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Applied Botany

Elixir Appl. Botany 51 (2012) 10743-10749

ISSN: 2229-712X

Productivity of some barley cultivars as affected by inoculation under water stress conditions

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ARTICLE INFO

Article history:
Received: 4 August 2012;
Received in revised form:
20 September 2012;
Accepted: 30 September 2012;

Keywords
Biofertilzers inoculation,
Water stress,
Barley cultivars,
Yield.

ABSTRACT

Water scarcity and drought are the main constraints of crop production. Many technologies have been developed to cope with this environmental problem. So improve crop production under limited amount of available water is a measure issue to maximize the return by unit of water (water productivity). To achieve the aforementioned objectives, two field experiments were carried out in the Experimental Farm of National Research Centre Shalkan Kalubia during the winter seasons of 2006/ 2007 and 2007/2008 to study the effect of seed inoculation with (phosphorine and cerealine) on the yield and yield components of some barley cultivars (Giza 126, Giza 130 and Giza 2000) subjected to water stress at different stages of growth (at tillering or milk- ripe stage), Data indicate that, water stress at any stage of growth (tillering or milk- ripe stage) depress most of the studied yield and yield attributes .Such effect was pronounced when barley plants were subjected to water deficit at milk- ripe stage. Dual application of biofertilizer (phosphorine and cerealine) improved yield and yield attributes of barley plants as compared with un-inoculated plants. The data also show that biofertilizers inoculation alleviate the adverse effect of water stress on barley yield. The results indicated that Giza 126 produced the highest grain yield and seed index

Introduction

Food productivity is decreasing due to detrimental effects of various biotic and abiotic stresses, therefore minimizing these losses is a major area of concern to ensure food security under changing climate and a world with water shortage (Anjum *et al.*, 2011). Drought, being the most important environmental stress, severely impairs plant growth and development, limits plant production and the performance of crop plants, more than any other environmental factor (Shao *et al.*, 2009). It affects every aspects of plant growth and the worldwide losses in yield from water stress probably exceed the losses from all other causes combined because drought even temporary can cause substantial losses in crop yields (Ashraf and Khan, 1993). Drought affects all developmental stages of crops, the reproductive stage being the most sensitive. Depending on the duration and severity of the stress, shortage of water at the reproductive stage can cause irreversible yield loss due to low test weight and fewer seeds per plant. Thus, it is necessary to determine the critical period that is affected greatly by soil moisture content and planning the best irrigation regime for obtaining maximum yield. Better performance of the crop depends upon availability of water during these stages. Thus, any degree of water imbalance may cause deleterious effects on growth potentials.

Since nutrient uptake is closely linked to water soil status, it is expected that, decline of available soil moisture might decrease the diffusion rate of nutrients from soil matrix to roots. Evidence of decreased ion uptake due water stress effect was attributed to the reduction in root absorption power (Aldesuquy *et al.*, 2012). However root growth and potential root hydraulic conductance have been found to increase with inoculation (Pereyra, *et al.*, 2006) who reported that inoculation is accompanied by biochemical changes in roots which, in turn, promote plant-growth and tolerance to water stress. Presumably, increased root growth would lead to a greater volume of soil explored and hence a greater potential reservoir of soil water. It is also possible that inoculation enables the plant to better withstand drought conditions due to its role in energy storage and protein formation. Thus, under such drought condition and continuous decrease in nutrient uptake of the soils the importance use of seed inoculation has been indicated by Damodar *et al.*, (1999). The suitable cultivar adapted with environmental condition and tolerant to water stress is one of the limited factors in barley production. Many researchers found that barley cultivars differed in their growth and yield response to unfavorable condition Rizza *et al.*, (2004) and Katerji *et al.*, (2009). Thus, the objective of this research is to study the productivity of some barley cultivars as affected by inoculation under water stress conditions during different stages of growth.

