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INFLUENCE OF DIFFERENT PLANT DENSITIES AND PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR) ON YIELD AND YIELD ATTRIBUTES OF CORN (*ZEA MAIZE* L.)

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Abstract

In order to study the effects of different plant densities and seed priming with plant growth promoting rhizobacteria (PGPR) on yield and yield attributes of corn (*Zea maize L*.), a factorial experiment based on randomized complete block design with three replications was conducted in 2010 at the Research Farm of Islamic Azad University, Ardabili Branch. Treatments were three densities containing, 7 (D_1), 9 (D_2) and 11 plant m^{-2}(D_3) plus seed priming with Plant Growth Promoting Rhizobacteria (PGPR) in three levels containing, without inoculation (as control), priming with *Azotobacter chroococcum* strain 5 and *Azosprilium lipoferum* strain OF. Maize hybrid was SC-404. Results indicated that plant density had significant effects on grain yield, plant height, number of kernels per ear, the number of grain rows and number of grains per ear row. These characteristics had different response to seed priming with PGPR. The highest grain yield obtained from D_2. The highest the number of kernel per ear and the number of grain per ear row recorded at D_1, while D_3 showed the highest values of plant height. The number of grain row did not affected by levels of plant density and seed priming with PGPR. In conclusion, it can be suggested that in order to increase of grain yield should be applied 9 plants m^{-2} in seed priming with *Azosprilium lipoferum* strain OF in conditions of Ardabil Plain.

Keywords: Corn, Density, Seed priming with PGPR, Yield

Introduction

Corn (*Zea mays L*.) belongs to the family Poaceae (Gramineae) and the tribe Maydeae. This plant forms major dietary part of the millions of the people in the form of bread, cake and porridge. Besides being an important food grain for human consumption, maize has also become as a major component of livestock and poultry feed (Ahmad et al, 2008). Maize grain yield is more affected by variations in plant density than other members of the grass family. Maize hybrids differ in their response to plant density (Luque et al., 2006).

One of the most important effective factors is non application of optimal plant population per hectare (Sangoi and Salvador,1998). Higher planting densities increase plant sterility and the interval between male and female blooms, and reduce the number of grains per ear (Sangoi *et al*., 2002). Planting density studies are also interesting to corn researchers for at least two reasons. Adequate planting densities can contribute towards significant grain yield increases for farmers (Cardwell, 1992). Secondly, because corn yield response to density depends on genotypic (Chandra & Gautan, 1997) and environmental influences (Bondavalli *et al.*, 1970), and even negative responses of the crop to a given factor can be verified beyond certain limits.

One of the other most important effective factors in increasing of corn yield is seed inoculation or priming with plant growth promoting rhizobacteria (PGPR).The mechanisms by which PGPRs promote plant growth are not fully understood. But, several mechanisms have been suggested by which PGPR can promote plant growth, including phytohormone production, enhancing stress resistance, N2 fixation, increasing the supply or availability of primery nutrients to the host plant (Wu et al ,2005), the synthesis of enzymes and fungicidal compounds (Ahmad et al, 2006).Kloepper and Beauchamp (1992) have been shown that cereal yield increased up to 30% with *Azotobacter* inoculation and up to 43% with *Bacillus* inoculation. Cakmake et al (2006) reported that inoculation of plants with *Azospirillum* could result in significant changes in various growth parameters, such as increase in total plant biomass, plant height, leaf size, leaf area index and root length of cereals (Bashan et al, 2004). Significant increases in growth and yield of agronomical important crops in response to inoculation with PGPR have been reported by Asghar et al (2002). Kloepper et al (1980a, b) reported that plant yields 10

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to 30% increased in non-legume crops such as corn and sugar cane. Trails with Plant growth-promoting rhizobacteria indicated that yield and dry matter accumulation increase in wheat (Cakmak1 et al., 2007), maize (Pal, 1998) and sugarcane (Sundara et al, 2002). The objectives of this study were to determine the effect seed priming with Plant Growth Promoting Rhizobacteria (PGPR) and various levels of plant densities on yield and yield attributes of corn (*Zea maize L*.) in condition of province of Ardabil –Iran.

Material and methods

A factorial experiment based on randomized complete block design with three replications was conducted in 2010 at the Research Farm of Islamic Azad University, Ardabili Branch. Climatically, the area placed in the semi-arid temperate zone with cold winter and hot summer. The most rainfall concentrated between winter and spring. The table 1 shows physical and chemical properties of farm soil used in the experiment.

Table 1- Soil physico-chemical properties at depth of 0-30 cm

K available (kg)	P available (kg)	N total (%)	O.C (%)	Texture	Sand (%)	Loam (%)	Clay (%)	Caco3 (%)	(%)SP	pH	Depth of pling (cm)
385	16	.16	.78	Silty-l	24	70	5	18.3	46	8.2	0-30

The soil was plowed by two harrowings, and was fertilized at sowing with 100 kg N (urea), 75 kg P_2O_5 (superphosphate), and 75 kg K_2O (Potassium chloride) per hectare. Corn seeds were planted in the first week of May. Treatments were three densities containing, 7 (D_1), 9 (D_2) and 11 plant m^{-2} (D_3) plus seed priming with Plant Growth Promoting Rhizobacteria (PGPR) in three levels containing, without inoculation (as control), priming with Azotobacter chroococcum strain 5 and Azosprilium lipoferum strain OF. Maize hybrid was SC-404. Row spacing was 75cm and distances between plants in the rows were 19.04, 14.81 and 12.12 for D_1, D_2 and D_3 sowing densities, respectively. Plot size was 5m×3.75m with five rows per plot. Plots and blocks were separated by 1m unplanted distances. The area was mold board-ploughed and disked before planting. Two seeds were sown per hill and later thinned to one plant per hill. Thinning was done at 4-6 leaves stage. The field was immediately irrigated after planting. All other agronomic operations except those under study were kept normal and uniform for all treatments.

