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Nutrient Uptake, Yield and Post harvest Soil Nitrogen Dynamics of Hybrid Maize (Zea *mays* L.) as Influenced by Plant stand and Nitrogen Management

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ABSTRACT

Field experiment was conducted to study the effect of plant stand, levels and time of nitrogen application on hybrid maize (*Zea mays* L) for consequtive two wet seasons of 2003 and 2004 at s v agricultural college, Tirupati. Total nitrogen uptake and grain yield of maize deferred significantly due to plant stand, levels and time of nitrogen application during both the years of study. Total N uptake and grain yield was the highest with 83333 plants ha^{-1}, which was however comparable with 66666 plants ha^{-1}. Total nitrogen uptake and Grain yield was found increased with each increment of nitrogen level up to 240 kg N ha^{-1}, but was at per with 180 kg N ha^{-1} beyond which the yield not statistically improved. Application of nitrogen as 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking, recorded higher N uptake and grain yield which was comparable with 1/3 basal + 1/3 knee high + 1/3 tasselling. With regard to interaction the highest nitrogen uptake and seed yield were obtained with 83,333 plants with 240 kg N ha^{-1}, applied as1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking which was comparable with 66,666 plants with 180 kg N ha^{-1}, applied in three equal splits at basal, knee high and taselling. Post harvest soil available N status was significantly influenced by plant stands and N levels, while the time of nitrogen application did not exert any noticeable influence during both the years of study. The interaction effect between plant population and N levels during second year and between the plant stands and time of N application as well as N levels and time of application, during first year significantly influenced the post harvest soil available nitrogen.

Key words : Maize, Nitrogen, Nitrogen uptake, Plant stand, Yield.

Maize is one of the most important cereal crops in the world's agricultural economy, both as a food for human and as a feed for livestock. It is known as a "Queen of cereals" because of its maximum yield potential coupled with wider adaptability. It has higher level of industrial utilization than any other cereal grains, in addition maize is gaining accelerated popularity because of its diversified by-products and higher production potential. The productivity of maize in India is very low (1.8 t ha^{-1}) compared to that of the world's average (4.3 t ha^{-1}). Despite the impressive strides in acreage and production over the last two decades, the productivity of maize remained far low in India. Maize being a C_4 plant has a tremendous yield potential and responds well to growth resources. The increase in grain yield was reported up to 225 kg N ha^{-1} with increase in plant population of 66,666 to 88,888 plants/ha (Tyagi *et al.,* 1998). Poor plant stands, in adequate and improper time of nitrogen application were some of the prime reasons attributed to low productivity and poor quality of maize hybrids. So, there is a need to optimize agro techniques like plant stand, level and time of nitrogen application for maximizing the productivity and improving the quality of maize.

MATERIALS AND METHODS

Field experiment was conducted at College Farm S.V. Agricultural College, Tirupati, Andhra Pradesh for two consecutive wet seasons of 2003 and 2004 with maize hybrid (DHM-103) as the test crop. The experimental soil (0-30cm) was sandy loam in texture having pH 7.0 and 6.93, EC 0.14 and 0.13 dS m^{-1} organic carbon 0.25 and 0.27% and available nitrogen 181 and 196 kg ha^{-1}), available phosphorus 29.3 and 29.1 kg ha^{-1}) and potassium (176 and 173 kg ha^{-1}) in the respective growing seasons. The experiment was laid out in split - split plot design replicated thrice with three plant stands viz. 83333 plants ha^{-1} (60x20cm), 66666 plants ha^{-1} (75x20cm) and 55555 plants ha^{-1} (90x20cm) assigned to main plots, three levels of nitrogen (120, 180 and 240 kg N ha^{-1}) allotted to sub plots and the time of nitrogen application *viz.* 1/2 basal + 1/4 knee high + 1/4 at tasselling , 1/3 basal + 1/3 knee high + 1/3 tasselling and 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking to sub-sub plots. Uniform dose of 60 kg ha^{-1} each of P_2O_5 and K_2O were applied as basal for all the treatments. Urea, single super phosphate and muriate of potash were used as a source of nitrogen, phosphorus and potassium respectively. The Grain yield was recorded after harvest of the maize, the grain and straw samples were digested in H_2SO_4 for determination of nitrogen. The available nitrogen in the soil was analyzed through alkaline potassium permanganate method duly following standard procedures.

