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Response of yield and yield components of maize (*Zea mayz* L.) to different bio fertilizers

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ABSTRACT

A experiment was lay out in order to evaluate the effects of different biofertilizers on yield and yield components of maize at the Lorestan provience, Iran. The experiment was a factorial design with three replications. Treatments were three nitrogen biofrtilizers (Nitrokara (N_1), O4 (N_2), O6 (N_3) and control (N_4)) and three phosphate biofrtilizers (Phosphate barvar2 (P_1), Biozarr (P_2), Mc1+p5 (P_3) and control (P_4)).Yield and yield components were determined. Results showed that that there were significant differences in the response of maize to the effect of treatments on yield and its components, but there was non significant differences in HI for two type of biofertilizers. However, maize yield and it components was significantly higher in application of biofertilizers treatments. The highest grain yield was belonged at application of MC1+B5 and the lowest grain yield was belonged at application of phosphat barvar2. Interaction between N×P shows that N_3P_3 treatment has the highest grain yield and the N_4P_2 treatment has the lowest grain yield and the differences were significant. In final results of this study reviled that application nitrogen and phosphate biofertilizers increased yield and yield components of maize under Boroujerd environmental condition.

Key words: Bio fertilizer, Maize, Yield

INTRODUCTION

Maize (Zea mays) or corn is the most important cereal crop in Iran and with rice and wheat, maize is one of the three most important cereal crops in the world. Maize is high yielding, easy to process, readily digested and cheaper than other cereal crops. It is also a versatile crop, growing across a range of agro ecological zones. Every part of the maize plant has economic value which the grain, leaves, stalk, tassel and cob can all be used to produce a large variety of food and non food production. Corn is a very versatile grain that benefits mankind in many ways. Each year, 6 billion bushels of corn are used as feed for cattle, hogs and poultry in the United State. Another 2 billion bushels were exported, which is an integral part of this country's balance are converted to sweeteners, starch, flower cereal, liquor, animal feed, vegetable oil, alcohol for fuel and hundreds of other products (Audrac Erickson, 2006). Biofertilizer

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is a material containing microorganism(s) added to a soil to directly or indirectly make certain essential elements available to plants for their nutrition. Various sources of biofertilizers include nitrogen fixers, phytostimulators, phosphate solubilizing bacteria, plant growth promoting rhizobacteria, etc… (Shekh, 2006). Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution (Shevananda, 2008). Bio-fertilizer usually contains microorganisms having specific function such as Azospirillum to fix N2 and P solubilizing bacteria to solubilize P from the soil and fertilizer to be available to the plants (Saraswati & Sumarno, 2008). Several researchers had conducted the experiments to evaluate the responses of various plants such as young Robusta coffee (Junaedi et al., 1999), soybean (Noor, 2003; Totok & Rahayu, 2007), and turfgrass (Guntoro et al., 2007) to the biofertilizer application, but the results were still inconsistent. Further research is still needed in this area. Phosphate and nitrogen are important for plant growth, however plants have a limited ability to extract them from the environment, and thus need microbes involved in “nutrient recycling,” to help a plant uptake and absorb these nutrients at optimal concentration, while plants donate waste byproducts to microbes for food. With this symbiotic relationship, plants develop stronger and bigger root systems. The larger the plants’ roots, the more living space and food there is for the microbes to use. In a way, microorganisms serve as biofertilizers (El-kholy ., 2005). An example is the fungus Penicillium bilaii, which allows plants to absorb phosphates from the soil. It does this by producing anorganic acid which dissolves soil phosphates into a form which plants may use. In field experiments in Argentina, corn inoculated with Azospirillum lipoferum showed double the seeds per ear, an increase in seed dry weight by 59 % , and a significant stimulation in root development at harvest time (Fulchieri and Frioni, 1994). Another example is the bacterium Rhizobium. (Shekh, 2006). Use of these microorganisms as environment friendly biofertilizer helps to reduce the much expensive phosphatic fertilizers. Phosphorus biofertilizers could help to increase the availability of accumulated phosphate (by solubilization), efficiency of biological nitrogen fixation and increase the availability of Fe, Zn etc., through production of plant growth promoting substances (Kucey ., 1989). Increased root, shoot weight with dual inoculation in maize have been reported by (Chabot et al ., 1993), while grain yields of the different maize genotypes treated with Azospirillum spp. Seed inoculation with Rhizobium , phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop(Panwar et al ., 2006). Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, (Lin et al ., 1983) stated that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil. There were positive and synergistic interactions between factors like interactions between mycorrhizal inoculation and phosphate biofertilizer on N concentration and phosphate biofertilizer and vermicompost on P concentration (Darzi et al ., 2009). For give to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important(Shaban, 2013a,b). For give the highest seed yield in barley should apply both nitrogen and phosphate biofertilizers (Azimi et al, 2013). Therefore this study was planned to examine effect of different biofertilizers on yield and yield components of maize at the Lorestan provience, Iran.

