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EFFECT OF FERTILIZER LEVELS AND PLANT DENSITIES ON YIELD AND PROTEIN CONTENTS OF AUTUMN PLANTED MAIZE

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A field experiment was conducted during 2006 and 2007 to determine the effects of different fertilizer levels and plant densities on yield of autumn planted maize. Maize hybrid Pioneer 30-Y-87 was selected as test. The treatments comprised of six fertilizer levels (150-0, 150-15, 200-0, 200-15, 250-0 and 250-15 kg N-Zn ha^{-1}) and three plant densities (57100, 71400 and 99900 plants ha^{-1}). The highest plant height and grain yield was recorded from those maize plots which were fertilized at 250 kg N ha^{-1} and 15 kg Zn ha^{-1} and the crop was sown at plant density of 99900 plants ha^{-1}against the significantly minimum plant height and grain yield where fertilizer was applied at 150 kg N $ha^{-1}$and 0 kg Zn ha^{-1} and crop was sown at plant density of 57100 plants ha^{-1}. Increasing fertilizer levels and plant densities linearly increased plant height and grain yield. Application of Zinc accelerated tasseling and silking of maize crop, however the application of nitrogen had no significant effect on tasseling and silking. The fertilizer levels and plant densities also significantly affected protein contents of maize grain. Application of nitrogen at higher levels improved protein contents of grain however, opposite was true for protein contents of grains collected from the crop sown under higher plant densities. It was concluded that application of fertilizer at 250 kg N ha^{-1} and 15 kg Zn ha^{-1} and the sowing of crop at plant density of 99900 plants ha^{-1} showed the best results.
Keywords: Maize, nitrogen, zinc, plant densities, protein, plant height, yield

INTRODUCTION

Maize (*Zea mays* L.) is often referred to as "king of grain crops" and is a significant food and feed crop of the world. It is the third most promising cereal crop of Pakistan after wheat and rice and is grown on an area of 1.02 million hectares with a total production of 3.56 million tones and average grain yield of 3.49 t ha^{-1} (Government of Pakistan, 2008). It is a versatile crop that adapts easily to a wide range of production environments and fits well in the existing cropping systems of Pakistan. Being a source of diversified products obtained from industrial inputs, such as starch, corn oil, glucose etc., the demand of maize crop has been constantly mounting. Maize grain has elevated nutritive value as it contains about 72% starch, 10% protein, 4.8% oil, 5.8% fibre, 3.0% sugar and 1.7% ash (Chaudhary, 1983).

Present day maize hybrids have high yield potential but their average yield do not appear to be satisfactory in Pakistan as compared to other maize growing countries of the world. Among various factors responsible for low yield of maize, imbalance nutrition and low plant density are of prime importance. Nitrogen being an essential element plays an important role in crop development and final grain yield (Tisdale *et al*., 1990; Ahmad, 1994). The deficiency of this element has been approved as one of the major yield limiting factors for cereal production (Shah *et al*., 2003). Application of nitrogen at low rates reduced grain yield by 43-74% and number of grains per plant up to 33-65% (Andrea *et al*., 2006). Yield and protein concentration in maize seed increased with increase in nitrogen rate (Raja, 2003).

Micronutrients deficiencies in plants are becoming increasingly important globally because of the increasing concerns over the effects of low levels of micronutrients especially Zn in human food (Chakmak, 2002). In Pakistan, about 70% of cultivated area is considered Zn deficient especially for highly sensitive crops like rice, maize, citrus, beans etc. (Rashid and Fox, 1992). Zinc deficiency in soils is common in arid and semi-arid regions. Little or no use of Zn fertilizers along with imbalanced fertilization further aggravated Zn deficiency in soils resulting lower Zn contents in grains (Rashid and Ryan, 2004).

Plant density is one of the most significant agronomic practices contributing towards grain yield, as well as other important attributes of this crop. Higher plant population increased the time interval between tasseling and silking. Efficiency of applied nitrogen to maize crop increased under higher plant densities

(Charles and Charles, 2006). Grain yield in maize increased with an increase in plant density (Toler *et al*., 1999; Mariga *et al*., 2000) and also increased with an increase in N rate (Pandey *et al*., 1999; Purcino *et al*., 2000). A study was, therefore, conducted to determine maize response to different planting densities under different N and Zn levels.