Materials & Methods

Two field experiments were carried out during the winter season in the Experimental Farm of the National Research Centre at Shalkan Kalubia Governorate during the winter seasons of 2006/ 2007 and 2007/2008 to investigate the influence of seed inoculation on the growth and yield of some barley cultivars subjected to water stress at different stages of growth. The mechanical and chemical analysis of the soil was conducted according to the method described by Klute (1982) and is presented in Table (1). Three barley cultivars (*Hordeum vulgare* L.) cv. Giza 126 and Giza 130 and Giza 2000 were evaluated under inoculation treatment and water stress at different stages of growth. The experimental design was split split block design with four replicates where the main plots allocated to the two inoculation treatment which include two inoculation treatments (inoculated grains and without

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inoculation). The seed was inoculated with both (1.35 kg/ha) cerealine (nitrogen fixing bacteria include *Azospirilum sp* strains) and (1.35 kg/ha) phosphorein (phosphate dissolving bacteria include *Bacillus megaterium*. Both cerealine and phosphorin are produced by biofertilizers unit, General Organization of Agriculture Equalization Fund (G.O.A.E.F.), Agriculture Research centre, Ministry of Agriculture, Giza , Egypt.

Each plot were divided to three sub plots and subjected to the following water stress treatment: (1) control (plants irrigated regularly), (2) plants subjected to water stress at tillering stage (28 days from sowing) and (3) plants subjected to water stress at milk- ripe stage (70 days from sowing). Borders were made between drought treatments. The three barley cultivars were assigned as sub sub plot. The plot size was 21 m^2 = 1/200 fed. Grains of barley were sown in 15 November in both winter seasons. Recommended rates of phosphorus 150 kg P_2O_5 / fed. as super phosphate (15.5 %) and potassium 48 kg K_2O /fed. as potassium sulphate (48 %), were applied just after land preparation and before planting. Nitrogen in the rate of 45 kg N / fed. as urea (46%) were added in two doses before 1st and 2nd irrigation. Random samples of ten plants from each treatment were taken at harvest time to estimate the following characters: Plant height (cm.), No. of tillers / plant, No. of spikes / plant, No. of grains / spike, No. of spikes / m^2, weight of grains / spike (gm), weight of grains/spike and seed index (weight of 100 grains in gm). On the basis of plot size the following traits were estimated: 1-Grain yield (ton / feddan). 2- Straw yield (ton / feddan). 3-Biological yield (grain yield plus straw yield in ton/ feddan). Total nitrogen content and soluble carbohydrate content of grains was determined by the method described by (AOAC, 1982). Crude protein was calculated by multiplying the N % by 5.75 factor. The obtained results were subjected to statistical analysis according to Snedcor and Cochran (1982) and the difference among treatment means were compared by L.S.D. test. Since the trend was similar in both seasons the homogeneity test Bartlet's equation was applied and the combined analysis of the two seasons was calculated according to the method of Steel and Torrie (1980).

Results & Discussion

Effect of biofertilizers inoculation on barley yield and yield attributes.

Data presented in Table (2) show that biofertilizer inoculation increased all yield and yield attributes characters as well as soluble carbohydrates and crude protein content, while the least values were observed with uninoculated barley plants. These results were supported by Sushila and Gajendra (2002) who reported that bio-fertilizers inoculation enhance the growth and yield of wheat plant. In this respect Ahmed *et al.*, (2008) added that, application of phosphorine showed an increment in plant growth. Regarding the effect of cerealine, Kabesh *et al.*, (2009) and Sary *et al*., (2009) reported excellent effect of bio-fertilizer inoculation with cerealine for improving growth, yield and yield components of wheat plants. The positive effect of bio fertilizers could be explained on a basis that maintaining sufficient available nutrients during the growth period. In addition the effect of bio-fertilizer may also be due to the effect of nutrients mobilizing microorganisms which help in availability of metals and increased levels of extractable minerals (Rybak, 2003). The promoting effect of phosphorine may be attributed to the presence of phosphorus dissolving bacteria that has the ability to bring the insoluble phosphate in soluble forms by secreting organic acids which lower the pH and bring about the dissolution of bonds forms of phosphate and render them available for growing plants (Sherif *et al*., 1997 and El- Sheekh ,1997). In this concern, Ahmed *et al.,* (2008) reported that application of phosphorine significantly improved plant height, yield and yield components. Moreover, Abeer and Hanaa (2008) cleared that inoculation with phosphorine generally induced an increase in weight of 1000 grains of wheat. They added that the beneficial effect of phosphorine on the yield of wheat plant grown under water stress condition was the highly significant. Such enhancing effect of phosphorine on yield and its components resulted from the effect of phosphorine in enhancing phosphorus solubilization. The positive effect of cerealine may be attributed to its action on nitrogen fixation by nitrogen fixing bacteria since it contain *Azospirilum sp* strains. In this respect, Mohamed (2003) reported that N- biofertilizer treatment promote the production of plants and roots at seed germination and colonized by N- fixing bacteria energetic bath ways such as glycolysis and conversion of IAA to active IAA are stimulated. He added that nitrogen fixing bacteria may increase the synthesis of the endogenous phytohermons indole acetic acid, gebberellic acid and cytokinene which play and important role in formation of bioactive root system that allow more nutrient uptake and therefore may promote photosynthesis and translocation as well as accumulation of dry matter within different plant organs.

