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Effect of Biological and Chemical phosphorus Fertilizers on yield components of maize (*Zea mays* L.) in different water stress conditions

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ABSTRACT

The effects of biological fertilizer and chemical phosphorus fertilizer in different irrigation (water stress)on yield components of maize (Zea mays L.) were studied in a field experiment at Tehran university . A factorial split experiment based on randomized complete blocks design (RCBD) with three replications was followed in the study. Water stress treatmentsin three levels (irrigation after 75mm (normal irrigation(a1)), 100mm (moderate stress (a2)) and 125mm (sever stress(a)) evaporation from A class pan were the main plots, and two levels of biological fertilizers (application(b1) and non application(b2)) together with chemical phosphorus fertilizers in four levels (0 (c1),75 (c2),150 (c3) and 225 (c4) kg/ha) as the factorial were sub plots. Results indicated that biological and chemical phosphorus fertilizers had a significant influence on growth, yield and yield components however cob diameter and ear length was not significantly affected by utilization of chemical phosphorus fertilizers and biological fertilizer s. The result showed that different irrigation and interaction between irrigation and biological fertilizers had significant effect on number of grain per ear.Results showed that applying the combined chemical phosphorus fertilizer with biological fertilizer can be practical and helpful method to increase maize yield and reduce the environmental pollution.

Keywords: water stress, biological fertilizer, chemical phosphorus fertilizer,corn

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INTRODUCTION

Corn undergoing drought stress prior to pollination still has many chances to regain most of the yield potential. Ear size, kernel rows and potential ovule numbers are starting to be determined by leaf stage V9 through V12. Drought stress can reduce these components. However, if adequate moisture occurs by pollination, the corn plant probably will recover and yield losses can be as little as 5 or 10%. Fertilized ovules develop into kernels and the first stage of this development following pollination is the blister stage. Dry conditions during this stage could result in aborted kernels. Aborted kernels are shrunken and white compared to plump, developing kernels. Kernels at the tip of the ear are most susceptible to abortion. The developing kernels will progress through the blister, dough and dent stage s before reaching physiological maturity. The kernels are gaining weight during the dough and dent stages. Water is a key component to kernel weight gain. Dry weather during the dough and/or dent stages will reduce final kernel weight and reduce yields. Dry weather will reduce yields more during the dough stage than during the dent stage.(nelson, 2002) Inorganic forms of P are solubilized by a group of heterotrophic microorganisms excreting organic acids that dissolve phosphatic minerals and/or chelate cationic partners of the P ions i.e. PO4 3- directly, eleasing P into solution (He *et al.*, 2002). Phosphate solubilizing bacteria (PSB) are being used as biofertilizer since 1950s (Kudashev, 1956; Krasilinikov, 1957). Release of P by PSB from insoluble and fixed / adsorbed forms is an import aspect regarding P availability in soils. There are strong evidences that soil bacteria are capable of transforming soil P to the forms available to plant. Microbial biomass assimilates soluble P, and prevents it from adsorption or fixation (Khan and Joergesen, 2009) Subsequently, PSB become a source of P to plants upon its. release from their cells. The PSB and plant growth promoting rhizobacteria (PGPR) together could reduce P fertilizer application by 50 % without any significant reduction of crop yield (Jilani*et al.*, 2007; Yazdani*et al.*, 2009). It infers that PSB inoculants / biofertilizers hold great prospects for sustaining crop production with optimized P fertilization. Evidence of naturally occurring rhizospheric phosphorus solubilizing microorganism (PSM) dates back to 1903 (Khan *et al.,* 2007). Bacteria are more effective in phosphorus solubilization than fungi (Alam*et al.,* 2002). Among the soil bacterial communities, ectorhizospheric strains from *Pseudomonas* and *Bacilli*, and endosymbiotic rhizobia have been described as effective phosphate solubilizers (Igual*et al.*, 2001).

MATERIALS AND METHODS

This experiment was carried out in 2007 at the field experiment of Tehran university, iran located in 33º28´ longitude and 51º46´ latitude and, 1180 m Altitude from sea level with an arid and semi-arid climate. Experiment was conducted in split factorial within a randomized complete block design with three replications. The main plots included Water stress treatments in three levels (irrigation after 75mm (normal irrigation(a1)), 100mm (moderate stress (a2)) and 125mm (sever stress(a3)) evaporation from A class pan and sub plot were considered two levels of biological fertilizers: (application(b1) and non application (b2)) together with chemical phosphorus fertilizers in four levels (0 (c1),75 (c2),150 (c3) and 225 (c4) kg/ha) as the factorial. Sowing was done as rows in 75cm wide rows with 20cm spacing within-rows with six rows per subplot by Single Cross 704 cultivar, (Single Cross 704 was chosen because this cultivar had superiority relative to other cultivar in the last few years in experimental region seeds were inoculated with biological fertilizer (*Bacillus lentus ,pseudomonas putida)* and chemical phosphorus fertilizer was utilized as strip takes under seed. All operations were done regularly during the growing season.

