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ORIGINAL ARTICLE

The Effect of Different Levels of Phosphorus Chemical and Biological Fertilizers on Distribution of Dry Matter and Grain Yield in Maize Single Cross 704 in Ahvaz Weather Conditions

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ABSTRACT
Biological fertilizers are among natural components which can be uses as supplement or alternative to chemical fertilizers in sustainable agriculture. The effects of triple super phosphate fertilizer and biological phosphate fertilizer (fertile 2) on distribution of dry matter and grain yield of Maize Single Cross 704 were examined in 2012 in Shahid Salemi Field in Ahvaz as a factorial experiment in the form of randomized complete block design with four replications. The experiment included two factors: first, biological phosphate fertilizer (fertile 2) at three levels of 0, 100, 200 g/ha; second, triple super phosphate chemical fertilizer at three levels of 0, 60, 90 kg/ha of pure phosphorus (P_2O_5). The obtained results indicated the increase of grain yield, leaf dry weight, stem dry weight, maize cob dry weight, tassel dry weight and total weight of maize in treatments with integration of phosphate bio-fertilizer (fertile 2) and triple super phosphate chemical fertilizer. P_2B_2 treatment (100 g/ha biological phosphate fertilizer (fertile 2) and 60 kg/ha triple super phosphate fertilizer) had the highest biological yield and grain yield. Generally, it could be said that the increase of yield and elements uptake by the plant is related to the increase of soluble phosphorus in soil so that phosphorus plays an important role in root development and prevention of the accumulation of phosphorus compounds and their negative effects on the absorption of some elements by the soil. With regard to the results obtained it seems like that the decrease of application of triple super phosphate chemical fertilizer to less than a half together with the use of biological phosphate fertilizer (fertile 2) is particularly important to achieve more grain yield in Ahvaz weather conditions. The results showed that phosphate (fertile 2) significantly increased the grain yield, leaf dry weight and stem dry weight.
Keywords: *biological phosphate fertilizer (fertile 2), triple super phosphate, Corn (SC704)*

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INTRODUCTION

Indiscriminate use of chemical fertilizers to achieve high yield and to compensate for lack of nutrients and consequently the increase of production costs and destruction of soil and water resources have made the specialists interested in healthy and stable crop systems in terms of ecology [23]. Maize is considered as one of the most important strategic and highly expected grains throughout the world. In order to have high quantitative and qualitative yield, maize must have an appropriate combination of nutrients [11]. Use of biological products for feeding grains is one useful solution to the achievement of a part of sustainable agriculture goals. Bio-fertilizer refers to fertilizing substances which contain sufficient number of microorganisms including bacteria and fungi and are used to supply one or several nutritional elements that are needed by plants [16]. Phosphorus is one of the main elements required by plants which has a basic role in the formation of seeds and is found in large quantities in fruits and seeds. However, unusual and inappropriate use of phosphorous fertilizers has unfortunately imposed deleterious effects on agricultural community [8]. Biological fertilizers are made up of useful bacteria and fungi each of which is produced for a particular purpose. Such bacteria are usually settled around the roots and help absorb a certain element and cause the absorption of other elements and plant further growth [28].

One of these fertilizers is phosphate bio-fertilizer (fertile 2). Its high capability as a solvent for phosphate, climatic adaptability, stability during the storage, easy consumption, cheap transport, and compatibility with other fertilizers and pesticides are mentioned as the features of this kind of fertilizer [5]. Jat and

Shaktawat showed that phosphate bio-fertilizer in comparison to triple super phosphate fertilizers considerably increased the yield. Phosphate solubilizing bacteria secrete phosphatase and organic acids and thus make phosphate solution and increase the phosphate uptake by plants [26,14].
Toro et al. [25] showed that the use of phosphate solubilizing bacteria increased the concentration of nitrogen and phosphorus in vegetative organs in comparison to the control treatment without using them. In an experiment, Peix et al. [13] reported that the use of phosphate solubilizing bacteria caused the increase solubility of insoluble phosphorus, increase of phosphorus uptake, and significant increase of yield in barley and peas. Sylvia et al., [22] concluded that in treatments which used phosphate biological fertilizer, the concentration of phosphorus and copper increased in corn's shoots and seeds. Goenadi et al. [4] reported that the use of bio-fertilizers and 50-75% chemical fertilizer led to a yield similar to the yield of the consumption of 100% chemical fertilizer.

