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IMPACT OF PLANT POPULATIONS AND NITROGEN LEVELS ON MAIZE

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Abstract

To study the impact of plant population and nitrogen levels on maize, an experiment was conducted at KPK Agricultural University, Peshawar, Pakistan during summer 2006.The experiment was carried out in randomized complete block (RCB) design with split plot arrangement having four replications. Plant populations (4, 6 and 8 plants m^{-2}) were kept in the main plots while nitrogen levels (0, 100, 130 and 160 kg ha^{-1}) were allotted to the subplots. The size of each subplot was 3 m × 5 m ($15m^2$) with row to row distance of 75cm. Azam variety was sown at the seed rate of 40 kg ha^{-1}. The required plant population i.e., 4, 6 and 8 plants m^{-2} were maintained by thinning after emergence. Ears m^{-2}, grain yield and biological yield consistently increased with increase in plant density from 4 to 8 plants m^{-2}. However, grains ear^{-1} and thousand grain weight lessened with increase in plant density. Harvest index declined with increase in plant density but harvest index of plant densities of 4 and 6 plants m^{-2} was statistically at par with each other. Ears m^{-2}, grains ear^{-1}, thousand grain weight, grain yield, biological yield and harvest index constantly improved with increasing level of N. Likewise, ears m^{-2}, grains ear^{-1}, thousand grain weight, grain yield, biological yield and harvest index were higher at the highest level of N. The plant density × nitrogen interactions for ears m^{-2}, grains ear^{-1} and grain yield were significant. Ears m^{-2}, grains ear^{-1} and grain yield continually enhanced with increase in N level from 0 to 160 kg ha^{-1} at all plant densities. It was concluded that the highest plant population of 8 plants m^{-2} and the highest N level of 160 kg ha^{-1} resulted in higher yield of maize.

Introduction

More maize is produced worldwide than any other cereal grain and it is of great importance to subsistence farmers and commercial farmers alike. In Pakistan, it is the third most important cereal grain crop after wheat and rice and is used as a staple food for humans, as feed for livestock and as raw material for industry (Harris *et al*., 2007).

Many factors affect grain yield of maize such as genetic constitution, fertilization and plant population. Nitrogen plays an important role in crop life and is one of the most important nutrients needed by plants in large quantities. It is essential to know the best level of nitrogen application for getting a higher crop yield so that maximum benefits could be achieved. Many investigators like Samira *et al*., (1998) and Torbert *et al*., (2001) found that N application increase yield and yield components of maize. Similarly, El-Sheikh (1998) reported that application of 160 Kg N/Fed significantly increased ear characters and grain yield of maize.

Within the grass family, maize is likely the species that presents the highest grain yield potential. In order to fully explore its capacity to transform solar radiation into grain production, it is necessary to understand how plants interact morphologically and physiologically in a community and to identify management practices which allow them to maximize the use of growth resources in their environment. Plant density is one of the most important cultural practices determining grain yield, as well as other important agronomic attributes of this crop (Sangoi, 2000). Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production and partition (Casal *et al*., 1985). Maize is more sensitive to variations in plant density than other members of the grass family (Almeida & Sangoi, 1996). At low densities, many modern maize hybrids don't tiller effectively and quite often produce only one ear per plant. Therefore, maize does not share the trait of most tillering grasses of compensating for low leaf area and small number of reproductive units by branching (Gardner *et al*., 1985). On the other hand, the use of high populations enhances interplant competition for light, water and nutrients. This may be detrimental to final yield because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Sangoi & Salvador, 1998). For each production system, there is a population that maximizes the utilization of available resources, allowing the expression of maximum attainable grain yield on that environment (Sangoi, 2000).

Keeping in view the importance of pant density and nitrogen, the present study was conducted to find out optimum plant population and appropriate level of nitrogen for obtaining higher yield of maize.

