International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 1163-1167

Received: 20-01-2019
Accepted: 22-02-2019

Chanchal Porte
Department of Agronomy, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

SK Jha
Department of Agronomy, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

SK Dwivedi
Department of Agronomy, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Correspondence
Chanchal Porte
Department of Agronomy, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Nitrogen use efficiency in African tall fodder maize (*Zea mays* L.) as affected by nitrogen levels and planting geometry

Chanchal Porte, SK Jha and SK Dwivedi

Abstract
An experiment was conducted during *Rabi* 2017-18 to study the response of agronomic, agro-physiological, apparent recovery, economic nitrogen use efficiency, nitrogen increment efficiency and nitrogen harvest index of African tall fodder maize (*Zea mays* L.) to nitrogen levels and planting geometry under Chhattisgarh condition conducted at the experimental field of Instructional cum Research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The treatment includes four levels of nitrogen and three planting geometries consisting of twelve treatment combinations laid out in factorial randomized block design (FRBD). Among all the treatment combinations apparent recovery efficiencies decreased to 56.1% with each increase in nitrogen levels from control to 160 kg N ha^{-1} and planting densities. However, agronomical nitrogen use efficiency increased with increase in N level up to 120 kg N ha^{-1} and tends to decrease with more increase in N level up to 160 kg N ha^{-1} and agro-physiological efficiency, economic nitrogen use efficiency, nitrogen increment efficiency and nitrogen harvest index efficiency was increased as 21.6 kg kg^{-1}, 0.73 kg Rs^{-1}, 1.7 kg kg^{-1} respectively with increase in nitrogen level from control to 160 kg N ha^{-1} but was unaffected with varying planting geometry.

Keywords: Agro-physiological, Apparent recovery, Nitrogen use efficiency, Nitrogen increment efficiency, formula

Introduction
Livestock production is the backbone of Indian agriculture. We stand high in case of total milk production but the productivity is very quiet low. The genetic potential contributes significantly towards higher milk production and the genetic potential of high yielding animals can be realized only if they are fed well with quality fodder. Maize has the potential to supply large amounts of energy-rich forage for daily animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh *et al.*, 2009) [3].

Nitrogen is a very important nutrient which is the building blocks of living organisms and the main component of proteins. It has a very important role in growing fodder maize with high production potential. Nitrogen increases the ptotoplasmic content and thus increases the cell size, leaf area and photosynthetic activity; hence it is the key factor responsible for dry matter production. The key problem of sustainable management of nitrogen in the soil- plant system is low productivity of applied nitrogen fertilizer, defined as nitrogen use efficiency (NUE). Nitrogen use efficiency in cereals has been categorized into: the efficiency of absorption (apparent recovery); use efficiency (physiological performance); efficient use of nitrogen (crop efficiencies). It is the crop production per unit input, which means nutritional efficiency consists in the amount of dry matter production per unit nutrient elements usage or uptake. Agronomic efficiency (AE) is defined as the additional grain yield produced due to application of nutrients over unfertilized control per unit of nutrient applied. The Apparent recovery efficiency (ARE) is an indicator of the potential for nutrient loss from the cropping system and to access the efficiency of management practices and is defined as the amount of nutrients absorbed per unit nutrient applied. Agro-Physiological efficiency (APE) shows the crop's ability to assemble the biological yield produced due to the uptake and utilization of applied nutrient over unfertilized control. The Economic Nitrogen Use Efficiency (ENUE) is the ratio of economic yield (grain) per unit of amount invested on the nutrient. Nitrogen Harvest Index (NHI) is defined as the ratio of nutrient uptake by economic yield (grain) to total nutrient uptake.

The practical implication of this is the improved utilization and lower loss of applied N to cause environmental pollution. The major objective of this study was to know the nitrogen use efficiency of African tall fodder maize as influenced by different nitrogen levels and planting geometry.

