American Journal of

Plant Physiology

ISSN 1557-4539

Academic
Journals Inc.

www.academicjournals.com

American Journal of Plant Physiology 6 (1): 44-49, 2011
ISSN 1557-4539 / DOI: 10.3923/ajpp.2011.44.49

Effect of Plant Density and Nitrogen Rate on PAR Absorption and Maize Yield

Mehdi Dahmardeh
Department of Agronomy, Faculty of Agriculture, Agronomy and Plant Breeding Group, University of Zabol, Sistan and Balouchistan Province, Iran

ABSTRACT
A field experiment was conducted at the University of Zabol, The experimental farm in Southeast of Iran during 2007-08 to investigate the impacts of nitrogen (N) rate and plant density of maize (*Zea mays* L.) c.v. K.S.C 704. Split plot experimental treatments comprising three plant densities under title subplot included (P_1 = 60,000 plants ha^{-1}, P_2 = 80,000 plants ha^{-1} and P_3 = 100000 plants ha^{-1}) and Four nitrogen rates (N_1 = 200 kg ha^{-1}, N_2 = 250 kg ha^{-1}, N_3 = 300 kg ha^{-1} and N_4 = 350 kg ha^{-1}) were kept in main plots. Maize produced significantly as well as grain yield at high than at low density. Grain yield and Photosynthesis Active Radiation (PAR) absorption increase with increasing N rate and the highest amount of grain yield were obtained at N_4 treatments. Grain yield and PAR absorption increase with increasing plant density and the highest amount of grain yield were obtained at P_3 treatment. It is concluded that growing maize at high density with application of 350 kg h^{-1} N rate that could result in maximum Grain yield of maize and hence increase productivity of maize crop.

Key words: Maize, plant density, nitrogen rate, photosynthesis active radiation, grain yield

INTRODUCTION
Maize (*Zea maize* L.) is the third most important cereal crop of the world. It is used as food, feed and forage. Maize is the most suitable fodder crop for silage. Therefore, it is called the king of crops suitable for silage (Muhammad *et al*., 1990).

Management of corn (*Zea mays* L.) row spacing and crowed has been used to increase corn productivity. Widdicombe and Thelen (2002) recorded yield increases up to 10% with reducing row spacing. Murphy *et al*. (1996) showed that corn planted at 50 cm rows intercepted about 8% more PAR at silking than crop at conventional rows, reducing biomass of late-emerging. Nitrogen fertilizer is universally accepted as a key component to high yield and optimum economic return as it plays a very important part in crop productivity (Ahmad, 2000) and its deficiency constitutes one of the major yield limiting factors for cereal production (Shah *et al*., 2003). Increasing plant density for short season maize increases cumulative intercepted PAR, which compensates for a short growing season to achieve high yield with substantially less irrigation (Edwards *et al*., 2005). The difference in the dry matter accumulation in maize is attributed to post-silking N uptake and it improves with increase in N rate (Rajcan and Tollenaar, 1999). Differences in biological yield and N uptake varied partly due to decreased soil N mineralization and partly due to the drier weather conditions of different years and N uptake rate has been found to assist the improvement of dry matter yield in the plant (Greef *et al*., 1999). Adequate planting densities can contribute towards significant grain yield increases for farmers (Cardwell, 1992). Because corn or maize yield response to density depends on genotypic (Chandra and Gautan, 1997) and environmental factors (Bondavalli *et al.*, 1970) and even negative responses of the crop to a given factor can be verified beyond certain limits. Its biomass yield increases with increase in plant density and N rate (Gaurkar and Bharad, 1998). Hamid and Nasab (2001) reported that both economical and biological yields are correlated with vegetative and reproductive phase duration in maize. Leaf area influence interception and utilization of solar radiation of crop canopies and consequently maize dry matter accumulation and economical yield. Leaf area and number are important factors in the estimation of canopy photosynthesis in crop growth simulation models that compute dry matter accumulation from temporal integration of canopies photosynthesis (Boote *et al.*, 1996). Valentinuz and Tollenaar (2006) reported that breadth of the area per leaf profile decreases under high soil nitrogen level and high plant density. They were reported that leaf area and yield increased with higher rate of N. According to Pandey *et al.* (2000), maize cultivars differs in its ability to maintain Leaf Area Index (LAI), Crop Growth Rate (CGR) and above ground dry matter biomass at different levels of water deficit and N supply. Plant height, inter-node length and ear height is greater under high density and leaf area decreases with increase in plant density in maize (Modarres *et al.*, 1998; Hassan, 2000). Plant height and yield in maize increases up to a plant density of 71900 plants ha^{-1} and 280 kg N ha^{-1}, but further increase in both plant density and N rate has no significant effect on the plant height and biomass yield (Turgut, 2000). Plant density in maize affects plant architecture, alters growth and developmental patterns and influences assimilate production and partition (Casal *et al.*, 1985). The aim of this study investigate to impacts of differential N rates and maize density at Southeast of Iran with the objective of evaluate the effect of plant densities and N dosages on maize yield and PAR absorption.

