http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 1 (4): 259-263, 1998 Research Article

Nitrogen Level and Plant Density Effects on Different Agro-physiological Traits of Maize

Tariq Mahmood and Muhammad Saeed
Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan

Abstract
Nitrogen level and plant density effects on different agro-physiological traits of maize cv., "Golden" were studies under field conditions at the Agriculture Research Area, University of Agriculture, Faisalabad in Autumn 1996. Treatments comprised four nitrogen levels, i.e., 0, 100, 200 and 300 kg N ha^{-1} and three plant densities viz., 11.11, 8.33 and 6.67 plants m^{-2}. Yield components, such as number of cobs per plant, number of grains per cob and 1000-grain weight were decreased at higher plant density and low nitrogen levels. The maximum grain yield of 7.11 t ha^{-1} was recorded from the crop fertilized at 300 kg N ha^{-1} and raised at 11.11 plants m^{-2}, while the minimum (2.03 t ha^{-1}) was found in control (plant density of 6.67 plants in without N fertilization). The results suggest that 200-300 kg N ha^{-1} along with 11.11 plants m^{-2} should be used to obtain the maximum grain yield to maize cv. "Golden" under the edaphic and climate conditions matching to those of the experiment.

Key words: Nitrogen level, plant density, agro-physiological traits, maize

Introduction
Average grain yield of maize (*Zea mays* L.) in Pakistan is substantially lower then production potential of the existing maize cultivars (Anonymous, 1995). Among different yield limiting factors in maize, sub-optimal plant population and inadequate use of nutrients, especially nitrogen, are of immense importance. An increase in yield of maize with increasing rate of nitrogen has been reported (Viera *et al*., 1980, Khan *et al*., 1994), primarily due to favourable effects of nitrogen on different grain yield components of maize (Alvi, 1994).

Plant population is an important determinant of grain yield of maize (Cardwill, 1982). Grain yield increases linearly with increasing plant population density untill other production factors become limiting (Arnon, 1972; Anjum *et al*., 1992). However, number of missing hills and barren per unit area increases with increasing plant population density (Kang and Park, 1986). Thus effect of nitrogen and plant density on agro-physiological traits of maize cv. "Golden" was investigated.

Materials and Methods
The experiment was conducted under field conditions at the Agronomic Research Area, University of Agriculture, Faisalabad during Autumn 1996. The treatments comprised four nitrogen levels (0, 100, 200 and 300 kg N ha^{-1}) and three plant densities (11.11, 8.33 and 6.67 plants m^{-2}). The experiment was laid out in randomized complete block design with split plot arrangement and three replications. Nitrogen levels and seeding densities were placed in main and sub plots, respectively. Net plot size was 2.4×7 m.

The crop was sown on August 10, 1996. A basal dose of phosphorus was applied at 90 kg ha^{-1}. All the phosphorus and one-third of nitrogen was incorporated in the soil at sowing, while remaining nitrogen was applied in two equal splits at first irrigation (10 days after sowing) and at tassel initiation. The crop was sown with the help of a dibble at plant spacings of 60×15, 60×20 and 6×25 cm with 2 seeds per hill and subsequently thinned out at 3-4 leaf stage to obtain one plant per hill in order to attain the plant densities as per treatments. All other agronomic practices were kept normal and uniform for all the treatments.

Number of plants m^{-2} at harvest, number of cobs per plant, number of grains per cob, 1000-grain weight, grain weight per cob, leaf area index, harvest index, plant mortality and sterility were recorded by using the procedures described by Saeed *et al*. (1997), while protein content was determined by the method of sulphuric acid digestion and distillation by Micro-Kjeldahl method (Jackson, 1960). Data collected were analysed statistically using the Fisher's analysis of variance technique and treatment means were compared by using the least significant difference (LSD) test at 5% level of probability (Steel and Torrie, 1984). Correlation and regression analysis were carried out using the Haward Graphic (HG3) computer programme.

Results and Discussion
Since both the individual and interactive effects of treatments on all the parameters under study were significant (Table 1 and 2), only the interactive effects are discussed.

Number of plants m^{-2}: The maximum number of plants m^{-2} (11.4) at harvest was recorded in the crop raised at a density of 11.11 plants m^{-2} and fertilized at 300 kg N ha^{-1} (N_3D_1) that was, however, statistically on a par with the cob raised at 11.11 plants m^{-2} but fertilized at 200 kg N ha^{-1} (Table 1). On the contrary, the lowest number of plants m^{-2} was in the control crop raised at 6.67 plants m^{-2} (N_0D_3). This variation in plants m^{-2} was due to the variable plant density and probably because of different nitrogen supply as nitrogen has been reported to affect plant survival in maize.