MATERIAL AND METHODS

This research was carried out in Shahid Salemi field 36 km away from northeast of Ahvaz at latitude 31° 36′ and longitude 48° 53′ and 51 m above the sea level. The kind of soil used in the experiment was clay loam with pH=7.8 and EC=6.7. It was a factorial experiment as randomized complete block design with 4 replications and two factors. The first factor included biological phosphate fertilizer (fertile 2) at three levels of 0, 100, 200 g/h and the second factor included triple super phosphate chemical fertilizer at three levels of 0, 60, 90 kg/ha of pure phosphorus (P_2O_5). The needed corn seeds were moistened by a little water before planting and were mixed by the contents of a 100-g package of phosphate biological fertilizer (fertile 2) as the desired factors in the experiment and then after complete drying of the seeds in the shade, they were planted manually by considering the density of 75000 plants per hectare in a space of 18 cm from each other on one side of the stack. The seeds were planted in early August. Each plot contained 6 planting lines as long as 5 m and as distant as 75 cm from each other. Nitrogen was used from urea source as much as 180 kg in two stages, so that 90 kg was used during the planting and the rest was added then as the head. Triple super phosphate fertilizer was used to provide the needed phosphorus according to each treatment need.

Table 1: soil test results of experimented field

pH	Type of soil	Soil components (%)			Absorbable elements			Soil depth (cm)
					Mg/kg		percent	
		sand	silt	clay	K	P	N	
7/8	Clay loam	41	16	45	120/12	9/2	0/093	0-30
8/1	Clay Loam	42	15	44	91/4	7/1	0/093	30-60

Studied Traits

In this experiments traits such as leaf dry weight, stem dry weight, maize cob dry weight, tassel dry weight, total weight of maize and grain yield were investigated.

Data Analysis

The experiment data were analyzed by means of SAS software and in order to draw the diagrams Excel software was used and Duncan's multi range test was used to compare the means.

RESULTS AND DISCUSSION

Grain Yield

The effect of phosphate bio-fertilizer (fertile 2), triple super phosphate and their interactive effect on grain yield was significant (table 1). The mean comparison results showed that the highest grain yield by 1128.29 g/m^2 belonged to the treatment with 60 kg/ha triple super phosphate chemical fertilizer and the treatment with 1261.98 g/m^2 phosphate bio-fertilizer (fertile 2) by 100 g/ha. (Table 2). The highest rate of grain yield by 1353.62 g/m^2 belonged to P_2B_2 treatment (100 g/ha phosphate fertilizer (fertile 2) and 60 kg/ha triple super phosphate) and the lowest rate belonged to P_1B_1(without phosphate fertilizer (fertile 2) and triple super phosphate) by 694.78 g/m^2. It seems like that the solubility of insoluble phosphates by microorganisms via producing organic acids and making oxoacids out of sugars and exchanging reactions in roots growth environment are other mechanisms of microorganisms in increasing nutrients uptake and consequently increasing the grain yield [31]. On the other hand, it could be concluded that the photosynthetic capacity of the plants treated with phosphorus solubilizing microorganisms has increased due to further phosphorus feeding and also the weight of grains has increased due to further assimilate mobilization to the seeds. Moreover, the studies done by Ortas [12] showed that such microorganism would increase nutrition uptake and grain yield through decreasing soil pH. To explain this point, Tohidi Moghadam et al [24] showed that the grain yield was more in treatments in which biological fertilizers and appropriate amount of phosphate chemical fertilizers were used. Mahdavi Damghani et al. [10] reported that the interactive application of bio-fertilizers and chemical fertilizers increased the grain yield and decreased the consumption of chemical fertilizers.

Leaf Dry Weight

The simple effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate and interactive effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate on leaf dry weight were significant (Table 2). Mean comparison results showed that the highest leaf dry weight by 34.51 g/m^2 belonged to the treatment with application of 60 kg/ha triple super phosphate chemical fertilizer and the treatment with application of 100 g/ha phosphate bio-fertilizer (fertile 2) by 40.39 g/m^2 (Table 3). The highest rate of leaf dry weight by 44 g/m^2 belonged to P_3B_3 (200 g/ha phosphate fertilizer (fertile 2) plus 90 kg/ha triple super phosphate) and the lowest rate by 14.24 g/m^2 belonged to P_3B_1 treatment (without application of phosphate bio-fertilizer (fertile 2) and with 90 kg/ha triple super phosphate). The results were consistent with the findings of Ekelof [3] who showed that the cited factors resulting from biological fertilizers could increase plant growth and synthesis of stored materials in potato tuber and consequently would increase dry matter in potato tuber.

