basha), Alexandria University, Alexandria, Egypt, during 2013/2014 and 2014/2015 growing seasons to study effect of sulphur application rates, nitrogen fertilizer sources and biofertilizers inoculation on growth, grain yield and components, besides grain chemical contents of six-rows barley cv. Giza 123. A split- split plot design with three replicates were used in both seasons. Three sulphur application rates (0, 200 and 400 kg/ha) were randomly assigned in the main plots, three nitrogen sources, i.e. urea (46% N), ammonium nitrate (33.5% N) and ammonium sulphate (20.6% N) were allocated in sub-plots and three biofertilizers treatments (uninoculation, mycorrhizae and phosphorein at 400 g/ha.) were randomly distributed in sub-sub plots. Barley was sown on 4^{th} and 8^{th} December in two growing seasons, respectively, after maize planting. Seeding rate was (70 kg/ha.) and plot size was 10.5 m^2 (1/400 fed.) with 3.5 m length and 3 m width. Sulphur applied during seed bed preparation, nitrogen fertilizer at 144 kg/ha., were applied in two equal doses before the first and second irrigations.

Phosphorene (*Bacillus megtherium phosphbacterium*) was performed by coating barely grains with each product individually using a sticking substance (Arabic gum 5%) just before sowing. A- mycorrhizal fungi (*Glomus macrocaripum*) was obtained from Plant Production Department, Faculty of Agriculture (Saba Basha), Alexandria Uinversity at the rate of 250 spores was mixed with grain. Recommended cultural practices for barley production were conducted Soil physical and analyses were carried out in the two growing seasons and showed in Table (1).

Table (1). Physical and chemical properties of experimental soil in 2013/2014 and 2014/2015 seasons.

Soil properties		
	2013/2014	**2014/2015**
A- Mechanical analysis		
Clay %	37	36
Sand %	33	34
Silt	30	30
Soil texture	Clay loam	Clay loam
B- Chemical properties		
pH (1:1)	8.30	8.41
EC (1:1) dS/m	3.70	3.65
1- Soluble cations (1:2)		
K^+	1.45	1.58
Ca^{++}	8.7	8.3
Mg^{++}	18.5	18.6
Na^{++}	13.8	13.8
2- Soluble anions (1:2)		
CO^-_3+ HCO^-_3	2.80	2.60
CL^-	19.80	18.80
SO^-_4	12.60	12.70
Calcium carbonate %	7.00	7.30
Total nitrogen %	0.91	0.81
Available Phosphorus (mg/kg)	3.55	3.41
Organic matter (%)	1.41	1.40

At harvest, one square meter was randomly taken in each sub- sub plot to determine number of spikes/m^2, ten random spikes were chosen in each sub-sub plot to calculate number of grains/spike and thousand kernel weight (g) was determined as an average of three samples. Biological and grain yield by harvesting all plants in each sub-sub and converted to tons/ha., harvest index besids protein N, P and K grain content were determined.

Protein percentage was determined by estimating the total nitrogen in the grains and multiplied by 6.25 to obtain the protein percentage according to grains protein percentage to AOAC (1990). NPK percentages were determined in the dry grains. Their dry weights were determined following drying in a drying chamber to a constant weight at 75°C for 72 hour according to Tandon (1995). After dryness, the plant samples were milled and stored for analysis as reported. However, 0.5g of the grains powder was wet-digested with H_2SO_4–H_2O_2 mixture according to (Lowther, 1980) and the following determinations were carried out in the digested solution to determine NPK. Total nitrogen was determined in digested plant material colorimetrically by Nessler`s method (Chapman and Pratt, 1978). Phosphorus was determined by the Vanadomolyate yellow method as given by Jackson (1973) and the intensity of colour developed was read in spectrophotometer at 405nm. Potassium was determined according to the method described by method Jackson (1973) using Beckman Flame photometer.