Crop sampling and calculation

Yield components such as Ear length, Cob diameter, Number of rows per ear, Number of grain rows per ear, Number of grain per ear and Grain weight were measured after of physiology maturity by selected five plants of each experimental plot randomly. Biological and seed yield were determined by eliminating the marginal effect. After drying, harvest index was obtained by divide seed yield to biologicalyield.

Statistical analysis

Data analysis was done by using SAS and MSTATC software. The ANOVA test was used to determine significant ($p \leq 0.01$ or $p \leq 0.05$) treatment effect and Duncan Multiple Range Test to determine significant difference between individual means.

RESULTS AND DISCUSSION

Component yields

Ear length

Results showed that the ear length wasn't significantly affected by different irrigation and chemical phosphorous fertilizers and biological fertilizers treatment (table 1), however means comparison showed that moderate stress and sever stress decreased 7% and 11% on the ear length in compare with control (table 2).

Cob diameter

(Table 1) indicated that cob diameter wasn't significantly affected by chemical phosphorus fertilizer and biological fertilizer and irrigation treatments, however moderate stress and sever stress decreased 4.5% and 8.1% on the cop diameter in compare with control (table 2).

Number of rows per ear
Effect of different irrigation and biological fertilizers treatments on number of rows per ear wasn't significant but chemical phosphorus fertilizer and interaction between different irrigation and biological fertilizers had significant effect on number of rows per ear (table 1).means comparison s showed that maximum number of rows per ear was obtained by utilization of 150 kg/ha chemical phosphorus fertilizers (table 4). However number of rows per ear wasn't significantly affected by different irrigation moderate stress and sever stress decreased 0.0083 % and 3.9% on the number of rows per ear in compare with control (table 2).

Number of grain rows per ear
(Table 1) reveals that the number of grain rows per ear was significantly affected by different irrigation.Highest number of grain rows per ear was obtained by normal irrigation .moderate stress and sever stress decreased 12.83% and 22.9% on the number of grain rows per ear in compare with control (table 2). There wasn't significant difference between utilization chemical phosphorus fertilizers and biological fertilizers treatments on the number of grain rows per ear (table 1).

Number of grain per ear
The result showed that different irrigation and interaction between irrigation and biological fertilizers had significant effect on number of grain per ear (table 1). means comparisons indicated that maximum number of grain per ear was gained by normal irrigation and in this condition ,utilization of biological fertilizers didn't increase number of grain per ear (table 5).

Grain weight
Analysis of variance indicated that grain weight was significantly affected by different irrigation and utilization of chemical phosphorus fertilizers and interaction between biological fertilizers and different irrigation (table 1). Moderate stress and sever stress decreased 6.53% and 19.3% on the grain weight in compare with control (table 2). The maximum grain weight was obtained by utilization of biological fertilizers and normal irrigation andIn the sever stress condition, application of biological fertilizers had significant effect on increasing grain weight (table 5) and (table 3).

Table 1. ANOVA of the effects of biological and chemical phosphorus fertilizer in different irrigation on component yield of corn

SOV	df	Ear length	Cob diameter	Number of rows per ear	Number of grains row per ear	Number of grain per ear	Grain weight
Replication	2	4.99^{ns}	0.19^{ns}	0.08^{ns}	37.47^{ns}	7449^{ns}	1.59^{ns}
Irrigation (a)	2	42.54^{ns}	11.4^{ns}	2.78^{ns}	692.10*	190948*	314**
ERROR	4	22.78	2.84	0.50	96.63	22991	4.72
Biological fertilizers (b)	1	4.2^{ns}	0.004^{ns}	1.53^{ns}	0.53^{ns}	361.3^{ns}	158**
Chemical phosphorus Fertilizers (C)	3	3.48^{ns}	0.78^{ns}	2.68*	25.49^{ns}	3319^{ns}	28.9**
irrigation×biological fertilizers	2	15^{ns}	0.71^{ns}	4.24**	160.97^{ns}	61769*	23.5**
irrigation×chemical phosphorus fertilizers	6	9.31^{ns}	1.18^{ns}	1.33^{ns}	32.75^{ns}	11939^{ns}	51.18^{ns}
Biological fertilizers×chemical phosphorus fertilizers	3	4.34^{ns}	0.48^{ns}	0.69^{ns}	29.43^{ns}	8309^{ns}	0.56^{ns}
irrigation×biologicalfertilizers ×chemical phosphorus fertilizers	6	4.20^{ns}	0.79^{ns}	1.47^{ns}	49.96^{ns}	17195^{ns}	5.04^{ns}
ERROR	42	6.45	0.85	0.78	52.37	14495.6	3.14

*1 - ns= Non significant, ** = p < 0.01 and * = p < 0.05*

Table2. Means comparison of effects of different irrigation on component yield of corn

Irrigation levels	Ear length (cm)	Cob diameter (cm)	Number of rows per ear	Number of grains row per ear	Number of grain per ear	Grain weight (gr)
Normal irrigation (a_1)	22.904a	16.86a	15.098a	46.757a	707.27a	36.869a
Moderate stress(a_2)	21.092a	16.089a	15.0971a	40.763ab	616.25ab	34.457b
Sever stress(a_3)	20.306a	15.485a	14.507a	36.042b	528.89b	29.756c