Table 1: Effect of nitrogen level and plant density on number of total and cob bearing plants m^{-2} at harvest, leaf area index, plant mortality and sterility

Treatments	No. of plants m^{-2} at harvest	No. of cob bearing plants m^{-2} at harvest	Plant mortality (%)	Plant sterility (%)	Leaf area index
A. Nitrogen level (N) (kg ha^{-1})					
N_0 (control)	6.07c	7.2d	10.90a	6.49a	2.05d
N_1 = 100	8.03b	7.7c	7.59b	3.75b	2.82c
N_2 = 200	9.10a	8.03b	4.59c	3.25b	3.41b
N_3 = 300	9.13a	8.2a	4.29c	1.20c	4.15a
B. Plant density (D) (Plants m^{-2})					
D_1 = High (11.11)	10.18a	9.67a	8.41a	4.92a	3.86a
D_2 = Medium (8.33)	7.78b	7.55b	6.64b	2.95b	3.17b
D_3 = Low (6.67)	6.30c	6.2c	5.46c	1.27c	2.95c
C. Treatment combinations					
N_0D_1	7.8d	8.9d	11.79a	9.1a	2.35e
N_0D_2	5.4g	7.0g	11.16a	5.40b	2.18f
N_0D_3	5.0g	5.8i	10.04b	3.33d	1.62g
N_1D_1	10.2b	9.7c	8.19c	4.9c	3.49c
N_1D_2	7.7d	7.5f	7.56d	2.59de	2.78d
N_1D_3	6.2f	6.0h	7.04d	1.61fg	2.19f
N_2D_1	11.3a	9.9b	7.29d	2.92d	4.29b
N_2D_2	9.0c	7.8e	3.96e	2.50de	3.47c
N_2D_3	7.0e	6.4i	2.54f	1.53fg	2.46e
N_3D_1	11.4a	10.2a	6.39d	1.92f	5.34a
N_3D_2	9.0c	7.9e	3.96e	1.25g	4.25b
N_3D_3	7.0e	6.5h	2.54f	0.00h	2.87c

Any two means not sharing the same latter differ significantly from each other at p = 0.0.5

Table 2: Yield, yield components and grain protein content of maize cv. "Golden" as affected by nitrogen level and plant density

Treatments	No. of cobs per plant	No. of grains per cob	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest index	Grain protein content (%)
A. Nitrogen level (N) (kg ha^{-1})						
N_0 (control)	0.94c	257c	101.7c	2.05d	20.39c	6.53d
N_1 = 100	1.03b	444b	115.5b	4.41c	31.80b	8.32c
N_2 = 200	1.17a	520a	124.0d	6.43b	38.99a	9.75b
N_3 = 300	1.20a	533a	125.9a	6.71a	39.80a	10.38a
B. Plant density (D) (Plants m^{-2})						
D_1 = High (11.11)	0.98c	410c	112.8c	5.20a	33.55a	8.41c
D_2 = Medium (8.33)	1.09b	442b	117.4b	4.93b	33.06b	8.72b
D_3 = Low (6.67)	1.18a	463a	120.2a	4.56c	31.61c	9.06a
C. Treatment combinations						
N_0D_1	0.90f	220g	95.3h	2.08h	18.88g	6.15j
N_0D_2	0.93e	266i	102.4g	2.04h	20.81f	6.30i
N_0D_3	1.00de	286h	107.4f	2.03h	21.47f	7.12h
N_1D_1	0.97def	386g	113.8e	4.63f	32.49d	8.05g
N_1D_2	1.00de	454e	114.8e	4.36g	31.62de	8.30f
N_1D_3	1.13c	485e	117.8d	4.24ge	31.28e	8.61e
N_2D_1	1.03d	506d	120.0cd	6.97ab	41.25a	9.35d
N_2D_2	1.20bc	518cd	125.1b	6.47c	39.05b	9.30c
N_2D_3	1.27ab	536ab	126.9ab	5.86e	36.67c	10.01b
N_3D_1	1.03d	326bc	122.0c	7.11a	41.59a	10.11b
N_3D_2	1.23b	530abc	127.2ab	6.85b	40.77a	10.49a
N_3D_3	1.33a	544a	128.6a	6.10d	37.04c	10.53a

Any two means not sharing the same latter differ significantly from each other at p = 0.0.5

