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Nutrient uptake and yield of hybrid maize (*Zea mays* L.) and soil nutrient status 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 yield and nutrient uptake of hybrid maize and soil nutrient status 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 the grain yield was higher under plant spacing of 75 x 20 cm. Grain yield increased with increasing levels of NPK upto 250:125:125 NPK kg ha^{-1} but the statistical disparity was not observed beyond 200:100:100 NPK kg ha^{-1}. Wider spacing and increased NPK levels resulted in higher NPK uptake and recorded higher soil available NPK.

Key words : Hybrid maize, Spacing, Fertilizer levels, Yield, Nutrient uptake, Nutrient level.

INTRODUCTION

Maize (*Zea mays* L.) 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. Besides its use as food and fodder, maize is now gaining increased importance on account of its potential uses in manufacturing of starch, plastic, rayon, textile, adhesive, dyes, resins, boot polish, syrups, ethanol, etc. 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. 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.

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, with these ideas in view, an attempt was, therefore, made to study the effect of different spacing and fertilizer levels on nutrient uptake 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 nutrient uptake 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 mainplot. Three fertilizer levels *viz*., 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

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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. Zn SO_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 the seeds. 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 oven dried plant samples of maize were chopped and ground in wiley mill and was analyzed for available N, P_2O_5, K_2O. The nitrogen, phosphorus and potassium content were analyzed by the standard procedure given by Yoshida *et al*. (1971), Olsen and Sommers (1982) and Piper, (1966), respectively. The nutrient values obtained as percentage in the analysis were computed to kg ha^{-1} by multiplying with the corresponding DMP obtained for each treatment. The grain yield was recorded for individual treatment at 14 per cent seed moisture and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

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 1). 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 might be due to optimum plant stand with adequate NPK levels, resulting in vigorous plant growth.

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 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.

Nutrient uptake:

Nitrogen:

Spacing had significant influence on the N uptake (Table 2). 75 x 20 cm spacing recorded higher N uptake. This might be due to lower plant population which led to higher dry matter production. Reddy and Khera (2000) have also reported that wider spacing was advantageous as compared to normal spacing for more nutrient uptake.

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	

Malaiya *et al.* (2004) also found that N, P and K uptake was higher with wider planting. Further the plant population was optimum with 75 x 20 cm might have resulted in higher nitrogen uptake than normal spacing of 60 x 20 cm. This is in confirmation with the findings of Yogananda *et al.* (1999), Nanjundappa and Manure (2002) who found that the quantum of N, P and K removal per unit area was found to be inversely related to plant density and nutrient absorption by individual plants.

Application of 250 N kg ha^{-1} recorded higher nutrient uptake. The increased uptake of N at higher doses resulted in initial build up of vigorous growth and higher photosynthetic rate which led to better uptake of nutrients throughout the crop growth period. Similar findings were also reported by Selvaraju and Iruthayaraj (1995), Shivay *et al*. (1999) and Parthipan (2000).

Table 2 : Effect of spacing and fertilizer levels on nutrient uptake and on post harvest soil available nutrients of hybrid maize

Treatments	Nutrient uptake at 60 DAS (kg ha^{-1}) N	P	K	Post harvest soil available Nutrients (Kg ha^{-1}) N	P	K
Spacing (cm)						
S_1 - 60 x 20 cm	98.59	20.2	154.6	153.2	11.44	547.5
S_2 - 75 x 20cm	109.6	21.4	164.6	173.1	14.65	576.4
S.E.±	1.97	0.39	3.22	3.05	0.24	10.59
C.D. (P = 0.05)	4.39	0.88	7.19	6.82	0.54	23.61
Fertilizer levels (NPK kg ha^{-1})						
F_1 - 150 : 75 : 75	88.00	18.8	150.7	149.1	10.90	544.8
F_2 - 200 : 100 : 100	104.4	21.1	160.6	163.2	13.32	563.9
F_3 - 250 : 125 : 125	119.7	22.4	166.5	177.1	14.85	577.5
S.E.±	2.09	0.41	3.20	3.21	0.25	10.92
C.D. (P = 0.05)	4.33	0.84	6.60	6.63	0.53	22.55
S x F Interaction	NS	NS	NS	NS	NS	NS

NS - Non significant

Phosphorus:

P uptake was significantly influenced by both spacing and fertilizer levels. The P uptake was high under wider spacing of 75 x 20 cm with 250:125:125 NPK kg ha^{-1}. This might be due to increased growth and dry matter production with the application of N and also due to increased N uptake. This is in line with the findings of Baskaran *et al.* (1992) and Parthipan (2000).

Potassium:

Wider spacing and higher dose of NPK improved the uptake of K. This might be due to synergistic effect of N and K and also due to better foraging capacity of roots due to increased NP application which resulted in increased dry matter production. Similar results were reported earlier by Nanjundappa *et al.* (1994) and Kumar and Singh (2003).

Post harvest soil available nutrients:

Post harvest soil available N, P and K were favorably influenced by both spacing and NPK levels. Wider spacing and increased NPK levels recorded higher soil available N, P and K. Irrespective of NPK levels, normal spacing of 60 x 20 cm recorded lower soil available nutrients. This might be due to optimum plant population and increased nutrient uptake. Similar findings were reported by Reddy and Khera (2000).

Conclusion:

The results of the experiment revealed that the grain yield was higher under plant spacing of 75 x 20 cm. Grain yield increased with increasing levels of NPK upto 250:125:125 NPK kg ha^{-1} but the statistical disparity was not observed beyond 200:100:100 NPK kg ha^{-1}. Wider spacing and increased NPK levels resulted in higher NPK uptake and recorded higher soil available NPK.

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