Table3. Means comparison of effects of biological fertilizers on component yield of corn

Biological fertilizers levels	Ear length (cm)	Cob diameter (cm)	Number of rows per ear	Number of grains row per ear	Number of grain per ear	Grain weight (gr)
Application of biological fertilizers (b_1)	21.6781a	16.1372a	14.755a	41.274a	615.23a	35.1769a
Non application of biological fertilizers (b_2)	21.1947a	16.1533a	15.0469a	41.101a	619.71a	32.211b

Table 4. Means comparison of effects of chemical phosphorus fertilizers on component yield of corn

Chemical phosphorus fertilizers levels	Ear length (cm)	Cob diameter (cm)	Number of rows per ear	Number of grains row per ear	Number of grain per ear	Grain weight (gr)
Non Application of chemical phosphorus fertilizers (c_1)	21.994a	16.421a	15.074ab	41.694a	633.20a	32.388c
Application of 75 kg/ha chemical phosphorus fertilizers (c_2)	21.552a	15.950a	14.547b	42.499a	623.65a	33.1711bc
Application of 150 kg/ha chemical phosphorus fertilizers (c_3)	20.980a	16.187a	15.363a	39.723a	610.21a	33.9472b
Application of 225 kg/ha chemical phosphorus fertilizers (c_4)	21.218a	16.022a	14.621b	40.833a	602.81a	35.3194a

Table 5. means comparison of interaction between different irrigations and biological fertilizers on component yield of corn

Irrigation × biological fertilizers		Number of rows per ear	Number of grain per ear	Grain weight (gr)
a1	b1	15.38a	714.9a	38.01a
	b2	15.25a	699.7a	35.72b
a2	b1	14.94a	659.1ab	35.16bc
	b2	14.82a	586.4b	33.75cd
A3	b1	13.94b	471.7c	32.35d
	b2	14.07a	573.1b	27.15e

CONCLUSION

Symbiotic relationship between PSB and plants is synergistic in nature as bacteria provide soluble phosphate and plants supply root borne carbon compounds (mainly sugars), that can be metabolized for bacterial growth (Pérez *et al.*, 2007). The PSM along with other beneficial rhizosphericmicroflora enhance crop production. Simultaneous application of *Rhizobium* with PSM (Perveen*et al.*, 2002) or arbuscularmycorrhizae (AM) fungi (Zaidi*et al.*, 2003) has been shown to stimulate plant growth more than with their sole inoculation in certain situations when the soil is P deficient. Synergistic interactions on plant growth have been observed by coinoculation of PSB with N2 fixers such as *Azospirillum*(Belimov*et al.*, 1995) and *Azotobacter*(Kundu and Gaur, 1984), or with vesicular arbuscularmycorrhizae (Kim *et al.*, 1998). Microorganismswith phosphate solubilizing potential increase the availability of soluble phosphate and enhance the plant growth by improving biological nitrogen fixation (Kucey*et al.*, 1989; Ponmurugan and Gopi, 2006). *Pseudomonas* spp. enhanced the number of nodules, dry weight of nodules, yield components, grain yield, nutrient availability and uptake in soybean crop (Son *et al.*, 2006). while coinoculation of PSM and PGPR reduced P application by 50 % without affecting corn yield (Yazdani*et al*., 2009). Inoculation with PSB increased sugarcane yield by 12.6 percent (Sundara*et al*., 2002). Sole application of bacteria increased the biological yield, while the application of the same bacteria along with mycorrhizae achieved the maximum grain weight enhancing microbial activity through P solubilizing inoculantsmay contribute considerably in plant P uptake. Phosphorus solubilizing bacteria mainly *Bacillus*, *Pseudomonas* and *Enterobacter*are very effective for increasing the plant available P in soil as well as the growth and yield of crops. So, exploitation of phosphate solubilizing bacteria through biofertilization has enormous potential for making use of ever increasing fixed P in the soil, and natural reserves of phosphate rocks. As in this study maximum yield in compared to control was obtained by this method application of fertilizer. Utilization of chemical phosphorus fertilizer decreased to 50% by integrating biological phosphorus fertilizers and chemical phosphorus fertilizer without yield loss. Also environmental pollution was reduced by decreasing consumption of chemical fertilizers. Overall utilization of biological phosphate fertilizers with chemical phosphate fertilizer in addition to increased yield could be a strategy to achieve sustainable agriculture. Specific yield loss levels were not mentioned throughout this article partly because the final yield of the corn plant depends so much on the amount and timing of stress. Water stress is never good but stress closer to pollination will result in the greatest yield losses, compared with water stress at other growth stages. Reductions in ear length, kernel row and/or kernel numbers can be offset by adequate moisture during seed fill, resulting in larger kernels. However, larger kernels cannot compensate fully for large losses in kernel number. Stress during seed fill will reduce seed size.(nelson, 2002)

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