MATERIALS AND METHODS

The present study was conducted on maize crop during autumn 2006 and 2007. The crop was sown at experimental area of Agronomy Department, University of Agriculture, Faisalabad, Pakistan. The experimental site was free from salinity. Some physical and chemical properties of experimental soil are presented in Table 1. The proportion of sand, silt and clay in the soil samples was determined by hydrometer method (Moodie *et al.,* 1959). Textural class was determined by using International Textural Triangle (Brady, 1990). Soil was analyzed for its different chemical properties by using the methods as described by Homer and Pratt (1961).

The variables of experiment consisted of six fertilizer levels (150-0, 150-15, 200-0, 200-15, 250-0 and 250-15 kg N-Zn ha^{-1}) and three plant densities (57100, 71400 and 99900 plants ha^{-1}) realized by maintaining plan to plant distance of 25, 20 and 15 cm, respectively. The crop was seeded in 70 cm spaced rows with a dibbler placing 2-3 seeds per hill. The experiment was laid down in randomized complete block design with split plot arrangement having four replications. Fertilizer levels were kept in main plots and plant densities were kept in sub plots measuring 7.0 m x 4.2 m. Maize hybrid Pioneer 30-Y-87 was sown on a well-prepared seedbed on 10th and 15th of August in 2006 and 2007, respectively. When the plants reached at four fully expanded leaf stages, thinning was done to maintain one plant per hill. Crop was kept free of weeds throughout the growth period of crop by manual hoeing twice at 25 and 50 DAS. Eight irrigations were applied as and when required at different plant growth and development stages, until the crop reached physiological maturity. Fertilizer was applied at 100 kg P_2O_5 and 100 kg K_2O ha^{-1} in the form of diammonium phosphate and potassium sulphate, respectively. Nitrogen and Zn were applied as per treatment in the form of urea and zinc sulphate in the respective plots. The whole of phosphorus and potash and 1/3rd.of nitrogen was applied as basal dose. The remaining 2/3rd of nitrogen was top dressed in two equal splits at knee height and at flowering stage. Carbofuran (Furadan 3-G) at 0.6 kg a.i. ha^{-1} was applied twice, first after thinning of crop and second at knee height to protect the crop from attack of borers. Crop was harvested manually on November 20 and November 23 during 2006 and 2007, respectively. Each year the harvested crops were kept in the field for two days for sun drying. Then harvested crops were tied into bundles and stalked for four weeks. The ears were then separated and sun dried for thirty days before the shelling. Data on phenological development, yield and yield components were recorded and subjected to analysis of variance (ANOVA). Least significant difference test at 5 % probability level was used for mean separation (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Days taken to 50% tasseling: Data regarding days taken to 50% tasseling in maize crop as influenced by different fertilizer levels and plant densities are presented in Table 2. Fertilizer levels and plant densities significantly affected time taken to 50% tasseling but their interactive effects were non-significant during both the years. In 2006, maximum days to 50% tasseling (50.24) were recorded by maize crop where the fertilizer was applied at 250 kg N ha^{-1}

Table 1. Physico-chemical analysis of the experimental soil

Determinations	Unit	Value	
		Year 2006	Year 2007
pH	-	8.1	8.4
Textural class	-	Sandy clay loam	
Organic matter	%	0.89	0.86
Total N	%	0.039	0.043
Available P	mg kg^{-1}	6.5	6.8
Available K	mg kg^{-1}	189	191
Zn	mg kg^{-1}	0.47	0.49
Ec	dsm^{-1}	0.17	0.15

Table 2. Effect of fertilizer levels and plant densities on phenological development of maize

Treatment	**Days to 50% tasseling**		**Days to 50% silking**	
A) Fertilizer levels (kg ha^{-1}) N Zn	2006	2007	2006	2007
F_1) 150 0	49.69 ab	49.32 ab	53.94 abc	53.15 ab
F_2) 150 15	46.46 c	46.01 c	50.07 d	49.36 c
F_3) 200 0	50.08 a	49.72 ab	54.65 ab	53.97 a
F_4) 200 15	47.20 c	46.75 c	50.81 cd	50.10 bc
F_5) 250 0	50.24 a	49.92 a	54.78 a	54.09 a
F_6) 250 15	47.90 bc	47.53 bc	51.24 bcd	50.75 bc
LSD(P≤0.05)	2.08	2.33	3.49	3.19
B) Plant densities (ha^{-1})				
D_1) 57100 plants	46.97 b	46.70 b	51.07 b	50.43 b
D_2) 71400 plants	48.43 ab	48.02 ab	52.39 ab	51.68 b
D_3) 99900 plants	50.38 a	49.90 a	54.29 a	53.59 a
LSD(P≤0.05)	**2.22**	**2.25**	**2.00**	**1.80**
Interaction		**NS**		