MATERIALS AND METHODS

This study was conducted in the Faculty of agronomy and plant breeding, Islamic Azad University, Boroujerd Branch, Boroujerd, Iran during the growing seasons 2011-2012. The experiment farm was in Bozazna village and it was lay out in order to evaluate the effects of nitrogen and phosphate biofertilizers on yield and yield components of corn (*zea mayz* L.). The Boroujerd region has a continental semi-arid climate with annual precipitation of 369 mm.The SC-704 maize cultivar was supply from station of agricultural research center, Lorestan provience (Boroujerd station), Iran. Soil of field was loam (pH= 6.8) with organic matter content 0.92% and N 0.43%. The experiment was a factorial design with three replications. Treatments were three nitrogen biofrtilizers (Nitrokara (N_1), O4 (N_2), O6 (N_3) and control (N_4)) and three phosphate biofrtilizers (Phosphate barvar2 (P_1), Biozarr (P_2), MC_1+P_5 (P_3) and control (P_4)).The SC-704 corn cultivar seeds were inoculate with biofertilizers before planting and seeds was planted in a 2m long, 3-row plot. Row to row and plant - plant distance was maintained at 50cm and, 10cm respectively. Seeds were placed at 3 to 4 cm depth in each row. Plant samples were taken with 10 plants from each plot. The plant height, ear weight, and the number of grain per ear were determined. To determine grain yield, biomass yield and harvest index, we removed and cleaned all the seeds produced within two central rows in the field. Then grain yield and biomass yield recorded on a dry weight basis. Yield was defined in terms of grams per square meter and quintals per hectare. Replicated samples of clean seed (broken grain and foreign material removed) were sampled randomly and 100-grain were counted and weighed. The harvest index was accounted with follow:

$$HI = (\text{Economical yield} / \text{Biological yield}) \times 100$$

The statistical analyses to determine the individual and interactive effects of time cultivation and weeds control methods were conducted using JMP 5.0.1.2 (SAS Institute Inc., 2002). Statistical significance was declared at $P \leq 0.05$ and $P \leq 0.01$. 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

Plant height

The effect of all treatments on plant height was significant (Table 1). The comparison of the mean values of the plant height showed that among the nitrogen biofertilizers, Nitrokara treatment has the highest (194cm) plant height and control treatment has the lowest plant height (185cm) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest plant height (193cm) was belonged at application of Biozar and the lowest plant height (182cm) was belonged at application of Mc1+p5 (Table 2). Interaction between $N \times P$ (Table 3) shows that N_1P_4 treatment has the highest (203cm) plant height and the N_4P_3 treatment has the lowest plant height (175cm) and the differences were significant.