RESULTS AND DISCUSSION

Total Nitrogen Uptake

Total nitrogen uptake of maize defered significantly due to plant stand, levels and time of nitrogen application during both the years of study. The total N uptake of maize was highest with 83,333 plant ha^{-1}, which was comparable with 66,666 plant ha^{-1} and significantly superior to 55555 plants ha^{-1}, during both the years of study (Table-1). The results are in line with the findings of Misra *et al.,* (1994). The nitrogen uptake is a product of N content (%) and dry matter production, though the percent of N was lower at higher plant population, the decrease in N content was more than compensated by increase in dry matter production under closer spacing. The lower N uptake with 55,555 plant ha^{-1} might be due to lower dry matter per unit area coupled with lower nitrogen content.

Total nitrogen uptake was found increased with each increment of nitrogen level up to 240 kg N ha^{-1}, but was in parity with 180 kg N ha^{-1} and significantly superior to120 kg Nha^{-1}. This might be due to cumulative effect of increased biomass

Table1. Seed yield (kg ha^{-1}) of maize as influenced by plant stand, levels and time of application of nitrogen, 2003 and 2004.

		2003				2004			
		P1	P2	P3	Mean	P_1	P_2	P_3	Mean
N_1	T_1	2540	2710	2550	2715	2557	2600	2500	2654
	T_2	2700	2862	2680		2680	2740	2620	
	T_3	2750	2940	2700		2730	2800	2660	
N_2	T_1	4250	4150	2783		4080	3987	2600	
	T_2	4400	4370	2850	3859	4240	4150	2731	3671
	T_3	4520	4500	2910		4280	4200	2770	
N_3	T_1	4350	4300	2900		4217	4150	2720	
	T_2	4470	4430	3103		4300	4240	2820	
	T_3	4500	4460	3150	3962	4300	4280	2850	3764
	Mean	3831	3858	2847		3709	3683	2697	
	Mean for T	3392	3540	3603		3268	3391	3430	

	2003 SEm±	2003 CD (P=0.05)	2004 SEm±	2004 CD (P = 0.05)
P	42.4	167	37.0	145
N	33.5	103	34.3	105
T	37.1	106	41.6	119
PN	63.6	220	61.0	207
PT	67.6	NS	69.5	NS
NT	62.2	NS	68.1	NS

Table 2. Total nitrogen uptake (kg ha^{-1}) of maize as influenced by plant stand, levels and time of application of nitrogen, 2003 and 2004.

		2003				2004			
		P1	P2	P3	Mean	P_1	P_2	P_3	Mean
N_1	T_1	75.0	72.5	66.2	73.2	74.2	72.0	65.1	73.0
	T_2	77.5	74.6	68.3		79.0	74.9	67.2	
	T_3	79.0	75.5	70.1		80.0	76.0	69.0	
N_2	T_1	98.7	99.3	82.9		97.8	98.7	80.9	
	T_2	102.9	104.0	86.8	97.0	107.0	105.3	85.8	97.8
	T_3	105.9	104.0	88.7		110.2	107.6	86.9	
N_3	T_1	103.0	100.7	88.7		102.7	102.1	89.3	
	T_2	106.7	105.7	91.7		107.0	105.5	95.8	
	T_3	107.3	105.0	90.0	99.8	107.3	107.2	93.0	101.1
	Mean	95.1	93.5	81.5		96.1	94.4	81.4	
	Mean for T	87.4	90.9	91.7		87.0	91.9	93.0	