Materials and methods

The experiment was conducted at Instructional cum Research farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.) in *Rabi* 2017 with adequate facilities for irrigation and drainage. The institute is situated at Raipur in the central part of Chhattisgarh, climatologically known as “Chhattisgarh Plains” and lies in between 21^0 16’ N latitude and 81^0 26’ E longitudes at altitude of 289.56 meters above the mean sea level (MSL). Based on climatic features prevailing, Raipur is characterized as slightly moist-hot zone, where the average annual rainfall receiving was 0.37 mm, the average maximum temperature was 32^0C and average minimum temperature was 15^0C during the whole crop growth period. According to soil analysis, the soil of the experimental site was sandy loam in texture. The soil was neutral in reaction pH (7.09) with electrical conductivity (EC) in the safer range (0.19dSm^{-1}), low in organic carbon (0.60%) and available N (237.50kg ha^{-1}) but medium in available phosphorus (14.34 kg ha^{-1}) and high in potassium (361.09 kg ha^{-1}). A uniform dose of P_2O_5 (50 kg ha^{-1}) and K_2O (40 kg ha^{-1}) were applied in the form of diammonium phosphate (DAP) and muriate of potash (MOP), respectively and nitrogen was applied in three splits, 40% at basal, 30% at knee high stage and 30 % at tasseling stage was scheduled through urea. The experiment was laid out in factorial randomized block design with three replications and comprising twelve treatment combinations with four nitrogen levels 0, 80 kg, 120 kg, and 160 kg N ha^{-1} and three planting geometries 50 x 20, 60 x 20 and 75 x 20 cm with 6 x 4 m net plot area. Nitrogen content and uptake in stalks as well as seeds were analyzed with the Kjeldahl method and the various nitrogen use efficiencies were calculated by following equations:

$$\text{Agronomic efficiency} = \frac{\text{Grain or economic yield with nutrient - Grain or economic yield without nutrient}}{\text{Nutrient applied}}$$

$$\text{Agro-physiological efficiency} = \frac{\text{Grain yield with nutrients - Grain yield without nutrients}}{\text{Nutrient uptake with nutrients – Nutrient uptake without nutrients}}$$

$$\text{Apparent Recovery Efficiency} = \frac{\text{Nutrient uptake with nutrients – Nutrient uptake without nutrients}}{\text{Nutrient applied}} \times 100$$

$$\text{Economic Nitrogen Use Efficiency} = \frac{\text{Grain or economic yield}}{\text{Amount invested on the nutrient}}$$

$$\text{Nitrogen increment efficiency} = \frac{\text{Grain yield or economic yield with } N_n \text{ amount of nutrient – Grain yield or economic yield with } N_{n-1} \text{ amount of nutrient}}{\text{Grain yield or economic yield with } N_{n-1} \text{ amount of nutrient}}$$

$$\text{Nitrogen Harvest Index} = \frac{\text{Nutrient uptake by Grain (or economic yield)}}{\text{Total nutrient uptake for production of biological yield}}$$

$$\text{Nutrient uptake} = \text{N concentration x Economic Yield}$$

Results and discussion

Seed yield

Yield ability is one of the most important quantitative characters in a crop and it depends on the development of plant characters. The table 1 revealed that seed yield obtained was significantly influenced by different nitrogen levels. The maximum seed yield was observed under treatment receiving 160 kg N ha^{-1} (28.6 q ha^{-1}) followed by 120 kg N ha^{-1} (24.8 q ha^{-1}) and 80 kg N ha^{-1} (17.1 q ha^{-1}) and significantly minimum with control treatment 0 kg N ha^{-1} (10.4 q ha^{-1}). The varied planting geometries also have significant effect on seed yield of fodder maize. However, the maximum seed yield was noted with 75 x 20 cm planting geometry (24 qha^{-1}) which was superior over other planting geometries tried.

The interaction effect of different nitrogen levels and planting geometry had a significant effect on seed yield of fodder maize. It is evident from the table 2 that the maximum seed yield was produced by the combination of treatment receiving 160 kg N ha^{-1} along with planting geometry of 75 x 20 cm (34.3 qha^{-1}) which was at par with 120 kg N ha^{-1} coupled with 75 x 20 cm (31 qha^{-1}). Although the lowest seed yield was observed under control treatment combinations as compared to other remaining treatment combinations (Table 2).

Stalk yield and harvest index

Accordingly, stalk yield and harvest index also increased with each increase in nitrogen level from 0 kg N ha^{-1} to 160 kg N ha^{-1} (Table 1). However stalk yield was significantly influenced by the varied planting geometries. Table 1 revealed that stalk yield was maximum (143.4 q ha^{-1}) under planting geometry of 50 cm x 20 cm followed by 60 cm x 20 cm (128.5 q ha^{-1}) and least (111.8 q ah^{-1}) with wider planting geometry of 75 cm x 20 cm. But harvest index was maximum (17.02 %) under wider planting geometry of 75 cm x 20 cm.

