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ORIGINAL ARTICLE

Effect of bio-priming on yield and yield components of maize (*Zea mays* L.) under drought stress

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ABSTRACT
This field experiment was laid out in order to evaluate effect of bio-priming under drought stress on yield and yield components of maize (Zea mays L.) in faculty of agronomy, Islamic Azad University, Boroujerd Branch, Boroujerd, Iran during the growing seasons 2013-2014. Treatments were three drought stress level low (stress at vegetative stages), medium (stress at vegetative and flowering stages) and severe drought stress (stress at vegetative, flowering and grain filling stages) and priming with biofertilizers (Nitroxin, Supernitroplas and combined application of them) with control for them. Results showed that, the effect of drought stress, bio-priming and interaction between them were significant on cob length, the number of cob per plant, number of row per cob and number of grain per row and grain yield. The comparison of the mean values of the grain yield and yield components for drought stress showed that control treatment had the highest and severe drought stress treatment had the lowest of them. Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest grain yield and yield components and control treatment had the lowest. In final results of this study reviled that non drought stress condition and application biofertilizers increased yield and yield components of maize. Then we can increase yield of maize with application of these biofertilizers and supply of water for maize in early stage, flowering and grain filling stages of maize.
Key words: Biopriming, drought stress, maize, and grain filling

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INTRODUCTION

Maize (*Zea mays* L.) is one of the three most important cereal crops in the world. Corn is one of the major cereal crops and is a very versatile grain that benefits mankind in many ways. It is a versatile crop and ranks third following wheat and rice in world production as reported by Food and Agriculture Organization [9]. Corn oil is used for salad, soap-making and lubrication. Odeleye and Odeleye [13] reported that maize varieties differ in their growth characters, yield and its components, and therefore suggested that breeders must select most promising combiners in their breeding programmes [13,8].

Drought stress causes deceleration of cell enlargement and thus reduces stem length by inhibiting inter nodal elongation and also checks the tillering capacity of plants [1,6]. Drought several studies have also shown that optimum yield can be obtained with irrigation at branching, flowering and pod formation stages [15]. In fact, well-regulated deficit irrigation regimes may increase crop yield compared to the crop grown under conditions of free from water deficit [7,12]. The increased crop yield with regulated irrigation is mainly due to the systems allowing crop plants to grow under certain degrees of water stress at non-critical growth stages. In water-limited environments, the most competitive individuals are likely to gain a disproportionate share of the water in the soil, but partitioning of limited assimilates to the roots to improve water capture requires a reduction in reproductive partitioning to grain. This competitive asymmetry may lead to excessive growth of some resource-foraging organs to such an extent that not only grain production but also total crop production may be lowered [23].

For gave to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important [19,20]. Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution [2, 3, 21]. In maize, application of biofertilizers increased growth and yield in many researches. Beyranvand et al [4] reviled that application nitrogen and phosphate biofertilizers increased yield and yield components of maize under Boroujerd environmental condition

[4]. Increased root, shoot weight with dual inoculation in maize have been reported by, while grain yields of the different maize genotypes treated with *Azospirillum* spp [5]. Seed inoculation with Rhizobium , phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop [14].
Therefore this study was planned to examine effect of bio-priming under drought stress on yield and yield components of maize.

MATERIALS AND METHODS

A filed experiment was conducted in the faculty of agronomy and plant breeding, Islamic Azad University, Boroujerd Branch, Boroujerd (field location: Poldokhtar), Iran during the growing seasons 2013-2014. According to soil analysis, details of experimental soil location was: pH=7.74, N (0.12%), P(21.5mg/kg), K(450mg/kg), EC(1ds/m) with sandy clay texture. The experiment was lay out in order to evaluate the effects of drought stress and bio-priming with biofertilizers on yield and yield components of maize (*zeamayz* L.). The experiment was a factorial design based of RCBD with three replications. Treatments were three drought stress level low (stress at vegetative stages), medium (stress at vegetative and flowering stages) and severe drought stress (stress at vegetative, flowering and grain filling stages) and priming with biofertilizers (Nitroxin, Supernitroplas and combined application of them) with control for them. The 100kg/ha maize seeds were planted in 5-rows in plot with 3m length for them. Row to row and plant to plant distance was maintained at 100 and 20cm respectively. Planting depth for seeds was 4-5cm. Plant samples were taken with 8 plants from each plot. The cob length, the number of cob per plant, number of row per cob and number of grain per row were determined. To determine grain yield, we removed and cleaned all the seeds produced within 1m^2 central rows in the field. Then grain yield recorded on a dry weight basis. Yield was defined in terms of grams persquare meter.
The statistical analysis to determine the individual and interactive effects of treatments were conducted using JMP 5.0.1.2 [17]. Statistical significance was declared at P≤0.05 and P≤0.01. Treatment effects from the two runs of experiments followed a similar trend, and thus the data from the two independent runs were combined in the analysis.