Mean values with different letter(s) in a column are significantly different at P≤0.05;
LSD= Least Significant difference; NS= Non-significant.

that was statistically at par with the treatments where nitrogen was applied at 200 and 150 kg ha^{-1}. These results are supported by the previous findings of Akbar *et al*. (2002) who observed that maize took less number of days to tasseling with the application of Zinc.

Maximum number of days to 50% (50.38) tasseling were recorded where the crop was sown at plant density of 99900 plants ha^{-1} that was statistically at par to the crop that was grown under plant density of 71400 plants ha^{-1}. The minimum number of days (46.97) to 50% tasseling was recorded in those plots where the crop was sown at plant density of 57100 plants ha^{-1}. The same trend prevailed during 2007. At higher plant densities, enhanced competition between crop plants for different growth resources especially moisture and nutrients might have slowed the pace of phenological development that ultimately delayed tasseling emergence. These results are in line with those of Hus and Huang (1984) who recorded that increase in plant densities delayed tasseling.

Days taken to 50 % silking: Data (Table 2) indicate non-significant effect of interaction between fertilizer levels and plant densities on time taken to 50% silking. Data exhibited significant (P≤0.05) effect of fertilizer levels on time taken to 50% silking. During 2006, crop fertilized at 250 kg ha^{-1}N + 0 kg ha^{-1} zinc significantly delayed silking that was statistically at par with the treatments where fertilizer was applied at 200 kg ha^{-1} N + 0 kg ha^{-1} zinc and 150 kg ha^{-1} N + 0 kg ha^{-1} zinc. Minimum number of days to 50% tasseling (50.06) was recorded in those plots which were fertilized at 150 kg ha^{-1} N + 15 kg ha^{-1} Zn. It was statistically at par where 200 or 250 kg ha^{-1} N was applied along with 15 kg ha^{-1} Zn. The trend was similar during 2007. The pattern of taking days to 50% silking in this study are similar to those reported by Akbar *et al*. (2002) and Rasheed *et al*. (2004).

Data presented in Table 2 indicate significant effect of plant densities on number of days to 50% silking. Plant density of 99900 plants ha^{-1} delayed silking than plant density of 57100 plants ha^{-1} and was statistically at par with the treatments where 71400 plants ha^{-1} were maintained. Delay in silking due to high plant densities has also been reported (Rasheed *et al*., 2004) previously.

Plant height: Fertilization (N and Zn) at different levels had significant (P≤0.05) effect on maize plant height during both the years of study (Table 3). In 2006, fertilizer applied at 250 kg ha^{-1} N + 15 kg ha^{-1} Zn produced significantly tallest plants (224.71 cm) than rest of the treatments. This increase in plant height in response to higher levels of nitrogen has been confirmed by the previous findings of Akbar *et al*. (2002) and Rasheed *et al.* (2004). Increase in plant height due to more nitrogen may be attributed to more vegetative development that resulted in increased mutual shading and internodal extension. Plant height was also enhanced as a result of zinc application. These results confirm the previous findings of Memon *et al*. (1989).

The effect of plant densities on plant height was significant. There was an increasing trend in plant height with the increase in plant densities during both the years. The maximum plant height (224.09 cm) was recorded where the crop was sown at plant density of

Table 3. Effect of fertilizer levels and plant densities on plant height (cm), protein content (%) and grain yield (t ha^{-1}) of maize