Table 1: Yield (q ha^{-1}), harvest index (%) and N uptake of fodder maize as influenced by nitrogen levels and planting geometry

Treatments			**Seed yield (q ha^{-1})**	**Stalk yield (q ha^{-1})**	**Harvest index (%)**	**N uptake (kg ha^{-1})**		
						Grain	**Stalk**	**Total**
Nutrient	N_1	0	10.4	92.6	10.3	73.4	85.2	85.2
level	N_2	80	17.1	131.1	11.7	120.2	140.4	140.4
(kg ha^{-1})	N_3	120	24.8	140.4	15.2	130.1	163.4	163.4
	N_4	160	28.6	147.4	16.5	138.1	172.8	172.8
		S.Em ±	0.6	2.5	0.3	3.7	4.2	4.2
		CD(P=0.05)	1.7	7.3	1.0	10.9	12.2	12.2

Planting	S_1	50	16.3	143.4	9.96	126.3	148.5	148.5
geometry	S_2	60	20.3	128.5	13.27	115.5	140.7	140.7
(cm)	S_3	75	24.0	111.8	17.02	104.5	132.2	132.2
		S.Em ±	0.5	2.2	0.30	3.2	3.6	3.6
		CD(P=0.05)	1.5	6.3	0.88	9.5	10.6	10.6
Interaction	NXS		S	NS	S	NS	NS	NS

followed by planting geometry of 60 cm x 20 cm (13.27 %) and least (9.96 %) under planting geometry of 50 cm x 20 cm.

Nitrogen uptake

Increase in NUE is the consequence of enhanced uptake and improved utilization of N by the crop. The significant increase in N uptake by fodder maize seeds as well as stalk was observed with the increase in levels of applied N (Table 1). However, the N uptake significantly decreased due to varied planting geometries being the highest under planting geometry of 50 cm x 20 cm followed by 60 cm x 20 cm and 75 cm x 20 cm (Table 1)

Agronomic efficiency

Results revealed significant effects of the nitrogen levels and planting geometries on agronomic efficiency of nitrogen. It more closely reflects the direct production impact of an applied fertilizer and relates directly to economic return. It is clear from the data shown in the table 4 that agronomic efficiency was increasing by increasing nitrogen levels from 80 kg N ha^{-1} to 160 kg N ha^{-1}. However, the highest (11.9 kg kg^{-1}) agronomic efficiency was recorded at 120 kg N ha^{-1} which was found at par with treatment receiving 160 kg N ha^{-1} (11.3 kg kg^{-1}) and lowest at 80 kg N ha^{-1} (8.3 kg kg^{-1}). Also the data in table 4 showed that wider planting geometry of 75 x 20 cm recorded highest (9.5 kg kg^{-1}) which was found at par with planting geometry of 60 x 20 cm (7.9 kg ka^{-1}), being the lowest with narrow planting geometry of 50 x 20 cm (6.3 kg kg^{-1}) agronomic efficiency.

Agro-physiological efficiency

The agro-physiological efficiency of nitrogen in fodder maize was increased by increasing nitrogen levels from 80 kg N ha^{-1} to 160 kg N ha^{-1}. The highest agro-physiological efficiency was recorded under the treatment receiving 160 kg N ha^{-1} (21.6 kg kg^{-1}) which was found at par with treatment receiving 120 kg N ha^{-1} (Table 4).This might be due to the yield increase in relation to the increase in crop uptake of the nutrient in above-ground parts of the plant. (Fixen Paul *et al* 2014), being the lowest with 80 kg N ha^{-1} (12.8 kg kg^{-1}). Varied planting geometry also had a significant effect in agro-physiological efficiency of nitrogen. the highest agro-physiological efficiency was recorded with wider planting geometry of 75 x 20 cm (17.7 kg kg^{-1}) which was found superior over other planting geometries tried (Table 4), this might be due to the fact that wider planting geometry enhances nutrient uptake due to adequate space for plants to develop.