MATERIALS AND METHODS

Experiment was conducted at the University of Zabol, The experimental farm in Southeast of Iran during 2007-08. The experimental site is located at 30°54' N, 61°41' E and 483 m above sea level and it has arid type of climate. Soil texture is sandy loam, extractable phosphorus (11 ppm), exchangeable potassium (115 ppm), exchangeable nitrogen (0.05%) and alkaline (pH 7.6); climatologically data are mean of rainfall this region is 53 mm annual and mean of evaporation at annually is 5000 mm (Research Center of Zabol Agriculture). A split plot experiment was conducted in a Randomized Complete Block (RCB) design with four replications. Split plot experimental treatments were three plant densities (P_1 = 60,000 plants ha^{-1}, P_2 = 80,000 plants ha^{-1} and P_3 = 100,000 plants ha^{-1}) applied to sub plot and four N rates (N_1 = 200 kg N ha^{-1}, N_2 = 250 kg N ha^{-1}, N_3 = 300 kg N ha^{-1} and N_4 = 350 kg N ha^{-1}) applied to main plots. K.S.C 704, corn variety was used in the experiment. A sub-plot size of 2 m×6 m, having 4 rows, 6 m long and 50 cm apart, was used. Fertilizer N (urea) was applied at the time of sowing and two stage (6 leaf and stem elongation). A uniform basal dose of 150 kg P_2O_5 (super phosphate) ha^{-1} and 100 kg K_2O (Sulphate of potassium) ha^{-1} was applied and mixed with soil during seedbed preparation. The plots were planted thicker and the three desired plant densities of 60,000, 80,000 and 100,000 plants ha^{-1} were obtained in the different experimental units by thinning two week after emergence. Ten plants in the four middle rows in each experimental unit were harvested at silking and physiological maturity. The plants were dried, weighed and then converted to yield ha^{-1}. The fraction of PAR intercepted was calculated by taking ten readings in rapid succession above the canopy and ten readings below the canopy at the soil surface using a Ceptometer CEP (Decagon Devices, Pullman, Washington State and USA). The soil surface measurements were taken by placing the Ceptometer at right angles to the plant rows.

Statistical analysis: All obtained data was subject to statistically analyzing according to Steel and Torrie (1980) and mean values were compared with treatments by Least Significant Different (LSD) at p = 0.05 level.

RESULTS AND DISCUSSION

Grain yield: Grain yield of maize showed positive relationship with increase in plant density (Table 1).

The highest grain yield was obtained at P_3 (3610 kg ha^{-1}) and the lowest grain yield was obtained at P_1 (2460 kg ha^{-1}). Light interception was increased with increased plant density, under high plant density increased plant heights as well as light interception. At high density vegetative growth of maize was extended, more number of leaves per plant were produced that increased light interception at the high density (Amanullah *et al.*, 2009), as a result more assimilates were produced by maize crop that increased plant heights as well as light interception (Amanullah *et al.*, 2008; Tollenaar *et al.*, 1997) which ultimately lead to higher grain yields at high than at low plant density. Toler *et al.* (1999) were reported 15% higher light interception and higher biomass yield at high than at low plant density of maize. Edwards *et al.* (2005) were suggested that increasing plant density for short season maize increased cumulative intercepted photo synthetically active radiation, which compensated for a short growing season to achieve high yield. At low plant density, the in adequate number of plants and therefore ears, that was concluded limits grain yield (Hashemi *et al.*, 2005). Aftab *et al.* (2004) were reported that a linear relationship between total biomass production and intercepted PAR. High yield thus require agronomic techniques that produce both a high level of radiation interception and a high rate of conversion of intercepted PAR to grain. Similar results was obtained by Hassan (2000) and Silva *et al.* (1999) that observed increase in grain yields with increasing plant density.