Stem Dry Weight

The simple effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate and interactive effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate on stem dry weight were significant (Table 2). Mean comparison results showed that the highest stem dry weight by 113.15 g/m^2 belonged to the treatment with application of 60 kg/ha triple super phosphate chemical fertilizer and the treatment with application of 100 g/ha phosphate bio-fertilizer (fertile 2) by 136.39 g/m^2 (Table 3). The highest rate of stem dry weight by 157.39 g/m^2 belonged to P_2B_2 (100 g/ha phosphate fertilizer (fertile 2) plus 60 kg/ha triple super phosphate) and the lowest rate by 81.06 g/m^2 belonged to P_3B_1 treatment (without application of phosphate bio-fertilizer (fertile 2) and with 90 kg/ha triple super phosphate). The results were consistent with the findings of Ekelof [3] who showed that the cited factors resulting from biological fertilizers could increase plant growth and synthesis of stored materials in potato tuber and consequently would increase dry matter in potato tuber.

Maize Cob Dry Weight

The simple effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate and interactive effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate on maize cob dry weight were not significant (Table 2). Mean comparison results showed that the highest maize cob dry weight by 13.91g belonged to the treatment with application of 90 kg/ha triple super phosphate chemical fertilizer and the treatment with application of 100 g/ha phosphate bio-fertilizer (fertile 2) by 16.73 g. The highest rate of maize cob dry weight by 18.85 g belonged to P_1B_3 (200 g/ha phosphate fertilizer (fertile 2) without triple super phosphate) and the lowest rate by 11.84 g belonged to P_1B_2 treatment (100 g/h phosphate bio-fertilizer (fertile 2) without triple super phosphate) (Table 3). As the reviews have shown, each level of phosphate bio-fertilizer (fertile 2) by itself has affected the weight of maize cob and better results have been obtained. The reason could be more absorption of phosphorus by phosphorus solubilizing microorganisms and provision of appropriate nutritional conditions such as increase of nitrogen uptake by plant during the growth stage. In other words, application of different levels of phosphate fertilizer (fertile 2) significantly increased the weight of maize cob. Consumption of more levels of phosphate fertilizer (fertile 2) did not have a significant effect although it increased the weight of maize cob (Table 2). In general, application of more levels of phosphate fertilizer (fertile 2) in this research, increased the plant access to nutrients particularly phosphorus and made their absorption easier and consequently the weight of maize cob increased. The results were consistent with the findings of Yazdani et al. [27] who showed that inoculation of maize single cross 604 with phosphorus solubilizing bacteria and growth promoting bacteria and consumption of adequate input increased the weight of maize cob.

Tassel Dry Weight

The simple effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate and interactive effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate on tassel dry weight were significant (Table 2). Mean comparison results showed that the highest tassel dry weight by 113.15 g/m^2 belonged to the treatment with application of 60 kg/ha triple super phosphate chemical fertilizer and the treatment with application of 100 g/ha phosphate bio-fertilizer (fertile 2) by 136.39 g/m^2 (Table 3). The highest rate of tassel dry weight by 157.39 g/m^2 belonged to P_2B_2 (100 g/ha phosphate fertilizer (fertile 2) plus 60 kg/ha triple super phosphate) and the lowest rate by 81.06 g/m^2 belonged to P_3B_1 treatment (without application of phosphate bio-fertilizer (fertile 2) and with 90 kg/ha triple super phosphate). The results were consistent with the findings of Ekelof [3] who showed that the cited factors resulting from biological fertilizers could increase plant growth and synthesis of stored materials in potato tuber and consequently would increase dry matter in potato tuber.