Apparent Recovery Efficiency

The apparent recovery was decreasing by increasing nitrogen level from 80 kg N ha^{-1} to 160 kg N ha^{-1} (Table 4). The maximum (69.1 %) apparent recovery efficiency of nitrogen was recorded with the application of 80 kg N ha^{-1}which was comparable with application of 120 kg N ha^{-1}, being least apparent recovery of nitrogen with 160 kg N ha^{-1} (56.1 %). Varied planting geometries significantly influenced the apparent recovery efficiency of nitrogen as, the maximum apparent recovery was recorded with narrow planting geometry of 50 x 20 cm (53.2 %) which was found statistically at par with planting geometry of 60 x 20 cm (48.7 %), being least with wider planting geometry of 75 x 20 cm (40.9 %). The results are in confirmation with the findings of Shahzad (2010) [6], he reported that there was a significant decrease in apparent recovery efficiency of nitrogen with the increase in levels of nitrogen from 80 kg N ha^{-1} to 200 kg N ha^{-1} and an increase in apparent recovery efficiency with maximum plant density.

Economic Nitrogen Use Efficiency

The maximum economic nutrient use efficiency was recorded with the application of 160 kg N ha^{-1}, which was significantly superior over other levels of nitrogen applied. It clear from the table 4 that economic nutrient use efficiency is increasing with increase in nitrogen levels from 80 kg N ha^{-1} to 160 kg N ha^{-1} (0.42, 0.59, and 0.73% respectively). There was a significant effect was observed with varied planting geometries in economic nutrient use efficiency. The maximum (0.52 kg Rs^{-1}) economic nutrient use efficiency was calculated with narrow planting geometry of 50 x 20 cm which was found superior over other planting geometries tried, being the least (0.38 kg Rs^{-1}) with wider planting geometry of 75 x 20 cm. The economic nutrient use efficiency of nitrogen applied was found significant with the interaction of different nitrogen levels and planting geometry. The highest economic nutrient use efficiency was recorded with the treatment combination of 160 kg N ha^{-1} along with 50 x 20 cm (0.91 kg Rs^{-1}) which was statistically superior over other remaining treatment combinations (Table 4).

Nitrogen increment efficiency

The nutrient incremental efficiency was increasing with each increment in nitrogen dose from 80 kg N ha^{-1} to 160 kg N ha^{-1}. The maximum (1.7 kg kg^{-1}) nutrient incremental efficiency of nitrogen was recorded with application of 160 kg N ha^{-1} which was found statistically superior over other levels of nitrogen applied, being least with 80 kg N ha^{-1} (0.7 kg kg^{-1}). The varied planting geometry did not influence significantly the nutrient increment efficiency of nitrogen (Table 4).

Nitrogen Harvest Index

The nutrient harvest index was increasing upto 120 kg N ha^{-1} and showed a decline in nutrient harvest index on the application of 160 kg N ha^{-1} (14%, 14.6%, 20.4% and 20% respectively). Increased nutrient harvest index is strongly correlated to improved grain N concentration (Fawcett and Frey, 1982) [4]. Chakwizira (2016) [1] reported that nutrient harvest index was not affected by N rate. Varied planting geometry showed the significant effect on nutrient harvest index by the plants. The maximum (19.9%) nutrient harvest index was recorded with wider planting geometry of 75 x 20 cm, which was statistically superior over other planting geometries tried (Table 4). The interaction effect of different nitrogen levels and planting geometry had a significant influence on nutrient harvest index. The maximum nutrient harvest index was recorded under the treatment combination of 160 kg N ha^{-1}along with 75 x 20 cm planting geometry which was noted superior over other planting geometries.

Table 2: Interaction effect of nitrogen level and planting geometry on seed yield (q ha^{-1}) of fodder maize

Nitrogen level (kg ha^{-1})	Seed yield (q ha^{-1})			
	Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean
0	8.7	10.7	12.0	10.5
80	15.0	17.7	18.7	17.1
120	18.3	25.0	31.0	24.8
160	23.3	28.0	34.3	28.5
Mean	16.3	20.4	24.0	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.58	0.50	1.00	
CD(P=0.05)	1.69	1.47	2.93	

Table 3: Harvest index (%) of fodder maize as influenced due to interaction effect of nitrogen levels and planting geometry

