Growth and yield of hybrid maize [*Zea mays* (L.)] as influenced by plant density and fertilizer levels

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ABSTRACT

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *kharif* 2007 to study the effect of plant density and fertilizer levels on the growth and yield of hybrid maize under irrigated condition. Two spacings *viz.*, 60 x 20 cm and 75 x 20 cm accommodating 83, 333 and 66, 666 plants ha^{-1} were assigned to the mainplot. Three fertilizer levels *viz.*, 150:75:75, 200:100:100 and 250:125:125 NPK kg ha^{-1} constituted the subplot treatments. The experiment was laid out in a split plot design with four replications. The results of the experiment revealed that among the spacing, normal spacing of 60 x 20 cm recorded taller plants, while wider spacing of 75 x 20 cm recorded higher LAI, DMP, number of leaves plant^{-1}, stem girth, yield attributes and yield. Application of 250:125:125 NPK kg ha^{-1} recorded significantly better growth parameters and yield. However, the yield was comparable with 200:100:100 NPK kg ha^{-1}.

Key words : Hybrid maize, Spacing, Fertilizer levels, Growth, Yield.

INTRODUCTION

Maize [*Zea mays* (L.)] is one of the three most important cereals next to rice and wheat, in the world as well in India. It is one of the most versatile crops and can be grown in diverse environmental conditions and has diversified uses in human food and animal feed. It has got immense potential and is, therefore, called as "miracle crop" and also "queen of cereals". Maize, being a C_4 plant is an efficient converter of absorbed nutrients into food. Maize is cultivated both in tropical and temperate regions of the world. In India, it occupies third place among the cereals after rice and wheat and is cultivated in an area of 7.59 million ha with a production of 14.71 million tonnes and the average productivity is 1938 kg ha^{-1} (Anonymous, 2007).

The productivity of any crop is the ultimate result of its growth and development. The growth of any crop is determined mainly in terms of its plant height, number of functional leaves and dry matter. These growth parameters are affected by nutrition and extent of population density. Plant population is the prime factor for getting maximum yield. Plant population is decided by the inter and intra row spacing of crops. Optimum plant population for any crop varies considerably due to environment under which it is grown. It is not possible to recommend a generalized plant population since the crop is grown in different seasons with different management practices under varied environment.

Among the plant nutrients primary nutrients such as, nitrogen, phosphorus and potassium play a crucial role in deciding the growth and yield. Nitrogen is the most deficient primary nutrient in Indian soils. The response of crops to nitrogen varies widely from place to place, depending upon the fertility level of soil and other environmental conditions. This necessitates the study on the response of crop to different levels of fertilizer. The use efficiency of applied nitrogen is only about 30 - 40 per cent (Parthipan, 2000). The nitrogen use efficiency can be improved with the use of hybrids, optimum plant population and application of nitrogen coinciding with peak need by the crop. Optimum nitrogen requirement will vary with plant population. Phosphorus is known to stimulate early and extensive development of root systems, which enables rapid maize growth and to mature early (Sankaran *et al.*, 2005). Maize has high yield potential and responds greatly to potassium fertilizer. Therefore, proper management of potassium nutrient is essential to realize maximum potential of the crop because it plays an important role in activating various enzymes (Tisdale *et al*., 1990). Hence an attempt was therefore made to study the effect of different plant densities and fertilizer levels on growth and yield of hybrid maize during *kharif* season.

MATERIALS AND METHODS

An experiment was conducted during *kharif* 2007 at Tamil Nadu Agricultural University, Coimbatore to study the effect of different spacing and fertilizer levels on growth and yield of hybrid maize. The experiment was laid out in a Split Plot Design with four replications. Two spacings *viz.*, 60 x 20 cm (S_1) and 75 x 20 cm (S_2) accommodating 83, 333 and 66, 666 plants ha^{-1} were assigned to the main plot. Three fertilizer levels *viz.*,

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150:75:75 (F_1), 200:100:100 (F_2) and 250:125:125 (F_3) NPK kg ha^{-1} constituted the subplot treatments.

The soil of the experimental field was sandy clay loam in texture belonging to *Typic Ustropept*. The nutrient status of soil was low in available nitrogen (242.6 kg ha^{-1}), medium in available phosphorus (16.5 kg ha^{-1}) and high in available potassium (552 kg ha^{-1}). Maize hybrid, COH (M) 5 a high yielding single cross hybrid released by Department of millets, Tamil Nadu Agricultural University, Coimbatore was chosen for the study.

