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GROWTH AND YIELD BEHAVIOUR OF TWO MAIZE HYBRIDS (*ZEA MAYS* L.) TOWARDS DIFFERENT PLANT SPACING

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ABSTRACT - A field experiment to evaluate the effect of different plant spacing on the growth and yield of maize hybrids was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during autumn, 2008. The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement having three replications using a net plot size of 6m x 3m. Two hybrids H_1 (30 Y 87) and H_2 (31 R 88) having density levels S_1 (15 cm), S_2 (20 cm), S_3 (25 cm) and S_4 (30 cm) were sown at row spacing of 60 cm. The hybrid 30 Y 87 was early in maturity, produced more number of cobs per plant, more number of grain rows per cob, less number of grains per row and less cob length than the hybrid 31 R 88. Similarly 1000-grain weight, grain yield and straw yield of hybrid H_1 (30 Y 87) was significantly greater than the hybrid H_2 (31 R 88 Although narrow plant spacing (15, 20 cm) caused substantial reduction in yield components such as grains/cob, number of cobs/plant and 1000-grain weight compared to the wide plant spacing (30 cm) yet it gave the maximum yield (7.69 t ha^{-1}) against the minimum of (5.01 t ha^{-1}) in the latter. The interactive effect of plant population density and hybrids was found to be non-significant in all the parameters under study.

Key words: Maize hybrids; Row spacing; Plant density; Interaction; Yields.

INTRODUCTION

Maize (*Zea mays* L.) belongs to family poaceae, is an important cereal crop of the world as well as of Pakistan. Maize is multipurpose crop, provides food for human beings, feed for animals, poultry and fodder for livestock. It has high nutritional value as it contains about 72% starch, 10% proteins, 4.8% oil, 8.5% fibre, 3.0% sugar and 1.7% ash (Chaudhary, 1983). At present, it is being cultivated on an area of 1.015 m hac with average yield of 2.893 t ha^{-1} and total annual production is 3.313 m tons (GOP, 2007-08). In spite of favorable agro-climatic conditions in Pakistan, grain yield of maize is very low as compared to its yield

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potential and the yield ha^{-1} of other maize growing countries like Italy (9.5 t ha^{-1}), USA (8.6 t ha^{-1}), Canada (6.6 t ha^{-1}), China (4.5 t ha^{-1}), and Argentina (5.6 t ha^{-1}) (Anonymous, 2007). There are many agronomic, edaphic and environmental factors responsible for this low yield. Among various factors responsible for low yield, plant population in the field and selection of unsuitable cultivars are of prime importance. The corn grain yield increased from 10.1 to 10.8 t ha^{-1} as plant density increased from 59000 to 89000 plants ha^{-1} (Farnham, 2001). Hybrids developed in recent years are able to withstand higher plant density levels than older hybrids (Tollenaar, 1989). The corn grain yield typically exhibits a quadratic response to plant density with a near-linear increase across a range of low densities, a gradually decreasing rate of yield increase relative to density increase and finally a yield plateau at some relatively high plant density (Shapiro and Wortmann, 2006).

MATERIALS AND METHODS

The experiment to determine the effect of different plant spacings on the growth and yield of maize hybrids was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (latitude 31.3 N, longitude 71.03 E and altitude 184 meter from sea level) during autumn, 2008 on sandy clay loam soil.The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement and having three replications. The experiment comprises of four different plant spacing levels i.e; S_1) 60 cm x 15 cm =111,111 plants ha^{-1}, $S_{2)}$ 60 cm x 20 cm = 83,333 plants ha^{-1}, $S_{3)}$ 60 cm x 25 cm = 66,666 plants ha^{-1} and $S_{4)}$ 60 cm x 30 cm = 55,555 plants ha^{-1}) and two maize hybrids H_1) 30 Y 87 and H_2) 31 R 88. A constant row spacing of 60 cm was kept, while plant to plant distance of 15, 20, 25 and 30 cm was maintained by hand dibbler having a net plot size was 6 m x 3 m with 5 rows in each plot. Nitrogen, Phosphorus and potassium were applied at the rate of 150: 100: 100 kg ha^{-1}. Nitrogen, Phosphorus and potassium were used in the form of urea, diammonium phosphate (DAP) and sulphate of potash (SOP), respectively. One third of nitrogen, whole of the phosphorus and potassium were applied at the time of sowing while one third of remaining nitrogen was applied at knee height and one third at tasseling. All other agronomic practices were kept uniform for all treatments. The observations such as plant height (cm), number of cobs per plant, cob length (cm), 1000-grain weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}) were recorded. The data collected was analyzed statistically by using Fisher‘s analysis of variance technique and least significantly difference test at 5% probability level was applied to compare the treatments means (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Plant height (cm). Plant height is an important component which helps in the determination of growth attained during the growing period. Data showed that the effect of plant population on plant height was significant, while the effect of hybrids and the interactive effect of plant population density and hybrids were non-significant. Plant population density in the *Table 1* showed that maximum plants height (221cm) were observed when the crop was raised at 60x15 cm spacing, which was statistically at par (218.83cm) when the crop was grown at 60x20 cm. Similarly minimum plant height (209.33) was recorded from the plots planted at 60x30 cm. The crop grown at 60x25 cm producing plant height (216) which was statistically at par as of 60x20 cm spacing. These results are in line with the findings of Konuskan (2000) and Griesh and Yakout (2001) who found that plant height increased with increases in plant density up to 10 plants m^{-2}, But Bobro and Bochassi (1994) and Turgut (2000) reported that there were no intra-row spacing effects on plant height.