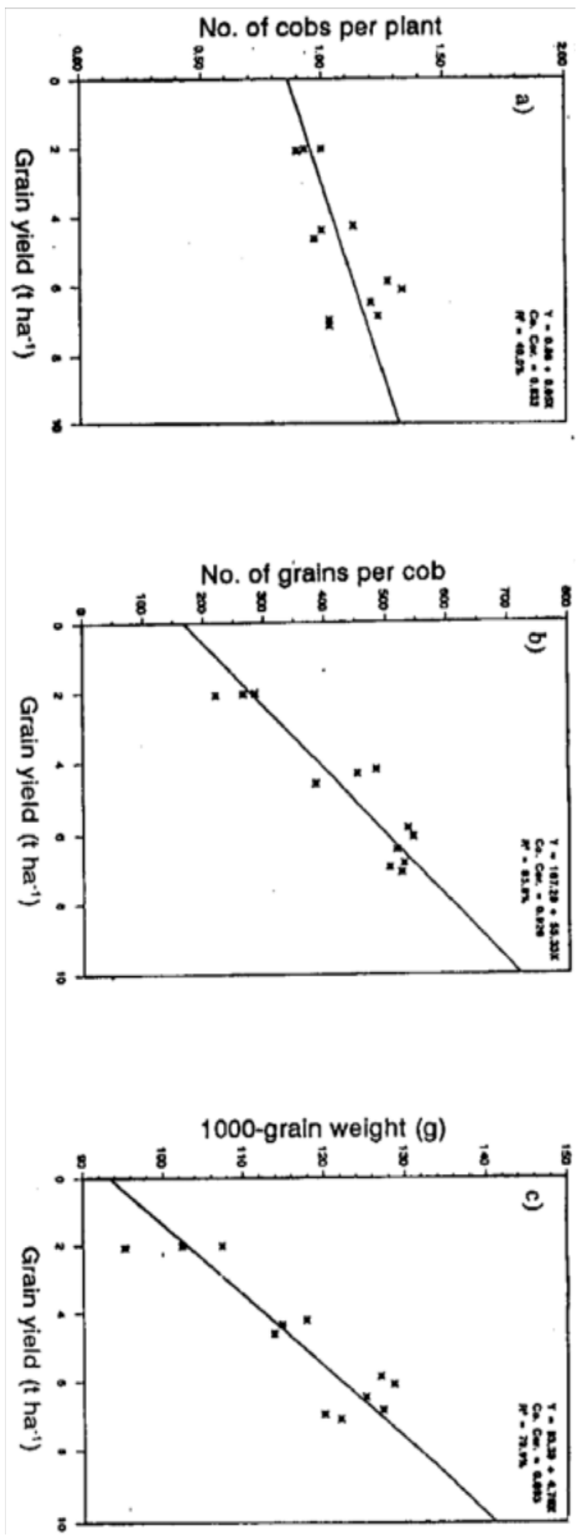

Fig. 1: Relationship between a) number of cobs per plant, b) No. Of grains per cob c) 1000-grain weight and grain yield of maize respectively at different nitrogen levels and planting densities.

A similar decrease in plant stand in response to increased plant density and at lower nutrient availability has also been reported by Kang and Park (1986).

Number of cob-bearing plants m^{-2}: The maximum number of cob-bearing plants (10.2) was produced by the crop fertilized at 300 kg N ha^{-1} with 11.11 plants m^{-2} (N_3D_1) (Table 1), while the minimum number of cob-bearing plants (5.8) was recorded in the control crop raised at 6.67 plants m^{-2} (N_0D_3) (Table 1). The results suggested that elevated nitrogen levels along with higher plant density increased the number of cob-bearing plants m^{-2}. Greater number of cob-bearing plants m^{-2} at higher nitrogen level and higher plant density was ascribed to greater number of total plants m^{-2} at harvest. Significant interactive effects of nitrogen and plants density have also been reported by Ali *et al*. (1986).

Plant mortality: The maximum plant mortality (11.79%) was observed in the control crop grown without N fertilization and with 11.11 plants m^{-2} that was however, statistically on a par with the control crop with 8.33 plants m^{-2} (Table 1). On the contrary, the lowest mortality was recorded in the crop with 6.67 plants m^{-2} and fertilized at 200 and 300 kg N ha^{-1}, respectively. The results suggest that decreased nitrogen level along with higher plant density increase the mortality rate.

Plant sterility: The maximum sterility (9.1%) was observed in the control crop with 11.11 plants m^{-2} (Table 1). On the contrary, no sterility was observed in the crop fertilized at 300 kg N ha^{-1} along with 6.67 plants m^{-2}. The results suggest that higher nitrogen and lower plant density cause a significant reduction in plant sterility. Kang and Park (1986), also reported reduced sterility with increased nitrogen supply and at lower plant density.

