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Effect of Rate of Nitrogen Fertilizer and Population Density on the Yield and Yield Attributes of Maize (*Zea mays*)

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Abstract: An experiment was conducted during the period from April to July 2001 to find out effect of 3 levels of plant population (53000, 66000, 80000 plants ha^{-1}) and 4 levels of nitrogen fertilizer (100, 140, 180 and 220 kg ha^{-1}) in silty clay loam soil. The results showed that the yield and yield attributes characters varied significantly due to the variation in population densities and nitrogen rates. The lower plant population (53000 plants ha^{-1}) produced higher cobs $plant^{-1}$, cob length, grains cob^{-1} and 1000-grain weight, but the higher plant population (66000 and 80000 plants ha^{-1}) resulted significantly higher grain yield than lowest plant population. The increasing level of nitrogen improve the yield and yield attributes. Maximum values of yield attributes and that of grain yield were with the 2nd highest level of nitrogen (180 kg N ha^{-1}). The highest grain yield (5.03 t ha^{-1}) was recorded from 80000 plants ha^{-1} with 180 kg N ha^{-1}.

Key words: Plant population, nitrogen level, maize and yield

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important grain crops in the world. Its has a great utility in agro-industry. This crop has much higher grain protein content than our staple food rice. Maize is now becoming an important cereal crop for its high productivity and diversified use (Islam and Kaul, 1986). The agro-climatic condition of Bangladesh is favourable for its cultivation round the year. The average yield of maize in the country is comparatively low (1.06 t ha^{-1}), whereas, the newly released varieties have the potential to produce more than 8 t ha^{-1} (BBS, 1995). Agronomic practices such as seed rate and plant population are known to effect crop environment, which influence the yield and yield components (Kirby, 1969). Optimum population levels should be maintained to exploit maximum natural resources, such as nutrients, sunlight, soil moisture etc. and to ensure satisfactory yield. High density is undesirable because it encourages inter plants competition for resources. Nitrogen is the key element in increasing productivity. Application of nitrogen fertilizer has also been reported to have significant effect on grain yield and quality of maize (Tanaki *et al*., 1988 ; Khot and Umrani, 1992 ; Sanjeev and Bangarwa, 1997). Hardas and Hrestou (1985) reported that 180 kg N ha^{-1} was optimum for maize. Singh *et al*. (2000) also reported that application of 200 kg N ha^{-1} increased grain yield of maize. However a substantial percentage of applied nitrogen is lost due to volatilization, leaching, de-nitrification etc. therefore, nitrogen should be applied in such a way that would maximize its utilization for grain production. There are some reports on nitrogen management and optimization of population density per unit area for maximum harvest of maize (Ahmed and Muhammad, 1999 ; Sabir *et al*., 2001). The present study was therefore planned to find out the yield and yield attributes of maize to higher levels of plant population and nitrogen fertilizers.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during the period from April to July, 2001. The soil was silty clay loam (P^H 6.10). The treatment comprising three levels of planting densities (53,000; 66,000 and 80,000 plants ha^{-1}) and four levels of nitrogen fertilizer (100, 140, 180 and 220 kg ha^{-1}). The individual plot size was 5m x 3.75m. Plant population of 53,000; 66,000 and 80,000 plants ha^{-1} was maintained, keeping the spacing of 75 x 25cm, 60 x 25cm, 50 x 25cm. The land was fertilized with 110 kg Triple Super Phosphate (TSP), 50 kg Muriate of Potash and 120 kg Gypsum ha^{-1}, respectively. The source of nitrogen was urea. The entire amount of TSP, MP, Gypsum and 1/3 of urea were applied at the time of final land preparation. The rest 2/3 urea was splitted equally and top-dressed at 28 and 53 DAS. Maize variety "Mohor" was sown on 2nd April, 2001. Initially 2-3 seeds were sown $hill^{-1}$. Necessary gap filling was done at 12 DAS. Twenty days after sowing seedling were thinned

to retain one healthy seedling hill^{-1}. Two hand weeding was done at 20 and 45 DAS. Earthing up was done at 28 and 53 DAS. The plot was irrigated three times (5, 30 and 60 DAS) during the growing period. The full mature crop was finally harvested plot wise in the first week of July, 2001. Data on yield and yield contributing characters were collected after harvest. The collected data were analyzed statistically and means were separated with LSD test.