Materials and Methods

Experimental site: Field experiment was conducted at KPK Agricultural University Peshawar, Pakistan during summer 2006. Peshawar has a warm to hot, semi-arid, sub-tropical, continental climate with mean annual rainfall of about 360 mm. Summer (May–September) has a mean maximum temperature of 40°C and mean minimum temperature of 25°C. Winter (December to the end of March) has mean minimum temperature of 4°C and a maximum of 18.4°C. The average winter rainfall is higher than that of summer. The highest winter rainfall has been recorded in March, while the highest summer rainfall is in August. Soil of the experimental site is deficient in N, P and available Zn, but have adequate K. Canal water is available for irrigation (Harris *et al*., 2007).

Experimental details: The experiment was laid out in Randomized Complete Block design with split plot arrangement having four replications. Plant population (4, 6 and 8 plants m^{-2}) was allotted to main plots and nitrogen levels (0, 100, 130 and 160 kg ha^{-1}) to subplots. Maize variety 'Azam' was sown at a seed rate of 40 kg ha^{-1} in a plot size of 3 m by 5 m (15 m^2) with row to row distance of 75 cm. The required plant populations i.e., 4, 6 and 8 plants m^{-2} were maintained by thinning after emergence. Number of plants per row was determined according to the respective plant population and then each row was thinned to achieve the respective plant population. Nitrogen was applied in three split doses i.e., one third each at the time of sowing, knee height and at pre-tassling stages. Urea was used as source of N. Phosphorus was applied @ 100 kg ha^{-1} before sowing. SSP was used as source of phosphorus. The experiment was sown on June 22, 2006 and harvested on October 03, 2006. All agronomic practices were applied uniformly to all plots. The data were recorded on ear m^{-2}, grains ear^{-1}, thousand grain weight, grain yield, biological yield and harvest index.

Statistical analysis: The data were statistically analyzed using analysis of variance appropriate for randomized complete block design with split plot arrangement. The treatment means were compared using LSD test at 0.05 level of probability (Steel & Torrie, 1984).

Results and Discussion

Ears m^{-2}, grain yield and biological yield consistently increased with increase in plant density from 4 to 8 plants m^{-2}. Higher number of ears m^{-2}, grain and biological yields were recorded at the highest plant density of 8 plants m^{-2}. However, grains ear^{-1} and thousand grain weight lessened with increase in plant density. Greater number of grains ear^{-1} and thousand grain weight was recorded at the lowest plant density of 4 plants m^{-2}. Harvest index also declined with increase in plant density but harvest index of plant densities of 4 and 6 plants m^{-2} was statistically at par with each other (Table 1, 2).

Ears m^{-2}, grains ear^{-1}, thousand grain weight, grain yield, biological yield and harvest index constantly improved with increase in N level from 0 to 160 kg ha^{-1}. All these parameters were higher at the highest level of N and decreased with descending order of N levels (Table 1, 2). The PD × N interactions for ears m^{-2}, grains ear^{-1} and grain yield were significant. Ears m^{-2}, grains ear^{-1} and grain yield continually enhanced with increase in N level from 0 to 160 kg ha^{-1} at all plant densities (Fig 1. a,b,c).

Maize grain yield turn down when plant density is increased beyond the optimum plant density mainly due to decrease in the harvest index and increase stem lodging (Tollenaar *et al*., 1997). High plant population beyond optimum leads to intense interplant competition for incident photosynthetic photon flux density, soil nutrients and soil water. This results in limited supplies of carbon and nitrogen and consequent increases in barrenness and decreases in kernel number per plant and kernel size (Lemcoff & Loomis, 1994). In our results, ears m^{-2}, grain yield and biological yield increased with increase in plant density from 4 to 8 plants m^{-2} which are in line with Olson & Sanders (1988) who reported that maize population for maximum economic grain yield varies between 30,000 to over 90,000 plants per hectare. The increase in ears m^{-2}, grain and biological yields may be due to the fact that increase in plant population increased plants per unit area and thus ear m^{-2} which resulted in enhancement of grain and biological yields. These results are in line with findings in Maryland where grain yield increased as plant density was increased from 56000 to 128000 plants ha^{-1} (Teasdale, 1998). Porter *et al*., (1997) reported maximum corn grain yield at 82000 to 89000 plants ha^{-1}. Likewise, Gul et al. (2009) and Amanullah et al. (2009) reported that increasing crop density increased biological yield.

