Madras Agric. J., 96 (1-6): 139-143, June 2009
https://doi.org/10.29321/MAJ.10.100460

Influence of Plant Density and Fertilizer on Yield Attributes, Yield and Grain Quality of Hybrid Maize

M. Srikanth*, M. Mohamed Amanullah and P. Muthukrishnan
Department of Agronomy,
Tamil Nadu Agricultural University, Coimbatore-641 003

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 yield and quality of hybrid maize under irrigated condition. The experiment was laid out in a split plot design with four replications. 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 results revealed that wider spacing of 75 x 20 cm recorded higher yield attributes, yield and higher crude protein content. Application of 250:125:125 NPK kg ha^{-1} recorded significantly higher yield parameters and yield. However the yield was comparable with 200:100:100 NPK kg ha^{-1}. Higher dose of NPK resulted in higher crude protein content but starch content showed a declining trend.

Key words: Hybrid maize, spacing, fertilizer levels, yield attributes, yield, grain quality

Maize (*Zea mays* L.) is one of the most versatile crops and can be grown in diverse environmental conditions and has diversified uses as human food and animal feed. Besides its use as food and fodder, maize is now gaining importance on account of its potential uses in manufacturing of starch, resins, 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.

The productivity of any crop is the ultimate result of its growth and development. Plant population is the prime factor for getting maximum yield which is decided by the inter and intra row spacing of crops.

Among the plant nutrients, primary nutrients such as, nitrogen, phosphorus and potassium play a crucial role in deciding the growth and yield. 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 density. 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. The maize grain is valued based on its quality (Starch and crude protein) in poultry industry. Although maize grain is valued by its starch content which is considered as important quality factor, any increase in the crude protein content is a welcome feature. Hence, an attempt was made to study the effect of different spacing and fertilizer levels on the yield attributes, yield and grain quality of hybrid maize during *kharif* season.

Materials and Methods

Field experiment was conducted during *kharif* 2007 at Tamil Nadu Agricultural University, Coimbatore to study the effect of different spacing and fertilizer levels on the yield attributes, yield and grain quality of hybrid maize.

*Corresponding author

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 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. The fertilizer 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 grain yield was recorded for individual treatment at 14 per cent seed moisture and expressed in kg ha^{-1}.The crude protein and starch content were analyzed by following standard procedures given by Yoshida *et* al. (1971) and Hedge and Hofreiter, (1962) respectively.

Results and Discussion

Yield Parameters

Maize raised at 75 x 20 cm crop geometry had significant influence on yield attributes *viz.,* cob length, girth, weight, number of rows cob^{-1} and number of grains row^{-1} when compared to 60 x 20 cm. This enhanced yield parameters could be attributed to the reduced interplant competition that resulted in adequate availability of moisture and nutrients and increased light interception. These factors positively reflected on increased LAI, higher photosynthetic rate and accumulation of more assimilates during the reproductive phase which in turn increased the sink size. Therefore, the higher availability of source under wider spacing recorded significantly higher values of the sink in terms of length, girth and weight of the cob. This is in accordance with the finding of Maddonni *et al.* (2006) in maize and Thavaprakaash *et al.* (2005) in baby corn. Similar increased yield attributes with wider spacing was also reported by Gozubenli *et al*. (2003) and Gollar and Patil (2000) in hybrid maize.

Successive increase in NPK levels from 150 to 250 kg ha^{-1} had marked influence on the yield attributes of hybrid maize but after 200 kg ha^{-1} the increase was comparatively low. The increased N levels increased the yield attributes by better uptake of all the nutrients and increased translocation of photosynthatates from source to sink in hybrid maize upto 200 kg as also reported by Parthipan (2000) and upto 225 kg by Singh *et al*. (1997). Increased doses of P and K had marked influence on yield attributes. Saleem *et al*. (2003) observed in hybrid maize that response was upto 150 kg P_2O_5 ha^{-1}. Elevated doses of phosphorus increased the forage activity, accumulation of food reserves, increased functional leaves and LAI, higher nutrient uptake which lead to higher yield attributes and yield. Ali *et al*. (2004) reported that with higher dose of K there is enhancement of LAI, better nutrient translocation from source to

