MEDWELL PUBLISHING
Research Journal of Biological Sciences 4 (4): 375-379, 2009
ISSN: 1815-8846

Effect of Population Density on Yield and Yield Attributes of Maize Hybrids

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Abstract: In order to study, the effects of plant density on yield and yield components in maize hybrids, a factorial experiment based on randomized complete block design with three replications was conducted in 2007 at the Research Farm of the Faculty of Agriculture University of Mohaghegh Ardabili. Experiment factors were: Maize hybrids (Sc-504, Sc-404 and Dc-370) with 3 levels of plant density (8, 10 and 12 plant m^{-2} as D_1, D_2 and D_3, respectively). Results indicated that plant density had significant effects on yield and yield components in maize hybrids. Maize hybrids had different response to this characteristic. The highest grain yield and harvest index obtained from D_2. The highest the number of kernel/ear, the number of grains/ear row, stem diameter, cob length, the number of kernel/ear recorded at D_1, while, D_3 showed the highest values of plant height. The number of grain row did not affected in maize hybrids by levels of plant density. In conclusion, it can be suggested that SC-504 hybrid should be applied and the plant density should be adjusted to 10 plants m^{-2} in conditions of Ardabil Plain.

Key words: Density, *Zea maize*, yield, attributes, maize hybrids, factorial

INTRODUCTION

Corn (*Zea mays* L.) is one of the most important cereal crop grown principally during the summer season in Iran. Maize grain is used for both human consumption and poultry feed. It has a great utility in agro industry. This crop has much higher grain protein content than our staple food rice. Based on area and production, maize is the 3rd most important cereal crop after wheat and rice in world. The yield of maize in Iran is very low as compared to other maize producing countries. One of the most important effective factors is non application of optimal plant population/ha and maize hybrids differ in their response to plant density (Xue *et al*., 2002). As maize do not have tillering capacity to adjust to variation in plant stand, optimum plant population for grain production is important. Agronomic practices such as plant population is known to effect crop environment, which influence the yield and yield components. Optimum population levels should be maintained to exploit maximum natural resources, such as nutrient, sunlight, soil moisture and to ensure satisfactory yield. On the other hand, in order to increase grain yield, we must plant maize at proper plant population. When plant density is too high, it encourage inter plants competition for resources. Then crop net photosynthesis process will be affected due to less light penetration in the crop canopy as well as increase in the competition for available nutrient which will affect grain yield. On the other hand, application of optimum plant density in corn production helps for the proper utilization of solar radiation.

If plant population is lower than optimum plant population then per hectare production will be low and weeds will also be more (Allard, 1999). Photosynthetic efficiency and growth in maize are strongly related to the effect of canopy architecture on the vertical distribution of light within the canopy. Increasing plant density is one of the ways of increasing the capture of solar radiation within the canopy. However, the efficiency of the conversion of intercepted solar radiation in to maize yield decreases with a high plant population density because of mutual shading in the plants (Zhang *et al*., 2006). In addition, a plant population density resulting in interplant competition affects vegetative and reproductive growth (Zhang *et al*., 2006). Many studies have been conducted with the aim of determining the optimm plant density for maize. Unfortunately, there is no single recommendation for all conditions, because the optimum plant density varies depending on environmental factors such as soil fertility, moisture supply, genotype (Gonzalo *et al*., 2006), planting date, planting pattern, plant population and harvest time. The differential response to plant density in maize cultivars have been reported by Xue *et al*. (2002). Generally, the yield of a single maize plant decreases with

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increasing plant population density whereas, the yield/unit area increases. Xue *et al.* (2002) suggested that the best way to effect future grains in yielding ability may be to make further improvements in tolerance to high plant densities, in combination with improvements in potential yield/plant under low stress environments. Xue *et al.* (2002) emphasized the importance of low stress conditions (i.e., very low plant density, so that competition among plants is avoided) in optimizing the effectiveness of selection for improved potential yield/plant, tolerance to stresses and responsiveness to input. The aim of this study, was to determine the effects of plant density on yield and yield components of maize hybrids.