Maize yield development is a chronological process in which the potential number of ears per plant is determined first, followed by grain number per inflorescence and by grain size (Sangoi, 2000). Therefore, variations in the level of carbon and nitrogen induced by different planting rates, or any other factor, can powerfully affect yield and its components successively (Jacobs & Pearson, 1991). Nitrogen demand also increases as plant density increases. Samira *et al*., (1998) and Torbert *et al*., (2001) found that yield and yield component of maize were increased by increasing the rate of applied nitrogen, El-Sheikh (1998) reported that applying 160KgN/Fed significantly increased ear characters and grain yield of maize.

Many researchers have reported increase in grain yield and yield components due to application of high levels of N (El-Sheikh, 1998; Samira *et al*., 1998); Satchithanantham & Bandara, 2001; Njui & Musandu, 1999; Mwato *et al*., 1999). In our results, both yield and yield components persistently enhanced with increase in N level from 0 to 160 kg ha^{-1}. Our results are supported by El-Sheikh (1998) who reported that application of 160 kg N ha^{-1} significantly increased grain yield of maize. Likewise, Chauhan *et al.*, (1995) reported that maize grown in soil amended with 140 kg N ha^{-1} gave the highest yield compared with the control; the increase might be due to increased availability of N, causing accelerated photosynthetic rate and thus leading to the production of more carbohydrates. These findings are also recognized by Chaudhry & Jamil (1998) who studied that increasing level of nitrogen significantly increased biological yield in maize. Mehmood & Saeed (1998) reported that lower nitrogen levels had suppressive effect on number of grains ear^{-1} as nitrogen plays central role in grain formation. The results are in agreement with Bangarwa *et al*. (1990) who reported that number of ear $plant^{-1}$ increased with increase in nitrogen level up to 180 kg ha^{-1}. Similar results were also obtained by Roy & Biswas (1992) and Karim *et al.*, (1984) who reported that ears m^{-2} increased with increase in nitrogen levels.

Table 1. Effect of plant density and N levels on ears m^{-2}, grains ear^{-1} and thousand grain weight of maize.

Plant density (PD) (Plants m^{-2})	Ears m^{-2}	Grains ear^{-1}	Thousand grain weight (g)
4	4.2 c	365 a	234.3 a
6	5.9 b	354 b	225.5 b
8	7.2 a	326 c	211.2 c
LSD	0.1855	5.606	4.150
N Levels (kg ha^{-1})			
0	3.1 d	143 d	178.0 d
100	5.9 c	383 c	223.7 c
130	6.6 b	417 b	238.8 b
160	7.4 a	451 a	254.1 a
LSD	0.1696	12.53	3.292
Interaction (Plant Density × Nitrogen)	* Fig 1 a	* Fig 1 b	NS

Table 2. Effect of plant density and N levels on grain yield, biological yield and harvest index of maize.

Plant density (PD) (Plants m^{-2})	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
4	2427 c	10910 c	21 ab
6	2820 b	11670 b	23 a
8	2925 a	12120 a	21 b
LSD	94.07	164.6	1.187
Nitrogen Levels (N kg ha^{-1})			
0	889 d	4944 d	16 c
100	2948 c	12190 c	22 b
130	3300 b	12760 b	23 ab
160	3759 a	13750 a	25 a
LSD	98.26	209.1	1.136
Interaction (Plant Density × Nitrogen)	* Fig 1 c	NS	NS

Means of the same category followed by different letters are significantly different from each other using LSD test at 0.05 level of probability.