Table 1. Effect of spacing and fertilizer levels on yield attributes and quality of hybrid maize

Treatments	Cob length (cm)	Cob girth (cm)	Number of grain rows cob^{-1}	Number of grains row^{-1}	Cob weight (g)	Test weight (g)	Shelling percentage	Crude protein content (%)	Starch content (mg g^{-1})
Spacing (cm)									
S_1 - 60 x 20 cm	17.70	13.70	13.60	36.60	181.8	28.40	69.00	10.51	68.05
S_2 - 75x 20 cm	21.00	15.30	14.90	39.70	207.6	30.30	71.20	11.07	68.14
SEd	0.36	0.27	0.27	0.71	3.62	0.55	1.42	0.20	0.94
CD (P = 0.05)	0.80	0.60	0.60	1.59	8.08	1.22	NS	0.44	NS
Fertilizer levels (NPK kg ha^{-1})									
F_1 - 150 : 75 : 75	18.50	14.10	13.90	37.30	183.6	28.80	68.60	9.78	67.52
F_2 - 200 : 100 : 100	19.50	14.50	14.30	38.20	192.2	29.40	70.60	10.52	69.81
F_3 - 250 : 125 : 125	20.10	15.10	14.70	39.10	203.8	29.90	71.10	12.06	66.95
SEd	**0.37**	**0.28**	**0.27**	**0.73**	**3.76**	**0.57**	**1.44**	**0.21**	**0.74**
CD (P = 0.05)	**0.77**	**0.58**	**0.57**	**NS**	**7.77**	**NS**	**NS**	**0.44**	**1.53**
SXN Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

sink and better nutrient uptake, hence these factors ultimately result in increase in yield attributes and finally the yield.

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. 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. This was comparable with the same spacing applied with 200:100:100 NPK kg ha^{-1} (6794 kg ha^{-1}).

This increase in yield was due to increased sink capacity (Table 1). 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)

Table 2. 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})			Stover yield (kg ha^{-1})		
	Spacing (cm)		Mean	Spacing (cm)		Mean
	S_1 60 x 20	S_2 75 x 20		S_1 60 x 20	S_2 75 x 20	
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	

	SEd	CD (P = 0.05)	SEd	CD (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**

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}.

Quality attributes

The starch content, an important quality parameter in maize was not influenced by plant population levels. But there existed significant difference in starch content among fertilizer levels. The fertilizer level, @ 200:100:100 NPK kg ha^{-1} recorded significantly higher starch content (69.81 mg g^{-1}) than the other two fertilizer levels.

Plant spacings and fertilizer levels influenced the crude protein content, which is also considered as an additional quality next to starch. Among the spacings tried, wider spacing of 75 x 20 cm recorded higher grain protein content (11.07 %) than normal spacing of 60 x 20 cm (10.51 %). Regarding the fertilizer levels, application of higher dose of 250:125:125 NPK kg ha^{-1} recorded significantly higher crude protein content (12.06 %) than the other two fertilizer levels.

Protein is the major nutritive constituent of seed, which determines the ultimate quality of seed. The crude protein content increased significantly with increase in fertilizer application. Maize hybrids need large amount of nitrogen for production of dry matter which also might have augmented protein synthesis. These findings are in conformity with those of Kurdikeri *et al.* (1973). Greater protein content at high K_2O levels might be due to the enhanced uptake and translocation of nitrate which provides nitrogen for amino acid synthesis. Moreover, K is involved in the synthesis of ATP that is required in both nitrogen uptake and protein synthesis. These results are in accordance with Chaudhry and Malik (2000).

