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Influence of Fertilizer Levels and Mycorrhiza on Yield Attributes, Yield and Grain Quality of Hybrid Maize

T. Ananthi*, M. Mohamed Amanullah and K.S. Subramanian
Department of Agronomy
Tamil Nadu Agricultural University, Coimbatore - 641 003

A field experiment was conducted at Agricultural Research Station, Bhavanisagar during *kharif* 2009 to study the influence of mycorrhizal inoculation and fertilizer levels on the yield and grain quality of hybrid maize under irrigated condition. The experiment was laid out in a factorial randomized block design with four replications. Four fertilizer levels *viz*., 200:100:100, 150:100:100, 200:75:100 and 150:75:100 NPK kg ha^{-1} were the treatments under factor 'A'. Two mycorrhizal treatments *viz*., no inoculation of mycorrhiza (control) (M^{-}) and inoculation of mycorrhiza (M^{+}) were included under factor 'B'. The results revealed that application of 200:100:100 NPK kg ha^{-1} recorded higher yield attributes, yield and higher crude protein content. Among the mycorrhiza, mycorrhizal inoculated treatments recorded higher grain and stover yield. Regarding the treatment combinations, application of 150: 75:100 NPK kg ha^{-1} along with mycorrhizal inoculation recorded significantly higher yield parameters and yield. However, the yield was comparable with 200:75:100 NPK kg ha^{-1} along with mycorrhizal inoculation. Higher dose of NPK resulted in higher crude protein content but starch content showed a declining trend.

Key words: Hybrid maize, fertilizer levels, mycorrhiza, 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 C4 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, inorganic and organic fertilization are the important prime factors that determine the yield of maize crop. 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, soil application of arbuscular mycorrhiza and application of fertilizers coinciding with peak need by the crop.

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). Enhancement of P uptake by mycorrhizal hyphae can also be indirectly attributed to the faster uptake rate of P by the hyphae and the disturbance of the solution solid P equilibrium, which will increase the sorption of absorbed phosphate into soil solution (Nye and Tinker, 1977).

*Corresponding author email: ananthu12@gmail.com

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 this 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 mycorrhizal inoculation and varying fertilizer levels on the yield attributes, yield and grain quality of hybrid maize during kharif season.

Materials and Methods

Field experiment was conducted at Agricultural Research Station, Bhavanisagar during *kharif* 2009 to study the influence of mycorrhizal inoculation and fertilizer levels on the yield attributes, yield and grain quality of hybrid maize under irrigated condition. The experiment was laid out in a factorial randomized block design with four replications. Four fertilizer levels *viz.*, 200:100:100, 150:100:100, 200:75:100 and 150:75:100 NPK kg ha^{-1} were the treatments under factor 'A'. Two mycorrhizal treatments viz., no inoculation of mycorrhiza (control) (M^{-}) and inoculation of mycorrhiza (M^{+}) were included under factor 'B'. The soil of the experimental field was red sandy loam in texture belonging to *Typic Ustropept.* The nutrient status of soil was low in available nitrogen (230 kg ha^{-1}), medium in available phosphorus (20.2 kg ha^{-1}) and medium in available potassium (268.2 kg ha^{-1}). Maize hybrid, COH (M) 5, a high yielding single cross hybrid released by Tamil Nadu Agricultural University, Coimbatore was chosen for the study.

Seeds of maize hybrids were sown on the side of the ridges by adopting a spacing of 75 x 20 cm along with vermiculite based mycorrhizal inoculum at a depth of 5 cm below the seeds. The mycorrhizal inoculum (*Glomus intraradices* TNAU-03-08) used in this study was purchased from the Department of Agricultural Microbiology, Tamil Nadu Agricultural University. This strain was cultured in maize plants and propagules comprised of infected root bits and spores were blended in sterile vermiculite. The inoculum with the spore density of 200 spores g^{-1} was applied as a thin layer beneath the seeds prior to sowing @ 100 kg ha^{-1}. Seeds were dibbled at the rate of one seed $hill^{-1}$.

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. As per the treatment schedule, nitrogen as urea was applied in three splits *viz*., 25: 50: 25 per cent as basal and on 25 and 45 DAS, respectively. The entire dose of phosphorus as single super phosphate was applied basally. The potassium as muriate of potash was applied in two equal split doses *viz*., basal and at 45 DAS.

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

The yield attributes such as cob length, cob girth, number of grain rows cob^{-1}, number of grains row^{-1}, cob weight and test weight were favourably influenced by fertilizer levels (Table 1).