RESULTS AND DISCUSSION

Cob length (cm): Population density and application of nitrogen fertilizer influenced significantly the cob length of maize (Table 1). Cob length generally decreased with increase in population density. Sparsely populated plants (53,000 ha^{-1}) had the longest cob and the shortest was in densely populated plants (80,000 ha^{-1}). Similar trend was also reported by Khan (1976). The longest cob produced by 180 kg N ha^{-1} and 100 kg N ha^{-1} gave the shortest cob. The interaction of planting density and nitrogen fertilizer did not significantly affected the cob length (Table 2).

Number of cobs plant^{-1} : Population density did not show any significant variation in respect of number of cobs plant^{-1}, but the levels of nitrogen fertilizer showed the significant results (Table 1). Number of cobs plant^{-1} increased with increasing nitrogen fertilizer reaching maximum at 220 kg N ha^{-1} although response of 140, 180 and 220 kg N ha^{-1} was statistically identical. Similar results were also reported by Nimje and Seth (1998). The reason for producing greater number of cobs plant^{-1} by the higher nitrogen application might be due to greater nutrients uptake by the maize plant enabling the plants to undergo more reproductive growth. The findings are in agreement with those of Ahmad and Muhammad (1999). Interaction of nitrogen fertilizer and population density was not significant (Table 2).

Number of grains cob^{-1}: Population density and application of nitrogen fertilizer exerted significant influence on the number of grains cob^{-1} (Table 1). The number of grains cob^{-1} ranged between 339.8 and 374.8 across planting density. The results are in general agreement with the findings of Tetio-Kagho and Gardner (1988). The highest grains cob^{-1} was found from the sparsely populated plants (53,000 ha^{-1}) and the lowest in densely populated ones (80,000 ha^{-1}). Increase in grains cob^{-1} from lower planting density might be due to the lower competition for radiation and nutrients that allowing the plants to accumulate more biomass with higher capability to convert more photosynthates into sink resulting in more grains cob^{-1}. It was observed that grains cob^{-1} was increased with the increase of nitrogen levels up to 180 kg N ha^{-1} and there after decreased. Plant treated with 180 kg N ha^{-1} produced maximum grains cob^{-1}, which was significantly different from the plants treated with 100 and 140 kg N ha^{-1}. The interaction effect of plant population and nitrogen level was significant (Table 2). The highest grains cob^{-1} was found in combination of (53,000 plants ha^{-1} x 180 kg N ha^{-1}) followed by (53,000 plants ha^{-1} x 220 kg N ha^{-1}) which was significantly higher than the others. Similar result was reported by Tyagi *et al.* (1998).

1000-grain weight: 1000-grain weight remained unaltered due to population density and nitrogen fertilizer application. Their interaction effect of density and nitrogen rates was also insignificant (Table 1 and 2). Increase in planting density tended to decrease in seed size across the nitrogen levels. Numerically the largest grains were found in sparsely populated plants than densely populated ones.

Grain yield ha^{-1}: Grain yield is the main target of crop production. Population density and levels of nitrogen fertilizer exerted significant influence on grain yield ha^{-1} (Table 1). The maximum grain yield (4.5 t ha^{-1}) was recorded from the densely populated plants (80,000 ha^{-1}), while the minimum (3.8 t ha^{-1}) from sparsely grown plants (53,000 ha^{-1}). A similar trend in yield differences across planting density have been reported by Tyagi *et al.* (1998) and Modarres *et al.* (1988). The higher grain yield with increasing population density came mainly from the number of plants per unit area. The grain yield of maize increased progressively with added nitrogen fertilizer up to 180 kg N ha^{-1} and there was a sharp reduction in yield with 220 kg N ha^{-1}. Selvaraju and Iruthayaraj (1993) observed that application of 180 kg N ha^{-1} gave significantly higher grain yield of Kharif maize over 100 and 140 kg N ha^{-1} . The yield advantage of nitrogen application up to 180 kg ha^{-1} was mainly due to higher number of grains cob^{-1}. Planting density and nitrogen levels interacted significantly in grain yield ha^{-1} (Table 2). Yield of maize varied from 2.51 to 5.03 t ha^{-1} due to planting density and nitrogen levels. There was almost a linear increase in grain yield with the increase of nitrogen fertilizer up to 180 kg ha^{-1} and further increase in nitrogen decreased the yield irrespective of planting density. The highest grain yield was obtained from 80,000 plants ha^{-1} with 180 kg N ha^{-1} and the lowest from 53,000 plants ha^{-1} with 100 kg N ha^{-1}. The lower number of plants per unit area was thus contributing for lower yield.