Grain yield increased significantly with increase in N rate (Table 2). The increase in grain yield at higher N than lower N rate might be due to the increase in leaf area and plant heights at higher than at lower N rate. Hamid and Nasab (2001) and Greef *et al.* (1999) were reported positive correlation between N rates and dry matter yield in maize. Rajcan and Tollenaar (1999) reported

Table 1: Impact of planting density on grain yield and PAR absorption at physiological maturity of maize during 2007-08

Planting density (P)	Grain yield (kg ha^{-1})	PAR absorption (%)
P_1	2460c	73b
P_2	2940b	75ab
P_3	3610a	79a
LSD ($p \geq 5\%$)	340	5

Where, P_1 = 60,000 plants ha^{-1}, P_2 = 80,000 plants ha^{-1} and P_3 = 100,000 plants ha^{-1}. Mean values of the same category followed by different letters are significant at $p \geq 0.05$ using LSD

Table 2: Impact of N rates on PAR absorption and grain yield at physiological maturity of maize during 2007-08

N rates (N)	Grain yield (kg ha^{-1})	PAR absorption (%)
N_1	2704c	70b
N_2	3073b	73ab
N_3	3104ab	77a
N_4	3170a	77a
LSD ($p \geq 5\%$)	85	6

Where, N_1 = 200 kg N ha^{-1}, N_2 = 250 kg N ha^{-1} , N_3 = 300 kg N ha^{-1} and N_4 = 350 kg N ha^{-1}. Mean values of the same category followed by different letters are significant at $p \geq 0.05$ using LSD that the difference in the dry matter accumulation in maize is attributed to post-silking N uptake and it significantly increases with increase in N rate. Mariga *et al.* (2000) resulted that total yield in maize considerably increased when N was applied up to tassel initiation stage.

Radiation interception was also influenced by the levels of nutrients in plants, mainly by nitrogen (Scott Green *et al.*, 2003). Kogbe and Adediran (2003) were reported that High fertilizer input is one of the conditions required to obtain maximum yield of hybrid maize. These results agree with those reported by Mahmood *et al.* (2001), Nunes *et al.* (1996), Shaikh *et al.* (1994), Ali *et al.* (2002) and Jehan *et al.* (2006).

CONCLUSIONS

Present results indicated that application of nitrogenous fertilizer increased grain yield of maize. This is possible because the presence of nitrogen helps in developing leaf area as a result of the increase in the physiological growth indices. The results showed that application of nitrogenous fertilizer increased the grain yield and absorption of PAR in maize. Also, our study showed that high planting density contributed to grain yield by increasing absorption of PAR.

Application of higher rate of 350 kg N ha^{-1} resulted in maximum biomass yields and PAR absorption. Further research work for understanding the impacts of different planting densities, higher rate of N for high sustainable grain production in arid agro ecological conditions is also suggested. Sowing maize in 50 cm width and 20 cm between plants (100,000 plants ha^{-1}) and application 350 kg ha^{-1} produced the highest grain yield and was absorbed the highest amount of PAR.

ACKNOWLEDGMENTS

The authors thank Ebrahim Mirshekar for useful comments on Agronomy Laboratory. Financial support from the Department of Agronomy, Faculty of Agriculture in Zabol University.

REFERENCES

Aftab, W., H. Abid, A. Ashfaq, R. Muhammad, A.R. Goheer and I. Muhammad, 2004. Effect of sowing date and plant density on growth, light interception and yield of wheat under semi arid conditions. Int. J. Agric. Biol., 6: 1119-1123.

Ahmad, N., 2000. Fertilizer scenario in Pakistan policies and development. Proceedings of the Conference on Agriculture and Fertilizer Use. Planning and Development Division, Government of Pakistan, Feb. 15-16, NFDC, Islamabad, Pakistan.

Ali, J., J. Bakht, M. Shafi, S. Khan and W. Ali, 2002. Uptake of nitrogen as affected by various combination of nitrogen and phosphorous. Asian J. Plant Sci., 1: 367-369.

Amanullah, R., H. Rahman and Z. Shah, 2008. Effects of plant density and N on growth dynamics and light interception in maize. Arch. Agron. Soil Sci., 54: 401-411.

Amanullah, R., A. Khattak and S.K. Khalil, 2009. Effects of plant density and N on phonology and yield of maize. J. Plant Nutr., 32: 246-260.

Bondavalli, B., D. Colyer and E.M. Kroth, 1970. Effects of weather, nitrogen and population on corn yield response. Agron. J., 62: 669-672.

Boote, K.J., J.W. Jones and N.B. Pickering, 1996. Potential uses and limitations of crop models. Agron. J., 88: 704-716.

Cardwell, V.B., 1992. Fifty years of Minnesota corn production: Sources of yield increase. Agron. J., 74: 984-995.

Casal, J.J., V.A. Deregibus and R.A. Sanchez, 1985. Variations in tiller dynamics and morphology in *Lolium multiflorum* Lam., vegetative and reproductive plants as affected by differences in red/far-red irradiation. Ann. Bot., 56: 533-559.

Chandra, D. and R.C. Gautan, 1997. Performance of maize varieties at varying plant densities. Ann. Agric. Res., 18: 375-376.

Edwards, J.T., L.C. Purcell and E.D. Vories, 2005. Light interception and yield potential of short-season maize (*Zea mays* L.) hybrids in the midsouth. Agron. J., 97: 225-234.