Successive increase in N levels from 150 to 200 kg ha^{-1} had marked influence on the yield attributes of hybrid maize. Application of higher levels of N at 200 kg ha^{-1} recorded more cob length (20.47 cm), cob girth (14.03 cm), number of grain rows cob^{-1} (13.71), number of grains row^{-1} (39.35), cob weight (206.7 g) and test weight (32.54 g). The increase in yield attributes due to increase in N levels might be due to the better uptake of all the nutrients and increased translocation of photosynthates from source to sink in hybrid maize upto 200 kg as also reported by Parthipan (2000).

Increased doses of P had marked influence on yield attributes. Saleem *et al.* (2003) observed response in hybrid maize upto 150 kg P_2O_5 ha^{-1}. Elevated doses of phosphorus might have increased the forage activity, accumulation of food reserves, increased functional leaves and LAI, higher nutrient uptake which lead to higher yield attributes and yield.

Inoculation of mycorrhiza significantly increased the cob length, cob girth, number of grain rows cob^{-1}, number of grains row^{-1}, cob weight and test weight. Although the mechanism by which early P nutrition and grain yield are related is unknown, it has been suggested that, since the meristems originating ears are formed at early maize developmental stages, an improved nutrition at those stages might increase the number of kernels formed and filled (Barry and Miller, 1989). Another possible explanation given was that the time to reach reproductive stage seems to be shortened by increased early P nutrition there could be more warm days for grain filling which could thereby increase grain yield. Khan (1975) also reported an increased yield and number of kernels in relation to early mycorrhizal development and P nutrition of maize in the field. The effect of mycorrhizal colonization in decreasing the time taken to initiate the reproductive stage and increasing fruit production has already been documented from field experiments (Mayra *et al.,* 1998).

Grain and stover yield

Fertilizer level of 200:100:100 NPK kg ha^{-1} recorded the highest grain yield of 6494 kg ha^{-1} but was comparable with 200:75:100 NPK kg ha^{-1}. The grain yield increase with 200:100:100 and 200:75:100 NPK kg ha^{-1} was 20.5 and 19.9 per cent, respectively, over the fertilizer level of 150:75:100 NPK kg ha^{-1}(Table 2).Mycorrhizal inoculation recorded higher grain yield (6736 kg ha^{-1}) than no inoculation (5869 kg ha^{-1}).

The interaction between fertilizer levels and mycorrhizal inoculation on maize grain yield was significant. The highest grain yield (7275 kg ha^{-1}) was recorded under the treatment combination 150:75:100 NPK kg ha^{-1} with mycorrhizal inoculation followed by 200:75:100 NPK kg ha^{-1}.

This increase in yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by crop. The yield potential of maize is mainly governed by the growth and yield components. The positive and significant improvement in yield attributes and nutrient uptake would have resulted in enhanced grain yield. The present findings are in line with the findings of Maddonni *et al.* (2006). The positive responses of hybrid maize upto 250 kg N ha^{-1} as reported by Srikanth *et al.* (2009) lend support to the present findings.

Since N is the major structural constitute of cells, as N level increased, the rate of vegetative and reproductive growth also increased in plants due to

Table 1. Yield attributes and quality of hybrid maize as influenced by different levels of nitrogen and phosphorus and mycorrhiza

Treatment	Cob length	Cob girth	No. of grain rows cob^{-1}	No. of grains row^{-1}	Cob weight (g)	Test weight (g)	Crude protein content (%)	Starch content (mg g $^{-1}$)
Fertilizer levels (NPK kg ha^{-1})								
F_1- 200:100:100	20.47	14.03	13.71	39.35	206.7	32.54	12.11	66.04
F_2- 150:100:100	18.83	13.52	13.10	36.72	193.8	29.73	11.72	67.53
F_3- 200:75:100	19.94	14.00	13.55	39.39	203.8	31.26	12.06	68.03
F_4- 150:75:100	20.36	13.76	13.44	38.93	198.5	30.35	11.38	70.03
SEd	0.52	0.18	0.184	0.96	4.50	1.25	0.27	0.70
CD (P = 0.05)	1.07	0.38	0.383	1.99	4.50	2.60	0.57	1.45
Mycorrhizal inoculation								
(M^-)	18.43	13.62	13.24	37.12	173.9	28.82	11.09	64.78
(M^+)	21.36	14.03	13.66	40.07	227.4	33.12	12.55	71.04
SEd	0.36	0.13	0.130	0.68	3.18	0.88	0.19	0.49
CD (P = 0.05)	0.76	0.27	0.271	1.41	6.62	1.84	0.40	1.03
FxM Interaction								
F_1 X (M-)	19.72	13.93	13.67	38.80	188.1	31.05	11.77	63.94
F_2 X (M-)	17.87	13.43	13.00	36.18	168.5	28.15	11.12	64.95
F_3 X (M-)	18.26	13.85	13.30	38.00	177.5	29.03	11.48	63.96
F_4 X (M-)	17.88	13.30	12.98	35.50	161.7	27.05	9.98	66.27
F_1 X (M+)	21.21	14.12	13.76	39.90	225.3	34.03	12.45	68.14
F_2 X (M+)	19.79	13.61	13.20	37.25	219.1	31.32	12.32	70.12
F_3 X (M+)	21.62	14.16	13.80	40.78	230.0	33.50	12.64	72.11
F_4 X (M+)	22.84	14.21	13.90	42.35	235.3	33.65	12.77	73.79
SEd	0.73	0.26	0.261	1.35	6.37	1.77	0.39	0.99
CD (P = 0.05)	1.52	NS	0.542	2.82	13.25	3.68	0.80	2.06