Collected data were statistically analyzed using Co stat (2005) statiscal program, and treatment mean were compared using the least significand differences method (L.S.D) at 5% probability level as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A- Yield and yield attributes:

Data presented in Table (2) showed that studied yield components, i.e. spikes number and weight/m^2, number of spikelets and grains/spike and 1000-grain weight were, significantly, affected by sulphur application levels, nitrogen fertilizer sources and biofertilizer inoculation in the two studied seasons.

Increasing sulphur application from zero to 400 kg/ha., significantly increased the previous traits by 23.11% for number of spikes/m^2, 26.66 % for spikes weight/m^2, 17.90% for number of spikelets/spike, 14.48% for number of grains/spike and 7.21% for 1000- kernel weight as an average of the seasons, respectively. These increases in the studied yield components in barley crop might be reffered to the favorable effect of sulphur for decreeing soil pH and increasing phosphorus and micronutrients availability to plant (Lindemenn *et al.*, 1991).

Results also, demonstrated that nitrogen application as ammonium sulphate produced the highest number of spikes/m^2 (394.14 and 388.96), heaviest spikes weight/m^2 (279.19 and 269.50g), highest number of spikelets/spike (51.74 and 52.51), highest number of grains/spike (38.66 and 39.70) and heaviest 1000- grain weight (46.46 and 49.55g) in the first and second growing seasons, respectively.

Concerning biofertilization treatments, results in Table (2) revealed that inoculated barley grains with mycorrhizae or phosphorein significantly increased all the studied yield attributes in the two seasons compared to uninoculated grains.

Barley grains inoculated with phosphorein biofertilizer showed the highest number of spikes/m^2 (402.20), spikes weight/m^2 (284.82g), number of spikelets/spike (52.96), number of grains/spikes (40.24) and 1000- grains weight (48.12g) as an average of the two seasons. These increase could be due to the stimulation effect of micro- organisms that produce plant pgytohormons as IAA, Gas and SKs, which promote plant growth cell division, hence encouraging photosynthesis and assimilates accumulation (El- Khawas, 1990 and Hussein and Radwan 2001).

Concerning sulphur appliacation levels X N sources interaction effect, results in Table (3) showed that applied 400 kg S/ha to barley fertilized by ammonium sulphate shoed the highest number of spikes/m^2 (418.66) in the second season, weight of spikes/m^2 (335.17 and 300.77g), number of spikelets/spike (57.88 and 58.66) and number of grains/spike (42.0 and 43.44) in the first and second seasons, respectively.

Results presented in Table (3) indicated that biological, straw and grain yield besides harvest index were significantly affected with the three studied factors, where applied 400 kg S/ha produced the highest biological yield (18.03 and 17.87 ton/ha) straw yield (11.03 and 10.83 ton/ha), grain yield (6.97 and 7.03 ton/ha) and harvest index (38.51 and 39.19%) in the first and second seasons, respectively.

Data in Table (3) also, revealed that using ammonium sulphate as nitrogen source gave the highest values(17.24 and 16.99 ton/ha), (10.30 and 9.98 ton/ha), (6.99 and 6.78ton/ha) and (40.11 and 39.70%) for the respective traits in the two seasons, respectively. Also, inoculated barley grains with phosphorein showed the highest values (17.46 and 17.19 ton/ha), (10.61 and 10.52 ton/ha), (6.84 and 6.66 ton/ha) and (38.93 and 38.44%) for the previous characters in the two successive seasons.

On the other side, applied 400 kg S/ha combined with ammonium sulphate fertilization showed the highest biological, straw and grain yields besides H.I in the two seasons Table (4). However, sulphur application at 400 kg/ha inoculated grains with phosphorein produced the highest straw yield (12.02 ton/ha) in the first season, biological yield (19.99 and 19.77 ton/ha), grain yield (7.96 and 8.05 ton/ha) and H.I. (39.66 and 40.66%) in the first and second seasons, respectively. as reported in Table (5).