	2003 SEm±	2003 CD (P=0.05)	2004 SEm±	2004 CD (P = 0.05)
P	0.73	2.9	0.48	1.9
N	0.84	2.9	1.05	3.4
T	1.07	3.1	1.02	2.9
PN	1.36	4.5	1.05	3.4
PT	1.68	NS	1.53	NS
NT	1.72	NS	1.59	NS

production and higher nitrogen content. Application of 120 kg N ha^{-1} recorded the lowest N uptake, during both the years of investigation. This might be due to lower nitrogen content. Application of nitrogen in four equal splits recorded higher nitrogen uptake which was comparable with nitrogen application in three equal splits during both the years of study. The results are in line with Bokde and khokher (1962) who also observed that nitrogen has to be applied in three equal installments, first at sowing, second at knee high and third at flowering time.

With regard to interaction, the highest nitrogen uptake was recorded with highest 83,333 plant ha^{-1} with 240 kg N ha^{-1}, which was comparable with 66666 plant ha^{-1} with 240 kg N ha^{-1}, 83333 plant ha^{-1} with 180 kg N ha^{-1} and 66666 plant ha^{-1} with 180 kg N ha^{-1}, which might be due to optimum plant stand with adequate supply of nitrogen.

Grain Yield

Grain yield of maize differed significantly with plant stands, levels and time of nitrogen application during both the years of investigation. Grain yield of maize increased significantly with increase in plant population up to 66,666 plants ha^{-1} beyond which the yield was not statistically significant. The magnitude of increase in grain yield with 66,666 plants ha^{-1} was 35.5 and 36.5 per cent higher than over 55,555 plants ha^{-1} during 2003 and 2004, respectively (Table 2). Though grain yield depends on the yield attributes, they were found to be higher at lower plant density, yet, increase in these parameters under lower population failed to compensate the increase in yield due to increased plant population. Grain yield increased with increase in plant population from 53333 to 88888 plants ha^{-1} but increase in yield was not significant beyond 66666 plants ha^{-1} (Singh *et al.*, 1997 and Raja, 2001). Lower yield with low plant population may be due to poor ground cover, leading to lower photosynthetic surface per unit land area as well as inefficient utilization of growth resources.

Grain yield increased with increasing levels of nitrogen up to 240 kg ha^{-1}, but the statistical disparity was not observed beyond 180 kg ha^{-1}.

Table 3. Post harvest soil available nitrogen status (kg ha^{-1}) of maize as influenced by plant stand, levels and time of application of nitrogen, 2003 and 2004.

		2003				2004			
		P1	P2	P3	Mean	P_1	P_2	P_3	Mean
N_1	T_1	146	158	189	161	166	180	205	176
	T_2	139	156	186		159	175	168	
	T_3	136	151	186		158	173	200	
N_2	T_1	167	177	186		185	197	231	
	T_2	163	174	215	181	183	195	228	202
	T_3	159	171	214		180	190	226	
N_3	T_1	198	212	210		215	230	278	
	T_2	194	210	260		213	236	273	
	T_3	193	211	258	216	213	223	270	239
	Mean	166	180	211		186	200	231	
	Mean for T	182	188	186		210	203	204	

	2003 SEm±	2003 CD (P=0.05)	2004 SEm±	2004 CD (P = 0.05)
P	3.5	14	2.6	10
N	2.5	8	2.5	8
T	1.9	NS	2.5	NS
PN	5.0	NS	4.5	15
PT	4.5	16	6.2	NS
NT	3.8	11	6.3	NS

Increase in yield with 180 kg N ha^{-1} was 42.1 and 38.8 per cent over 120 kg N ha^{-1} during 2003 and 2004, respectively. Grain yield of maize is the result of simple product of yield attributes, which in the present case were significantly and favorably influenced by the application of comfortable level of nitrogen. Further, nitrogen nutrition might have improved source-sink relationship with better translocation of photosynthates to grain formation. These results are in conformity with the findings of Rameshwar Singh and Totawat (2002). Higher dry matter production coupled with significantly higher number of seeds and 100-seed weight might have resulted in higher grain yield with application of nitrogen as 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking and it was comparable with application of nitrogen in three equal splits.