RESULTS

Number of cob per plant

Results showed that, the effect of drought stress, bio-priming and interaction between them on number of cob per plant was significant (table 1). The comparison of the mean values of the number of cob per plant for drought stress showed that control treatment had the highest (1.6) number of cob per plant and severe drought stress treatment had the lowest number of cob per plant (1.1) and the differences were significant (figure 1). Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest (1.7) number of cob per plant and control treatment had the lowest (0.9) number of cob per plant (figure 2).

Table1. Analysis of variance (mean squares) for effects of bio-priming on yield and yield components of maize under drought stress

treatments	df	Number of cob per plant	Cob length	number of row per cob	number of grain per row	grain yield
R	2	0.03	20.92	0.13	27.74	1780.95
Drought stress (A)	3	0.67**	92.47**	2.75**	243.37**	7857.40**
Bio-priming (B)	3	0.01*	2.71*	0.02*	1.58*	24.50*
A*B	9	1.54**	93.90**	14.83**	330.46**	11771.13**
Error	30	0.08	5.00	0.26	9.37	523.83
CV(%)		0.01	5.04	0.15	7.98	61.13

* and **: Significant at 5% and 1% probability levels, respectively

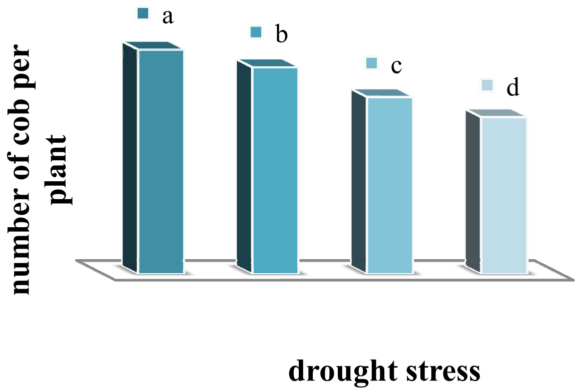

Figure 1. Mean comparison effect of drought stress on number of cob per plant in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

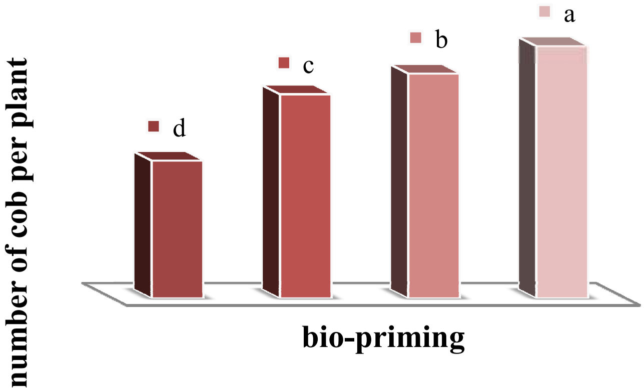

Figure 2. Mean comparison effect of bio-priming on number of cob per plant in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

Cob length

The analysis of variance showed that, the effect of drought stress, bio-priming and interaction between them on cob length were significant (table 1). The comparison of the mean values of the cob length for drought stress showed that control treatment had the highest (25cm) cob length and severe drought stress treatment had the lowest cob length (17cm) and the differences were significant (figure 3). Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest (26cm) cob length and control treatment had the lowest (18cm) cob length (figure 4).

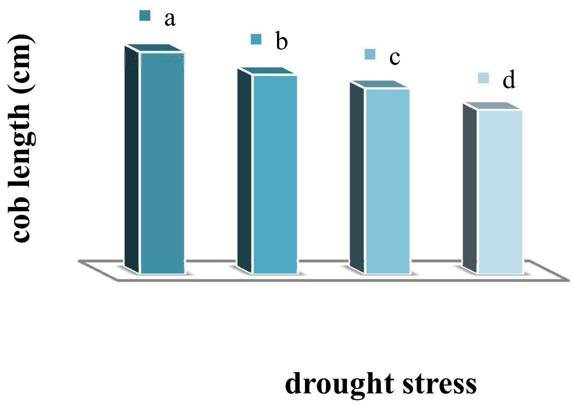

Figure 3. Mean comparison effect of drought stress on cob length in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

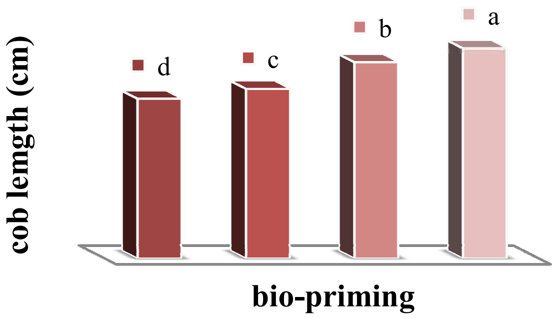

Figure 4. Mean comparison effect of bio-priming on cob length in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

Number of row per cob

The effect of drought stress, bio-priming and interaction between them on number of row per cob were significant (table 1). The comparison of the mean values of the number of row per cob for drought stress showed that control treatment had the highest (15) number of row per cob and severe drought stress treatment had the lowest number of row per cob (14) and the differences were significant (figure 5). Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest (16) number of row per cob and control treatment had the lowest (13) number of row per cob (figure 6).