With respect to nitrogen sources X biofertilizers inoculation effect, results presented in Table (10) indicated that phosphorein inoculation combined with fertilization with ammonium sulphate produced that highest straw yield (10.81 ton/ha) in the first season, biological yield (18.72 and 18.78 ton/ha), grain yield (7.90 and 7.92 ton/ha) and harvest index (42.21 and 42.18%) in the two successive seasons, respectively..

Regarding three factors interaction effect, results presented in Table (7) showed that the highest straw yield in the first season (12.68 ton/ha), biological yield (21.77 and 21.78 ton/ha), grain yield (9.09 and 9.16 ton/ha) and HI (41.53 and 42.05%) in the first and second seasons, respectively. resulted from using 400 kg S/ha, ammonium sulphate as N source application to inoculated barley grains with phosphorein.

Table (2). Effect of sulphur application level, nitrogen fertilizer source and biofertilizers on barley yield components during 2013/2014 and 2014/2015 seasons.

Treatment	No. of number spikes/m^2		Spikes weight/m^2		No. of spikelets/spike		No. of grains/spike		1000- grain weight	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
A) Sulphur rate (kg/ha)										
0	325.44c	332.48c	233.35c	238.62c	45.40c	45.81c	34.21c	35.88c	43.76c	46.66c
200	385.74b	392.29b	253.23b	252.84b	49.18b	49.14b	37.26	37.24b	45.57b	48.62b
400	410.59a	399.18a	303.96a	293.63a	52.29a	54.25a	39.66a	40.55a	46.87a	50.7a
L.S.D.at 0.05	7.07	4.56	3.78	2.35	0.29	0.55	0.56	0.46	0.82	1.22
B) N Sources										
Urea	358.48c	364.11c	249.32c	251.42c	47.11c	47.29c	35.10c	36.10c	44.51c	47.34c
Nitrate	369.14b	370.88a	262.03b	264.18b	49.03b	49.40b	49.03b	37.88b	45.23b	48.46b
Sulphate	394.14a	288.96a	279.19a	269.50a	51.74a	52.51a	38.66a	39.70a	46.46a	49.55a
L.S.D.at 0.05	2.08	2.66	1.26	1.60	1.03	0.55	0.51	0.46	0.70	0.61
C) Biofertilizer										
Control	343.44c	348.66c	242.75c	244.78c	45.92c	46.29c	34.81c	35.03c	44.25c	46.78c
Mycorrhizae	377.06b	372.14b	262.96b	255.51b	49.18a	49.85b	36.55b	37.95b	45.61b	48.68b
Phosphorein	401.25a	403.14a	284.83a	284.81a	52.85a	53.07a	39.77a	40.70a	46.35a	49.89a
L.S.D.at 0.05	2.79	2.71	1.40	1.98	0.79	0.60	0.83	0.31	0.61	0.76
Interactions										
A×B	ns	*	*	*	*	*	*	*	ns	ns
A×C	*	*	*	*	*	*	*	*	ns	ns
B×C	*	*	*	*	ns	ns	*	*	ns	ns
A×B×C	*	*	*	*	ns	*	ns	*	ns	ns

Means at the same column followed by the same letter are statistically equaled according to L.S.D. at 0.05 value, ns: not significant and *: significant difference at 0.05 level of probability.

Table (3). Effect of sulphur application level, nitrogen fertilizer source and biofertilizers on barley yield during 2013/2014 and 2014/2015 seasons.