Ear weight

The effect of all treatments on ear weight was significant (Table 1). The comparison of the mean values of the ear weight showed that among the nitrogen biofertilizers, O4 treatment has the highest (330g) ear weight and control treatment has the lowest ear weight (255g) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest ear weight (306g) was belonged at application of Biozar and the lowest ear weight (265g) was belonged at application of Mc1+p5 (Table 2). Interaction between $N \times P$ (Table 3) shows that N_2P_2 treatment has the highest (420g) ear weight and the N_4P_4 treatment has the lowest ear weight (240g) and the differences were significant.

Number of grain per ear

The effect of all treatments on number of grain per ear was significant, excluding nitrogen biofertiliaers treatments (Table 1). The comparison of the mean values of the number of grain per ear showed that among the nitrogen biofertilizers, Nitrokara treatment has the highest (630) number of grain per ear and control treatment has the lowest number of grain per ear (510) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest number of grain per ear (599) was belonged at application of Biozar and the lowest number of grain per ear (544) was belonged at control (Table 2). Interaction between N×P (Table 3) shows that N_2P_3 treatment has the highest (655) number of grain per ear and the N_2P_2 treatment has the lowest number of grain per ear (610) and the differences were significant.

100 grain weight

The effect of interaction between N×P on 100 grain weight was significant only (Table 1). The comparison of the mean values of the 100 grain weight showed that among the nitrogen biofertilizers, Nitrokara treatment has the highest (37g) 100 grain weight and O6 treatment has the lowest 100 grain weight (32g) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest 100 grain weight (38g) was belonged at control and the lowest 100 grain weight (32g) was belonged at application of phosphat barvar2 (Table 2). Interaction between N×P (Table 3) shows that N_3P_3 treatment has the highest (40g) 100 grain weight and the N_4P_3 treatment has the lowest 100 grain weight (31g) and the differences were significant

Grain yield

The effect of all treatments on grain yield was significant, excluding nitrogen biofertiliaers treatments (Table 1). The comparison of the mean values of the grain yield showed that among the nitrogen biofertilizers, O4 treatment has the highest (11100kg/ha) grain yield and Nitrokara treatment has the lowest grain yield (7700kh/ha) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest grain yield (10200kg/ha) was belonged at application of MC1+B5and the lowest grain yield (8000kg/ha) was belonged at application of phosphat barvar2 (Table 2). Interaction between N×P (Table 3) shows that N_3P_3 treatment has the highest (11920kg/ha) grain yield and the N_4P_2 treatment has the lowest grain yield (6850kg/ha) and the differences were significant.

Biomass yield

The effect of all treatments on biomass yield was significant, excluding nitrogen biofertiliaers treatments (Table 1). The comparison of the mean values of the biomass yield showed that among the nitrogen biofertilizers, O4 treatment has the highest (24600kg/ha) biomass yield and Nitrokara treatment has the lowest biomass yield (18300kh/ha) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest biomass yield (25600kg/ha) was belonged at application of MC_1+B_5 and the lowest biomass yield (17750kg/ha) was belonged at application of phosphat barvar2 (Table 2).

Harvest index

The effect of any treatments on harvest index was not significant (Table 1). The comparison of the mean values of the harvest index showed that among the nitrogen biofertilizers, O4 treatment has the highest (45%) harvest index and O6 treatment has the lowest harvest index (39%) and the differences were significant (Table 2). Among the phosphate biofertilizers treatments, the highest harvest index (45%) was belonged at application of phosphat barvar2 and the lowest harvest index (36%) was belonged at control (Table 2).