As for the effect of biofertilizers on soluble carbohydrate and crude protein content in barley grains, the same table (Table 2) show that biofertilizer inoculation significantly increased soluble carbohydrate and crude protein content. These results coincide with those obtaine by Ozturk, *et al.*, (2003) in their study on response of wheat and barley cultivar to inoculation with bio-fertilizers, they found that crude protein content increased by 4.1% in wheat and 5.1% in barley, respectively, as compared with control. Such positive effect of bio- fertilizers (cerealine and phosphorine) may be attributed to the effect of cerealine since it contains (nitrogen fixing bacteria including *Azospirilum sp* strains) and phosphorein containing (phosphate dissolving bacteria include *Bacillus megaterium*) which have a considerable effect on increasing carbohydrate and protein content of barley seeds. Similar results were obtained by Islam *et al.,* (2004).

Effect of water stress time on barley yield and yield attributes.

Data presented in Table (2) show that withholding irrigation at any growth stage significantly reduced plant height, number of tillers /plant, number of spikes /plants, number of grains /spike, weight of grains /spike, weight of grains /plant and seed index. Accordingly, number of spikes/m^2, grain yield (Ton/fed.), straw yield (Ton/fed.) as well as biological yield (Ton/fed.). The same table indicate also that, weight of grains / spike, wt. of grains / plant, seed index and grain yield clearly affected when barley plants was subjected to water deficit during milk- ripe stage. In this connection O'Toole and Baldia (1982) reported that shortage of water at the reproductive stage can cause irreversible yield loss due to low test weight and fewer seeds per plant. They added that in cereals, moderate drought causes senescence and wilting of leaves. They also added that the depressive effect of drought on yield and yield components may be attributed to the effect of drought in declining the available soil moisture that might decrease the diffusion rate of nutrients from soil matrix to roots and under this condition, assimilates from photosynthetic organs of the spike can sustain grain development and if the drought is severe, availability of assimilates from the spike will be limited leading to reduced grain filling. These results were in harmony with those obtained by Qadir *et al*., (1999) who reported that water stress at different growth stages led to significant reduction in the productivity of wheat plants. Hussain *et al.,* (2004) on wheat also stated that small reduction in grain and dry matter yields has been detected when plants were stressed at tillering and grain filling stage. Walck *et al*., (2007) reported that final barley grain or biomass yield was sensitive to drought timing. Table (2) also show significant increase of carbohydrate content of barley seeds subjected to drought during tillering or at milk- ripe stage. The same table also show that drought cause increase of crude protein content in barley grains, such effect was observed when barley plants were subjected to water stress during milk–ripe stage. The same observation was also recorded by Ibrahim and Kandil (2007) who stated that seed protein content of soybean tended to increase under water deficit conditions,

Effect of different cultivars performance on barley yield and yield attributes.

Data presented in Table (2) show significant differences between cultivars in yield and yield attributes. Giza 2000 surpassed Giza 126 and Giza 130 in number of tillers / plant, number of grains/ spike, weight of grains /s pike and weight of grains / plant , but Giza 126 recorded the highest values for plant height and seed index as well as the highest grain yield/ (ton) fed. On the other hand, Giza 130 recorded the highest values for number of spikes / plants, number of spikes / m^2, straw yield / (Ton) fed and biological yield / (Ton) fed. The difference in yield characters among barley cultivars may be attributed to the difference in their genetic background. The difference of growth and yield of barley cultivars was also recorded by and Katerji *et al*., (2009). The same table also show that there were significant difference among cultivars concerning soluble carbohydrate and crude protein content but in general Giza 130 cultivar recorded the highest values for soluble carbohydrate and crude protein content. The difference in the chemical contents of barley seeds was also reported by Gorny (2001).