Well decomposed farm yard manure at the rate of 12.5 t ha^{-1} was applied uniformly over the field before last ploughing. $ZnSO_4$ @ 37.5 kg ha^{-1} was applied uniformly as basal to all the plots. Ridges and furrows were formed in the beds as per the spacing treatments. Seeds of maize hybrids were sown on the side of the ridges by adopting different spacings in the mainplot as per the treatment schedule. Seeds were dibbled at the rate of one seed $hill^{-1}$. The seeds were pre-treated with ridomil @ 2g kg^{-1} of seeds and *Azospirillum*, 600 g per hectare of seeds (15 kg ha^{-1}) before sowing. As per the treatment schedule, nitrogen was applied in three splits *viz*., 25: 50: 25 per cent as basal, 25 and 45 DAS, respectively. The entire dose of phosphorus was applied basally. The potassium was applied in two equal split doses *viz*., basal and at 45 DAS. The N, P and K fertilizers were applied in the form of urea (46 % N), single super phosphate (16 % P_2O_5) and muriate of potash (60 % K_2O), respectively. The fertilizers were placed at 5 cm depth on sides of the ridges by forming small furrows.

The LAI was calculated by using the following formula as suggested by Balakrishnan *et al*. (1987):

$$LAI = \frac{L \times B \times N \times 0.796}{Spacing\ (cm^2)}$$

where,

L = Mean maximum length of the leaf (cm)

B = Mean maximum breadth of the leaf (cm)

N = Mean number of leaves per plant

0.796 = Constant

For dry matter production (DMP), the plant samples were sun dried for three days followed by oven drying at 70°C till constant weight was obtained and the dry weight was recorded and expressed in kg ha^{-1}.

Grain yield was recorded for individual treatment at 14 per cent seed moisture and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Growth parameters:

Crop geometry had significant influence on all the growth parameters *viz.*, plant height, stem girth, number of leaves, LAI and DMP. Plants were taller under normal spacing of 60 x 20 cm than wider spacing of 75 x 20 cm. This might be due to the higher interplant competition for sunlight which might have made the plants to grow taller to trap more sunlight and it decreased with increase in the plant spacing. Crop sown at closer spacing normally exhibits higher plant height than wider spacing as reported by Reddy and Reddy (2002) and Singh *et al*. (1997) lend support to the present finding. Wider spacing of 75 x 20 cm recorded significantly higher number of leaves, stem girth, LAI and higher DMP than 60 x 20 cm spacing. This might be due to efficient utilization of space and nutrients by maize hybrids under wider spacing. Higher plant densities produced taller plants with lower stem diameter. A similar result of increased stem girth positively by wider spacing was reported by Bruns and Abbas (2005). Better utilization of available resources might have increased the functional leaves and in turn enhanced the LAI. This might be due to the utilization of available resources to a greater extent that could have favoured higher stem girth and LAI which in combination caused an increase in DMP at 75 cm spacing as compared to 60 cm spacing. Further, more availability of sunlight and CO_2 under wider spacing might have resulted in higher photosynthetic activities and ultimately higher production of dry matter. The present findings are in consonance with the reports of Cox *et al.* (2006) in maize and Thavaprakaash *et al.* (2005) in baby corn.

The fertilizer levels also significantly influenced the plant height, stem girth, number of leaves, LAI and DMP. Application of 250:125:125 NPK kg ha^{-1} recorded better growth parameters. Application of 250:125:125 NPK kg

Table 1 : Effect of spacing and fertilizer levels on growth parameters of hybrid maize

Treatments	60 DAS				
	Plant height (cm)	No of leaves $plant^{-1}$	Stem girth (cm)	LAI	DMP (kg ha^{-1})
Spacing (cm)					
S_1 - 60 x 20 cm	207.0	14.20	8.10	4.79	6859
S_2 - 75 x 20 cm	184.9	15.80	8.70	5.85	7551
S.E.±	3.78	0.28	0.17	0.09	143.8
C.D. (P = 0.05)	8.43	0.64	0.38	0.21	320.5
Fertilizer levels (NPK kg ha^{-1})					
F_1 - 150 : 75 : 75	186.3	14.40	8.10	5.03	7073
F_2 - 200 : 100 : 100	197.1	15.10	8.50	5.30	7410
F_3 - 250 : 125 : 125	204.6	15.50	8.80	5.63	7631
S.E.±	3.89	0.29	0.17	0.10	145.5
C.D. (P = 0.05)	8.04	0.59	0.34	0.21	300.3
S x F Interaction	NS	NS	NS	NS	NS

NS- Non significant

Table 1 : Effect of plant density and fertilizer levels on grain and stover yield (kg ha^{-1}) of hybrid maize