DISCUSSION

Table 1. indicates that there were significant differences in the response of maize to the effect of treatments on yield and its components, but there was non significant differences in HI for two type of biofertilizers, may relate to instability of HI due to different biofertilizres, 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 (Kucey *et al* ., 1989,Tiwari *et al* ., 1989,Afzal *et al* ., 2005, and Ozuturk *et al* ., 2003). According to the data of table 2, the effect of nitrogen and phosphate biofertilizers were evaluated positively, there were an increase in plant height, ear weight, number of grain per ear, grain yield and biomass yield. Some researchers determined that enhanced phosphorus release increases evaluations for the trait of grain yield, biomass and 100-seed weight (Rovira and Ridge, 1979; Khaliq and Sanderz, 2000). It has also been reported that photosynthetic material exchange activity is stimulated through symbiosis with microorganisms in inoculated plants that increases the efficiency of photosynthetic phosphorus. Therefore, it may be concluded that photosynthetic capacity of plants treated with phosphors-solving microorganisms increases due to increased supply of phosphors nutrition. Seed weight also increases due to better transfer of photosynthetic substances. The content of corn seeds in terms of conservation of plant materials is a function of numbers of endosperm and starch granules generated 10 to 14 days after pollination (Hay and Gilbert, 2001). Therefore, reduced production of photosynthetic substances due to a smaller green surface area, decreased the conservation content of photosynthetic substances due to having short internodes or high levels of absysic acid during the above–mentioned critical period, restrict the 100-seed variance analysis, the effects biological fertilizers. Results were similar to previous research(Shekh, 2006, El-kholy et al ., 2005 and Sarig et al ., 1990). Ear weight increase may under the effect of the phosphorus biofertilizer which induced the uptake ability of the roots to nutrients and positive increase in the yield parameters because of improving the root system as a source-sink relationship to the reproductive part (shoot), that agree with (Mohammed et al ., 2001), (Ozturk et al ., 2003) and (Panwar et al ., 2006). There were indications to shoot increase too under the effect of biofertilizer because there were general modifications in growth performance. Grain yield and biomass 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. Biomass yield was increased under application of biofertilizers, because there were significant increasing in the dry weight of shoot at the prestilking stage, that may related to the favorite of some environmental factors which directly affected the bio fertilizer and its impact on the nutrient availability and growth (table 1,2), which positively influenced the maize photosynthesis and dry matter accumulation more actively that agree with (Lin et al ., 1983, Salmone and Dobereiner, 2004, Shevananda, 2008, and Darzi et al ., 2009). Long term field studies showed a significant contribution of biofertilizers for the yield increase of the field crops, which vary in range from 8–30% of control value depending on crop and soil fertility. The rhizosphere competence of native bacteria for C sources was major determinant for the success of inoculants (Gyaneshwar et al., 2002). As free living, non-photosynthetic bacteria depend on soil organic matter as a food source, enhanced bacterial populations in the mixtures possibly increased competition for energy sources in the soil (Azimi et al, 2013). Mixed microbial cultures allow their components to interact with each other synergistically, thus, stimulating each other through physical or biochemical activities (Vassilev et al., 2001). The interaction of N2-fixing bacteria with other bacteria could also inhibit their diazotrophic activity (Rojas et al., 2001). Soil microbial cultures with similar or different functions might express beneficial actions in a soil or rhizosphere (Bashan, 1998). As well as increasing the availability of phosphorus for a plant microorganisms

may release growth-increasing compounds such as oxin, gibberellin, and cytokines that are effective in increasing root and plant growth (Sattar and Gaur, 1987). Research by Ortas *et al.*, (1996) showed that these microorganisms increase absorption of food elements and yield by lowering the pH level in the soil. Results of this research clearly demonstrated the useful effect of integrating microbial fertilizer to increase seed yield under Boroujer condition. The research of various other studies has demonstrated that mixed treatments increase plant vegetative growth, resulting in increased yield in crops and legumes under farm conditions (Hoflich *et al.*, 1994; Hoflich and Khan, 1996). In final results of this study reviled that application nitrogen and phosphate biofertilizers increased yield and yield components of maize under Boroujerd environmental condition.

