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The effect of different levels of phosphorus from triplesuperphosphate fertilizer sources and biosuperphosphate fertilizer on yield and yield components of corn in the climatic conditions of Izeh

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Abstract

In order to investigate the biological application of bio superphosphate fertilizer and different quantities of triple superphosphate on yield and yield components of maize Mobin 704, research was conducted in February 2012 in a field located in the city of Izeh. The present research was carried out in split plot in form of randomized complete block design, in three replications and two factors: the main factor consisted of 4 of triple superphosphate levels (application 0, 130, 65, 195 kg per hectare) and the sub-factor at two levels (application and in-application of bio superphosphate fertilizer). The results of this research indicated that the effect of phosphorus on the yield and yield components was significant in such as a manner that as the application of phosphorus level increased, seed yield, number of kernels in maize, number of seeds per row and weight of one thousand seeds significantly increased at 130 kg per hectare. The application of bio superphosphate fertilizer significantly increased seed yield and yield components. Combining treatments of bio superphosphate fertilizer and quantities of triple superphosphate fertilizer also increased yield and yield components of maize. Meanwhile the application of bio superphosphate fertilizer and 130 kg hectare of triple superphosphate had the highest seed yield and it had higher yield than other treatments in general.

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Introduction

Although the use of biological fertilizers in agriculture has a long history, but scientific exploitation of these sources has no long previous record. However, the application of the fertilizers has decreased in recent decades, but nowadays with respect to the problems that uncontrolled use of fertilizers has posed, their use has been reintroduced in agriculture (Moalem and Eshghizadeh 2007). Biological fertilizers have a considerable advantage compared with other chemicals including that they participate in the food chain of toxic and microbial substances, have the self-reproducibility and cause to reform physical and chemical properties of soil (Stark Condron, *et al.,* 2007). In recent decades, the use of chemical inputs in agriculture has given rise to environmental problems such as water pollution, poor quality crops and reducing soil fertility (Sharma, 2002). Biological fertilizers are not exclusively referred to organic substances from animal fertilizers and plant residues, but it does apply to products from the activity of microorganisms that are active in relation to nitrogen fixation and availability of phosphorus and other nutrients in soil (Rastin, 1998). One of the ways to achieve sustainable agriculture is the use of microorganisms that play an important role in plant nutrient (Jackson *et al.,* 1992).

The capability of low-phosphorus in most non-fertilized soils has been considered as a major limiting factor in plant growth (Hinsinger, 2001). This does not mean that the amount of phosphorus in the soil is low, but it means that part of the phosphorus that can be absorbed in plant is limited due to complex chemical reactions of phosphorus in the soil that led to its preservation and maintenance in soil. In low-usable phosphorus soils, different plants and even different varieties of one species have different abilities in growth and development (Wang *et al.,* 2005). In other words, they have different use efficiency of phosphorus. “Use efficiency” of phosphorus in the soil depends on two factors (Moll *et al.,* 1982) 1- Consumption efficiency, which, is the plant’s ability to convert small amounts of absorbed nutrient element in yield, is relatively high. 2 - Absorption efficiency in fact is the plant's ability to extract nutrient elements from the soil in the deficiency of the elements conditions. For most agricultural plants, phosphorus-absorption efficiency is of special importance in the growth and development of the plant (Fohse *et al.,* 1988). Phosphorus-absorption efficiency from soil primarily depends on two factors: The first one is the size of the root system and the second one the flow towards the inside (Bhadoria *et al.,* 2002). The flow towards the inside of phosphorus actually is the phosphorus movement into plant root based on mole per area unit or root length that is expressed per time unit. The flow towards the inside of phosphorus on the one hand is related to the plant's ability in absorption and on the other hand to restrictions of the movement of phosphorus in the soil (Claassen *et al.,* 1990).

This research was carried out based on achieving the goals of sustainable agriculture and decreasing the use of chemical fertilizers and also examining the effects of phosphate bio-fertilizer as an economically and environmentally efficient and a healthy fertilizer source, on the yield and yield components of corn.

Materials and methods

Field experiment

This experiment was conducted in Izeh city in February 2012 with geographical longitude of 45 degrees, 42 minutes east, 33 degrees of geographical latitude, 21 minutes north with 19.5 meters height and using maize Mobin 704. The experimenting soil texture was silty clay loam with pH of 6.7 and EC of 1,7. This research was carried out in split plot in form of randomized complete block design, in three replications and two factors. The main factor consisted of four levels of triple superphosphate (application P_0=0, P_1=65, P_2=130, P_3=195 kg per hectare of phosphorus) and the sub-factor in two levels (B_1 application or B_2 inapplication of bio superphosphate fertilizer) were performed. The needed maize seeds were treated and wet with a little water and then mixed with bio superphosphate fertilizer and finally seeds were planted by hand with consideration of a density of 75,000 shrubs per hectare with a gap of 18 cm in a bed. Planting the seeds was carried out in early February. Each plot was consisted of six lines with a length of 5 m and a distance of 75 cm. Nitrogen was applied according to the amount of 200 kg of net nitrogen from urea in two stages that 100 kg of it was given simultaneously with planting and the rest as the surplus. Triple superphosphate fertilizer also was given to meet the need of phosphorus according to the amount of each treatment. The first irrigation was performed immediately after planting and during the growing period totally 9 times it was done according to the plants' needs and irrigation period common of the area. In this experiment, the seed yield characteristics, number of seeds per row, number of kernels per maize and one thousand seeds weight were examined.