Effect of interaction between treatments on barley yield and yield attributes.

Data presented in Table (3) obviously indicated that in general water stress treatments either at tillering or at milk- ripe stage significantly depressed most the studied characters as compared with control treatment either under inoculation or without. Such effect was more pronounced for weight of grains/ spike, weight of grain /plant and grain yield under both condition of inoculation. Similar results was obtained by O'Toole and Baladia (1982). The same authors indicated that such effect may be attributed to the effect of drought in causing senescence and wilting of leaves under this condition, assimilates from photosynthetic organs can sustain grain development and the availability of assimilates from the spike will be limited leading to reduced grain filling. However, the highest values of soluble carbohydrates content was recorded in uninoculated barley plants subjected to water stress at milk-ripe stage , while the highest values of crude protein content were recorded in the inoculated plant subjected to water stress at milk-ripe stage.

Referring to the interaction between inoculation treatments and barley cultivars, it is clear from Table (4) that there is a clear difference between cultivars in most studied yield characters under both condition of inoculation. Such difference among cultivars may be attributed to their genetic background. Regarding to grain yield, it is obviously noticed that Giza 130 cultivar recorded the highest values than the other two cultivars. The same table also show that all studied cultivars positively responded to bifertilizer inoculation .These results were in agreement with Gorny (2001) and Rizza *et al*., (2004) on barley and Hassanein and Goma (2001) on wheat . However, the highest values of soluble carbohydrates content was recorded in the uninoculated Giza 130 cultivars, while the highest values of crude protein content were recorded in the inoculated Giza 130 cultivars.

As for the interaction between cultivars and time of water stress application, data presented in Table (5) indicate that barley cultivars significantly differed in their response to the time of water stress in most of the studied characters. With respect to grain yield, Giza 2000 cultivar recorded slightly increase than the other cultivars under water deficit condition during tillering and milk- ripe stage. Similar results were obtained by Ahmed and Badr (2004) who reported variation in growth and yield of wheat cultivars as result of missing irrigation at different stages of growth. However, the highest values of soluble carbohydrates content was recorded in Giza 130 cultivars subjected to water stress at tillering stage , while the highest values of crude protein content were recorded in Giza 130 cultivars subjected to water stress at milk-ripe stage.

Data presented in Table (6) show significant difference between the interactions of the three factors (inoculation x water stress x cultivars). The highest values for grain yield under water stress and inoculation treatment was recorded in Giza 2000 cultivar subjected to water stress at tillering stage under dual inoculated with phosphorine and cerealine. In general, the three factors acting together and reflected on yield and most yield attributes. Similar results were reported by Sushila *et al.*, (2000). However, the highest values of soluble carbohydrates content was recorded in uninoculated Giza 130 cultivar subjected to water stress at tillering stage, while the highest values of crude protein content was recorded in the inoculated Giza 2000 cultivars subjected to water stress at milk-ripe stage of growth. Finally, these results may be attributed to the effect of bio-fertilizers in providing both the macro as well as micro nutrients, required for healthy growth. Therefore, improves yields and the quality of agricultural crops. In addition, the use of phosphorus bio-fertilizers may increase the efficiency of phosphorus utilization in enhancing the vegetative growth and the yield under stress. In this connection Kapoor *et al*., (1989) reported that much of the inorganic phosphate applied to soil as a fertilizer is rapidly converted to unavailable forms with low solubility. They added that soluble phosphorus is released from insoluble phosphates by a variety of solubilization reactions involving rhizosphere microorganisms. Inoculation with phosphate solubilizing microorganisms (PSM) may help to solubilize native soil phosphate, as well as phosphorus from rock phosphate. In addition, cerealine containing (nitrogen fixing bacteria including *Azospirilum sp* strains), which in turn induce excellent effect on growth, yield and all yield components of barley plants.