Maize Total Weight

The simple effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate and interactive effect of phosphate bio-fertilizer (fertile 2) and triple super phosphate on maize total weight were not significant (Table 2). Mean comparison results showed that the highest total weight of maize by 815.16 g belonged to the treatment with application of 90 kg/ha triple super phosphate chemical fertilizer and the treatment with application of 200 g/ha phosphate bio-fertilizer (fertile 2) by 872.22 g. The highest rate of total weight of maize by 981.66 g belonged to P_1B_3 (200 g/ha phosphate fertilizer (fertile 2) without triple super phosphate) and the lowest rate by 611.66 g belonged to P_1B_2 treatment (100 g/h phosphate bio-fertilizer (fertile 2) without triple super phosphate). This might be due to different reasons such as more absorption of phosphorus by phosphorus solubilizing microorganisms or solubility of insoluble phosphates by such microorganisms through the decrease of soil pH and production of organic acid, chelating exoacids from sugars and exchanging reactions in root growth environment, providing adequate nutritional conditions for plant such as increase of nitrogen uptake, reducing abortion of spikelet and increasing the number and weight of grains. On the other hand, it can be concluded that photosynthetic capacity of plants treated by phosphorus solubilizing microorganisms has increased due to more phosphorus nutrition, and since more assimilates or mobilized into grains the weight of grains and ultimately the total weight of maize will increase. The results were consistent with the findings of Yazdani et al. [27] who showed that inoculation of maize single cross 604 with phosphorus solubilizing bacteria and growth promoting bacteria and consumption of adequate input increased the total weight of maize.

Table 2: The ANOVA results of dry mater distribution and grain yield of Maize

Experimented traits						Degree of freedom (DF)	Sources of variation
Grain yield	Total weight of maize (g/m^2)	Dry weight of tassel	dry weight of maize cob	dry weight of stem	dry weight of leaf		
14177.77*	119815.88$^{n.s}$	9.03**	9.92$^{n.s}$	9.036**	8.27**	2	Block
572438.17**	48618.26$^{n.s}$	4738.23**	7.56$^{n.s}$	4738.23**	145.93**	2	Super phosphate
96362.71**	37207.74$^{n.s}$	133.93**	26.19$^{n.s}$	133.93**	436.27**	2	Biological phosphate fertilizer (fertile 2)
18567.71**	54948.72$^{n.s}$	1548.9**	12.23$^{n.s}$	1548.9**	229.71**	4	Interactive effect of triple super phosphate and Biological phosphate fertilizer (fertile 2)
2966.25	35965.28	0.023	12.02	0.023	0.038	16	Experiment error

Table 3: mean comparison of the effects of different levels of phosphorus biological and chemical fertilizers on distribution of dry matter and grain yield of maize.

Grain yield (g/m^2)	Total weight of maize (g/m^2)	Dry weight of tassel (g/m^2)	Weight of maize cob (g/m^2)	Weight of stem (g/m^2)	Weight of leaf (g/m^2)	Treatment
						Triple super phosphate fertilizer
760.76^{c}	725.56^{b}	110.28^{b}	13.27^{c}	110.28^{b}	26.52^{c}	P1 (0 kg/ha)
1128.29^{a}	743.89^{b}	113.15^{a}	13.84^{c}	113.15^{b}	34.51^{b}	P2 (60 kg/ ha)
1060.34^{a}	815.16^{a}	90.65^{c}	13.91^{c}	90.65^{c}	29.47^{c}	P3 (90 kg/ha)
						Biological phosphate fertilizer (fertile 2)
921.57^{c}	852.78^{a}	115.9^{b}	14.64^{a}	115.9^{b}	34.53^{b}	B1 (0 g/ha)
1261.98^{a}	852.94^{a}	136.39^{a}	16.73^{a}	136.39^{a}	40.39^{a}	B2 (100 g/ha)
1033.21^{b}	872.22^{a}	108.28^{c}	15.74^{a}	108.28^{b}	37.49^{a}	B3 (200 g/ha)

CONCLUSIONS

The results of the research showed that application of treatments with integration of phosphate bio-fertilizer (fertile 2) and triple super phosphate chemical fertilizer led to better distribution of dry matter and increase of maize yield. Fertile 2 phosphate bio-fertilizer in combination with appropriate amount of triple super phosphate chemical fertilizer reduces the need to phosphorus chemical fertilizers and increases their efficiency by releasing phosphorus gradually and changing it to absorbable form by plant. Phosphate solubilizing bacteria in fertile 2 phosphate bio-fertilizer, by releasing organic acids and phosphatase acid, will cause enzymatic analysis of organic compounds and nutrients solution in soil and increase nutrients absorption in soil. Therefore, the importance of such microorganisms is not only due to their contribution to the absorption of certain elements but also other elements uptake and improvement of soil structure are the positive consequences of fertile 2 phosphate bio-fertilizer and thus the increase of phosphorus which is available for plants. Moreover, by using biological fertilizer in this experiment, the rate of phosphorus fertilizer consumption decreased as much as 50% without the significant decrease of the yield which is economically and environmentally considerable.

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