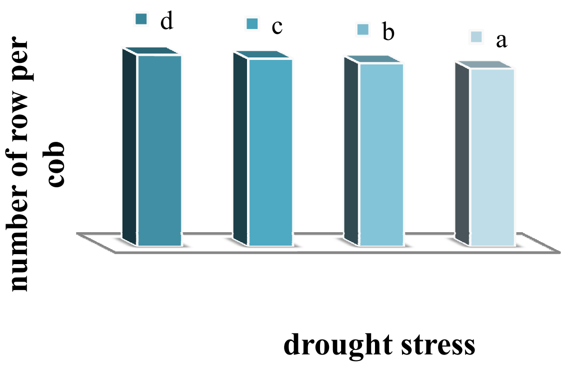

Figure 5. Mean comparison effect of drought stress on number of row per cob in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

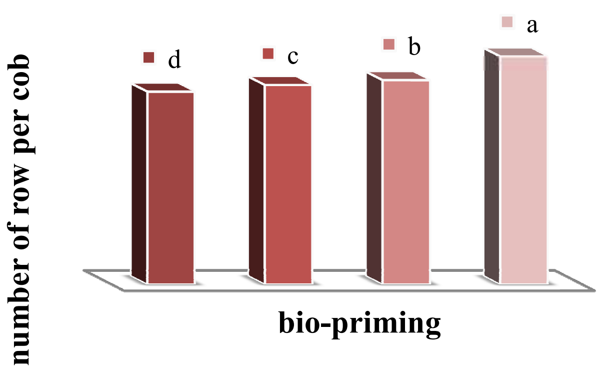

Figure 6. Mean comparison effect of bio-priming on number of row per cob in maize
Means by the uncommon letter in each column are significantly different (p<0.05).

Number of grain per row

For number of grain per row, the effect of drought stress, bio-priming and interaction between them on number of grain per row were significant (table 1). The comparison of the mean values of the number of grain per row for drought stress showed that control treatment had the highest (45) number of grain per row and severe drought stress treatment had the lowest number of grain per row (35) and the differences were significant (figure 7). Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest (46) number of grain per row and control treatment had the lowest (34) number of grain per row (figure 8).

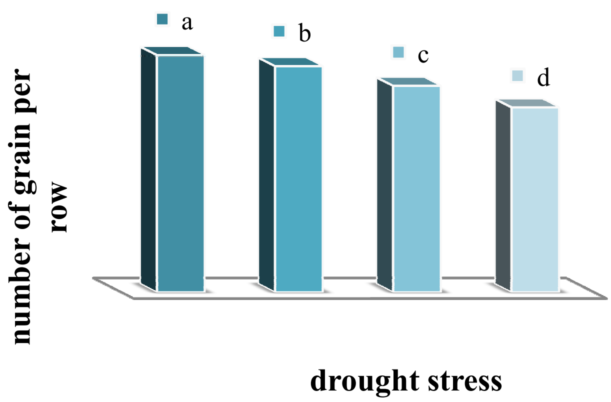

Figure 7. Mean comparison effect of drought stress on number of grain per row in maize
Means by the uncommon letter in each column are significantly different ($p<0.05$).

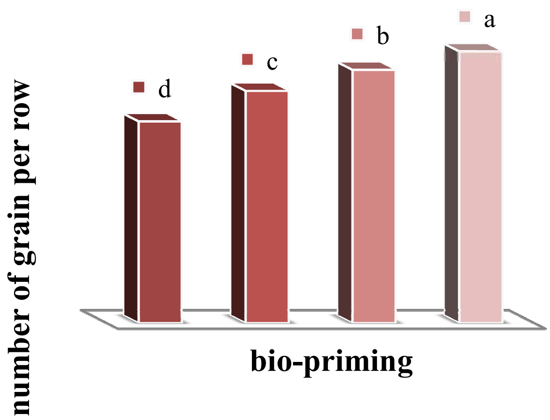

Figure 8. Mean comparison effect of bio-priming on number of grain per row in maize
Means by the uncommon letter in each column are significantly different ($p<0.05$).