M^- - Uninoculated (control), M^+ - Inoculated with AMF (Glomus intraradices)

increase in assimilating surface of plants as well as total photosynthesis. In physiological terms, the grain yield of maize is largely governed by source (photosynthesis) and sink (grain) relationship which is directly related to N. These resulted in more grain yield when N was higher.

Mycorrhiza had positive influence on grain yield of maize crop. The improved nutritional status of AM fungus-inoculated plants resulted in higher grain yields by 20% in comparison to uninoculated treatments. This yield gain in mycorrhizal plants was mainly caused by the intense flow of minerals and metabolites from the leaf to the developing kernel. The increased yields of AM fungus inoculated plants thus suggest that significant amounts of P and N were translocated from the source to the sink to support kernel development and grain yield (Subramanian and Charest, 1997). A higher yield of maize due to mycorrhizal inoculation has been reported previously (Subramanian *et al.,* 2008).

Increasing the fertilizer levels increased the stover yield significantly. Fertilizer level of 200:100:100 NPK kg ha^{-1} recorded higher stover yield (9894 kg ha^{-1}) followed by 200:75:100 NPK kg ha^{-1}. The positive and significant improvement in LAI and DMP at different stages and higher nutrient uptake due to higher dose of fertilizer would have resulted in enhanced stover yield. These results are in conformity with the findings of Srikanth *et al.* (2009). Mycorrhizal inoculated plants recorded significantly higher (10041 kg ha^{-1}) stover yield, which might be due to increase in plant height, leaf area index and total biomass as evidenced in the present investigation. Similar results of increase in stover yield due to mycorrhizal inoculation were also reported earlier by Lauzon and Miller (1997) in maize.

Quality attributes

The starch content, considered to be an important quality parameter in maize was significantly altered by fertilizer levels and mycorrhiza. The fertilizer level of 150:75:100 NPK kg ha^{-1} recorded the highest starch content (70.03 mg g^{-1}) followed by 200:75:100 NPK kg ha^{-1} but, both were comparable with each other (Table 1).

With increase in levels of NPK, there was a decrease in carbohydrate in maize which 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

Table 2. Grain and stover yield of hybrid maize as influenced by different levels of nitrogen and phosphorus and mycorrhiza

Fertilizer levels NPK Kg ha^{-1}	Grain yield (kg ha^{-1}) Mycorrhizal Inoculation			Stover yield (kg ha^{-1}) Mycorrhizal Inoculation		
	(M^-)	(M^+)	Mean	(M^-)	(M^+)	Mean
F_1- 200:100:100	6388	6600	6494	9875	9913	9894
F_2- 150:100:100	5775	6313	6044	9025	9700	9363
F_3- 200:75:100	6151	6755	6453	9450	10025	9738
F_4- 150:75:100	5163	7275	6219	8838	10525	9681
Mean	5869	6736		9297	10041	
	SEd	CD				
(P=0.05)		SEd	CD			
(P=0.05)						
F	147	306		170	354	
M	104	217		120	251	
F x M	208	433		241	501	

M^- - Uninoculated (control), M^+ - Inoculated with AMF (Glomus intraradices)

synthesis of amino acids. These results are in line with findings of 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).

Among mycorrhizal inoculation treatments, mycorrhizal inoculation recorded higher starch content (71.04 mg g^{-1}) than control (no inoculation) (64.78 mg g^{-1}).The interaction effect between fertilizer levels and mycorrhiza was significant. Fertilizer level of 150:75:100 NPK kg ha^{-1} with mycorrhiza recorded higher starch content (73.79 mg g^{-1}) followed by the treatment combination 200:75:100 NPK kg ha^{-1} along with mycorrhiza and both were comparable. Fertilizer level of 200:100:100 NPK kg ha^{-1} without mycorrhizal inoculation recorded the least starch content (63.94 mg g^{-1}). Mycorrhiza might have helped in transport of sugars which resulted in higher starch accumulation as reported by Subramanian *et al.* (1995).