Treatment	Biological yield (ton/ha)		Straw yield (ton/ha)		Grain yield (ton/ha)		Harvest index (H.I%)	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
A) Sulphur level (kg/ha):								
0	14.25c	14.35c	8.88c	9.07c	5.58c	5.28c	39.16a	36.79c
200	15.56b	15.26b	9.66b	9.63b	5.89b	5.71b	37.55b	37.30b
400	18.03a	17.87a	11.06a	10.83a	6.97a	7.03a	38.85a	39.34a
L.S.D. at 0.05	0.06	0.02	0.01	0.21	0.23	0.02	0.18	0.11
B) Nitrogen fertilizer Source:								
Urea	14.61.c	14.97c	9.35c	9.48b	5.26c	5.49c	35.48c	36.53c
Nitrate	15.98b	15.51b	9.72b	9.76ab	6.26b	5.76b	37.57b	36.97b
Sulphate	17.24a	16.99a	10.30a	9.98a	6.94a	6.78a	40.26a	39.70a
L.S.D. at 0.05	0.06	0.02	0.02	0.39	0.20	0.02	0.20	0.11
C) Biofertilizer:								
Control	14.40c	14.48c	9.18c	8.93c	5.44c	5.33c	36.11c	36.77c
Mycorrhizae	15.97b	15.80b	9.978b	9.76b	6.18b	6.03b	38.49b	37.99b
Phosphorein	17.46a	17.19a	10.61a	10.52a	6.48a	6.66a	38.93a	38.44a
L.S.D. at 0.05	0.09	0.02	0.01	0.37	0.18	0.01	0.22	0.07
Interaction:								
A×B	*	*	*	ns	*	*	*	*
A×C	*	*	*	ns	*	*	*	*
B×C	*	*	*	ns	*	*	*	*
A×B×C	*	*	*	ns	*	*	*	*

Means at the same column followed by the same letter are statistically equaled according to L.S.D. at 0.05 value, ns: not significant and *: significant difference at 0.05 level of probability.

Table (4). The interaction between sulphur application levels and nitrogen fertilizer sources for biological yield, straw yield, grain yield (ton/ha) and harvest index (%) during 2013/2014 and 2014/2015 seasons.

Sulphur level (kg/ha)	N-source	Biological yield (ton/ha)		Straw yield (ton/ha)	Grain yield (ton/ha)		Harvest index (%) (H.I.)	
		2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14
0	Urea	13.61	14.06	8.90	4.70	4.93	34.58	35.10
	Nitrate	14.24	14.24	9.0	5.90	5.16	36.79	36.29
	Sulphate	14.90	145.76	8.75	6.14	5.74	39.01	38.75
200	Urea	13.83	14.29	9.94	4.89	5.17	35.36	36.22
	Nitrate	15.95	14.84	9.91	6.04	5.27	37.46	35.59
	Sulphate	16.89	16.64	10.13	6.76	6.70	39.84	40.08
400	Urea	16.38	16.56	10.15	6.17	6.36	37.58	38.26
	Nitrate	17.76	17.46	10.92	6.84	6.48	38.47	39.03
	Sulphate	19.94	19.57	12.02	7.91	7.91	40.49	40.27
L.S.D. 0.05		0.10	0.03	0.03	0.35	0.35	0.35	0.19

Table (5). Effect of sulphur application level and biofertilizers on biological yield, straw yield, grain yield (ton/ha) and harvest index (%) during 2013/2014 and 2014/2015 seasons.

Sulphur level (kg/ha)	Bio-fertilizer	Biological yield (ton/ha)		Straw yield (ton/ha)	Grain yield (ton/ha)		Harvest index (H.I %)	
		2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14
0	Control	13.0	13.39	8.26	4.99	4.93	35.25	36.76
	Mycorrhizae	14.30	14.16	8.85	5.45	5.12	37.87	36.17
	Phosphorein	15.45	15.51	9.54	5.90	5.79	38.12	37.21
200	Control	14.10	14.15	9.10	5.40	5.19	36.40	36.72
	Mycorrhizae	15.64	15.34	9.60	6.04	5.81	38.39	37.73
	Phosphorein	16.64	16.29	10.28	6.65	6.15	39.02	37.45
400	Control	16.11	15.91	10.18	5.92	5.87	36.67	36.82
	Mycorrhizae	17.98	17.91	10.88	7.05	7.18	39.20	40.07
	Phosphorein	19.99	19.77	12.02	7.96	8.05	39.66	40.66
L.S.D. 0.05		0.08	0.03	0.02	0.32	0.02	0.39	0.12

Table (6). Interaction between nitrogen fertilizer sources and biofertilizers for biological yield, straw yield, grain yield (ton/ha.) and harvest index (%) during 2013/2014 and 2014/2015 seasons.