Treatment			Plant height (cm)		Grain yield (t ha^{-1})		Protein (%)	
A) Fertilizer levels (kg ha^{-1})			**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
	N	Zn						
F_1)	150	0	198.63 e	194.72 e	5.66 e	6.02 e	8.82 e	8.92 f
F_2)	150	15	213.60 d	199.68 d	6.09 d	6.39 d	9.02 d	9.15 e
F_3)	200	0	212.13 c	207.70 c	6.52 c	6.89 c	9.44 c	9.52 d
F_4)	200	15	214.59 c	212.58 b	6.94 b	7.26 b	9.54 c	9.64 c
F_5)	250	0	219.64 b	214.83 b	7.03 b	7.40 b	9.80 b	9.96 b
F_6)	250	15	224.71 a	220.35 a	7.48 a	7.79 a	10.00 a	10.12 a
LSD(P≤0.05)			**3.12**	**3.18**	**0.14**	**0.17**	**0.07**	**0.08**
B) Plant densities (ha^{-1})								
D_1) 57100 plants			200.29 c	197.75 c	5.63 c	6.06 c	9.66 a	9.78 a
D_2) 71400 plants			212.27 b	209.17 b	6.77 b	7.15 b	9.46 b	9.42 b
D_3) 99900 plants			224.09 a	218.01 a	7.46 a	7.66 a	9.16 c	9.18 c
LSD(P≤0.05)			**2.90**	**1.92**	**0.09**	**0.08**	**0.04**	**0.05**
Interaction			**6.59**	**4.99**	**0.23**	**0.25**	**0.11**	**0.12**
C) Fertilizer x plant densities								
F1D1			184.25 h	186.62 j	4.85 k	5.3 j	9.06 i	9.05 i
F1D2			207.23 ef	197.32 t	5.78 hi	6.12 h	8.82 j	8.90 j
F1D3			204.41 f	200.24 hi	6.37 g	6.66 e	8.57 k	8.65 k
F2D1			193.85 g	190.02 j	5.25 j	5.58 i	9.27 h	9.22 h
F2D2			205.13 ef	202.90 gh	6.19 g	6.57 ef	9.06 i	9.02 i
F2D3			211.84 cde	206.11 fg	6.19 g	7.04 d	8.72 j	8.80 j
F3D1			201.46 f	196.20 i	6.84 f	6.08 h	9.65 de	9.63 e
F3D2			208.23 def	209.58 ef	5.58 i	7.07 d	9.40 g	9.35 g
F3D3			226.71 b	217.31 cd	6.62 f	7.54 c	9.27 h	9.20 h
F4D1			202.04 f	200.38 hi	5.92 h	6.31 gh	9.72 cd	9.78 d
F4D2			211.59 cde	212.51 de	7.09 e	7.48 c	9.42 fg	9.49 f
F4D3			230.14 ab	224.85 b	7.82 bc	7.99 b	9.25 h	9.18 h
F5D1			205.74 ef	203.84 gh	5.90 h	6.38 fg	10.04 b	10.10 b
F5D2			216.88 c	214.86 cd	7.25 de	7.66 c	9.79 c	9.92 c
F5D3			235.14 a	225.80 b	7.96 b	8.18 b	9.57 ef	9.50 f
F6D1			214.43 cd	209.45 ef	6.31 g	6.74 e	10.24 a	10.31 a
F6D2			224.56 b	217.82 c	7.70 c	8.04 b	10.19 a	10.25 a
F6D3			236.29 a	233.78 a	8.43 a	8.59 a	9.58 ef	9.48 f
LSD(P≤0.05)			**6.59**	**4.99**	**0.23**	**0.25**	**0.11**	**0.12**

Mean values with different letter(s) in a column are significantly different at P≤0.05;
LSD= Least Significant difference; NS= Non-significant.

99900 plants ha^{-1} against the minimum plant height (200.29 cm) recorded, where the crop was sown at plant density of 57100 plants ha^{-1}. These results are contradictory to the previous findings of Genter and Camper (1973) who stated increase in plant height in lower plant densities. The plant height increased at higher plant densities due to competition for light as a result of mutual shading effect.

Interaction between fertilizer levels and plant densities was also found to be significant during both the years. Significantly taller plants (236.29 cm) was recorded where the fertilizer was applied at 250 kg ha^{-1} N + 15 kg ha^{-1} Zn and crop was sown at plant density of 99900 plants ha^{-1} that was statistically at par where the fertilizer was applied at 250 kg ha^{-1} N and crop was sown at plant density of 99900 plants ha^{-1} as well as where the fertilizer was applied at 200 kg ha^{-1} N + 15 kg Zn ha^{-1} and crop was sown at plant density of 99900 plants ha^{-1}+ 15 kg Zn ha^{-1}. The minimum plant height (184.25 cm) was recorded where the fertilizer was applied at 150 kg N ha^{-1}and crop was sown at plant density of 57100 plants ha^{-1}. Almost similar trend was noted during 2007. Plant height was positively correlated with grain yield (Fig.1-3).