Data Analysis

The SAS software was employed to analyze the data variance and comparison of the means was done using Duncan test at 5% and 1% level.

Results and discussion

Number of rows per maize

The effect of bio superphosphate fertilizer and triple superphosphate fertilizer alone and interaction of bio superphosphate fertilizer and triple superphosphate on the number of rows per maize was not significant (Table 1). The results of comparison of means showed that the maximum number of rows per maize was 14.54 row number of triple superphosphate fertilizer treatment of 130 kg per hectare, 14.47 row number of bio superphosphate fertilizer treatment was observed (Table 2).

Table 1. Results of variance analysis of seed yield, seed yield and other traits of maize.

S.O.V	df	Number of row in maize	Number of seed in row	Number of kernel in maize	1000 of seed weight	Seed yield g/m2
R	2	0.21317	1.957	946.6	8.85	2013
triple superphosphate(P)	3	0.20875$^{n.s}$	69.962**	15909.5**	786.89**	70110**
E a	6	0.36530	2.24	582.4	96.41	1461
Bio superphosphate(B)	1	0.90388$^{n.s}$	12.531**	5601.9**	244.17*	23141**
B*P	3	0.26448$^{n.s}$	0.416$^{n.s}$	1667*	1.90$^{n.s}$	6832*
E b	8	0.06572	1.62	300.9	50.22	1450

Number of seeds per row

The effect of bio superphosphate fertilizer and triple superphosphate fertilizer on the seed number per row was significant at the one percent level and their interaction on the seed number per row was not significant (Table 1). Comparison of means showed that the highest number of seeds per row of 24.9 seeds from triple superphosphate fertilizer treatment of 195 kg per hectare and 22.31 seeds from bio superphosphate fertilizer treatment were observed (Table 2). Integrating biological and chemical fertilizer application were not significant. The reason appears to be more absorption of phosphorus by solubilizing microorganisms providing adequate nutritional conditions including increasing nitrogen absorption for the plant during the period, differentiation of spikelets and growing flowers and thus reducing abortion of spikelets, increasing the number of seeds, improving photosynthesis and better partition of substances in seeds. The results were consistent with those of Yazdani *et al* (2007) and Zarabi *et al* (2010).

The number of kernels per maize

The number of kernels per maize was significantly affected by bio superphosphate fertilizer and chemical superphosphate fertilizer was significant at one percent level and interaction of bio superphosphate fertilizer and triple superphosphate fertilizer was significant at five percent level (Table 1). The results of means comparison showed that the highest number of kernels per maize averagely of 355.7 seeds from triple superphosphate fertilizer treatment of 195 kg per hectare and 324.34 seeds from bio superphosphate fertilizer treatment were observed (Table 2). The highest amount of kernel per maize from the treatment of B_2P_3 (application of bio superphosphate fertilizer 195 kg per hectare of triple superphosphate) and the lowest from the treatment of B_1P_0 (inapplication of bio superphosphate fertilizer without triple superphosphate) were obtained 386 and 192.2 kernels respectively (Table 3). As investigations have shown, although triple superphosphate fertilizer and bio superphosphate fertilizer were effective on the maize seeds individually, but when biological fertilizer was used with phosphatized chemical fertilizer, better results obtained. The reason appears to be more absorption of phosphorus by solubilizing microorganisms providing adequate nutritional conditions including increasing nitrogen absorption for the plant during the period, differentiation of spikelets and growing flowers and thus reducing abortion of spikelets, increasing the number of seeds, improving photosynthesis and better partition of substances in seeds. The results were consistent with those of Behzadisani *et al* (2007) and Yosefi *et al* (2010).

Table 2. Comparison of effects mean of triple superphosphate fertilizer and bio superphosphate fertilizer on seed yield and other traits.

