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Application effects of nitrogen rates and seed biopriming with PGPR on yield, yield attribute and nitrogen use efficiency of corn (Zea maize L.) hybrids

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Abstract: Corn (Zea maize L.) is one of the most important cereals from the family Poaceae (Gramineae). Maize grain is used for both human consumption and poultry feed. It has a great utility in agro-industry. Objective:In order to evaluate the effects of seed bio priming with PGPR on grain yield, yield attribute and nitrogen use efficiency of corn (Zea maize L.) hybrids, an experiment was carried out as split plot factorial based on randomized complete block design with three replications. Nitrogen fertilizer in four levels (0, 60, 120 and 180 kg N/ha as urea) were assigned to the main plots and the combination of seed bio priming with plant growth promoting rhizobacteria (no priming as control), seed bio priming with Azotobacter chroococcum strain 5, Azosprilium lipoferum strain OF, Psedomonas strain 186) with corn hybrids (SC-504, SC-404, DC-370) were factorial assigned to the subplots. The results showed that seed bio priming with plant growth promoting rhizobacteria was significantly affected grain yield and yield attribute. Maximum of these characteristics were obtained in seed priming with Azotobacter. Mean comparison of treatment compound of corn hybrids× seed bio priming with PGPR showed that maximum grain yield was obtained by the plots which was applied SC-504 with Azotobacter and minimum of it was obtained in DC-370 hybrid without of seed bio priming. Results:The results showed that nitrogen use efficiency was significantly affected by nitrogen rates, corn hybrids and interaction of nitrogen rates ×corn hybrids. The highest grain yield was related to SC-504 and the least of it was DC-370 hybrid. Means comparison showed that increasing of application nitrogen rates decreased nitrogen use efficiency. Nitrogen use efficiency decreased from 9.16 kg/kg in application 60 kg N/ha to 6.84 kg/kg in application 180 kg N/ha. Nitrogen use efficiency affected by corn hybrids. It was in SC-504 hybrid more than DC-370 hybrid. Means comparison of treatment compound corn hybrids×nitrogen rates showed that maximum nitrogen use efficiency was obtained in SC-54 hybrid with application of 60 kg N/ha and minimum of it was in DC-370 hybrid with the highest rate from nitrogen fertilizer. Conclusion: Means comparison of nitrogen rates × seed bio priming with PGPR showed that maximum nitrogen use efficiency was obtained in SC-54 hybrid × seed bio priming with Azotobacter and the least of it was in no priming × the highest level of nitrogen application. Thus, it can be suggested that in order to increasing of grain yield, SC-504 hybrid should be inoculated with Azotobacter in application of 180 kg N/ha .

Keywords: Nitrogen Rates, Seed Biopriming, PGPR

Introduction

In our country, the yield of corn is very low as compared to other corn producing countries. One of the most important effective factors in increasing of yield is seed bio priming with plant growth promoting rhizobacteria and application of nitrogen fertilizer. Zahir *et al* (1998) reported 19.8% increase in grain yield of maize due to seed bio priming with *Azotobacter* and *Pseudomonas*. Tilak *et al* (1982) reported improving grain yield of maize due to seed bio priming with *Azotobacter* and *Azospirillum*. Kloepper *et al* (1980 b) reported that corn yield 10 to 30% increased in inoculation wit PGPR. Dilfuza (2007) suggested that inoculation of corn seeds with *Azospirillum brazilance* increased grain yield. Gholami *et al* (2009) and Asghar *et al* (2002) reported that yield of corn increased in response to inoculation with PGPR

Nitrogen fertilizer is the key element in increasing yield. Singh *et al* (2000) also reported that application of 200 Kg N/ha increased grain yield of maize. Torbertet *et al* (2001) suggested that yield and yield attribute of maize were increased by increasing the rate of applied nitrogen. El-Sheikh (1998) reported that application of 160 Kg N/ha significantly increased number of grain per ear and grain yield of maize. But, large rates of fertilizer N loss to the environment could cause a serious environmental problem such as groundwater contamination (Chen *et al*, 2004). Raun and Johnson (1999) reported that nitrogen use efficiency is variable with mean of only 33% of applied nitrogen recovered by cereal crops. Nitrogen use efficiency may be affected by crop species, soil type, application rate of N fertilizer (Halverson and Wienhold 2001). Lopez-Bellido and Lopez-Bellido (2001) showed that nitrogen efficiency indices were significantly affected by N fertilizer rates. According to Sowers *et al*.(1994), the application of high N rates may result in poor N uptake and low nitrogen use efficiency due to excessive N losses. The objectives of this research were to evaluate application effects of nitrogen rates and seed biopriming with PGPR on yield, yield attribute and nitrogen use efficiency of corn (*Zea maize* L.) hybrids