Table 1: Effect of population density and level of nitrogen fertilizers on the yield and yield contributing characters of maize

Treatment	Cob length (cm)	Cobs plant^{-1} (No.)	Grains cob^{-1} (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Population							
53,000 (No.ha^{-1})	17.2	1.04	374.8	236.3	3.8	9.19	29.08
66,000 (No.ha^{-1})	17.0	1.02	349.3	225.7	4.2	11.32	26.85
80,000 (No.ha^{-1})	15.9	1.01	339.8	216.5	4.5	13.69	24.47
LSD(0.05)	0.65	NS	10.8	NS	0.27	0.87	0.98
CV(%)	4.0	4.56	8.7	7.6	9.4	6.39	5.83
N – level							
100 kg ha^{-1}	16.1	1.00	334.5	212.8	3.1	10.88	22.00
140 kg ha^{-1}	16.2	1.03	354.8	225.1	4.3	11.17	28.11
180 kg ha^{-1}	17.1	1.03	366.7	235.4	4.7	11.20	29.90
220 kg ha^{-1}	16.7	1.03	362.5	231.3	4.5	12.35	27.10
LSD(0.05)	0.33	0.01	9.4	NS	0.18	0.49	0.86
CV(%)	4.0	4.56	8.7	7.6	9.4	6.39	5.83

Table 2: Interaction effect of population density and levels of nitrogen fertilizers on the yield and yield components of maize

Interaction of Population and N fertilizer (000'No.ha^{-1} x kg ha^{-1})	Cob length (cm)	Cobs plant' (No.)	Grains cob (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
53 x 100	16.7	1.01	340.6	220.0	2.51	9.18	21.51
53 x 140	17.1	1.04	375.3	235.8	3.92	8.76	27.91
53 x 180	17.6	1.05	393.3	250.0	4.43	9.00	29.98
53 x 220	17.3	1.04	390.0	239.4	4.40	9.83	27.92
66 x 100	16.5	1.01	332.6	217.8	3.20	11.03	22.48
66 x 140	16.8	1.02	352.0	224.4	4.31	11.17	27.84
66 x 180	17.3	1.03	357.6	231.0	4.70	11.01	29.91
66 x 220	17.2	1.03	355.0	229.6	4.58	12.06	27.17
80 x 100	15.1	1.00	330.3	200.7	3.50	12.42	21.98
80 x 140	16.2	1.02	337.6	215.2	4.67	13.59	25.57
80 x 180	16.5	1.02	349.3	225.3	5.03	13.59	27.01
80 x 220	15.6	1.02	342.6	224.8	4.62	15.17	23.34
LSD(0.05)	NS	NS	16.3	NS	0.3	0.86	1.49
CV(%)	4.0	4.6	8.7	7.6	9.4	6.39	5.83

Stover yield ha^{-1}: Planting density and levels of nitrogen fertilizer effect on stover yield was statistically significant across the treatment variables (Table 1). The highest stover yield was (13.69 t ha^{-1}) recorded from the densely populated plants (80,000 ha^{-1}) and the lowest was (9.19 t ha^{-1}) from the sparsely populated plants (53,000 ha^{-}). [1] Application of 220 kg N ha^{-1} produced the highest stover yield. Plants grown with 140 and 180 kg N ha^{-1} produced statistically identical and high stover yield and the lowest for those received 100 kg N ha^{-1}. The interaction effect of planting density and rates of nitrogen fertilizer on stover yield ha^{-1} was statistically significant (Table 2). There was almost a linear increase of stover yield with the increase of nitrogen fertilizer application irrespective of population density. A combination of 80,000 plants ha^{-1} and 220 kg N ha^{-1} produced the highest stover yield while 53,000 plants ha^{-1} with 140 kg N ha^{-1} gave the lowest.

Harvest index: The highest harvest index was recorded from 53,000 plants ha^{-1} while the lowest from 80,000 plants ha^{-1}. Application of nitrogen fertilizer also exerted significant influence on HI (Table 1). Plants receiving 180 kg N ha^{-1} had the highest HI which was statistically different from the rest of nitrogen levels. The lower nitrogen rates 100 kg ha^{-1} had the lowest HI. Nitrogen rates and densities interaction on the HI was also statistically significant (Table 2). The highest HI was in 53,000 plants ha^{-1} with 180 kg N ha^{-1} and the lowest from 100 kg N ha^{-1} irrespective of densities.

Based on the results it was concluded that maize yield could be increased substantially by adjusting population density with sufficient amount of nitrogen fertilizer.

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