As regarded the data for hybrids, the two hybrids produced plant height, not statistically significant. The hybrid 30 Y 87 produced tallest plants (217.16) which was statistically at par as of 31 R 88 (215.41). These results are in contrast with Gozubenli *et al*. (2001) and Konuskan (2000) who found that there is a considerable varietal variation for the plant height.

The increased plant height in narrow plant spacing might be due to thick plant stand. The stem diameter is reduced as compared to wider plant spacing. In wider plant spacing there is abundance of available resources and hence the plants were healthier than thick plant stands. In narrow plant spacing there was more competition for available resources and hence plants were tall but weaker than wider plant spacing.

Number of cobs per plant. The number of cobs per plant is an important yield parameter of maize. Data regarding to the number of cobs per plant as affected by plant population density levels and hybrids revealed that the number of cobs per plant was changed significantly with plant population density and hybrids. But the interactive effect of plant population density and hybrids was non-significant.

As regarded plant population density showed in *Table 1*, the maximum number of cobs per plant (1.42) was produced at plant population density of 60x30 cm followed by plant population density of 60x25 cm. The plant population density of 60x20 cm produced cobs (1.27) followed by the minimum number of cobs (1.21) which were produced by the plant population density of 60x15 cm. Increasing density from S_4 to S_1, the number of cobs per plant was significantly reduced possibly due to more competition for light, aeration and nutrients and consequently enabling the plants in these treatments to under go less reproductive growth. These results are in line with the findings of Tianu *et al.* (1983), Sharma and Adamu (1984) and Tyagi *et al*. (1998) who reported that increasing plant population density increased number of ears per meter square and decreased number of cobs per plant.

As data of hybrids is regarded, the two hybrids showed significant results. The maximum number of cobs per plant were produced in the hybrid 30 Y 87 (1.43) followed by the second hybrid 31 R 88 (1.19). This might be due to the changes in the genetic make up of two hybrids. These results are in conformity with the findings of Roy and Biswas (1992), Konuskan (2000) and Gozubenli *et al*. (2001) who reported that number of cobs per m² increased with increasing plant density.

Cob length (cm). Both plant population density and hybrids had significant effects on cob length as shown in *Table 1*. But the interactive effect of plant population density and hybrids was non-significant.

In case of plant population density maximum (20.48) length of cob was produced at plant population density of 60x30 cm, followed by treatment S_3 (60x25 cm) which produced (18.86) length of cob. The treatment S_2 (60x20 cm) produced cob length of (17.52) cm, followed by a minimum of (16.62) in case of S_1 (60 x15 cm) treatment. The data showed that the cob length decreased as the plant population increased. These results are in line with the findings of Karim *et al.* (1983), Kamel *et al.* (1983) and Akcin *et al.* (1993) who concluded that the cob length decreased linearly with increase in plant population. These results indicate that there is a positive relationship between plant spacing and cob length of maize, probably due to variable plant competition.As data of hybrids is regarded the maximum cob length (18.87) was observed in hybrid 31 R 88 followed by 30 Y 87 which produced a length of (17.52). These results are in line with the findings of Konuskan (2000) and Gozubenli *et al*. (2001) who reported that variations in ear characteristics of maize depend upon genotype and environmental conditions.

1000-grain weight (g). 1000-grain weight is an important yield contributing factor, which plays an important role in showing the potential of a variety. Data in *Table 2* indicates that highly significant effect of plant population density on 1000-grain weight. A plant population density of 60x30 cm produced significantly maximum (253.82) weight of 1000 grains, followed by plant population density of 60x25 cm which produced (242.32) grams 1000-grain weight. The treatment S_2 (60x20 cm) produced a weight of (233) followed by a minimum of (223.78) in most populated treatment S_1 (60x15 cm).Results showed that the lowest plant population density resulted in the heaviest grains. Akcin *et al. (*1993) also reported that 1000-grain weight increased with decreasing plant population density in maize. Low grain weight in high PPD might be due to availability of less photosynthates for grain development because of high interspecific competition which could have resulted in low rate of photosynthesis and high rate of respiration as a result of enhanced mutual shading. Reduction in 1000-grain weight due to high plant population density has also been reported by Mannino *et al.*, 1990, Dong and Nian (1995), Cox (1996) and Tyagi *et al.* (1998).