Results

In order to evaluate the effects of seed bio priming with PGPR on grain yield, yield attribute and nitrogen use efficiency of corn (Zea maize L.) hybrids, an experiment was carried out as split plot factorial based on randomized complete block design with three replications at the Research Farm of Islamic Azad University. Nitrogen fertilizer in four levels (0, 60, 120 and 180 kg N/ha as urea) were assigned to the main plots and the combination of seed bio priming with plant growth promoting rhizobacteria (no priming as control), seed bio priming with Azotobacter chroococcum strain 5, Azosprilium lipoferum strain OF, Psedomonas strain 186) with corn hybrids (SC-504, SC-404, DC-370) were factorially assigned to the subplots. Climatically, the area placed in the semi-arid temperate zone with cold winter and hot summer. The table 1 shows physicochemical properties of farm soil used in the experiment.

Table 1. physicochemical properties of farm soil used in the experiment

K available (mg/kg)	P available (mg/kg)	N total (%)	O.C (%)	Texture	Sand (%)	Loam (%)	Clay (%)	Caco3 (%)	(%)SP	pH	Depth of sampling (cm)
372	14	.14	.76	Silty-loam	23.2	68	5	17.2	44	8.1	0-30

Row spacing was 75cm and plot size was 5×3.75 m^2 with five rows per plot. Plots and blocks were separated by 1m unplanted distances. For seed bio priming with PGPR were coated with gum Arabic as an adhesive and rolled into the suspension of bacteria until uniformly coated. The strains and cell densities of microorganisms used as PGPR in this experiment were 10^7 bacteria/gram. Two seeds were sown per hill and later thinned to one plant per hill. All other agronomic operations except those under study were kept normal and uniform for all treatments. Nitrogen use efficiency was determined with using of 1 equation (Goodroad and Jellum, 1988).

(1) $E_e = (TDM_f - TDM_c) / F$

TDM_f and TDM_c refer to grain yield (kg ha^{-1}) in the fertilized and control plots. F is rates of fertilizer-N added in soil (kg ha^{-1}).

Grain yield was harvested of 2 m long of three middle rows. The other characteristics such as number of kernel per ear, number of grains per ear row and the number of grains rows were determined in the center three rows of each plot according to Ulger (1998). Analysis of variance was performed using SAS computer software packages. The main effects and interactions were tested using the LSD test.

Nitrogen rates, seed bio priming with PGPR and corn (Zea maize L.) hybrids had significant effects on grain yield, yield attribute and nitrogen use efficiency. Effects of treatment compounds corn hybrids×nitrogen rates were significant on grain yield and nitrogen use efficiency. Treatment compounds corn (Zea maize L.) hybrids× seed bio priming with PGPR were significant on grain yield, the number of grains per ear row and number of kernels per ear. The effects nitrogen rates× seed bio priming with PGPR were significant on grain yield, number of kernels per ear and nitrogen use efficiency (table of variance analysis not shown).

Number of grain per ear: number of kernels per ear plays an important role to determining grain yield. The effects of nitrogen rates, seed bio priming with PGPR and corn (*Zea maize* L.) hybrids on number of grain per ear was significant (Table 2). Mean comparison of treatment compound nitrogen rates× seed bio priming with PGPR showed that the number of grains per ear ranged between 295.9 and 476.6. Maximum number of grains per ear (476.9) was recorded at the highest nitrogen rates (180 kg N/ha) × seed bio priming with *Azosprilum* and minimum of it (295.9) was recorded at no N application and without seed priming with PGPR (table 4).On the other hand, the number of grains per ear increased in seed inoculation with PGPR and increasing of nitrogen rates.

Our results concur partly with observations made by Gholami et al (2009) and Seyed Sharifi (2011) who reported that the grain number increased in seed priming with PGPR. Similar results have been reported by Taghizadeh and Seyed Sharifi (2011). Increase in grains per ear at higher nitrogen levels might be due to the lower competition for nutrient that allowing the plants to accumulate more biomass with higher capacity to convert more photosynthesis into sinks resulting in more grains per ear. These results are also in agreement with Zeidan, et al (2006) who concluded that grain number per ear was maximum at the highest of nitrogen levels. The response of corn hybrids to seed inoculation with PGPR was different. Means comparison showed that maximum of number of kernels per ear (414.9) was observed in seed inoculation of DC-370 hybrid with *Azotobacter*.