The crude protein content which is considered as an additional quality next to starch was also influenced by fertilizer levels and mycorrhiza inoculation. Considering the fertilizer levels, application of 200:100:100 NPK kg ha^{-1} recorded higher crude protein content (12.1%) than the other three fertilizer levels. Regarding mycorrhiza, the mycorrhiza inoculated treatments recorded higher crude protein content (12.5 %) than control.

The interaction between fertilizer levels and mycorrhiza inoculation was significant. The highest crude protein content (12.7%) was recorded under the treatment combination 150:75:100 NPK kg ha^{-1} with mycorrhizal inoculation followed by 200:75:100 NPK kg ha^{-1} along with mycorrhizal inoculation, 150:75:100 NPK kg ha^{-1} along with mycorrhizal inoculation and 200:100:100 NPK kg ha^{-1} along with mycorrhizal inoculation which were comparable with each other. The least crude protein content was obtained under the treatment combination 150:75:75 NPK kg ha^{-1} without mycorrhizal inoculation.

Protein is the major nutritive constituent of grain, which determines the ultimate quality of grain. The crude protein content increased significantly with increase in fertilizer dose. Increase in fertilizer dose might have enhanced the uptake and translocation of nitrogen for amino acid synthesis and hence the protein synthesis. These findings are in conformity with the findings of Kurdikeri *et al.* (1973).

The reason for increase in crude protein content (12.9 %) with the inoculation of mycorrhiza might be ascribed to the fact that the protein content had a higher degree of positive relationship with the mycorrhizal plants which have assimilated greater amounts of N and translocated to grains which assisted in enrichment of protein in grains. Similar results of increase in crude protein content due to mycorrizal inoculation were also reported by Subramanian *et al.* (2009).

The results of the present study indicated that application of 200:100:100 NPK kg ha^{-1} and inoculation of mycorrhiza recorded higher yield attributes. However the yield attributes were comparable with 200:75:100 NPK kg ha^{-1}. Application of 150:75:100 NPK kg ha^{-1} along with mycorrhizal inoculation recorded higher grain, stover yield and crude protein content. Higher dose of NPK resulted in higher crude protein content but starch content showed a declining trend.

References

Barry, D.A.J. and Miller, M.H. 1989. Phosphorus nutritional requirement of maize seedlings for maximum yield. *Agron. J.,* **81**: 95-99.

Duraisami, V.P., Raniperumal, M. 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.

Hedge, J.E. and Hofreiter, B.T. 1962. Determination of Total Carbohydrate by Anthrone Reagent. In: Carbohydrate Chemistry, 17 (Eds. Whistler, R.L. and Be Miller, J.N.), Academic Press, New York.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.

Lauzon, J.D. and Miller,M.H. 1997. Comparative response of corn and soybean to seed-placed phosphorus over a range of soil test phosphorus. *Commun. Soil Sci. Plant Anal.,* **28**: 205-215.

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

Mayra, E., Gavito and Miller, M.H. 1998. Early phosphorus nutrition, mycorrhizae development, dry matter partitioning and yield of maize. *Plant Soil,* **199**: 177-186.

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.

Nye, P.H. and Tinker, P.B. 1977. Solute movements in the soil system. Blackwell Scientific Publishers, Oxford, UK.

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. p.98.

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

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

Srikanth, M., Mohamed Amanullah, M., Muthukrishnan, P. and Subramanian, K.S. 2009. Nutrient uptake and yield of hybrid maize (*Zea mays* L.) and soil nutrient status as influenced by plant density and fertilizer levels. *Inter. J. Agric. Sci.,* **5**: 193-196.

Subramanian, K.S. and Charest, C. 1997. Nutritional, growth and reproductive responses of maize (*Zea mays* L.) to arbuscular mycorrhizal inoculation during and after drought stress at tasselling. *Mycorrhiza.,* **7**: 25-32.

Subramanian, K.S., Charest, C., Dwyer, M. and Hamilton, R.I. 1995.Arbuscular mycorrhiza and water relations in maize under drought stress at tasseling. *New Phytol.,* **129**: 643-650.

Subramanian, K.S., Tenshia, V., Jayalakshmi, K. and Ramachandran. V. 2009. Role of arbuscular mycorrhizal fungus (*Glomus intraradices*) - (fungus aided) in zinc nutrition of maize. *J. Agric. Biotech.* and Sus. Devel., **1**: 029-038.

Yoshida, S., Foron, D.A. and Cock, J.H. 1971. Laboratory Manual for Physiological Studies of Rice. *Inter. Rice Res. Inst.*, Los Banos, Philippines. 70 p.

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