Grain yield and the other traits studied in this research were determinated in the following ways:

Grain yield: grain yield was harvested of 3 m long of three middle rows.

Plant height: mature plant heights of 8 random plants/plot were measured in cm as the distances from ground level to the lowest branch of the panicle.

Number of kernel per ear: the number of kernels in 8 ears was counted after they had been shelled, and was divided by the number of ears.

The other characteristics such as number of grains per ear row and the number of grain rows were determined in the center three rows of each plot according to Ulger (1998). Analysis of variance and mean comparisons were performed using SAS computer software packages. The main effects and interactions were tested using the LSD test.

Results and Discussion

Density had significant effects on grain yield, plant height, number of kernels per ear, the number of grain rows and number of grains per ear row. These characteristics had different response to seed priming withPGPR.

Characteristics / Treatments	Plant height (cm)	Number of kernels per ear	The number of grains rows	grain yield (ton/ha)	The number of grains per ear row
Seed priming with PGPR					
without inoculation (as control)	185.25 c	346.14 c	15.93 a	b 5.93	c 17.67
Azosprilium	201.12 a	382.66 a	15.73 a	a 6.85	b 18.06
Azotobacte	191.55 b	367.88 b	15.96 a	ab 6.54	a 19.67
Plant densities (plant m^2)					
7	179.67c	396.56 a	14.212	5.53 b	19.204 a
9	197.63 b	357.6b	15.45	6.91 a	17.61 b
11	206.62 a	342.1 c	15.95	6.78 a	16.9 c

Table1. Means comparison of seed priming with PGPR on yield and yield attribiutes of corn in various levels of plant densities

Values followed by the different letters are significantly different

Number of kernels per ear: Number of kernels per ear plays an important role to determining grain yield. Data regarding the effect of plant density and seed priming with PGPR on number of kernels per ear are given in table 1. Means of comparisons for different plant densities indicated the maximum (396.56) plant density was recorded for 7 plant m^2 and minimum value (342.1) was recorded for 11 plant m^2 (table 1). Higher planting densities increase plant sterility and the interval between male and female blooms, and reduce the number of grains per ear (Sangoi *et al*., 2002).

The response of number of kernels per ear to seed inoculation with PGPR was significant. The number of kernels per ear ranged between 346.14 and 382.66 in ssed priming with PGPR. Among of seed inoculation with PGPR, maximum number of kernels per ear was recorded to inoculation with Azosprilium (382.66) and minimum it was recorded at control treatment (346.14) (table 1). Our results concur partly with observations made by Golami et al (2009), who reported that the kernels number increased with seed priming with PGPR. Increase in grains cob^{-1} with inoculation might be due to the positive response of corn at priming with PGPR. These results are also in agreement with De Freitas (2000) who concluded that grain number per ear in wheat was highest at inoculation with PGPR

Plant height: seed priming with PGPR significantly increased the plant height. Data regarding the effect of plant density and seed priming with PGPR on plant height are given in table 1. In general, the maximum plant height (201.12 cm) was obtained to seed inoculation with Azosprilium, while the least value (185.25) was recorded at without inoculation. Similar results have been reported by Bashan et al (2004). They reported that inoculation of plants with Azospirillum could result in significant changes in various growth parameters, such as plant height. Means of comparisons for plant density indicated the maximum (206.62 cm) plant height was recorded for 11 plant m^2 and minimum value (179.67 cm) was recorded for 7 plant m^2 (table 1).

The number of grains rows: Data recorded on average the number of grains rows of different plant densities is represented in table 1. Means comparisons indicated that the number of grains rows hadn't significantly affected by different plant densities and seed priming with PGPR. Similar results have been reported by Tetio–Kargho and Gardner (1988) who reported that the number of grains rows isnt significantly affected by environmental factors.

The number of grains per ear row: The response of the number of grains per ear row to seed priming with PGPR was significant. Maximum (19.204) the number of grains per ear row was recorded seed priming with Azospirillum and minimum it was recorded at control treatment (16.9). Similar results have been reported by De Freitas (2000); Cakmak1 et al (2007) in wheat and Pal (1998) in maize. Means comparisons indicated that maximum the number of grains per ear row (19.67) was observed for 7 plant m^2 and minimum value(17.67) was observed for 11 plant m^2. Similar results have been reported by Tetio–Kargho and Gardner(1988) who reported that the number of grains per ear row of corn were significantly affected by plant densities.

Grain yield: The grain yield was significantly affected by both plant density and seed priming with PGPR. Seed priming with PGPR significantly increased the grain yield. The grain yield varied between 5.93 ton/ha in without priming till 6.85 ton/ha in seed priming with Azosprilium (tasble 1). A similar trend in yield differences across seed priming with PGPR have been reported by Dobbelaere et al (2003). They have been

reported that PGPR can increase yield. Kloepper and Beauchamp (1994) have been shown that wheat yield increased up to 30% in seed priming with PGPR. Maximum grain yield was produced by 9 plant m^2 (6.91 ton /ha) while minimum by 7 plant m^2 (5.53 ton/he). Similar results have been reported by Sundara et al (2002) at sugarcane and Pal (1998) in maize. They reported that seed priming with PGPR increased grain yield. Of course , grain yield in 9 and 11 plant densities weren't significant.

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