N Source	Bio-fertilizer	Biological yield (ton/ha)		Straw yield (ton/ha)	Grain yield (ton/ha)		Harvest index (H.I%)	
		2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14
Urea	Control	13.54	13.88	8.78	4.76	4.99	35.13	35.97
	Mycorrhizae	14.47	14.92	9.16	5.26	5.60	36.22	37.37
	Phosphorein	15.82	16.11	10.06	5.75	5.87	36.16	36.24
Nitrate	Control	14.25	14.30	9.16	5.75	2.25	35.45	36.76
	Mycorrhizae	15.86	15.56	9.70	6.16	5.82	38.74	37.25
	Phosphorein	17.85	16.67	10.87	6.87	6.20	38.43	36.90
Sulphate	Control	15.41	15.27	9.61	5.80	5.75	37.64	37.57
	Mycorrhizae	17.59	16.93	10.48	7.11	6.68	40.49	39.35
	Phosphorein	18.72	18.78	10.81	7.90	7.92	42.21	42.18
L.S.D. 0.05		0.08	0.03	0.02	0.32	0.02	0.39	0.12

Table (7). The interaction effect among sulphur application levels, nitrogen sources and biofertilizers inoculation for biological yield, straw yield, grain yield (ton/ha) and harvest index (%) during 2013/2014 and 2014/2015 seasons.

Sulphur rate	N-Source	Bio-fertilizer	Biological yield (ton/ha)		Straw yield (ton/ha)	Grain yield (ton/ha)		Harvest index (H.I %)	
			2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14
0	Urea	Control	12.68	13.21	8.22	4.71	4.78	34.56	34.55
		Mycorrhizae	13.50	13.89	8.78	5.02	4.86	34.93	34.58
		Phosphorein	14.67	14.95	9.64	6.72	5.17	34.26	37.57
	Nitrate	Control	12.94	13.34	8.29	6.19	4.96	36.49	36.57
		Mycorrhizae	14.04	14.21	8.85	5.81	5.19	36.99	35.76
		Phosphorein	15.75	15.30	9.94	5.10	5.32	36.88	36.96
	Sulphate	Control	13.38	13.63	8.27	6.45	5.04	38.14	36.98
		Mycorrhizae	15.38	14.37	8.93	6.88	5.31	41.68	42.31
		Phosphorein	15.94	16.28	9.05	4.68	6.89	43.22	36.81
200	Urea	Control	13.16	13.60	9.47	4.81	5.01	35.58	36.90
		Mycorrhizae	13.62	14.10	8.81	5.18	5.20	35.32	34.96
		Phosphorein	14.72	15.18	9.54	4.79	5.31	35.19	36.33
	Nitrate	Control	14.05	13.75	9.26	6.26	5.07	33.62	35.25
		Mycorrhizae	16.15	15.16	9.89	7.06	5.34	38.76	35.18
		Phosphorein	17.65	15.40	10.59	5.51	5.42	40.0	37.01
	Sulphate	Control	15.09	14.89	9.57	7.04	5.51	36.54	41.05
		Mycorrhizae	17.14	16.75	10.09	7.72	6.88	41.09	42.20
		Phosphorein	18.44	18.29	10.72	5.21	7.72	41.88	35.35
400	Urea	Control	14.79	14.71	9.57	6.26	5.20	35.26	40.25
		Mycorrhizae	16.29	16.77	9.88	6.26	6.75	38.43	39.19
		Phosphorein	18.07	18.21	10.99	7.06	7.14	39.05	36.93
	Nitrate	Control	15.75	15.74	10.0	5.75	5.73	36.53	36.93
		Mycorrhizae	17.40	17.33	10.35	7.04	6.92	40.47	39.95
		Phosphorein	20.14	19.32	12.40	7.73	7.87	38.41	40.76
	Sulphate	Control	17.78	17.30	10.98	6.80	6.70	38.24	38.74
		Mycorrhizae	21.77	19.65	12.42	7.85	7.86	38.71	40.02
		Phosphorein	21.77	21.78	12.68	9.09	9.16	41.53	42.05
L.S.D. 0.05			0.13	0.05	0.04	0.55	0.04	0.67	0.21

