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Performance of Kharif maize under different plant populations and nitrogen levels in southern Telangana

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ABSTRACT

An experiment was conducted during 2013 to find out the effects of 3 levels of plant populations (66666, 88888 and 111111 plants/ha) and 4 levels of nitrogen (120, 180, 240 and 300 kg/ha) on Kharif maize in sandy loam soils of Hyderabad. The results showed that population density of 111111 plants/ha recorded higher grain yield (7704 kg/ha) and stover yield (10453 kg/ha) due to significantly more plant height (169 cm), LAI (5.16) at six leaf stage, silking, dough and harvest, however it was on a par with population density of 88888 plants/ha. The population density of 66666 plants/ha produced significantly higher number of rows per cob (14.4), number of grains per row (29.4), number of grains per cob (428) and test weight (29.7 g). Different plant populations did not influence the phenology of Kharif maize. Among the nitrogen levels application of 240 kg N per ha recorded significantly more grain yield (8349 kg/ha) and stover yield (10525 kg/ha) over 120 and 180 kg N/ha due to positive influence on growth parameters and yield attributes. However it was comparable with 300 kg N per ha. Early silking was observed with 240 and 300 kg N per ha and early maturity was observed with 120 and 180 kg N per ha.

Keywords: Maize; plant populations; nitrogen levels; yield; yield attributes

INTRODUCTION

Maize is one of the oldest food sources and is a fully domesticated plant. Human and maize have lived and evolved together since ancient times. It is used as fasten food in many countries and ranks third most essential cereal crops in world with highest production ie 872.79 MT in 2012 (http://faostat.fao.org/site/291/default.aspx). India ranks fourth in production with 22.50 MT including 5.50 MT in Rabi in 2012-13 with productivity of 2552 kg/ha (www.indiastat.com/default.aspx). As maize is the highest yielding cereal crop in the world, it is of very important for countries like India where rapidly increasing population has already short of existing food supplies. Its importance is apparent in daily life food stuff as it uses edible oil and high valued food for human beings, feed for livestock and poultry and a raw material for various agro-based industries.

Many factors affect grain yield of maize such as genetic constitution, fertilization and plant population. At present a number of maize hybrids of different origins and agro-physiological traits are under cultivation in India as well as in Telangana state. These hybrids vary in their response to the agronomic management practices. For each production system there is a population that maximizes the utilization of available resources allowing the expression of maximum attainable grain yield in that environment (Sangoi 2000).

The maize growing farmers of Telangana state are using nearly 11 plants/m^2 instead of recommended 6.6 plants/m^2 and applying more than 200 kg N/ha and harvesting good yields. So under these circumstances it is imperative to study the various plant densities and nitrogen levels to better understand the resource use efficiencies.

MATERIAL and METHODS

The experiment was conducted during Kharif season of 2013 at college farm, Rajendranagar, Hyderabad having 17°19' N Latitude, 78°23' E Longitude and 542.3 m amsl. The soil of the experimental site was sandy loam in texture, neutral in reaction, medium in available nitrogen and phosphorus and high in available potassium. The experiment was laid out in randomized block design (factorial) with three plant densities (66666, 88888 and 111111 plants/ha) as one factor and four nitrogen levels (120, 180, 240 and 300 kg/ha) as another factor replicated thrice. Nitrogen was applied as per the treatments in the form of urea (46% N) in three equal splits (at sowing, knee height stage and silking). Other cultural operations and plant protection measures were followed as per the recommendations. During the crop period rainfall of 475.6 mm was received in 34 rainy days in 2013 as against the decennial average of 634 mm received in 35 rainy days for the corresponding period.

RESULTS and DISCUSSION

Growth parameters

Plant height: Plant height increased as the age of crop advanced. Maximum plant height was recorded in the treatment 111111 plants/ha at silking (166 cm), dough (169 cm) and physiological maturity (169 cm) stages which was significantly superior to 88888 and 66666 plants/ha; in turn these two significantly differed with each other and the treatment 66666 plants/ha recorded the lowest plant height at silking, dough and physiological maturity stages (Table 1). The increased height might be due to severe competition for light and higher intra-row competition for nutrients and water due to overcrowding (Kumar 2008). Plants growing within the dense canopy under high plant density receive a different quality of light enriched with far red (FR) and impoverished in red (R) radiations. The higher FR/R ratio triggers many morphological changes in plant architecture, stimulating stem elongation, favouring apical dominance and decreasing stem diameter (Rajcon and Swarton 2001).