Similar results have been reported by Soleymanifard and Sidat (2011).

The number of grain rows: data recorded on average the number of grain rows of was represented in table 2. Statistical analysis of the data revealed that nitrogen levels, seed bio priming with PGPR are not significant. Similar results have been reported by Roy and Biswas (1992).

The number of grains per ear row: data regarding the effect of nitrogen rates, seed bio priming with PGPR and corn (*Zea maize* L.) hybrids on the number of grains per ear row are given in table 2. Maximum (37.18) the number of grains per ear row was recorded at application of 180 Kg N/ha and minimum of it was recorded at 0 Kg N/ha (29). Seed bio priming with PGPR increased the number of grains per ear row. The response of corn hybrids was different in the number of grains per ear row (table 2). Means comparison of treatment compound corn hybrids× seed bio priming with PGPR indicated that maximum the number of grains per ear row (36.7) was observed in SC-504 hybrid× seed bio priming with Azotobacter and minimum of it was in DC-370 hybrid× no priming with PGPR. Our results concur partly with observations made by Golami et al (2009), who reported that the kernels number per ear row increased with seed priming with PGPR. Increase in the number of grains per ear row with inoculation might be due to the positive response of corn at inoculation with PGPR. These results are also in agreement with De Freitas (2007), who concluded that grain number per ear in wheat was highest at inoculation with PGPR.

Table2. Means comparision of the effects of Nitrogen rates, Seed bio priming with PGPR on yield, yield attribute and nitrogen use efficiency of corn (Zea maize L.) hybrids

characteristics / **Treatments**	grain yield (ton/ha)	The number of grains rows	The number of grains per ear row	Number of kernels per ear	Nitrogen use efficiency kg/kg)
Nitrogen rates (kg /ha)					
zero	4.27 cd	16 a	d 29	d 306.91	-
60	4.42 c	16.3 a	c 32.95	c 382.91	a 9.16
120	5.2 b	16.11 a	b 35.9	b 440.34	b 6.94
180	5.93 a	16.5 a	a 37.18	a 455.71	b 6.82
Seed bio priming with PGPR					
NO Priming as control	4.41 c	16.85 a	cd 31.18	d 360.95	c 7.84
Psedomonas	4.75 b	16.83 a	c 32.1	c 383.64	c 7.86
Azosprilium	5.12 ab	17.21 a	b 33.51	b 404.28	b 8.24
Azotobacter	5.37 a	17.25 a	a 36.27	a 414.47	a 9.27
Corn hybrids					
SC-504	5.08 a	17.06 a	b 33.12	b 384.82	8.07a
SC-404	4.68 b	17.04 a	ab 33.84	b 382.26	8.57a
DC-370	4.47 c	15.88 b	a 34.7	a 397.26	7.27b

Means with similar letters in each column are not significantly different

Table 3 . Means comparision of the effects of nitrogen rates× corn (Zea maize L.) hybrids on yield and nitrogen use efficiency

characteristics / Treatments		grain yield (ton/ha)			Nitrogen use efficiency kg/kg)	
Corn hybrids	**SC-504**	**SC-404**	**DC-370**	**SC-504**	**SC-404**	**DC-370**
Nitrogen rates (kg /ha)						
zero	fgh 4.41	4.21 gh	h 4.07	-	-	-
60	de 4.94	efg 4.57	fgh 4.33	11.46	11.17 a	10.84a
120	bc 5.6	d 5.09	def 4.79	7.26	6.8b	6.76b
180	a 6.13	ab 6.01	bc 5.65	7	6.83b	6.62b

Means with similar letters in each column are not significantly different

Table 4. Means comparison of the effects of nitrogen rates× seed bio priming with PGPR on grain yield

characteristics / Treatments			GY (ton/ha)				NUE (kg/kg)			NKPE		
Seed bio priming with PGPR	NO Prim	Pse	Azos	Azoto	NO Prim	Pse	Azos	Azoto	NO Prim	Pse	Azos	Azoto
Nitrogen rates (kg /ha)												
zero	3.83j	4.27jhi	4.51ghi	5.32cde	-	-	-	-	295.9h	370.6f	426.44d	425.4d
60	4.13ji	4.45ghi	4.85efg	5.73bc	9.82b	10.21b	11.74ab	13.13a	296.5h	369.9f	449.17c	441.16c
120	4.58ghi	4.61ghi	5.24def	6.18ab	6.89def	7.14de	7.72d	8.02c	312.4g	390.5e	460.5b	440.3c
180	4.67gh	4.84gf	5.5cd	6.49a	6g	6.24fg	6.25fg	6.65efg	320.3g	400.4e	476.6a	464.9b