With regard to interaction 83333 plants with 240 kg N ha^{-1} has resulted in the highest seed yield of maize, which was comparable with 66666 plants with 180 kg N ha^{-1}. The highest yield obtained with a plant stand of 66666 plants with 180 kg N ha^{-1} was due to population optima coupled with adequate supply of nitrogen to promote the growth and development and there by producing higher level of yield attributes. Even though yield was the highest with the highest levels of individual factors *i.e.,* 83333 plants ha^{-1} with 240 kg N ha^{-1}, but it was comparable with optimum values of both the factors *i.e.,* 66666 ha^{-1} plants with 180 kg N ha^{-1}. (Misra *et al.*,1998).This might be due to optimum plant stand with adequate nitrogen resulting in vigorous plant growth leading to higher yield of maize. Combination of 66666 plants with 180 kg N ha^{-1} increased the grain yield to the tune of 63.0 and 54.8 per cent over 55,555 plants with 120 kg N ha^{-1} during 2003 and 2004, respectively during both the years of study.

Soil nitrogen dynamics

Post harvest soil available nitrogen status was significantly influenced by plant stands and N levels, while time of N application did not exert any noticeable influence, during both the years of study. The interaction effect between plant population and N levels during second year and between the plant stands and time of nitrogen application as well as N levels and time of application, during first year significantly influenced the post harvest soil available N (Table3).

During both the years of study, the highest post harvest soil available nitrogen was recorded with 55,555 plant ha^{-1}, followed by 66,666 plant ha^{-1} and 83333 plant ha^{-1}, with a significant disparity between any two of the three plant populations tried, during both the years of investigation. This might be due to excessive withdrawal of nutrients from soil by higher plant density, consisting of relatively more number of plants per unit area compared to other plant densities tried. Higher level of plant stand poses severe competition for nutrients, which is evident by the production of higher dry matter per unit area with higher plant stands. Similar results were also reported by Flierasu and Draghicio (1989).

The highest post harvest soil available N was associated with 240 kg N ha^{-1} followed by 180 kg N ha^{-1} and 120 kg N ha^{-1}, with a significant disparity between any two of the three N levels tried, during both the years of investigation. The lowest post harvest soil available N was observed with 120 kg N ha^{-1} due to inadequate N supply.

With regard to interaction, during second year of study, the highest soil available N was observed with 55555 plants with 240 kg N ha^{-1}, while the lowest was associated with 83333 plants with 120 kg N ha^{-1}. During first year of study, with respect to interaction effect of plant stand and time of nitrogen application, the highest post harvest soil available nitrogen was observed with 55555 plants with 180 kg N ha^{-1}, which was on par with 55555 plants with application of nitrogen as 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking, while the lowest was observed with 83333 plants ha^{-1} applied as 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking, which were comparable with 83333 plants with application of nitrogen in three splits (P_1T_2, P_1T_1) and 66666 plants with 1/4 basal + 1/4 knee high + 1/4 flag leaf emergence + 1/4 silking (P_2T_3). Regarding the interaction of levels and time of application of N, the highest soil available nitrogen was observed with 240 kg N ha^{-1}. Applied in three equal splits (N_3T_2), which was however, comparable with 240 kg N ha^{-1} applied in four equal splits (N_3T_3).

Conclusions

The study revealed that there is ample scope for enhancing the yield and quality of maize with a Plant stand of 66,666 along with 180 kg N/ha applied in three splits 1/3 basal, 1/3 kneehigh, 1/3 tasseling and silking with out mining the nutrients.

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