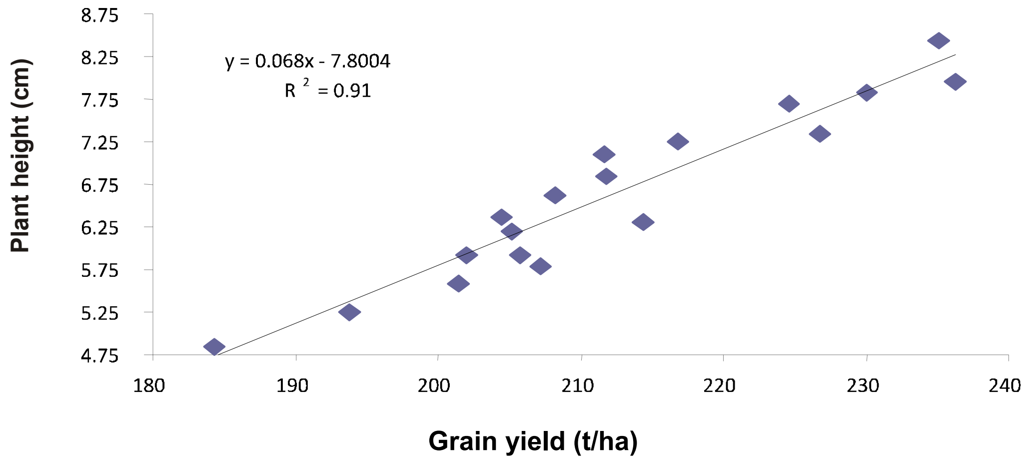

Figure 1. Relationship between plant height and grain yield (t/ha) in maize during 2006.

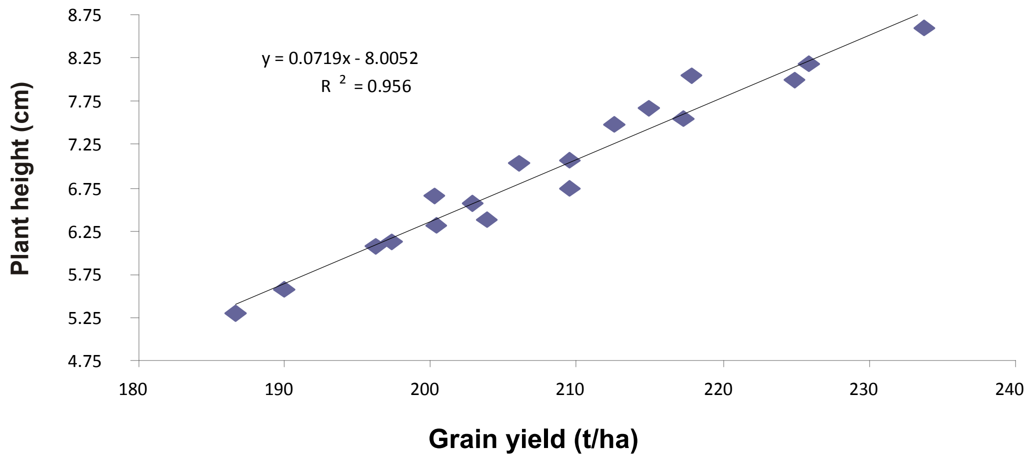

Figure 2. Relationship between plant height and grain yield (t/ha) in maize during 2007