More plant height was observed in nitrogen 300 kg/ha at silking (170 cm), dough (176 cm) and physiological maturity (176 cm) stages and was on a par with 240 kg/ha but significantly superior over 180 and 120 kg/ha (Table 1). Higher nitrogen application increases cell division, cell elongation, nucleus formation as well as green foliage. It also encourages the shoot growth. Therefore higher doses of nitrogen increases the chlorophyll content which in turn increases the rate of photosynthesis and stem elongation resulting in increased plant height (Dawadi and Sah 2012).

Phenology: Plant densities didn't show any significant influence on days taken to attain each phenological stage. However graded levels of nitrogen exerted significant influence on the phenology of the maize. More number of days was taken to attain tasseling and silking (57.5 and 62.3 respectively) with nitrogen 120 kg/ha that was significantly superior to 180 and 240 and 300 kg/ha (Table 2). Increase in nitrogen rate might have increased the rate of photosynthesis (Oikeh et al 1997) that resulted in the leaf longevity and delayed phenological characteristics in maize (Gungula et al 2003).

Leaf area index (LAI): Significantly higher leaf area index was noticed at silking stage with 111111 plants/ha (5.16) that was significantly superior to 88888 (4.38) and 66666 (3.49) plants/ha (Table 3). The increase in LAI might be due to increasing plant population as the LAI is the product of plant population and leaf area per plant and in turn the leaf area per plant is the product of leaf number and size.

Among nitrogen levels maximum LAI was observed with 300 kg/ha at all stages of crop growth (0.17, 4.76, 4.33 and 2.15 at six leaf, silking, dough and maturity respectively) that was significantly superior to 180 and 120 kg/ha (Table 3). Khaliq (2008) opined that increased nitrogen might have increased the leaf size and longevity resulting in increased size and duration of the crop canopy (leaf area index and leaf area duration). The decrease in leaf area might be attributed to reduction in turgidity and succulence of leaves as the crop proceeds towards maturity.

Yield parameters: Maximum number of rows/cob, number of grains/row, number of grains/cob and test weight (14.4, 29.4, 428 and 29.7 g respectively) were noticed in the treatment 66666 plants/ha that was significantly superior to 88888 and 111111 plants/ha (Table 4). Bavec and Bavec

Table 1. Plant height (cm) of maize at different growth stages as influenced by plant densities and nitrogen levels

Treatment	Plant height (cm) at growth stages			
	Six leaf	Silking	Dough	Maturity
Plant density (PD) (plants/ha)				
66666	18[a]	157[c]	164[c]	164[c]
88888	18[a]	162[b]	167[b]	167[b]
111111	18[a]	166[a]	169[a]	169[a]
SEm±	0.2	1.2	0.6	0.6
$CD_{0.05}$	NS	3.5	1.8	1.8
Nitrogen (N) (kg/ha)				
120	18[a]	146[c]	152[c]	152[c]
180	18[a]	162[b]	165[b]	165[b]
240	18[a]	169[a]	175[a]	175[a]
300	18[a]	170[a]	176[a]	176[a]
SEm±	0.2	1.3	0.7	0.7
$CD_{0.05}$	NS	4.1	2.1	2.1
Interaction (PD x N)				
SEm±	0.3	2.4	1.2	1.2
$CD_{0.05}$	NS	NS	NS	NS

Figures in the column having same superscripted alphabet do not differ significantly

(2002) reported that number of grain rows and number of rows/ear significantly changed due to increase in plant population. This might be due to increased competition between maize plants for light, soil fertility and other environmental factors with increase in plant population (Arif et al 2010). Increase in grains/cob from lower planting density might be due to the lower competition for radiations and nutrients that allow the plants to accumulate more biomass with higher capability to convert more photosynthates to sink resulting in more grains/cob (Alam et al 2003). Low test weight under high plant population density might be due to availability of less photosynthates for grain development and due to high interspecific competition which could have resulted in low rate of photosynthesis and high rate of respiration as a result of enhanced mutual shading (Zamir et al 2011).