MATERIALS AND METHODS

A factorial experiment based on randomized complete block design with three replications was conducted in 2007 at the Research Farm of the Faculty of Agriculture University of Mohaghegh Ardabili (lat 38°15'N; long 48°15'E; Alt 1350 m). Climatically, the area placed in the semi-arid temperate zone with cold winter and hot summer. Average rainfall is about 363 mm that most rainfall concentrated between winter and spring. The soil was salty loam with EC about 3.61 ds m^{-1}, pH about 8.2 and SP about 46%. Before sowing of the crop, the field was well prepared by plowing twice with tractor followed planking to make a fine seed bed. Treatments were 3 densities containing, 8 (D_1), 10 (D_2) and 12 plant m^{-2} (D_3) plus maize hybrids (DC-370, SC-404 and SC-504). Row spacing was 75 cm and distances between plants in the rows were 16.6, 13.3 and 11.1 for D_1, D_2 and D_3 sowing densities, respectively. Plot size was 6×3.75 m with 5 rows/plot. Plots and blocks were separated by 1.5 m unplanted distances. The area was mold board-ploughed and disked before planting. Corn seeds were planted in the 3rd week of May. Two seeds were sown/hill and later thinned to one plant/hill. Thinning was done at 3-4 leaves stage. The field was immediately irrigated after planting. All other agronomic operations except those under study were kept normal and uniform for all treatments. Harvest sample was taken of 3 m long from the 3 middle rows for measuring harvest index and grain yield. The other traits studied in this research were determinated in the following ways:

Plant height: Mature plant heights of 8 random plants/plot were measured in cm as the distances from ground level to the lowest branch of the panicle. Number of kernel/ear: the number of kernels in 8 ears was counted after they had been shelled and was divided by the number of ears. Grain yield/ear: The grain of the same 8 ears mentioned above was weighed and divided by the number of ears. Grain yield: Grain yield was harvested of 3 m long of 3 middle rows. The other characteristics such as number of cobs/plant, cob length, ear diameter, number of grains/ear row, stem diameter and the number of grains rows were determined in the center 3 rows of each plot. Analysis of variance and regression were performed using SAS computer software packages. The main effects and interactions were tested using the LSD test.

RESULTS AND DISCUSSION

Density: Density had significant effects on grain yield, plant height, number of kernels/ear, the number of grains row, number of grains/ear row, harvest index, number of cobs/plant, cob length, ear diameter and stem diameter. Maize hybrids had different response to these characteristics (Table 1).

Plant height: Plant density significantly increased the plant height in maize hybrids. Data regarding the effect of maize hybrids and plant density on plant height are given in Table 2. In general, the maximum plant height (205.96 cm) was obtained with the highest plant density (12 plants m^{-2}), while the least value (193.8) was recorded at the lowest plant density (8 plants m^{-2}). Similar results have been reported by Zhang *et al.* (2006) in maize hybrids and Mobasser *et al.* (2007) in rice cultivars. Means of comparisons for maize hybrids indicated the maximum (211.59 cm) plant height was recorded for SC-504 hybrids and minimum value (183.9 cm) was recorded for DC-370 hybrid (Table 2).

Number of kernels/ear: Data regarding the effect of maize hybrids and plant density on number of kernels/ear are given in Table 2. The response of number of kernels/ear to plant density was significant (Table 1). The number of kernels/ear ranged between 354.2 and 391.8. Across planting density maximum number of kernels/ear was recorded 8 plant m^{-2} (391.8) and minimum it was recorded at 12 plant m^{-2} (354.2). On the other hand, the number of kernels/ear increased with reduced plant density. Our results concur partly with observations made by Zhang *et al.* (2006), who reported that the kernels number decreased with increasing plant density. Similar results have been reported by Mobasser *et al.* (2007) in rice cultivars. Increase in grains cob^{-1} from lower planting density might be due to the lower competition for radiation and nutrient that allowing the plants to accumulate more biomass with higher capacity to convert more photosynthesis into sink

Table 1: Analysis of variance for the effects of plant density on studied traits in maize hybrids

		MS									
S.O.V	df	Plant height	Number of kernels/ ear	The number of grains rows	The number of grains/ ear row	Harvest index	Number of cobs/ plant	Cob length (mm)	Ear diameter (mm)	Stem diameter (mm)	Grain yield (t ha^{-1})
Replication	2	628.39**	32765**	61.79**	182.46**	130.44**	0.097	8.17**	0.335**	0.0011	2.22**
Density	2	1777.22**	7347.4**	34.21**	19.57**	105.56**	0.28**	7.02**	0.266**	0.051*	3.41**
Cultivar	2	340.11**	3180.1**	0.0151	18.15**	141.47**	0.85**	28.6**	1.86**	0.47**	5.17**
Density×Cultivar	4	2.85	33.75	0.0046	0.0168	3.48	0.032	0.012	0.035	0.033	0.85
Error	16	4.85	22.93	0.074	0.0817	4.74	0.056	0.92	0.066	0.018	0.165

*,** and ns show significant differences at 0.05, 0.01 probability level and no significant, respectively