Grain yield

The effect of drought stress, bio-priming and interaction between them on grain yield per row were significant (table 1). The comparison of the mean values of the grain yield for drought stress showed that control treatment had the highest (250 g/m^2) grain yield and severe drought stress treatment had the lowest grain yield (190 g/m^2) and the differences were significant (figure 9). Results for bio-priming showed that, combined application of Nitroxin with Supernitroplas treatment had the highest (255 g/m^2) grain yield and control treatment had the lowest (185 g/m^2) grain yield (figure 10).

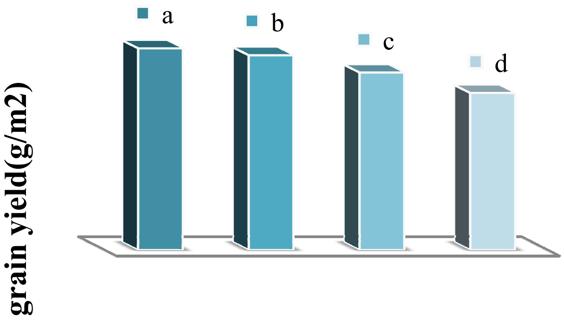

Figure 9. Mean comparison effect of drought stress on grain yield in maize
Means by the uncommon letter in each column are significantly different ($p<0.05$).

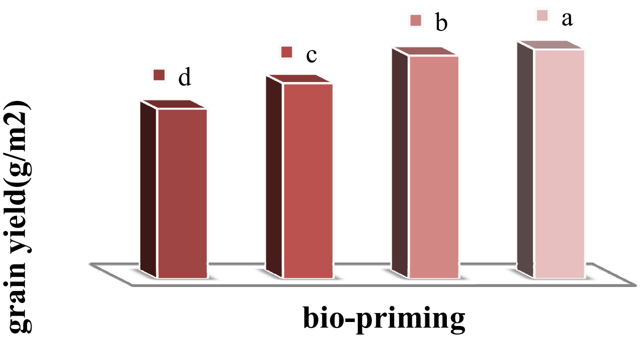

Figure 10. Mean comparison effect of bio-priming on grain yield in maize
Means by the uncommon letter in each column are significantly different ($p<0.05$).

DISCUSSION

In the present study results indicates that there were significant differences in the response of yield and yield components of maize cultivars to application of different biofertilizers and drought stress (table 1). With increase in drought stress level yield and it components were decreased. Maximum cob length, the number of cob per plant, number of row per cob and number of grain per row and grain yield were obtained at non drought stress treatment. Water deficit is deleterious for plant growth, yield and plant nutrition (10)and drought stress is one of the worst scourges of agriculture (16). This study has showed that maize grain yield and yield components decreased significantly in water deficit condition. The reduction in number of cob per plant non irrigation treatment may be attributed to the limitation of dry matter partitioning to the reproductive sink or even grain formation factors as has been reported by (22). Water deficit occurrence in relation to an thesis stage causes a drastic reduction in yield and yield components (18). In the present study, the reduction in grain yield under non irrigation treatment was associated with dramatic decrease in all yield components. Supporting evidences were reported by many researchers (11,24). They attributed the reduction in grain yield under non irrigation treatment to the reduction in number grain and grain weight. Turk and Hall (1980) attributed the reduction in grain yield under non irrigation condition to the secondary detrimental effects of water deficit avoidance on CO_2 assimilation (22). This result suggests that maize exhibit reproductive plasticity under non irrigation condition.

Application of any biofertilizers specially combined application of Nitroxin and Supernitroplas was very useful for increase of yield and yield components of maize (refer to figure 1-10). The result of this study reviled that positive effect of biofertilizer may resulted from its ability to increase the availability of phosphorus and other nutrients especially under the specialty of the calcareous nature of the soil which cause decreasing on the nutrients availability, results agree with [1,2]. Based on results, the effect of biofertilizers were evaluated positively, there were an increase in all traits in maize. The photosynthetic capacity of maize treated with biofertilizers increases due to increased supply of nutrition. Grain yield increasing was reported with the biofertilizer application which account important benefit to the maize producers and maize production, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield. Azimi et al [2] found that application of Supernitroplus biofertilizer with Phosphate barvar2 treatment has the highest seed yield (7.6 ton/ha) and non-application of biofertilizers treatment has the Pishtaz cultivar has the lowest seed yield (6.3 ton/ha) [2]. Also Azimi *et al* [3] found that that application nitrogen and phosphate biofertilizers increased yield and yield components of barley under Boroujerd environmental condition (3). In final results of this study reviled that non drought stress condition and application biofertilizers increased yield and yield components of maize. Then we can increase yield of maize with application of these biofertilizers and supply of water for maize in early stage, flowering and grain filling stages of maize.

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