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ORIGINAL ARTICLE

Effect of Different Biofertilizers on Yield and Yield Components of Maize (*Zea mays* L.)

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ABSTRACT
*This experiment was laid out in order to evaluate the effect of N and P biofertilizers 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 2012-2013. The experiment was a factorial design based of RCBD with three replications. Treatments were three N fertilizers (Nitroxin, Nitrokara and azot barvar1) and P biofertilizers (Phosphate barvar2, biosuperphosphate and Phosphatin) with control for them. Results showed that, the effect of N fertilizer, P fertilizer and interaction between them on all traits were significant instead of number of row per cob and harvest index. The comparison of the mean values showed that Nitroxin*phosphate barvar2 treatment had the highest cob weight, cob length and biomass. However combined application of Nitroxinand Biosuperphosphate treatment had the highest 1000 grain weight and grain yield. Also single application of Nitrokara had the highest number of row per cob. Single application of Biosuperphosphatebiofertilizer had the highest number of row per cob and HI. In final results of this study reviled that application N and P biofertilizers increased yield and yield components of maize.*
Key words: Biofertilizers, maize, yield and yield components

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INTRODUCTION

Maize (*Zea mays* L.) 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 [7]. Corn is one of the three most important cereal crops in the world. It is a versatile crop and ranks third following wheat and rice in world production as reported (7). Maize is a staple human food, a feed for livestock and raw material for many industrial products. It is an important food crop grown commercially in large scale and at subsistence level by many resource poor farmers. In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol [6]. Corn oil is used for salad, soap-making and lubrication. Odeleye and Odeleye [15] 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 programmers [15].Bio-fertilizer usually contains microorganisms having specific function such as *Azospirillum* to fix nitrogen and P solubilizing bacteria to solubilize P from the soil and fertilizer to be available to the plants [18]. Several researchers had conducted the experiments to evaluate the responses of various plants such as young Robusta coffee, soybean, and turfgrass to the biofertilizer application (8). Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution (22). For gave to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important [20,21]. Azimi et al (2013a) found that application of Supernitroplass 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) [1]. They suggested that Grain yield and biomass yield increasing was reported with the biofertilizer application which account important benefit, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield [2].In maize, application of biofertilizers increased growth and yield in many researches. Increased root, shoot weight with dual inoculation in maize have been reported by (4), 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 [17]. Beyranvand et al [3] suggested that effect of nitrogen and phosphate biofertilizers were evaluated positively, there were an increase in plant height, ear weight, and number of grain per cob, grain yield and biomass yield. Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, stated that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil (12). 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 [5].
Therefore this study was planned to examine effect of different N and P biofertilizers on yield and yield components of maize.

MATERIALS AND METHODS

This experiment was conducted in the faculty of agronomy and plant breeding, Islamic Azad University, Boroujerd Branch, Boroujerd (field location: Malayer), Iran during the growing seasons 2012-2013. According to soil analysis, details of experimental soil location was: N (0.17%), P(7.68mg/kg), K(240mg/kg), EC(5.82ds/m) with clay loam texture. The experiment was lay out in order to evaluate the effects of different N and P biofertilizers on yield and yield components of corn (*zeamayz* L.). The experiment was a factorial design based of RCBD with three replications.Treatments were three N fertilizers (Nitroxin, Nitrokara and azot barvar1) and P biofertilizers (Phosphate barvar2, biosuperphosphate and Phosphatin) with control for them. The 120kg/ha (each plot 150g) corn seeds were planted in 6-rows in plot with 6m length for them. Row to row and plant to plant distance was maintained at 75 and 20cm respectively. Planting depth for seeds was 5-6cm. Plant samples were taken with 8 plants from each plot. The cob weight and the number of row per cob were determined. To determine grain yield, biomass yield and harvest index, we removed and cleaned all the seeds produced within $1m^2$ 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 1000-grain were counted and weighed. The harvest index was accounted with follow:

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

The statistical analysis to determine the individual and interactive effects of treatments were conducted using JMP 5.0.1.2 (19). 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

Cob weight: Results showed that, the effect of N fertilizer, P fertilizer and interaction between them on cob weight were significant (table 1). The comparison of the mean values of the cob weight for interaction between N and P biofertilizers showed that Nitroxin*phosphate barvar2 treatment had the highest (286g) cob weight and control for N and P fertilizer treatment had the lowest cob weight (187g) and the differences were significant (table 3).
Cob length: The analysis of variance showed that, the effect of N fertilizer, P fertilizer and interaction between them on cob weight were significant (table 1). The comparison of the mean values of the cob length for interaction between different biofertilizers showed that Nitroxin*phosphate barvar2 treatment had the highest (22cm) cob length and control for N and P fertilizer treatment had the lowest cob length (10cm) and the differences were significant (table 3).
Number of row per cob: The effect of N and P biofertilizers on number of row per cob were significant only (table 1). The comparison of the mean values of the number of row per cob for N fertilizers showed that Nitrokara treatment had the highest (14.9) number of row per cob and control treatment had the lowest number of row per cob (12.6) and the differences were significant. Among the P biofertilizers, Biosuperphosphate treatment had the highest (14.9) number of row per cob and control treatment had the lowest number of row per cob (11.8) and the differences were significant (table 2).