The highest number of rows/cob, number of grains/row, number of grains/cob and test weight (14.6, 29.9, 439 and 30.7 g respectively) were recorded with nitrogen 300 kg/ha that was comparable with 240 kg/ha (14.4, 28.9, 417 and 29.8 g respectively) but significantly superior to 180 and 120 kg/ha (Table 4). Higher dry matter accumulation and efficient

Table 2. Number of days to attain different phenophases of maize as influenced by plant densities and nitrogen levels

Treatment	Days taken to attain phenophase			
	Six leaf	Tasseling	Silking	Physiological Maturity
Plant density (PD) (plants/ha)				
66666	23.9[a]	56.5[a]	60.8[a]	114.2[a]
88888	24.0[a]	56.5[a]	61.1[a]	114.3[a]
111111	24.3[a]	56.6[a]	61.1[a]	114.4[a]
SEm±	0.3	0.2	0.2	0.1
$CD_{0.05}$	NS	NS	NS	NS
Nitrogen (N) (kg/ha)				
120	23.4[a]	57.5[a]	62.3[a]	112.3[a]
180	23.8[a]	56.8[b]	61.3[b]	114.7[b]
240	24.3[a]	56.3[bc]	60.6[bc]	115.0[bc]
300	24.6[a]	55.7[c]	60.0[c]	115.3[c]
SEm±	0.3	0.2	0.2	0.1
$CD_{0.05}$	NS	0.7	0.8	0.4
Interaction (PD x N)				
SEm±	0.6	0.4	0.5	0.3
$CD_{0.05}$	NS	NS	NS	NS

Figures in the column having same superscripted alphabet do not differ significantly

translocation to the reproductive parts due to supply of adequate nitrogen levels might be responsible for realizing more number of rows/cob (Dawadi and Sah 2012). Under nitrogen stress environments there may be asynchronous flowering, abortion of seed and ultimately the reduction in the number of seeds (Gungula et al 2007).

Grain yield (kg/ha): The maximum grain yield (7704 kg/ha) was recorded from densely populated plants (111111 plants/ha) while the minimum (6893 kg/ha) from sparsely populated plants (66666 plants/ha). However plant density of 88888 and 111111 plants/ha produced statistically identical grain yield (Table 5). Although yield components per plant were lower at higher plant stands, linear increment in grain yield per hectare at higher plant populations might be ascribed to higher grain number and grain weight per unit area. The difference in grain yield of maize was conspicuous with graded levels of nitrogen application up to 240 kg/ha. However grain yield obtained from nitrogen 300 kg/ha (8425 kg/ha) was comparable with 240 kg/ha (8349 kg/ha) (Table 5). The present results are similar to the findings of Dawadi and Sah (2012) who reported that increased grain yield with

Table 3. Leaf area index (LAI) of maize at different growth stages as influenced by plant densities and nitrogen levels

Treatment	LAI at growth stage			
	Six leaf	Silking	Dough	Maturity
Plant density (PD) (plants/ha)				
66666	0.13[c]	3.49[c]	3.07[c]	1.41[c]
88888	0.16[b]	4.38[b]	3.95[b]	1.81[b]
111111	0.19[a]	5.16[a]	4.08[a]	2.10[a]
SEm±	0.01	0.08	0.14	0.06
$CD_{0.05}$	0.02	0.24	0.37	0.19
Nitrogen (N) (kg/ha)				
120	0.14[c]	3.83[c]	2.90[c]	1.09[c]
180	0.15[abc]	4.16[b]	3.41[b]	1.87[b]
240	0.16[ab]	4.61[a]	4.14[a]	2.09[a]
300	0.17[a]	4.76[a]	4.33[a]	2.15[a]
SEM±	0.01	0.09	0.16	0.07
$CD_{0.05}$	0.02	0.27	0.43	0.22
Interaction (PD x N)				
SEm±	0.01	0.16	0.25	0.13
$CD_{0.05}$	NS	NS	NS	NS

Figures in the column having same superscripted alphabet do not differ significantly

increase in nitrogen levels might be due to increased number of rows/cob, number of kernels/cob and test weight which in turn increased the grain yield. Higher yield at increased levels of nitrogen might be owing to better nitrogen uptake leading to greater dry matter production and its translocation to the sink.