From the obtained results, it can be concluded that the dual application of phosphorus and nitrogen biofertilizer resulted in improve yield and quality of agricultural crops and overcome the depressive effect of water stress during plant growth. In addition, biofertilizers are important component in integrated nutrients managements. They are cost effective, eco-friendly and renewable source of plant nutrients.

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Table (1) Soil chemical and mechanical analysis (average value of 2006/ 2007 and 2007/2008 seasons)

Chemical analysis		Mechanical analysis	
pH	7.59	Clay %	33.3
Ec (dsm^{-1})	0.27	Silt %	59.4
K^+ (meq L^{-1})	0.82	Sand %	7.3
Mg^{++} (meq L^{-1})	0.49	Soil texture	Clay loam
HCO_3 (meq L^{-1}	0.41		
Ca^{++} (meq L^{-1})	1.09		
$SO4^{--}$ (meq L^{-1})	0.57		

Table (2) Effect of biofertilizer inoculation, time of water stress and cultivars performance on barley yield and yield attributes.

Treatments	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Inoculation treatments													
Uninoculated	105.22	5.28	4.83	58.01	304.56	3.00	10.38	53.87	2.97	4.78	7.75	60.85	10.13
Inoculated	106.48	5.50	5.17	60.79	323.50	3.20	11.66	55.14	3.13	4.94	8.07	62.36	10.30
L.S.D. 5%	5.38	0.43	0.52	3.45	26.93	0.20	0.76	3.56	0.21	0.31	0.36	1.80	0.16
Water stress treatments													
Regular irrigation	110.91	5.75	5.29	62.22	331.83	3.22	12.29	55.82	3.49	5.24	8.73	59.72	10.09
At tillerimg stage	100.88	5.04	4.71	56.19	298.04	3.05	10.59	54.50	2.94	4.55	7.49	63.16	10.20
At milk- ripe stage	105.77	5.38	5.00	59.79	312.21	3.03	10.17	53.19	2.73	4.78	7.51	61.93	10.35
L.S.D. 5%	3.52	0.59	0.70	2.96	36.18	0.11	1.06	3.41	0.23	0.28	0.41	0.61	0.12
Cultivars													
Giza126	112.83	5.25	4.46	57.50	283.67	3.02	10.40	58.65	3.17	4.47	7.64	59.12	10.02
Giza 130	103.36	5.38	5.46	59.29	332.58	3.08	10.78	50.43	2.89	5.53	8.42	63.81	10.37
Giza 2000	101.36	5.54	5.08	61.41	325.83	3.20	11.88	54.43	3.10	4.57	7.67	61.88	10.25
L.S.D. 5%	3.27	0.47	0.37	2.14	22.62	0.19	1.12	3.01	0.28	0.25	0.42	1.36	0.13

Table (3): Effect of the interaction between biofertilizer inoculation and time of water stress on barley yield and yield attributes.

Inoculation treatment	Time of water stress	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Uninoculated	Control	110.25	5.75	5.17	60.81	322.25	3.13	11.69	55.17	3.36	5.14	8.50	60.94	10.03
	Tillering	100.33	4.92	4.58	55.27	288.17	2.92	9.98	53.61	2.86	4.52	7.37	64.13	10.11
	Milk-ripe	105.08	5.17	4.75	57.95	303.25	2.95	9.45	52.83	2.69	4.69	7.38	62.01	10.25
Inoculated	Control	111.57	5.75	5.42	63.64	341.42	3.31	12.88	56.47	3.62	5.34	8.97	58.50	10.15
	Tillering	101.42	5.17	4.83	57.10	307.92	3.19	11.20	55.39	3.02	4.59	7.61	62.20	10.29
	Milk-ripe	106.45	5.58	5.25	61.63	321.17	3.11	10.90	53.54	2.76	4.87	7.64	61.86	10.30
LSD 5%		4.98	0.83	0.99	4.18	51.17	0.20	1.50	4.82	0.33	0.40	0.57	0.87	0.17

Table (3): Effect of the interaction between biofertilizer inoculation and time of water stress on barley yield and yield attributes.