Fertilizer levels (kg ha^{-1})	Grain yield (kg ha^{-1}) Spacing (cm) S_1 60 x 20	S_2 75 x 20	Mean	Stover yield (kg ha^{-1}) Spacing (cm) S_1 60 x 20	S_2 75 x 20	Mean
F_1 - 150 : 75 : 75	5048	5363	5205	8471	9208	8840
F_2 - 200 : 100 : 100	5761	6794	6278	9785	11815	10800
F_3 - 250 : 125 : 125	5923	7045	6485	10042	12144	11093
Mean	5578	6400		9433	11056	
	S.E.±	C.D. (P = 0.05)		S.E.±	C.D. (P = 0.05)	
S	93.32	207.9		169.9	378.4	
F	103.7	214.1		198.6	409.9	
S at F	151.8	322.8		285.4	605.6	
F at S	146.7	302.8		280.8	579.7	

ha^{-1} recorded higher DMP (7631 kg ha^{-1}) than the other fertilizer levels. However, it was comparable with 200:100:100 NPK kg ha^{-1} which recorded 7410 kg ha^{-1} (Table 1). The increase in DMP was due to the improved foraging ability, higher nutrient availability and uptake of nutrients with better assimilation which could have helped the plant to grow taller with more LAI as already reported by Verma and Joshi (1999) as plant height and LAI were directly correlated to DMP. The better LAI indicating the better photosynthetic efficiency as a reflection of assimilation and dry matter production due to continuous release of nutrients by split application of nitrogen and potassium might be the plausible reason for such an increase in dry matter production.

Grain and stover yield:

Plant spacing of 75 x 20 cm recorded significantly higher grain yield (6400 kg ha^{-1}) than 60 x 20 cm plant spacing (Table 2). The increase in grain yield under this treatment was 12.8 per cent over 60 x 20 cm spacing. Among the fertilizer levels, fertilizer application at 250:125:125 NPK kg ha^{-1} recorded the highest grain yield of 6485 kg ha^{-1}, but was comparable with the yield obtained with 200:100:100 NPK kg ha^{-1}. The grain yield increase with 250:125:125 and 200:100:100 NPK kg ha^{-1} was 19.7 and 17.1 per cent, respectively over fertilizer application at 150:75:75 NPK kg ha^{-1}.

The interaction effect between plant spacing and fertilizer levels was significant on maize yield. The highest maize yield was recorded with 250:125:125 NPK kg ha^{-1} (7045 kg ha^{-1}) and plant spacing of 75 x 20 cm (S_2F_3). This was comparable with the same spacing applied with 200:100:100 NPK kg ha^{-1} (6794 kg ha^{-1}) (S_2F_2).

This increase in yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop. The yield potential of maize is mainly governed by the growth and yield components. The positive and significant improvement in LAI and DMP noticed at different stages, increased yield attributes and nutrient uptake would have resulted in enhanced cob yield. Paulpandi *et al*. (1998) reported higher yield of maize under wider row spacing due to better availability of resources. The present finding corroborates with the findings of and Maddonni *et al.* (2006) in maize and Thavaprakaash *et al.* (2005) in baby corn.

Since N is the major structural constitute of cells, as N level increased, the rate of vegetative and reproductive growth also increased in plant due to increase in assimilating surface of plant as well as total photosynthesis. In physiological terms, the grain yield of maize is largely governed by source (photosynthesis) and sink (grain) relationship as it directly related to N. These resulted in more grain yield when N was higher.

Plant spacing and fertilizer levels influenced the stover yield significantly as that of grain yield. Among the spacings, wider spacing of 75 x 20 cm recorded higher stover yield (11056 kg ha^{-1}) than 60 x 20 cm. Increasing fertilizer levels increased the stover yield significantly. The higher level of 250:125:125 NPK kg ha^{-1} recorded higher stover yield (11093 kg ha^{-1}) followed by 200:100:100 NPK kg ha^{-1}. Fertilizer level of 150:75:75 NPK kg ha^{-1} recorded the least stover yield (8840 kg ha^{-1}). The interaction between spacing and fertilizer levels was significant.

The results of the experiment revealed that among the spacing, normal spacing of 60 x 20 cm recorded taller plants, while wider spacing of 75 x 20 cm recorded higher LAI, DMP, number of leaves plant^{-1}, stem girth, yield attributes and yield. Application of 250:125:125 NPK kg ha^{-1} recorded significantly better growth parameters and yield. However the yield was comparable with 200:100:100 NPK kg ha^{-1}.

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