B- Chemical composition of grains:

Data in Table (8) illustrated the three studied factors effect on crude protein, nitrogen, phosphorus and potassium content of grain in the two seasons. Increasing sulphur application up to 400 kg/ha produced the highest protein (9.03 and 7.27 %), nitrogen (1.44 and 1.163 %), phosphorus (0.273 and 0.299 %) and potassium (0.550 and 0.616 %) content in the first and second seasons, respectively.

Also, barely fertilized with ammonium sulphate produced the highest mean values of the studied traits (9.27 and 7.23 %) for protein (1.485 and 1.157 %) phosphorus, (0.266 and 0.285 %) and potassium (0.550 and 0.616 %) content in the two successive seasons, respectively.

Inoculation with phosphorein gave the highest protein content (9.14 and 7.27 %) nitrogen (1.433 and 1.163 %) and potassium (0.540 and 0.619 %) in the first and second seasons, respectively. However, mycorrhizae inoculation produced the highest phosphorus content (0.273 and 0.287 %) in the first and second seasons, respectively.

Concerning the three factors of interaction, results presented in Table (8) revealed that there were significant interactions among the traits under this study.

The previous results pointed out that interaction among the three studied factors had significant interaction for the yield, yield components and grain chemical composition.

Plant responses are deeply affected by the proportion of mineral N sources (Andrews *et al.*, 2013). While NH^{+}_{4} as sole nutrient can induce toxicity symptoms, its co-provision with NO_3^- generally promotes a synergistic effect leading to growth enhancement (Britto and Kronzucker, 2002). It is noteworthy that NH^{+}_{4} tolerance was related to high root N metabolism sus- tained by high GS activities (Cruz *et al.*, 2006), which in maize appear to be associated with the capacity to cope with the C skeleton demands (Schortemeyer *et al.*, 1997).

Table (8). Effect of sulphur application level, nitrogen fertilizer source and biofertilizers on protein in grains %, N, P and K percentage during 2013/2014 and 2014/2015 seasons.

Treatment	Protein %		N %		P %		K %	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2013/14
A) Sulphur level (kg/ha):								
0	7.23c	6.92c	1.157c	1.108c	0.246c	0.255c	0.455c	0.463c
200	8.44b	7.20b	1.352b	1.153b	0.258b	0.268b	0.537b	0.268b
400	9.03a	7.27a	1.448a	1.163a	0.273a	0.299a	0.599a	0.697a
L.S.D. at 0.05	0.09	0.02	0.012	0.004	0.001	0.001	0.001	0.001
B) Nitrogen fertilizer source:								
Urea	7.18c	6.99c	1.148c	1.118c	0.251c	0.261c	0.512c	0.567c
Nitrate	8.26b	7.18b	1.324b	1.148b	0.259b	0.276b	0.529b	0.277b
Sulphate	9.27a	7.23a	1.485a	1.157a	0.266a	0.285a	0.550a	0.616a
L.S.D. at 0.05	0.08	0.01	0.014	0.002	0.001	0.002	0.001	0.002
C) Biofertilizer:								
Control	7.29c	6.97c	1.166c	1.115	0.250c	0.256c	0.503c	0.553c
Mycorrhizae	8.28b	7.16	1.358b	1.147	0.273a	0.287a	0.509	0.604b
Phosphorein	9.14a	7.27a	1.433a	1.163a	0.264b	0.278b	0.540a	0.619a
L.S.D. at 0.05	0.06	0.01	0.011	0.002	0.001	0.001	0.001	0.001
Interaction								
A×B	*	*	*	*	*	*	*	*
A×C	*	*	*	*	*	*	*	*
B×C	*	*	*	*	*	*	*	*
A×B×C	*	*	*	*	*	*	*	*

Means at the same column followed by the same letter are statistically equaled according to L.S.D. at 0.05 value., ns : not significant and *: significant difference at 0.05 level of probability.