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Table1. Analysis of variance (mean squares) for effects of different bio fertilizers on yield and yield components of maize

source	df	Plant height	ear weight	number of grain per ear	100 grain weight	grain yield	biomass yield	harvest index
R	2	173.41	1046.37	2395.04	11.83	0.0092	0.147	1.946
Nitrogen biofertilizer(N)	3	181.40**	16729.27**	1714.15ns	7.09ns	0.011ns	0.13ns	2.220ns
Phosphate biofertilizer(P)	3	398.81**	3654.34**	5487.32**	9.85ns	0.093**	0.330**	1.844ns
N*P	9	268.76**	7145.17**	11536.19**	26.70**	0.093**	0.224**	6.05ns
E	24	17.89ns	465.64ns	760.89ns	6.05ns	0.0063ns	0.060ns	3.00ns
CV		2.24	7.39	4.73	7.11	8.82	12.21	3.93

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

Table 2. Mean comparisons for effects of different bio fertilizers on yield and yield components of maize

treatments	plant height(cm)	ear weight(g)	number of grain per ear	100 grain weight(g)	grain yield(kg/ha)	biomass yield(kg/ha)	harvest index(%)
Nitrogen biofertilizer(N)							
Nitrokara (N_1)	194a	300b	630a	37a	7700c	18300c	42ab
O4(N_2)	186b	330a	512b	34b	11100a	24600a	45a
O6(N_3)	187b	258c	530b	32b	8850b	22300ab	39b
Control(N_4)	185b	255c	510b	36a	9230b	21320b	43ab
Phosphate biofertilizer(N)							
Phosphat barvar2(P_1)	183b	300a	590a	32b	8000c	17750b	45a
Biozar(P_2)	193a	306a	599a	35b	8910bc	21000ab	42ab
MC_1+B_5(P_3)	182b	265b	586a	34b	10200a	26500a	38b
Control(P_4)	192a	290a	544b	38a	9100b	25000a	36b

Means by the uncommon letter in each column are significantly different (p<0.05)

Table 3. Interaction effect of treats for effects of different bio fertilizers on yield and yield components of maize

treatments	plant height(cm)	ear weight(g)	number of grain per ear	100 grain weight(g)	grain yield (kg/ha)
N_1P_1	182^{de}	256^{f}	540^{d}	33^{cd}	7200^{hi}
N_1P_2	202^{a}	310^{e}	620^{ab}	36^{abc}	1500^{abc}
N_1P_3	190^{bc}	280^{ef}	515^{d}	34^{bcd}	11400^{ab}
N_1P_4	203^{a}	370^{b}	630^{ab}	37^{ab}	7900^{gh}i
N_2P_1	183^{cde}	380^{b}	622^{ab}	34^{bcd}	8250^{fgh}
N_2P_2	177^{e}	420^{a}	510^{d}	32^{cd}	7790^{gh}i
N_2P_3	185^{bcd}	375^{ef}	655^{a}	38^{ab}	8300^{efgh}
N_2P_4	201^{a}	377^{ef}	512^{d}	34^{bcd}	11250^{ab}
N_3P_1	192^{b}	251^{f}	592^{bc}	38^{ab}	7250^{hi}
N_3P_2	192^{b}	260^{f}	650^{a}	35^{bcd}	10350^{abcd}
N_3P_3	183^{de}	242^{f}	640^{ab}	40^{a}	11920^{a}
N_3P_4	180^{de}	290^{cd}	555^{d}	32^{d}	8330^{efgh}
N_4P_1	176^{e}	280^{ef}	610^{ab}	34^{bcd}	10100^{bcde}
N_4P_2	201^{a}	271^{f}	602^{ab}	34^{bcd}	6850^{i}
N_4P_3	175^{e}	260^{f}	553^{cd}	31^{cd}	9630^{cdef}
N_4P_4	191^{b}	240^{f}	538^{d}	36^{abc}	9100^{defg}

Means by the uncommon letter in each column are significantly different ($p<0.05$)

Three nitrogen biofertilizers (Nitrokara (N_1), O4 (N_2), O6 (N_3) and control (N_4)) and three phosphate biofrtilizers (Phosphate barvar2 (P_1), Biozarr (P_2), Mc1+p5 (P_3) and control (P_4)).