Table1. Analysis of variance (mean squares) for effects of different N and P biofertilizers on yield and yield components of maize

treatments	df	cob weight	cob length	number of row per cob	1000 grain weight	biomass yield	grain yield	harvest index
R	2	44.4	267	0.18	5719	80668977	62830833	155
N fertilizer (A)	3	6436**	106**	13**	4619**	527937383**	20152916**	4
P fertilizer (B)	3	7231**	69**	22**	9682**	258467939**	32710972**	31**
A*B	9	74*	1.02**	0.29	141**	12203115**	842129**	0.74
Error	30	24.4	0.07	0.27	26	3949777	29055	1.6
CV(%)		7.9	11.5	3.8	12.8	3.92	11.5	5.79

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

1000 grain weight: The effect of N fertilizer, P fertilizer and interaction between them on cob weight were significant (table 1). The comparison of the mean values showed that Nitroxin*Biosuperphosphate treatment had the highest (332g) 1000 grain weight and control in both N and P biofertilizers treatments had the lowest 1000 grain weight (237g) and the differences were significant (table 3).

Table2. Simple means comparison for effects of different N and P biofertilizers on yield and yield components of maize

N biofertilizer	number of row per cob	HI	P biofertilizer	number of row per cob	HI(%)
Nitroxin	14.5a	21.64ab	Phosphate barvar2	14.5a	21.8b
Nitrokara	14.9a	21.5b	Biosuperphosphate	14.9a	23.2a
Azot Barvar1	13b	21.4b	Phosphatin	13.9b	22.6ab
Control	12.6c	22.6a	control	11.8c	19.5c

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

Biomass yield: The effect of all treatments was significant on biomass yield (table 1). The comparison of the mean values of the biomass yield for interaction between N and P biofartilizers showed that Nitroxin*phosphate barvar2 treatment had the highest (62590kg/ha) biomass yield and control treatment had the lowest biomass yield (38517kg/ha) and the differences were significant (table 3).

Grain yield: The effect of N fertilizer, P fertilizer and interaction between them on grain yield were significant (table 1). The comparison of the mean values of the grain yield for interaction between traits showed that Nitroxin*Biosuperphosphate treatment had the highest (14233kg/ha) grain yield and control treatment had the lowest grain yield (7816kg/ha) (table 3).

Harvest index (HI): The analysis of variance showed that, the effect of P biofertilizer on HI was significant only (table 1). The comparison of the mean values of the HI for P biofertilizer showed that Biosuperphosphate treatment had the highest (23.2%) HI and control treatment had the lowest HI (19.5%) and the differences were significant (table 2).

Table 3. Interaction effect of treats for effects of different N and P biofertilizers on yield and yield components of maize

N biofertilizer	P biofertilizer	cob weight (g)	cob length(cm)	1000 grain weight(g)	biomass yield(kg/ha)	grain yield(kg/ha)
Nitroxin	Phosphate barvar2	286a	22a	320b	62590a	13750b
Nitroxin	Biosuperphosphate	281ab	21b	332a	60733ab	14233a
Nitroxin	Phosphatin	273bcd	20c	315b	58650bc	13216c
Nitroxin	control	239f	15h	253g	47900g	9066k
Nitrokara	Phosphate barvar2	277abc	20c	305c	59250abc	12383e
Nitrokara	Biosuperphosphate	271cd	19d	314b	56550cd	12916d
Nitrokara	Phosphatin	265de	18ef	295d	53283de	12050f

Nitrokara	control	214h	14i	241h	45567gh	9150k
Azot Barvar1	Phosphate barvar2	273bcd	19de	280e	53217de	11366g
Azot Barvar1	Biosuperphosphate	262e	18fg	290d	51383ef	11800f
Azot Barvar1	Phosphatin	257e	18fg	275e	48383fg	10866h
Azot Barvar1	control	210h	14.5i	237h	44917ghi	8716l
Control	Phosphate barvar2	234f	14.3i	273e	44067hi	10216i
Control	Biosuperphosphate	226g	13.6j	277e	43917hi	10416i
Control	Phosphatin	215h	13.1k	263f	41450ij	9700j
Control	control	187i	10l	228i	38517j	7816m

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

DISCUSSION

For gave to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important (1,2. In the present study results indicates that there were significant differences in the response of yield and yield components of maize cultivars to different N and P biofertilizers (table 1). 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 [23]. Based on results, the effect of nitrogen and phosphate biofertilizers were evaluated positively, there were an increase in cob length, cob weight, number of row per cob, 1000 grain weight, grain yield and biomass yield. Phosphate biofertilizers were evaluated positively, there were an increase in harvest index. Some researchers determined that enhanced phosphorus release increases evaluations for the trait of grain yield, biomass and 100-seed weight (11). 1000 grain weight 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 [9]. It may be concluded that photosynthetic capacity of plants treated with phosphors-solving microorganism's increases due to increased supply of phosphors nutrition. Cob 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 [13,16]. 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, which positively influenced the maize photosynthesis and dry matter accumulation more actively that agree with [5,12].Azimi et al (2013a) found that application of Supernitroplus biofertilizer with Phosphate barvar 2 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) [1]. Also Azimi et al [2013b] found that that application nitrogen and phosphate biofertilizers increased yield and yield components of barley under Boroujerd environmental condition [2]. They suggested that Grain yield and biomass yield increasing was reported with the biofertilizer application which account important benefit, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield [2]. 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 [10]. In final results of this study reviled that application N and P biofertilizers increased yield and yield components of maize.

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