NS = Non-significant, * = Significant at 0.05 level of probability

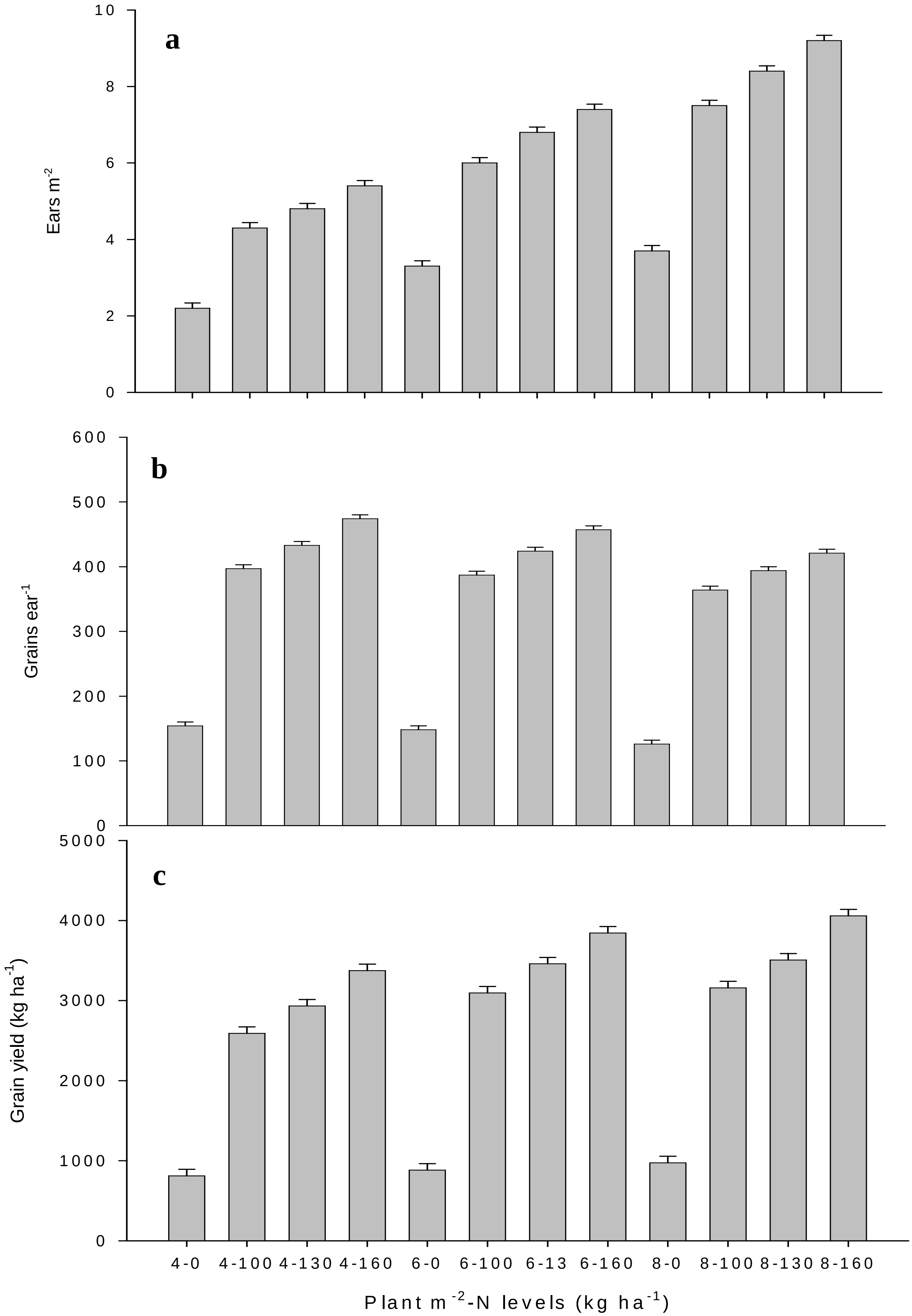

Fig. 1(a, b, c). Interaction between plants population and nitrogen levels for grains ear^{-1} (a), ear m^{-2} (b) and grain yield (c) of maize. Vertical bars denote standard errors of means.

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