Contrary to crude protein, the carbohydrate exhibited a reverse trend. With increase in levels of NPK there was a decrease in carbohydrate in maize. This decrease might be due to the enhanced synthesis of protein at the expense of sugar at higher levels of NPK and derivation of carbon skeleton from sugars for synthesis of amino acids. These results are in line with Duraisami *et al*. (2002). Similar result of decrease in starch content due to increase in nitrogen level was also reported by Miao *et al*. (2006)

The results of the present study indicated that wider spacing of 75 x 20 cm recorded higher yield attributes, yield and higher crude protein content. Application of 250:125:125 NPK kg ha^{-1} recorded significantly higher yield parameters and yield. However the yield was comparable with 200:100:100 NPK kg ha^{-1}. Higher dose of NPK resulted in higher crude protein content but starch content showed a declining trend.

Reference

Ali, T., Anwar, S., Shah, W.A. and Ahmad, B. 2004. Response of maize hybrids/cultivars to various levels of potassium and irrigation frequencies. *J. Agron.,* **3**: 201-207.

Chaudhry, A.U. and Malik, J.K. 2000. Determination of optimum levels of potash and its effects on yield and quality of maize. *Pak. J. Biol. Sci.,* **3**: 1994-1995.

Duraisami, V.P., Raniperumal and Mani, A.K. 2002. Grain quality as influenced by fertilizer nitrogen, coirpith and biofertilizer in sole and intercropped sorghum-maize-soybean sequence. *Mysore J. Agric. Sci.,* **36**: 97-103.

Gollar, R.G. and Patil, V.C. 2000. Effect of plant density on growth and yield of maize genotypes during *rabi* season. *Karnataka J. Agric. Sci.,* **13**: 1-6.

Gozubenli, H., Sener, O., Konuskan, O. and Kilinc, M. 2003. Effect of hybrid and plant density on grain yield and yield components of maize (*Zea mays*). *Indian J. Agron.,* **48**: 203-205.

Hedge, J.E. and Hofreiter, B.T. 1962. In Carbohydrate Chemistry. R.L. Whistler and J.N. De Miller (Eds). Academic Press, New York, USA, P.17.

Kurdikeri, G.B., Patil, R.V. and Krishnamurthy, K. 1973. Response of cowpea to varying fertilizer levels. *Mysore J. Agric. Sci.,* **7:** 170-174.

Maddonni, G.A., Cirilo, A.G. and Otegui, M.E. 2006. Row width and maize grain yield. *Agron. J.,* **98:** 1532-1543.

Miao, Y., Mulla, D.J., Robert, P.C. and Hernadez, J.A. 2006. Within-field variation in corn yield and grain quality responses to nitrogen fertilization and hybrid selection. *Agron. J.,* **98**: 129-140.

Parthipan, T. 2000. Nitrogen management strategies in hybrid maize (COH 3) using SPAD meter and predictions using CERES - MAIZE model. *M.Sc(Ag.) Thesis.* Tamil Nadu Agric. Univ., Coimbatore.

Paulpandi, V.K., Solaiyappan, U. and Palaniappan, SP. 1998. Effect of plant geometry and fertilizer levels on yield and yield attributes in irrigated maize. *Indian J. Agric. Res.,* **33**: 125-128.

Sankaran, N., Meena, S. and Sakthivel, N. 2005. Input management in maize. *Madras Agric.J.,* **92**: 464-468.

Saleem, A., Javed, H. I. and Z. A. Ullah. 2003. Response of maize cultivars to different NP-levels under irrigated condition in Peshawar Valley. *Pak. J. Biol. Sci.,* **6**: 1229-1231.

Singh, D., Tyagi, R.C., Hooda, I.S. and Verma, O.P.S. 1997. Influence of plant population, irrigation and nitrogen levels on the growth of spring maize. *Haryana J. Agron.,* **13**: 54-58.

Thavaprakaash, N., Velayudham, K. and Muthukumar, V.B. 2005. Effect of crop geometry, intercropping systems and integrated nutrient management practices on the productivity of baby corn (*Zea mays* L.) based intercropping systems. *Res. J. Agric. biol. Sci.,* **1**: 295-302.

Yoshida, S., Forno, D.A. and Cock, J.H.1971. Laboratory Manual for Physiological Studies in Rice. IRRI., Philippines.

Manuscript number : 147/08

Date of receipt : August 6, 2008

Date of acceptance : April 10, 2009