CONCLUSION

In conclusion, applying 400 kg S/fed., and ammonium sulphate as nitrogen fertilizer source to inoculated barley grains of Giza 123 cultivar with phosphorein produced the highest grains yield, yield attributes and grains quality studied traits under Alexandria Governorate conditions.

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الملخص العربي

استجابة الشعير لمصادر السماد النتروجينى وإضافة الكبريت والتلقيح بالميكوريزا والبكتيريا المذيبة للفوسفور تحت ظروف التربة المتأثرة بالأملاح

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أجريت تجربتان حقليتان بالمزرعة البحثية بكلية الزارعة سابا باشا بمنطقة أبيس جامعة الإسكندرية خلال الموسمين ٢٠١٤/٢٠١٣ ، و٢٠١٥/٢٠١٤،وذلك لدراسة تأثير مصادر السماد النتروجينى وإضافة الكبريت والتلقيح بالميكوريزا والبكتيريا المذيبة للفوسفور على الشعير تحت ظروف التربة المتأثرة بالأملاح . وتم استخدام تصميم القطع المنشقة مرتين في ثلاث مكررات في تنفيذ التجربتان ، حيث وزعت (معاملات إضافة الكبريت بمعدل ٠ ، ٢٠٠ ، ٤٠٠ كجم/هكتار) القطع الرئيسية ، ووزعت مصادر السماد النتروجينى (يوريا ، نترات امونيوم ،سلفات الأمونيوم) في القطع تحت الرئيسية ، التلقيح بالسماد الحيوي (بدون ، الميكوريزا ، الفوسفورين) كانت في القطع تحت الرئيسية.

ويمكن تلخيص أهم النتائج فيما يلي:

- أدت إضافة الكبريت بمعدل ٤٠٠ كجم لزيادة معنوية في جميع الصفات المدروسة في الموسمين.
- التسميد بسماد النتروجين في صورة سلفات الأمونيوم حقق أعلى قيم للصفات تحت الدراسة ، مقارنة بالصور الأخرى (يوريا ، نترات امونيوم) بالنسبة لارتفاع النبات ولصفات المحصول ومكوناته في موسمي الزراعة.
- حقق تلقيح حبوب الشعير بالميكوريزا أعلى قيم لمحصول ، يليه التلقيح بالفوسفورين ، مقارنة بمعاملة الكنترول (بدون تلقيح بالسماد الحيوي) الذى حقق أقل القيم لهذه الصفات خلال موسمي الدراسة.
- أدى زراعة الشعير تحت معدل إضافة الكبريت ٤٠٠ كجم + سماد النتروجين فى صورة سلفات الأمونيوم أعلى القيم للصفات المحصول المدروسة خلال موسمي الزراعة ، مقارنة بين بالمعاملات الأخرى حيث المعاملة بدون كبريت (الكنترول) سجلت أقل القيم.
- سجل إضافة الكبريت ٤٠٠ كجم + التلقيح بالفوسفورين أعلى استجابة للزيادة المحصولية ، حيث حقق أعلى قيم لمحصول الحبوب والقش والمحصول البيولوجي خلال موسمي الزراعة.
- سجل تسميد الشعير بالسماد النتروجين فى صورة سلفات الأمونيوم مع تلقيح الحبوب بالفوسفورين أعلى قيم لمحصول الحبوب ، والقش والبيولوجي ودليل الحصاد فى الموسمين ٢٠١٤/٢٠١٣ ، و ٢٠١٥/٢٠١٤.
- أدت إضافة سماد الكبريت بمعدل ٤٠٠ كجم مع السماد النتروجين فى صورة سلفات الأمونيوم مع تلقيح الحبوب بالفوسفورين إلي الحصول علي أعلي القيم للمحصول (محصول الحبوب، والقش البيولوجي (طن/هكتار) وأيضاً دليل الحصاد (%) في كلا الموسمين.