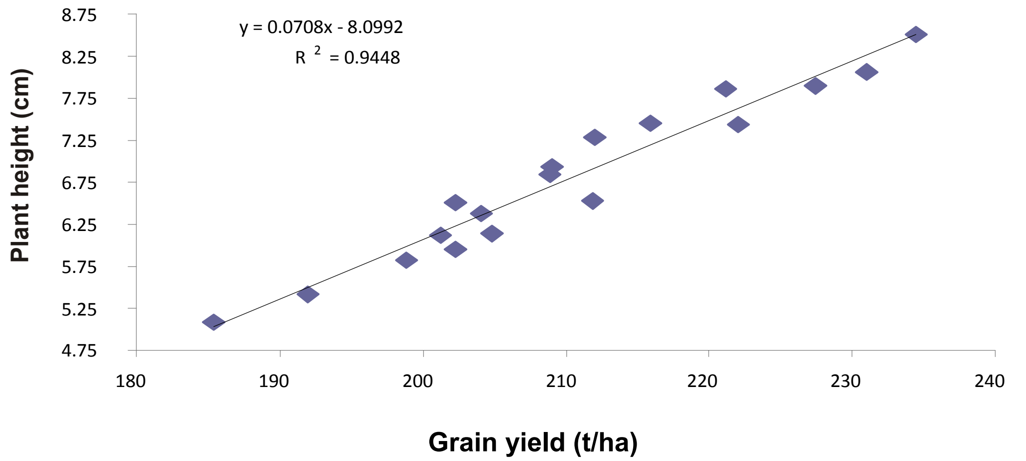

Figure 3. Relationship between plant height and grain yield (t/ha) in maize (pooled).

Protein contents (%): Fertilizer applied at different levels significantly (P≤0.05) affected protein contents (%) of maize grain during both the years (Table 3). During 2006, maximum protein contents (10.00 %) were observed where fertilizer was applied at 250 kg N ha^{-1} + 15 kg Zn ha^{-1}. The minimum protein contents (%) were recorded where fertilizer was applied at 150 kg N ha^{-1}. Each increase in fertilizer level linearly increased grain protein content. Increasing levels of nitrogen (being a major constituent of proteins) contributed towards increase in protein content as well as Zn is vital for protein and amino acid synthesis (Loneregen, 1982). These results confirm the previous findings of Uribelarrea *et al*. (2004).

Maize crop sown at different plant densities significantly affected protein contents (%). Maximum protein contents (9.66%) was recorded where the crop was sown at plant density of 57100 plants ha^{-1} against the minimum protein contents (9.16%) recorded under plant density of 99900 plants ha^{-1}**.** At higher plant populations, competition for photo-assimilates due to deficiency of N and Zn caused reduction in protein content. Reduction in grain protein contents of maize has also been reported by Akcin *et al*. (1993 and 1994).

The interaction between fertilizer levels and plants densities was also found to be significant. Maximum protein contents (10.24%) was recorded where fertilizer was applied at 250 kg N ha^{-1} + 15 kg Zn ha^{-1} and the crop was sown at plant density of 57100 plants ha^{-1}. It showed statistical parity to protein contents (10.19%) recorded where fertilizer was applied at 250 kg N and the crop was sown at plant density of 71400 plants ha^{-1}.The minimum protein contents (8.57%) were recorded where fertilizer was applied at 150 kg N ha^{-1} and the crop was sown at plant density of 99900 plants ha^{-1}.

Grain yield: Different levels of fertilizer significantly (P≤0.05) affected grain yield (Table 3). Application of fertilizer at 250 kg N ha^{-1} + 15 kg Zn ha^{-1} produced maximum GYH (7.48 tons) followed by GYH (7.03) where fertilizer was added at 250 kg N ha^{-1} which showed statistical parity with GYH (6.94) in plots where crop was grown by applying 200 kg N ha^{-1} + 15 kg Zn ha^{-1} against the minimum grain yield (5.66 tons) where fertilizer was applied at 150 kg N ha^{-1}. These results confirm the findings of Banerjee and Sing (2003) and Blumenthal *et al*. (2004) who reported the promotive effect of N on maize grain yield. Maize grain yield increases as a result of Zn application which had been reported by Uribelarrea *et al.* (2004) and Abunyewaa and Quareshie (2004) who observed that application of Zn at higher levels increased grain yield. The results confirmed that higher levels of fertilizers enhanced grain yield on account of higher leaf area index and leaf area duration (data not given) that lead to more radiation interception, photosynthetic efficiency, growth rate and therefore grain number and grain weight per ear.

Different plant densities significantly affected grain yield. Grain yield substantially increased in response to higher plant densities. The maximum grain yield (7.46 tons) was recorded where the crop was sown at plant density of 99900 plants ha^{-1} which was followed by grain yield (6.77 tons) recorded in plant density of 71400 plants ha^{-1}. The minimum grain yield (5.63 tons) was recorded where the crop was sown at plant density of 57100 plants ha^{-1} These results are in line with the finding of Widdicombe and Thelen (2004). Although yield components per plant were lower at higher plant stands, linear increment in grain yield per hectare at higher plant populations might be ascribed to higher grain number and grain weight per unit area (data not given).