Inoculation treatment	Time of water stress	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Uninoculated	Control	110.25	5.75	5.17	60.81	322.25	3.13	11.69	55.17	3.36	5.14	8.50	60.94	10.03
	Tillering	100.33	4.92	4.58	55.27	288.17	2.92	9.98	53.61	2.86	4.52	7.37	64.13	10.11
	Milk-ripe	105.08	5.17	4.75	57.95	303.25	2.95	9.45	52.83	2.69	4.69	7.38	62.01	10.25
Inoculated	Control	111.57	5.75	5.42	63.64	341.42	3.31	12.88	56.47	3.62	5.34	8.97	58.50	10.15
	Tillering	101.42	5.17	4.83	57.10	307.92	3.19	11.20	55.39	3.02	4.59	7.61	62.20	10.29

	Milk-ripe	106.45	5.58	5.25	61.63	321.17	3.11	10.90	53.54	2.76	4.87	7.64	61.86	10.30
LSD 5%		4.98	0.83	0.99	4.18	51.17	0.20	1.50	4.82	0.33	0.40	0.57	0.87	0.17

Table (4): Effect of the interaction between biofertilizer inoculation and cultivars performance on barley yield and yield attributes.

Inoculation	Variety	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Uninoculated	Giza 126	112.17	5.08	4.25	55.27	271.50	2.87	9.48	58.11	3.10	4.41	7.51	59.587	9.897
	Giza 130	102.75	5.25	5.33	57.71	323.42	3.00	10.26	49.75	2.84	5.47	8.30	64.832	10.297
	Giza 2000	100.75	5.50	4.92	61.05	318.75	3.13	11.39	53.75	2.97	4.47	7.44	62.652	10.197
Inoculated	Giza 126	113.49	5.42	4.67	59.72	295.83	3.17	11.32	59.19	3.23	4.54	7.77	58.658	10.143
	Giza 130	103.98	5.50	5.58	60.87	341.75	3.16	11.29	51.10	2.95	5.60	8.55	62.788	10.447
	Giza 2000	101.97	5.58	5.25	61.78	332.92	3.27	12.37	55.12	3.23	4.67	7.90	61.112	10.295
LSD 5%		4.63	0.67	0.52	3.02	31.99	0.11	1.58	4.26	0.40	0.35	0.60	1.92	0.18

Table (4): Effect of the interaction between biofertilizer inoculation and cultivars performance on barley yield and yield attributes.

Inoculation	Variety	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Uninoculated	Giza 126	112.17	5.08	4.25	55.27	271.50	2.87	9.48	58.11	3.10	4.41	7.51	59.587	9.897
	Giza 130	102.75	5.25	5.33	57.71	323.42	3.00	10.26	49.75	2.84	5.47	8.30	64.832	10.297
	Giza 2000	100.75	5.50	4.92	61.05	318.75	3.13	11.39	53.75	2.97	4.47	7.44	62.652	10.197
Inoculated	Giza 126	113.49	5.42	4.67	59.72	295.83	3.17	11.32	59.19	3.23	4.54	7.77	58.658	10.143
	Giza 130	103.98	5.50	5.58	60.87	341.75	3.16	11.29	51.10	2.95	5.60	8.55	62.788	10.447
	Giza 2000	101.97	5.58	5.25	61.78	332.92	3.27	12.37	55.12	3.23	4.67	7.90	61.112	10.295
LSD 5%		4.63	0.67	0.52	3.02	31.99	0.11	1.58	4.26	0.40	0.35	0.60	1.92	0.18

Table (5) : Effect of the interaction between time of water stress and cultivars performance on barley yield and yield attributes.

Time of water stress	Cultivars	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Control	Giza 126	119.23	5.50	4.63	59.45	296.00	3.09	11.27	59.98	3.80	5.02	8.82	56.418	9.928