Gaurkar, S.G. and G.M. Bharad, 1998. Effect of plant population, detopping and nitrogen levels on growth and yield of maize. PKV Res. J., 22: 136-137.

Greef, J.M., H. Ott, R. Wulfes and F. Taube, 1999. Growth analysis of dry matter accumulation and N uptake of forage maize cultivars affected by N supply. J. Agric. Sci., 132: 31-43.

Hamid, A. and A.D.M. Nasab, 2001. The effect of various plant densities and N levels on phenology of two medium maturity corn hybrids. Iranian J. Agric. Sci., 32: 857-874.

Hashemi, A.M., S.J. Herberts and D.H. Putnam, 2005. Yield response of corn to crowding stress. Agron. J., 97: 839-846.

Hassan, A.A., 2000. Effect of plant population density on yield and yield components of eight Egyptian maize hybrids. Bull. Fac. Agric. Univ. Cairo, 51: 1-16.

Jehan, B., A. Shakeel, T. Mohammad, A. Habib and S. Mohammad, 2006. Response of maize to planting methods and fertilizer N. J. Agric. Biol. Sci., 1: 8-14.

Kogbe, J.O.S. and J.A. Adediran, 2003. Influence of nitrogen, phosphorus and potassium application on the yield of maize in the Savanna zone of Nigeria. Afr. J. Biotechnol., 2: 345-349.

Mahmood, M.T., M. Maqsood, T.H. Awan, S. Rashid and R. Sarwar, 2001. Effect of different levels of nitrogen and intra-row plant spacing on yield and yield components of maize. Pak. J. Agric. Sci., 38: 48-49.

Mariga, I.K., M. Jonga and O.A. Chivinge, 2000. The effect of timing of application of basal and topdressing fertilizers on maize (*Zea mays* L.) yield at two rates of basal fertilizer. Crop Res., 20: 372-380.

Modarres, A.M., R.I. Hamilton, M. Dijak, L.M. Dwyer, D.W. Stewart, D.E. Mather and D.L. Smith, 1998. Plant population density effects on maize inbred lines grown in short season environments. Crop Sci, 38: 104-108.

Muhammad, D., A. Hussain and M.B. Bhatti, 1990. Location differences in forage yield and quality of maize cultivars. Pak. J. Sci. Ind. Res., 33: 454-456.

Murphy, S.D., Y. Yakubu, S.F. Weise and C.J. Swanton, 1996. Effect of planting patterns and inter-row cultivation on competition between corn (*Zea mays*) and late emerging weeds. Weed Sci., 44: 865-870.

Nunes, G.H.S. and P.S.L. Silva, 1996. Response of maize to nitrogen levels and weed control. Ciencia-e-Agrotecnol., 20: 205-211.

Pandey, R.K., J.W. Maranville and M.M. Chetima, 2000. Deficit irrigation and nitrogen effects on maize in a Sahelian environment. II. Shoot growth. Agric. Water Manage., 46: 15-27.

Rajcan, I. and M. Tollenaar, 1999. Source: Sink ratio and leaf senescence in maize: I. Dry matter accumulation and partitioning during grain filling. Field Crops Res., 60: 245-253.

Scott Green, D., J.E. Erickson and E.L. Kruger, 2003. Foliar morphology and canopy nitrogen as predictors of light-use efficiency in terrestrial vegetation. Agric. Forest Meteorol., 115: 163-171.

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 Res., 83: 1-11.

Shaikh, A.A., A.S. Jadhav, B.D. Koli and M.J. Wattamwar, 1994. Effects of planting layouts, mulching and fertilizers on dry matter accumulation and energy relationship in rainfed pearl millet. J. Maharashtra Agric. Univ., 19: 421-423.

Silva, P.R.F., G. Argenta, F. Rezera and P.R.F. Silva, 1999. Response of irrigated maize hybrids to plant density and three sowing dates. Pesquisa Agropecuaria Brasileira, 34: 585-592.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Edn., McGraw Hill Book Co. Inc., New York, USA., ISBN-13: 9780070610286, pp: 188-189.

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.

Tollenaar, M., A. Aguilera and S.P. Nissanka, 1997. Grain yield is reduced more by weed interference in an old than in a new maize hybrid. Agron. J., 89: 239-246.

Turgut, I., 2000. Effects of plant populations and nitrogen doses on fresh ear yield and yield components of sweet corn (*Zea mays saccharata* Sturt.). Grown under bursa conditions. Turk. J. Agric. For., 24: 341-347.

Valentinuz, O.R. and M. Tollenaar, 2006. Effect of genotype, nitrogen, plant density and row spacing on the area-per-leaf profile in maize. Agron. J., 98: 94-99.

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.