Means with similar letters in each column are not significantly different

Notes: Nitrogen use efficiency (NUE); Grain yield (GY); NO Priming as control (N0 Prim); Pseudomonas (Pse) ; - Azosprilium (Azos),; Azotobacter (Azoto)
Number of kernels per ear (NKPE)

Table 5. Means comparison of the effects of corn (Zea maize L.) hybrids ×Seed bio priming with PGPR on grain

characteristics / Treatments			GY (ton/ha)				NGPR			NKPE		
Seed bio priming with PGPR	NO Prim	Pse	Azos	Azoto	NO Prim	Pse	Azos	Azoto	NO Prim	Pse	Azos	Azoto
corn hybrids												
SC-504	4.12d	4.97abc	5.24abc	5.46a	32def	33.4cde	34.7abcd	36.7a	186.4b	395.3b	407.7ab	423.31a
SC-404	4.26d	4.78bcd	5.09abc	5.4ab	31ef	32.7def	34.3abcd	36.2ab	184.9b	388.1b	402.5ab	412.3a
DC-370	4.18d	4.63d	5.09abc	5.25abc	30.5f	32.1def	33.7bcde	35.7abc	184.4b	375.7b	400.5ab	414.9a

Means with similar letters in each column are not significantly different

; Notes: Nitrogen use efficiency (NUE); Grain yield (GY); NO Priming as control (N0 Prim); Pseudomonas (Pse) ; - Azosprilium (Azos),; Azotobacter (Azoto)

Number of grain per row (NGPR) ; (Number of kernels per ear (NKPE

Grain yield: Grain yield is the main target of crop production. The grain yield was significantly affected by all factors (nitrogen rates, corn hybrids and seed priming with PGPR). Nitrogen rates significantly increased the grain yield. The grain yield varied between 4.27 ton/ha in no nitrogen application and 5.93 ton/ha in application of 180 kg N /ha (table 2). A similar trend in yield differences across nitrogen rates have been reported by Zeidan et al (2006) and Lawrence et al (2008). Sanjeevand and Bangarwa (1997) reported that grain yield increased with increasing nitrogen rates. Our findings are in agreement with observations made by many researchers such as Lawrence et al (2008). Maximum grain yield was produced by seed priming with *Azotobacter* while minimum by no priming. Results of interaction effects nitrogen rates× seed bio priming with PGPR indicated that maximum of it (6.49 ton/ha) was obtained in application of 180 kg N ha^{-1}×seed bio priming with *Azotobacter* and minimum of it (3.83 ton/ha) was recorded at no N application× without seed inoculation. Our results concur partly with observations made by Egamberdiyeva (2007) in corn and Salantur et al.(2006) in wheat. They reported that PGPR can increase yield by several mechanisms such as phytohormone production, enhancing stress resistance, N2 fixation, the synthesis of enzymes and fungicidal compounds (Ahmad et al, 2006)

Nitrogen use efficiency: the results showed that nitrogen use efficiency was significantly affected by nitrogen rates, corn hybrids and interaction of nitrogen rates ×corn hybrids and nitrogen rates × seed priming with PGPR (tables 2,3 and 4). Means comparison showed that increasing of application nitrogen rates decreased nitrogen use efficiency (table 2). Nitrogen use efficiency decreased from 9.16 kg/kg in application 60 kg N/ha to 6.84 kg/kg in application 180 kg N/ha. Raun and Johnson (1999) reported that rates of high nitrogen decrease NUE in cereal. Nitrogen use efficiency affected by corn hybrids. It was in SC-504 hybrid more than DC-370 hybrid (table 2). Means comparison of treatment compound corn hybrids×nitrogen rates showed that maximum nitrogen use efficiency was obtained in SC-54 hybrid with application of 60 kg N/ha and minimum of it was in DC-370 hybrid with the highest rate from nitrogen fertilizer. Means comparison of nitrogen rates × seed bio priming with PGPR showed that maximum nitrogen use efficiency was obtained in SC-54 hybrid × seed bio priming with *Azotobacter* and the least of it was in no priming × the highest level of nitrogen application.

Conclusion

In this experiment, nitrogen rates and seed priming with PGPR showed significantly effects on yield, yield attribute and nitrogen use efficiency of corn (*Zea maize* L.) hybrids. It seems that in order to increasing of grain yield, SC-504 hybrid should be inoculated with *Azotobacter* in application of 180 kg N/ha.

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