Treatment	Number of row in maize	Number of seed in row	Number of kernel in maize	1000 of seed weight	Seed yield g/m2
P_0(0)	14.12^{a}	15.16^{c}	221.3^{c}	196.33^{c}	312.9^{c}
P_1(65)	14.17^{a}	21^{b}	299.07^{b}	216.28^{b}	458.2^{b}
P_2(130)	14.54^{a}	23.33^{a}	339.7^{a}	218.58^{ab}	557.4^{a}
P_3(195)	14.26^{a}	24.9^{a}	355.7^{a}	221.60^{a}	591.8^{a}
B_1 (Inapplication of bio superphosphate)	14.08^{a}	19.9^{b}	279.08^{b}	210.75^{b}	444.7^{b}
B_2 (Application of bio superphosphate)	14.47^{a}	22.31^{a}	324.34^{a}	215.65^{a}	529^{a}

One thousand of seeds weight

The effect of bio superphosphate fertilizer on the one thousand of seeds weight was significant at the one percent level and triple chemical superphosphate fertilizers on the one thousand of seeds weight was significant at the five percent level and interaction of bio superphosphate fertilizer and triple superphosphate fertilizer on the one thousand of seeds weight was not significant (Table 1). The results of means comparison showed that the highest of the one thousand of seeds weight of 221.60 g from triple superphosphate fertilizer of 195 kg per hectare and 215.65 seeds from bio superphosphate fertilizer treatment were observed (Table 2). Integrating biological and chemical fertilizer application was not significant. The results of Ruiz, Lozano and Azkon's investigations (1995) showed that symbiosis with solubilizing microorganisms of phosphorus, increased photosynthetic phosphorus use efficiency in relation to non-symbiotic plants. This matter is due to the useful effects of biological fertilizer on the increasing of root growth, proper supplying of nutrients, increasing leaf surface, improving photosynthesis and better partitioning substances in the seeds. Therefore, it can concluded that the photosynthetic capacity of the treated plants with phosphorus solubilizing microorganisms increases by more nutrition of phosphorus which is due to the more transfer of photosynthetic substances to the place of seeds and seed weight increases (Koide, 1993). Some researchers have considered increase of one thousand of seeds weight as a result of the release of phosphorus and its absorption by phosphorus solubilizing microorganisms (Khaliq and sanders, 2000).

Table 3. Comparison of the combined analysis means of triple superphosphate fertilizer and bio superphosphate fertilizer on seed yield and other traits.

Treatment		Number of kernel in maize	Seed yield
b	p		g/m^2
1	0	192.2^{e}	280.7^{e}
2	0	232.4^{d}	345.2^{d}
1	1	281.7^{c}	451.6^{c}
2	1	316. 4^{c}	518.8^{b}
1	2	316.9^{a}	512.1^{b}
2	2	362.5^{a}	602.6^{a}
1	3	325.5^{ab}	534.2^{b}
2	3	386^{a}	649.3^{a}

Yield of seed

The effect of bio superphosphate fertilizer interaction, triple superphosphate and interaction of bio superphosphate fertilizer and triple superphosphate on the yield of seed was significant (Table 1). The results of means comparison showed that the highest of seed to the treatment of triple superphosphate fertilizer application of 195 kg per hectare and the treatment of bio superphosphate fertilizer application were observed (Table 2). The highest yield of seed from the treatment of B_2P_3 (application of bio superphosphate fertilizer 195 kg per hectare of triple superphosphate) and the lowest from the treatment of B_1P_0 (inapplication of bio superphosphate fertilizer without triple superphosphate) were obtained 649.3 and 280.7 kg per square meter respectively (Table 3). It seems that solubility of insoluble phosphates by microorganisms is done through the production of organic acids, chelating oxoacids of sugars and interchanging of reactions in the environment of root growth are of the other mechanisms of microorganisms in increasing of nutrients absorption and consequently it results in increasing yield components and seed yield. The results were consistent with those of Tavhidimoghadam and colleagues that in the presence of phosphate soluble bacteria, the amount of phosphate chemical fertilizers decreases by 50 percent. Ghasemi and colleagues (2009) reported that the beneficial effect of combining phosphatized bio fertilizer with phosphorus chemical fertilizer was quite evident from the standpoint of seed yield increase under the condition of dehydration tension in maize single cross 704.

Conclusion

The results of the research indicated that the effect of phosphorus on yield and yield components was significantly in such manner that as phosphorus application level increased, seed yield, number of kernels per maize, number of seeds per row and one thousand of seeds weight showed a significant increase at p_3 level. The application of bio superphosphate fertilizer significantly increased seed yield and yield components. Combining treatments of bio superphosphate fertilizer triple chemical superphosphate fertilizer also increased yield and yield components of maize. Meanwhile B_2P_2 (the application of bio superphosphate fertilizer and 130 kg hectare of triple superphosphate) had the highest seed yield and it had higher yield than other treatments in general. Adding bio superphosphate fertilizer to the soil increases absorption of other elements required by the plant including a variety of low-consumption elements by providing balance in density of nutrient elements in the soil that it includes a variety of different phosphorus solubilizing bacteria that they have the ability to produce a variety of organic and mineral acids and secrete phosphatized enzymes thus, it converts organic and mineral phosphorus reserves in the soil, which are normally unusable, to a usable form for plants.

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