Table 1 - Growth, yield and yield components of maize as affected by spacing levels and hybrids

Spacing /Hybrids	Plant height (cm)			Number of cobs/plant			Cob length (cm)		
	H_1	H_2	Means	H_1	H_2	Means	H_1	H_2	Means
S_1	222.33	219.67	221.00 A	1.30	1.12	1.21 D	16.43	16.80	16.62 D
S_2	219.33	218.33	218.83 ab	1.38	1.17	1.27 c	17.03	18.00	17.52 c
S_3	216.00	216.00	216.00 b	1.50	1.20	1.35 b	18.47	19.27	18.87 b
S_4	211.00	207.67	209.33 c	1.55	1.29	1.42 a	20.00	20.97	20.48 a
Means	217.17	215.42		1.43 a	1.19 b		17.98 b	18.76 a	

Table 2 - Growth, yield and yield components of maize as affected by spacing levels and hybrids

Spacing/Hybrids	1000-grain weight			Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
	H_1	H_2	Means	H_1	H_2	Means	H_1	H_2	Means
S_1	223.37	224.20	223.78 D	7.41	7.31	7.36 B	13.54	12.57	13.06 A
S_2	235.90	230.10	233.00 c	7.89	7.48	7.69 a	10.23	10.46	10.34 b
S_3	246.97	237.67	242.32 b	6.42	6.21	6.32 c	10.20	9.42	9.81 c
S_4	259.83	247.80	253.82 a	5.25	4.76	5.01 d	9.18	8.22	8.70 d
Means	241.52 a	234.94 b		6.74 a	6.44 b		10.79 a	10.17 b	

As the data for hybrids is concerned maximum 1000-grain weight (241.51) was observed in the hybrid 30Y87 followed by a weight of (234.94) in the second hybrid. These results are in conformity with the findings of Rogers and Lomman (1988), Konuskan (2000) and Gozubenli *et al*. (2001) who stated that there were varietal differences in 1000-grain weight, which increased with increasing plant spacing.

Grain yield (t ha^{-1}). Grain yield is a function of integrated effects of genetic make up of cultivars and growing conditions on the yield components of a crop. Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of a crop. The growing conditions are changed by different plant spacings.

Data on grain yield as influenced by plant population density and two hybrids are given in *Table 2*. It is clear from the data that the plant population densities differed highly significantly in grain yield from each other. The maximum grain yield (7.69) was observed in spacing level S_2 (60x20 cm), followed by S_1 (60x15 cm) which produced (7.36) yield. The S_3 (60x25 cm) produced a grain yield of (6.32) followed by a minimum of (5.01) in S_4 (60x30 cm) spacing. Grain yield is the product of crop dry matter accumulation and the proportion of the dry matter allocated to the grain (i.e., harvest index) and harvest index in corn declines when plant density increases above the critical plant density. Our findings are in good agreement with by Tollenar, 1991. Farnham (2001) determined that corn grain yield increased from 10.1 to 10.8 t ha^{-1}. Porter *et al*. (1997) reported inconsistent optimal plant density levels ranging from 86000 to 101270 plants ha^{-1} for corn grain yield across three Minnesota locations.

As hybrids are regarded, the hybrids differed significantly for grain yield. The hybrid 30 Y 87 gave better yield of (6.74) t ha^{-1} as against 31 R 88 which gave (6.44) t ha^{-1} yield. These differences in the grain yield of hybrids are due to the differences in their potential yields. The present results are in good agreement with the findings of Konuskan (2000), Gozubenli *et al*. (2001) and Farnham (2001).

The interactive effect of PPD and hybrids was found to be non-significant. Statistically higher grain yield was (7.89) obtained at density of 60x20 cm spacing and in hybrid H_1 (30 Y 87), while the minimum (4.76) was obtained at planting density of 60x30 cm and in hybrid H_2 (31 R 88).

Straw yield (t ha^{-1}). According to data given in the *Table 2*, the effect of plant population density on straw yield was found to be highly significant. Statistically maximum straw yield of (13.06t ha^{-1}) was achieved in plant population density of 60x15 cm, followed by plant population density of 60x20 cm where straw yield was (10.34 t ha^{-1}). Similarly the plant spacing of 60x25 cm gave a straw yield of (9.81 t ha^{-1}) followed by a minimum of (8.70 t ha^{-1}) which was in the spacing of 60x30 cm. It is clear from the data that the straw yield was progressively decreased with each decrease in plant population. The variability in straw yield per hectare is the result of variation in the crop stand per unit area. These results are in line with the findings of Knapp and Reid (1981), Anjum (1987) and Tetio-Kagho and Gardner (1988 b).

Table 2 showed that the maximum straw yield (10.78) was obtained from the hybrid 30 Y 87 followed by the second hybrid 31 R 88 which gave (10.16 t ha^{-1}) yield. The differences in grain yield may be due to contradiction in their genetic make up. These results are in agreement with Rezuvaev (1981) and Roy and Biswas (1992) who reported that fodder yield increased with increasing plant density.

CONCLUSION

From the above experiment we concluded that under the agro-climatic conditions of Faisalabad, the maize hybrid 30 Y 87 performed best for grain yield when sown at 60 cm row spacing and 20 cm plant to plant spacing than the other hybrid 31 R 88.

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