Table 2: Means for yield components of maize hybrids at different densities

Characteristics/ Treatments	Plant height (cm)	Number of kernels/ ear	The number of grains rows	The number of grains/ ear row	Harvest index (%)	Grain yield (T ha^{-1})	Number of cobs/ plant	Cob length (mm)	Ear diameter (mm)	Stem diameter (mm)
Plant density m^{-2}										
8	193.8c	391.8a	16.34a	29.35a	0.32b	3.91c	1.01a	172a	439a	237a
10	198.2b	367.7b	16.1a	27.93b	0.34a	4.77b	1.035a	163b	4.17b	219b
12	205.96a	354.2c	16.3a	26.5c	0.31c	4.65a	1.02a	148c	391c	194c
Maize hybrids										
DC-370	183.9c	350.7c	14.55c	26.37c	0.26c	3.38c	1.01a	161c	382c	186c
SC-404	202.39b	366.2b	15.82b	28.13b	0.32b	4.64b	1a	172b	427b	197b
SC-504	211.59a	406.1a	18.38a	29.3a	0.34a	5.1a	1.02a	197a	452a	203a

Values followed by the same letters are not significantly different at 1% level

resulting in more grains cob^{-1}. These results are also, in agreement with Zhang *et al.* (2006), who concluded that grain number/cob was highest at the least plant density. The response of maize hybrids was significant to number of kernels/ear. On the other hand, means comparisons indicated that the maximum (406.1) number of kernels/ear was recorded for SC-504 hybrids and minimum value was recorded for DC-370 hybrids (350.7). Number of kernels/ear plays an important role to determining grain yield.

The number of grains rows: Data recorded on average the number of grains rows of maize hybrids is represented in Table 2. Statistical analysis of the data revealed that plant density and their interaction cultivars × plant density are not significant. Means comparisons indicated that maximum number of grains rows (18.38) was observed for SC-504 hybrids and minimum value (14.55) was observed for DC-370 hybrids. Similar results have been reported by Ma *et al.* (2007) who reported that the number of grains rows had significantly affected by maize hybrids.

The number of grains/ear row: Data regarding the effect of maize hybrids and plant density on the number of grains/ear row are given in Table 2. The response of the number of grains/ear row to plant density was significant. Maximum (29.35) the number of grains/ear row was recorded 8 plant m^{-2} and minimum it was recorded at 12 plant m^{-2} (26.5). Means comparisons indicated that maximum the number of grains/ear row (29.3) was observed for SC-504 hybrids and minimum value (26.37) was observed for DC-370 hybrids. Similar results have been reported by Zhang *et al.* (2006), who reported that the number of grains/ear row of corn had significantly affected by maize hybrids.

Harvest index: The physiological efficiency and ability of a crop for converting the total dry matter into economic yield is known as Harvest Index (HI). Plant densities showed significant difference for HI. Crop sown at density 10 plants m^{-2} had maximum HI (0.34%), followed by 8 plants m^{-2} (0.32%), which was similar to 12 plants m^{-2} (0.31%) (Table 2). On the other hand, with increasing plant density was decreased HI. Mobasser *et al.* (2007) reported that harvest index in rice declines when plant density increases above the critical plant density. The yield reduction/plant may be due to the effects of interplant competition between plants for using of light, water, nutrients and other yield-limiting environmental factors. Similar results have been reported by Li *et al.* (2007) in maize hybrids and Mobasser *et al.* (2007) in rice cultivars. Means comparisons indicated the maximum (0.34%) harvest index was recorded for SC-504 hybrid and minimum value was recorded for DC-370 hybrid (0.26%).

Cob length: Population density influenced significantly the cob length of maize hybrids (Table 1). Cob length generally decreased with increase in population density. Sparsely populated plants (80000 ha^{-1}) had the longest cob and the shortest was in density populated plants (120000 ha^{-1}). Similar trend was also reported Zhang *et al.* (2006). The longest cob produced by SC-504 hybrid (197 mm) and the shortest it was DC-370 hybrid (161 mm). The interaction of planting density and maize hybrids did not significantly affected the cob length (Table 2).

Number of cobs $plant^{-1}$: Population density and maize hybrids did not show any significant variation in respect of number of cobs $plant^{-1}$ (Table 1). The findings are in agreement with those of Ma *et al.* (2007). Gonzalo *et al.* (2006) have been reported that number of cobs $plant^{-1}$ had not significantly affected by maize hybrids.

Grain yield: Grain yield is the main target of crop production. The grain yield was significantly affected by both maize hybrids and plant density. Plant density significantly increased the grain yield. The grain yield varied between 3.91 t ha^{-1} in 8 plants m^{-2} and 4.65 t ha^{-1} in 12 plants m^{-2} (Table 2). A similar trend in yield differences across planting density have been reported by Zhang *et al.* (2006). Xue *et al.* (2002) reported that grain yield increased with increasing plant density from 54000-94000 plants ha^{-1}, but decreased after 97000 plants ha^{-1}. Since, yield reduction/ha at high plant densities is due to the effects of interplant competition for light, water, nutrition and other potentially yield-limiting environmental factors, a plant population above a critical density has a negative effect on yield/plant (Xue *et al.*, 2002). Our findings are in agreement with observations made by many researchers (Bangarwa *et al.*, 1988; Mobasser *et al.*, 2007). In addition, this suggests that the optimum plant density depends upon environmental conditions and the cultivars used. Maximum grain yield was produced by SC-504 hybrid (5.1 t ha^{-1}) while minimum by DC-370 hybrid (3.38 t he^{-1}). These results are in agreement with harvest index. This might be related to correlation between grain yield with harvest index.