Stover yield (kg/ha): The maximum stover yield (10453 kg/ha) was recorded from densely populated plants (111111 plants/ha) while the minimum (8186 kg/ha) from sparsely populated plants (66666 plants/ha). However plant density of 88888 and 111111 plants/ha produced statistically identical stover yield (Table 5). The increase in stover yield with increase of plant densities might be due to increasing number of plants and dry matter yield (Dawadi and Sah 2012). The highest stover yield (10594 kg/ha) was noticed with nitrogen 300 kg/ha that was significantly superior to 180 and 120 kg/ha and in turn 120 kg/ha registered the lowest stover yield (8109 kg/ha). However stover yield obtained from nitrogen 240 kg/ha was on par with 300 kg/ha (Table 5). Increased stover yield under higher level of nitrogen might be due to higher plant height, leaf area index and dry matter accumulation/ plant. The above results are in confirmity with the results of Patel et al (2006) and Rani et al (2013).

Table 4. Yield attributes of maize as influenced by plant densities and nitrogen levels

Treatment	# rows/cob	# grains/row	# grains/cob	Test weight (g)
Plant density (PD) (plants/ha)				
66666	14.4[a]	29.4[a]	428[a]	29.7[a]
88888	14.0[b]	27.1[b]	383[b]	28.2[b]
111111	13.9[b]	26.1[b]	366[b]	27.4[b]
SEm±	0.11	0.53	8.1	0.3
$CD_{0.05}$	0.3	1.5	24	0.9
Nitrogen (N) (kg/ha)				
120	13.6[c]	24.7[c]	338[c]	26.3[c]
180	14.0[b]	26.7[b]	375[b]	27.6[b]
240	14.4[a]	28.9[a]	417[a]	29.8[a]
300	14.6[a]	29.9[a]	439[a]	30.7[a]
SEm±	0.1	0.62	9.4	0.3
$CD_{0.05}$	0.3	1.8	28	1.1
Interaction (PD x N)				
SEm±	0.20	1.07	16.3	0.6
$CD_{0.05}$	NS	NS	NS	NS

Figures in the column having same superscripted alphabet do not differ significantly

Table 5. Grain yield, stover yield and harvest index (HI) of maize as influenced by plant densities and nitrogen levels

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Plant density (PD) (plants/ha)			
66666	6893[b]	8186[b]	45.5
88888	7597[a]	9929[a]	43.3
111111	7704[a]	10453[a]	42.3
SEm±	136	190	
$CD_{0.05}$	401	558	
Nitrogen (N) (kg/ha)			
120	6027[c]	8109[c]	42.6
180	6790[b]	8862[b]	43.5
240	8349[a]	10525[a]	44.2
300	8425[a]	10594[a]	44.5
SEm±	158	219	
$CD_{0.05}$	463	644	
Interaction (PD x N)			
SEm±	273	380	
$CD_{0.05}$	NS	NS	

Figures in the column having same superscripted alphabet do not differ significantly

Harvest index: Harvest index shows the physiological efficiency of plants to convert the fraction of photo assimilates to grain yield. Among the different plant densities the highest harvest index (45.5) was obtained in the treatment 66666 plants/ha that was followed by 88888 and 111111 plants/ha (43.3 and 42.3 respectively) (Table 5). The current results are confirmed by the findings of Arif et al (2010) where the increasing plant density enhanced grain as well as stover yields of hybrid maize but grain/stover ratio was decreased. With regard to the nitrogen levels the highest harvest index was noticed in 300 kg/ha nitrogen level (44.5). With increase in the dose of nitrogen the harvest index also increased. The lowest harvest index was obtained with nitrogen 120 kg/ha (42.6). The difference in harvest index was as a consequence of respective growth stage duration (Abbas et al 2005).

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