	Giza 130	109.17	5.63	5.88	62.11	355.50	3.22	12.22	51.83	3.19	5.78	8.97	61.908	10.263
	Giza 2000	104.32	6.13	5.38	65.10	344.00	3.35	13.37	55.65	3.49	4.92	8.41	60.835	10.075
At tillering	Giza 126	106.91	5.00	4.25	55.20	272.00	3.02	10.35	58.48	2.94	4.03	6.98	61.135	9.948
	Giza 130	97.85	5.13	5.13	56.57	312.38	3.06	10.70	50.59	2.92	5.33	8.24	64.868	10.370
	Giza 2000	97.88	5.00	4.75	56.78	309.75	3.08	10.73	54.44	2.96	4.30	7.25	63.485	10.285
At Milk- ripe	Giza 126	112.35	5.25	4.50	57.84	283.00	2.95	9.56	57.50	2.76	4.36	7.12	59.815	10.185
	Giza 130	103.07	5.38	5.38	59.18	329.88	2.96	9.41	48.85	2.57	5.49	8.06	64.655	10.483
	Giza 2000	101.88	5.50	5.13	62.35	323.75	3.17	11.55	53.22	2.86	4.49	7.35	61.325	10.378
LSD 5%		5.66	0.82	0.64	3.70	39.18	0.19	1.93	5.22	0.49	0.43	0.73	2.35	0.22

Table (6): Effect of the interaction between biofertilizer inoculation, time of water stress and cultivars performance on barley yield and yield attributes.

Inoculation treatment	Time of water stress	Cultivars	Plant height	Number of tillers /plant	Number of spikes /plants	Number of grains /spike	Number of spikes / m^2	Weight of grains /spike	weight of grains /plant	Seed index	Grain yield / (Ton) fed.	Straw yield / (Ton) fed.	Biological yield / (Ton) fed.	Soluble carbohydrate content	Crude protein content
Un Inoculated	Control	Giza 126	118.50	5.50	4.50	58.19	288.00	3.00	10.67	59.25	3.72	4.95	8.67	58.30	9.73
		Giza 130	108.50	5.50	5.75	60.50	342.75	3.13	11.72	51.25	3.06	5.64	8.70	63.22	10.24
		Giza 2000	103.75	6.25	5.25	63.73	336.00	3.26	12.69	55.00	3.31	4.84	8.15	61.31	10.13
	At tillering stage	Giza 126	106.25	4.75	4.00	52.44	256.00	2.79	9.11	58.09	2.88	4.02	6.90	61.47	9.88
		Giza 130	97.25	5.00	5.00	55.19	304.50	2.92	9.96	49.25	2.85	5.30	8.15	66.02	10.29
		Giza 2000	97.50	5.00	4.75	58.19	304.00	3.05	10.87	53.50	2.84	4.22	7.06	64.90	10.18
	At milk-ripe stage	Giza 126	111.75	5	4.25	55.19	270.5	2.82	8.65	57	2.71	4.25	6.96	59.00	10.08
		Giza 130	102.50	5.25	5.25	57.44	323.00	2.95	9.10	48.75	2.60	5.47	8.07	65.27	10.37
		Giza 2000	101.00	5.25	4.75	61.23	316.25	3.08	10.60	52.75	2.77	4.35	7.11	61.75	10.29
Inoculated	Control	Giza 126	119.96	5.50	4.75	60.71	304.00	3.18	11.87	60.71	3.88	5.09	8.97	54.54	10.13
		Giza 130	109.84	5.75	6.00	63.73	368.25	3.31	12.72	52.42	3.32	5.93	9.25	60.60	10.29
		Giza 2000	104.90	6.00	5.50	66.48	352.00	3.44	14.05	56.29	3.67	5.01	8.67	60.36	10.03
	At tillering stage	Giza 126	107.56	5.25	4.50	57.96	288.00	3.25	11.59	58.86	3.01	4.05	7.05	60.81	10.02
		Giza 130	98.45	5.25	5.25	57.96	320.25	3.20	11.44	51.93	2.98	5.35	8.34	63.72	10.46
		Giza 2000	98.25	5.00	4.75	55.38	315.50	3.12	10.58	55.38	3.08	4.37	7.45	62.08	10.40
	At milk-ripe stage	Giza 126	112.95	5.50	4.75	60.50	295.50	3.08	10.48	58.00	2.80	4.47	7.27	60.63	10.29
		Giza 130	103.64	5.5	5.5	60.92	336.75	2.98	9.73	48.95	2.54	5.51	8.04	64.05	10.60
		Giza 2000	102.75	5.75	5.50	63.48	331.25	3.26	12.49	53.68	2.94	4.64	7.59	60.90	10.47
LSD 5%			8.01	0.33	0.90	5.23	55.40	0.46	2.74	7.38	0.69	0.60	1.03	3.33	0.31