Interactive effects of different fertilizer levels and plants densities on grain yield were found to be significant. Maximum grain yield (8.43 tons) was recorded where fertilizer was applied at 250 kg N ha^{-1} + 15 kg Zn ha^{-1} and crop was sown at plant density of 99900 plants ha^{-1}. The minimum grain yield (4.85 tons) was recorded where the fertilizer was applied at 150 kg N $ha^{-1}$and the crop was sown at plant density of 57100 plants ha^{-1}.

CONCLUSION

Application of fertilizer at 250 kg N + 15 kg Zn ha^{-1} and the sowing of crop at plant density of 99900 plants ha^{-1} significantly increased maize plant height and finally the grain yield. It was further concluded that application of Zn accelerated silking and tasseling of maize crop and also significantly increased plant height in combination with higher doses of N. Application of Zn @15 kg ha^{-1} also increased protein contents in maize grain. Increase in plant density increased the days taken to 50% silking and tasseling and finally grain yield but decreased protein contents of maize grain.

REFERENCES

Abunyewa, A.A., and H.M. Quarshie. 2004. Response of maize to magnesium and zinc application in the semi arid zone of West Africa. Asian J. Plant Sci. 3(1):1-5.

Ahmad, S., M.R. Sabir, A. Tanveer, Z.A. Cheema and M.A. Cheema. 1994. Effect of nitrogen application and planting density on the yield of autumn maize. Pak. J. Soil Sci. 9(1-2):25-28.

Andrea, K.E.D., M.E. Otegui, A.G. Cirilo and G. Eyherabide. 2006. Genotypic variability in morphological and physiological traits among maize inbred lines. Crop Sci. 46:1266-1276.

Anonymous. 2009. Economic Survey of Pakistan, Govt. of Pakistan. Economic Advisor's Wing, Finance Division, Islamabad, Pakistan.

Akbar, H., M.T. Miftahullah Jan, A. Jan and Ihsanullah. 2002. Yield potential of sweet corn as influenced by different level of nitrogen and plant population. Asian J. Plant Sci. 1(6):631-633.

Akcin, A., B. Sade, A. Tamkoe and A. Topal. 1993. Effects of different plant densities and nitrogen fertilizer on grain yield, yield components and some morphological characters of maize (*Zea mays* L.) hybrid TTM-813 grown at Konya. Doga, Turk tarim Ve Ormancilik Dergisi. 17: 281-294.

Andrade, F.H., C. Vega, S. Uhart, A. Cirilo, M. Cantarero and O. Valentinuz. 1999. Kernel number determination in maize. Crop Sci. 39: 453-459.

Baqnerjee, M. and S.N. Sigh. 2003. Effect of nitrogen and plant population on yield components and yield of popcorn varieties of maize. Annals of Agri. Res. 24(4):968-970.

Bangarwa, A.S., M.S. Kairon, K.P. Singh. 1988. Effect of plant density, level and proportion of nitrogen fertilizer on growth, yield and yield components of winter maize. Ind. J. Agri. Sci. 58(11):854-856.

Blumenthal, J.M., D.J. Lyon and W.W. Stroup. 2004. Optimum plant population and nitrogen fertility for dry land corn in Western Nebraska. Agon. J. 95:878-883.

Brady, N.C. 1990. The Nature and Properties of Soil, 10^{th} Ed. Macmillan Publishing Company, New York. USA. p.99.

Chakmak, I. 2002. Plant nutrition research: Priorities to meet human needs for food in sustainable ways. Plant Soil 247:3-24.

Charles, A.S. and S.W. Charles. 2006. Corn response to nitrogen rate, row spacing, and plant density in Eastern Nebraska. Agron. J. 98:529-535.

Chaudhary, A.R. 1983. Agronomy. In: Maize in Pakistan. Punjab Agriculture Coordination Board, Univ. Agri, Faisalabad, Pakistan.

El-Hattab, H.S., M.A. Hussain, A.H. El- Hattab, M.S.A. Raouf and A.A. El-Nomany. 1980. Growth analysis of maize plant in relation to grain yield as affected by nitrogen levels. Zeit. Fur Ackerund Pflanzenbau 149(1):46-47.

Genter, C.F. and H.M. Camper.1973. Components of plant part development on maize as affected by hybrids and population density. Agron J. 65 (4):669-672.