Leaf area index: The maximum leaf area index (LAI) (5.34) was recorded in the crop fertilized at 300 kg N ha^{-1} with 11.11 plants m^{-2} (N_3D_1), followed by N_2D_1 and N_3D_2 (Table 1). On the contrary, the minimum LAI (1.62) was observed in the control crop with 6.67 plants m^{-2} (N_0D_3). It is obvious that both reduced supply of nitrogen and lower plant density caused a substantial reduction in LAI of maize. These results are in line with that of Kang and Park (1986), who reported a substantial increase LAI by increasing nitrogen and plant density. The variable LAI in treatment combinations was attributed to different leaf area and ground area per plant. These results suggest that adequate nitrogen supply and proper plant density are essential for attaining the optimum LAI, the most important indicator of size of the assimilatory system in maize to maximize harvest of the incident solar radiation.

Number of cob per plant: The maximum number of cobs per plant (1.33) was produced by the crop with 6.67 plants m^{-2} and fertilized at 300 kg N ha^{-1} (N_3D_3) that was, however, statistically equal to N_2D_3 (1.27) (Table 2), while the minimum number of cob per plant (0.90) was recorded in the control crop at a density of 11.11 plants m^{-2} (N_0D_1). Greater number of cobs per plant at lower plant density could be due to less plant competition for different production factors such was water, nutrients, etc. The

suppressive effect of higher density on number of cobs per plant has also been recorded by Putnam *at al*. (1986) and Ramison and Lucas (1982). Similarly nitrogen deficiency results in less number of cobs per plant of maize (Short *at al*., 1982).
A positive but weak correlation was observed between grain yield and number of cobs per plant (Fig. 1a). Regression analysis also indicated dependence of grain yield on number of cobs per plant.

Number of grains per cob: The maximum number of grain per cob (544) was found in the crop with 6.67 plants m^{-2} and fertilized at 300 kg N ha^{-1} (N_3D_3) that was, however, statistically on a par with N_2D_3 (536 and N_3D_2 (530)) (Table 2). On the contrary, the minimum number of grains per cob (220) was produced by the control crop with 11.11 plants m^{-2} (N_0D_1). The increased nitrogen supply and reduced plant density enhanced the number of grains per cob. These results are in line with findings of Liang *at al*. (1992) who reported that high plant density and lower nitrogen level suppressive effect on number of grains per cob as nitrogen plays an important and essential role in grain formation (Arnon, 1972).
A strong positive correlation was observed between grain yield and number of grains per cob (Fig. 1b). Regression analysis indicated a strong dependence of grain yield on number of grains per cob.

1000-grain weight: The crop raised at 6.67 plants m^{-2} and fertilized at 300 kg N ha^{-1} (N_3D_3) had the maximum 1000-grain weight (128.6 g) that was, however, statistically on a par with N_3D_2 (127.2 g) and N_2D_3 (126.9 g) (Table 2). On the contrary, the minimum 1000-grain weight (95.3 g) was recorded in the control crop with 11.11 plants m^{-2} (N_0D_1). The results indicated that grain weight increased gradually by increasing nitrogen level but decreasing plant density. More 1000-grain weight at elevated nitrogen levels and reduced plant density was probably attributed to the better growth facilities especially more nitrogen availability at lower plant density then that at elevated plant density and inadequate supply of nitrogen. Similar results have been reported by Amano and Salazar (1989) who stated that more 1000-grain weight was associated with reduced plant density and higher nitrogen rate.
A strong positive correlation was observed between grain yield and 1000-grain weight (Fig. 1c). Regression analysis showed a strong dependence of grain yield on 1000-grain weight.

Grain yield: The maximum grain yield (7.11 t ha^{-1}) was produced by the crop with 11.11 plants m^{-2} fertilized at 300 kg N ha^{-1} (N_3D_1) that was, however, statistically on a par with that of N_2D_1 (6.97 t ha^{-1}) (Table 2). On the contrary, the minimum grain yield (2.03 t ha^{-1}) was recorded in the control crop with 6.67 plants m^{-2} (N_0D_3). Thus an increase in the nitrogen supply and plant density enhanced maize grain yield. These results concur with the findings of Nedic *at al.* (1991). The maximum grain yield ha^{-1} at the highest nitrogen level and plant density was primarily attributed to the most dense plant stand and not to the other individual yield components which were suppressed at higher plant densities due to competition among plants for various development determinants such as light, water nutrients (other then nitrogen) etc.