Nitrogen level (kg ha^{-1})	Harvest index (%)			
	Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean
0	8.0	10.3	12.5	10.3
80	9.1	12.0	14.0	11.7
120	10.4	15.0	20.3	15.2
160	12.4	15.7	21.3	16.5
Mean	10.0	13.3	17.0	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.35	0.30	0.60	
CD(P=0.05)	1.02	0.88	1.76	

Table 4: Nitrogen use efficiencies as influenced by different nitrogen levels and planting geometry of fodder maize

Treatments			Nitrogen Use Efficiencies					
			Agronomic Efficiency (kg kg^{-1})	Agro-Physiological Efficiency (kg kg^{-1})	Apparent Recovery Efficiency (%)	Economic Nutrient Use Efficiency (kg Rs^{-1})	Nutrient Incremental Efficiency (kg kg^{-1})	Nutrient Harvest Index (%)
Nutrient	N_1	0	0.0	0.0	0.0	0.00	0.0	14.0
(kg ha^{-1})	N_2	80	8.3	12.8	69.1	0.42	0.7	14.6
	N_3	120	11.9	19.6	65.2	0.59	1.4	20.4
	N_4	160	11.3	21.6	56.1	0.73	1.7	20.0
		S.Em ±	0.7	1.7	3.8	0.01	0.1	0.8
		CD (P=0.05)	2.0	5.0	11.2	0.04	0.2	2.2
Planting	S_1	50	6.3	10.1	53.2	0.52	0.9	14.3
geometry	S_2	60	7.9	12.8	48.7	0.41	0.9	17.7
(cm)	S_3	75	9.5	17.7	40.9	0.38	1.0	19.9
		S.Em ±	0.6	1.5	3.3	0.01	0.1	0.7
		CD (P=0.05)	1.8	4.3	9.7	0.03	0.2	1.9
Interaction	NXS		NS	NS	NS	S	NS	S

Table 5: Interaction effect of nitrogen level and planting geometry on economic nutrient use efficiency of fodder maize

Nitrogen level	Economic nutrient use efficiency (kg Rs^{-1})			
	Planting geometry			
	50 x 20	60 x 20	75 x 20	Mean
0	0.00	0.00	0.00	0.00
80	0.52	0.41	0.34	0.42
120	0.64	0.57	0.57	0.59
160	0.91	0.64	0.63	0.73
Mean	0.52	0.41	0.39	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.01	0.01	0.02	
CD(P=0.05)	0.04	0.03	0.07	

Table 6: Interaction effect of nitrogen level and planting geometry on nutrient harvest index of fodder maize at 80 DAS

Nitrogen level (kg ha^{-1})	Nutrient harvest index			
	Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean
0	10.5	16.1	15.6	14.07
80	11.9	16.9	15.1	14.63
120	18.2	21.3	21.8	20.43
160	16.6	16.4	27.0	20.00
Mean	14.30	17.68	19.88	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.76	0.66	1.32	
CD(P=0.05)	2.24	1.94	3.88	

References

1. Chakwizira E, Teixeira Ruiter de JM, Maley S, George MJ. Harvest index for biomass and nitrogen in maize crops limited by nitrogen and water. The New Zealand Institute for Plant & Food Research Limited, Private Bag 4704, 2016.
2. Cusicanqui A, Lauer JG. Plant density and hybrid influenced on corn forage yield and quality. Agronomy Journal. 1999; 91:911-915.
3. Dahmardeh M, Ghanbari A, Syasar B, Ramroudi M. Effect of intercropping maize with cowpea on green forage yield and quality evaluation. Asian Journal of Plant Science. 2009; 8(3):235-239.
4. Fawcett J, Frey KJ. Nitrogen harvest index variation in *Avena sativa* and *A. sterilis*. Proceedings of Iowa Academic of Science, 1982.
5. Fixen Paul E, Tom Bruulsema W, Tom Jensen L, Robert Mikkelsen, Scott Murrell T, Steve Phillips B *et al*. The fertility of North American soils, Better Crops. 2010; 94(4):6-8.
6. Shahzad JS *et al.* Response of Agronomical, Physiological, Apparent Recovery Nitrogen Use Efficiency and Yield of Potato Tuber (*Solanum tuberosum* L.), to Nitrogen and Plant Density. Young Researchers Club, Islamic Azad University, Ardabil Branch, Ardabil, Iran, American-Eurasian J Agric. & Envion. Sci. 2010; 9(1):16-21.