Government of Pakistan. 2008. Pakistan Economic Survey 2007-08, Finance division, Economic Advisor's Wing, Islamabad, Pakistan. p.24.

Rashid, A. and R.L. Fox. 1992. Evaluating the internal Zn requirement of grain crops by seed analysis. Agron. J. 84(3):469-474.

Homer, D.C, and P.F. Pratt. 1961. Methods of Analysis for Soils, Plants and Waters. Uni. of California, Div. of Agric. Sci., USA. pp.150-196.

Hus, A.N. and S.C. Haung. 1984. Effect of plant density, yield and agronomic characteristics of maize in spring and autumn cropping season. Bulletin Taichung District Agricultural Improvement Station 9:13-21.

Logeragan, J.K., D.L. Grunes, R. M. Welch, E.A. Aduayi, A. Tengah, V.A. Lazar and E.E. Cary. 1982. Phosphorus accumulation and toxicity in leaves in relation to zinc supply. Soil Sci. Soc. Amer. J. 46:345-352.

Mariga, I.K., M. Jonga and O.A. Chivinge. 2000. The effect of timing of application of basal and top-dressing fertilizrs on maize yield at two rates of basal fertilizer. Crop Res. Hisar. 20:372-380.

Moodie, C.D., N.W. Smith and R.A. McCreery. 1959. Laboratory Manual for Soil Fertility. Dept. Agron. State College of Washington, Pullman, pp.31-39.

Pandey, A.K., V.P. Mani, V.S. Chauhan and R.D. Singh. 1999. Effect of plant population, row spacing and nitrogen level on extra early composite – VL Makka 88 under mid-hills of the North-Western Himalayas. J. Hill Res. 12:88-91.

Purcino, A.A.C., M.R.E. Silva, S.R.M. Andrade, C.L. Belele, S.N. Parentoni and M.X. Santos. 2000. Grain filling in maize: The effect of nitrogen nutrition on the activities of nitrogen assimilating enzymes in the pedicel placento chalaza region. Maydica 45:95-103.

Raja, V. 2003. Effect of N rates and plant population on yield and quality of super sweet corn. Indian J. Agron. 46:246-249.

Rasheed, M., M. Tariq, M.S. Nazir, W.A. Bhutta and W.A. Abdul-Ghaffar. 2004. Nutrient efficiency and economics of hybrid maize under different planting methods and nutrient levels. Int. J. of Agri. Biol. 6(5):922-925.

Rashid, A. and R.L. Fox. 1992. Evaluating the internal Zn requirement of grain crops by seed analysis. Agron. J. 84(3):469-474.

Rashid, A. and J. Rayn. 2004. Micronutrient constraints to crop production in soils Mediterranean-type characteristics: A review. Plant Nutr. 27(6):959-975.

Reddy, S.R. 2004. Agronomy of field crops. Kalyani publishers, Ludhiana, India. pp.21.

Shah, Z., S.H. Shah, M.B. Peoples, G.D. Schwenke and D.F. Herriedge. 2003. Crop residue and fertilizer N effects on nitrogen fixation and yields of legume-cereal rotations and soil organic fertility. Field Crops Research 83:1-11.

Short, K.E., M.S. Islam, A.A. Pahlwan and S.K. Roy. 1982. Yield response of maize to different rates of nitrogen and sulphur during the kharif season. Bangladesh J. Agric. 7(3/4): 40-47.

Steel, R.G.D., J.H. Torrie and D. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd ed. McGraw Hill Book Co. Inc. New York, USA.

Subedi, K.D. and B.L. Ma. 2005. Nitrogen uptake and partitioning in stay green and leafy maize hybrids. Crop Science 45:740-747.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1990. Soil Fertility and Fertilizers. MacMillan Pub. Co., Newyork. Pp.60-62, 172-177.

Toler, J.E., E.C. Murdock, G.S. Stapleton and S.U. Wallace. 1999. Corn leaf orientation effects on light interception, intra-specific competition and grain yields. J. Prod. Agric. 12:396-399.

Uribelarrea, M., F.E. Below and S.P. Moose. 2004. Grain composition and productivity of maize hybrids derived from the Illinois protein strains in response to variable nitrogen supply. Crop Sci. 44:1593-1600.

Widdicombe, W.D. and K.D. Thelen. 2002. Row width and plant density effects on corn grain production in the northern corn belt. Agron. J. 94:1020-1023.