Harvest index: The maximum harvest index (HI) of 41.59% was recorded for the crop raised at 11.11 plants m^{-2} and fertilized at 300 kg N ha^{-1} (N_3D_1) that was, however, on a par with N_2D_1 (41.25%) and N_3D_2 (40.77%) (Table 2) the contrary, the lowest HI (18.88%) was observed for the crop with 11.11 plant m^{-2} and no nitrogen fertilization (N_0D_1). The suppressive effects of lower nitrogen level and elevated plant density on HI may be ascribed to the immense interplant competition which exhibited more adverse effect on dry matter accumulation by against than other plant parts. These results are in line with Asare *et al*. (1989) who observed the maximum HI at higher plant density and nitrogen level.

Grain protein content: The maximum grain protein content (10.53%) was produced by the crop fertilized at 300 kg N ha^{-1} and with the lowest plant density (N_3D_3) that was however, statistically equal to N_3D_2 (Table 2). On the contrary, the minimum grain protein content (6.15%) was recorded in N_0D_1. These results are in line with those of Arnon (1972) who also reported high grain protein content at elevated nitrogen levels and lower plant density. Reduced protein content at lower nitrogen level and dense plant stand might be due to the limited nitrogen availability. However, higher nitrogen level minimize the interplant competition for nitrogen and thus resulted in high grain protein content.

Conclusion

Application of 200-300 kg N ha^{-1} along with 11.11 plants m^{-2} should be used to harvest the maximum grain yield of cv. "Golden" under the edaphic and climatic conditions matching to those of the experiment.

References

Ali, A., M. Arshad and S. Ahmad, 1986. Response of maize to different fertilizer levels with different planting patterns. Pak. J. Agric. Res., 24: 289-293.

Alvi, M.I., 1994. Effect of different levels of NPK on growth and yield of spring maize. M.Sc. Thesis, Department Agroomy University Agriculture, Faisalabad, Pakistan.

Amano, L.O. and A.M. Salazar, 1989. Comparative productivity of corn and sorghum as affected by population density and nitrogen fertilisation. Philipine Agric., 72: 247-254.

Anjum, J.I., C.N. Ali, F.H. Sahi, Z.H. Khan and M. Jafar, 1992. Effect of plant population and fertilizer application on growth and yield of summer maize. J. Agric. Res., 30: 453-457.

Anonymous, 1995. Agriculture Statistics of Pakistan. Government of Pakistan, Ministry of Food, Agriculture and Livestock Economic Wing, Islamabad, Pakistan.

Arnon, I., 1972. Crop Production in Dry Regions, Volume 1: Background and Principles. Leonard Hill, London, Pages: 650.

Cardwill, V.B., 1982. Fifty years of minnesota corn production: Sources of yield increase. Agron. J., 74: 984-990.

Jackson, M.L., 1960. Soil Chemical Analysis. Prentice Hall, Englewood Cliffs, New Jersey, USA.

Kang, J.H. and B.H. Park, 1986. Effect of nitrogen levels and plant population on agronomic characteristics and yield of silage maize. J. Korean Soc. Grassland Sci., 6: 44-48.

Khan, A., M. Sarfraz, N. Ahmad and B. Ahmad, 1994. Effect of nitrogen dose and irrigation depth on nitrate movement in soil and N uptake by maize. J. Agric. Res., 32: 47-54.

Liang, B.C., A.F. MacKenzie and M. Remillard, 1992. Effects of hybrids, population densities, fertilization and irrigation on grain corn (*Zea mays* L.) in Quebec. Can. J. Plant Sci., 72: 1163-1170.

Nedic, M., D. Glamoclija, V. Milutinovic and Z. Jelicic, 1991. The effect of N application date and rate on maize yield. Arhiv za Poljoprivredne Nauke, 52: 215-227.

Putnam, D.H., S.J. Herbert and A. Vargas, 1986. Intercropped corn-soyabean density studies. II. Yield composition and protein. Exp. Agric., 22: 373-381.

Ramison, S.U. and E.O. Lucas, 1982. Effects of planting density on leaf area and productivity of two maize cultivars in Nigeria Exp. Agric., 18: 93-100.

Saeed, M., M.T. Masood, M.B. Gill and M. Akhtar, 1997. Agro-morphological response of maize to water stress. Pak. J. Bot., 29: 103-111.

Short, K.E., M.S. Islam, A.A. Pahlwan and S.K. Roy, 1982. Yield response of maize to different rates of nitrogen and sulfur during the Kharif season in Bangladesh. Bangladesh J. Agric., 7: 40-47.

Steel, R.G.D. and J.H. Torrie, 1984. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edn., McGraw Hill Book Co. Inc., New York.

Viera, F.Z.G., J.F.A. Neto and J.R.P. 1980. Effect of macronutrients on maize cultivation. Empresa de Pesquisa Agropecuaria do Ceara, Fortaleza, Brazil, pp: 10-18.