Ear diameter: Maize hybrids and plant density significantly affected ear diameter. Maximum ear diameter was recorded by SC-504 hybrid (45.2 mm) and minimum it was recorded by DC-370 hybrids (38.3 mm). Gozubenli *et al.* (2001) and Konuskan (2000) indicated that ear diameter was affected by genotyps. Ear diameter decreased with the increasing plant density. The thickest ears were obtained at density 8 plants m^{-2} with 43.9 mm and the thinnest ears were obtained at density 12 plants m^{-2} with 39.1 mm (Table 2). Konuskan (2000) reported plant densities affected ear diameter and thinner ears were obtained at high densities.

Stem diameter: Maize hybrids and plant density significantly affected stem diameter. The highest stem diameter was determinated at SC-504 hybrid with 20.3 mm and the lowest at DSC-37 hybrid with 18.6 (Table 2). Considerable varietal variations have been observed in stem diameter by Konuskan (2000). Stem diameter decreased with the increasing plant density and the highest stem diameter (23.7 mm) was determined at 8 plants m^{-2} and the lowest stem diameter (19.4 mm) was determined at 12 plants m^{-2} (Table 2). Stem diameter is strongly influenced by environmental conditions during stem elongation. Konuskan (2000) and Mobaser *et al.* (2007) reported that stem diameter were lower in higher plant densities as a consequence of inter plant competition.

CONCLUSION

In this experiment, density showed significant effects on maize hybrids yield and its attributes. The highest grain yield recorded at 10 plants m^{-2} density. In conclusion, it can be suggested that SC-504 hybrid should be applied and the plant density should be adjusted to 10 plants m^{-2} in conditions of Ardabil Plain.

REFERENCES

Allard, R.W., 1999. History of plant population genetics. Ann. Rev. Gen., 33: 1-27 (Review). PMID: 10690402.

Bangarwa, A.S., M.S. Kairon and K.P. Singh, 1988. Effect of plant density and level and proportion of nitrogen fertilization on growth, yield and yield components of winter maize (*Zea mays*). Indian J. Agric. Sci., 11: 854-856.

Gonzalo, M., T.J. Vyn, J.B. Holland and L.M. McIntyre, 2006. Mapping density response in maize: A direct approach for testing genotype and treatment interactions. Genetics, 173 (1): 331-348. PMID: 16489238.

Gozubenli, H., A.C. Ulger and O. Senser, 2001. The effect of different nitrogen doses on grain field and yield-related characters of some genotypes grown as second-crop. J. Agric. Fac., 16: 39-48.

Konuskan, O., 2000. Effects of plant density on yield and yield related characters of some maize hybrids grown in hatay conditions as 2nd crop. M.Sc. Thesis, Science Institute. M.K.U., pp: 71.

Li, C.H., Y.L. Zhao, G.H. Yang, L.M. Luan, Q. Wang and N. Li, 2007. Effects of shading on photosynthetic characteristics of different genotype maize. Ying Yong Sheng Tai Xue Bao, 18 (6): 1259-1264 (Chinese). PMID: 17763726.

Ma, G.S., J.Q. Xue, H.D. Lu, R.H. Zhang, S.J. Tai and J.H. Ren, 2007. Effects of planting date and density on population physiological indices of summer corn (*Zea mays* L.) in central Shaanxi irrigation area. Ying Yong Sheng Tai Xue Bao, 18 (6): 1247-1253 (Chinese). PMID: 17763724.

Mobasser, H.R., M.M. Delarestaghi Khorgami, A. Tari, and D.B. Pourkalhor, 2007. Effect of planting density on agronomical characteristics of rice (*Oryza sativa* L.) varieties in north of Iran. Pak. J. Biol. Sci., 10 (18): 3205-3209. PMID: 19090127.

Xue, J., Z. Liang, G. Ma, H. Lu and J. Ren, 2002. Population physiological indices on density-tolerance of maize in different plant type. Ying Yong Sheng Tai Xue Bao, 13 (1): 55-59 (Chinese). PMID: 11962320.

Zhang, J., S. Dong, K. Wang, C. Hu and P. Liu, 2006. Effects of shading on the growth, development and grain yield of summer maize. Ying Yong Sheng Tai Xue Bao, 17 (4): 657-662 (Chinese). PMID: 16836097.