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Effect of different nitrogen levels and planting geometry on growth parameters and seed yield of African tall fodder maize (*Zea mays* L.)

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Abstract
The experiment was conducted to study the response of different nitrogen levels and planting geometry on growth parameters of African tall fodder maize (*Zea mays* L.), under Chhattisgarh condition 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, application of 160 kg N ha^{-1} contributed in better crop growth parameters namely**,** plant height, stem girth, number of internodes plant^{-1}, dry matter accumulation plant^{-1}, days taken to 50% silking and physiological maturity and found at par with application of 120 kg N ha^{-1}, the planting geometry of 75 x 20 cm resulted in better crop growth and development which was at par with 60 x 20 cm planting geometry at each successive growth stages as compared to other planting geometries tried however, days taken to 50% silking and physiological maturity didn't affected by varied planting geometry. Among all the treatment combinations application of 160 kg N ha^{-1} along with 75 x 20 cm planting geometry recorded the maximum growth and development of maize plants, yield attributing characters and hence the seed yield of 28.6 q ha^{-1} as compared to other treatment combinations tried. Therefore, the treatment combination of 160 kg N ha^{-1} along with 75 x 20 cm planting geometry was found best and was at par with 120 kg N ha^{-1} and 60 x 20 cm planting geometry for better growth and development and increasing seed yield of fodder maize.

Keywords: Plant height, internodes, dry matter accumulation, silking, physiological maturity, nitrogen levels, planting geometry, attributing

Introduction
Livestock production is the backbone of Indian agriculture. We stand high in case of total milk production, but the productivity is quite low. Although the genetic potential contributes significantly towards higher milk production but 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) [6]. African tall maize (*Zea mays* L.) is a composite variety and one of the most nutritious non- legume green fodder. The high acceptability of maize as fodder can be judged from the fact that it is free from any anti- nutritional components. For the growth and development of plant nitrogen plays a very important role as this 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 protoplasmic content and thus increases the cell size, leaf area and photosynthetic activity. Hence, it is the key factor responsible for dry matter production. The maize crop is raised for fodder purpose and harvested before maturity of seeds. In general, it is not in practice of the farmers to raise the fodder maize for seed production. Paucity of quality seeds of fodder maize is a burning problem. Therefore, to meet out the demand of quality seeds, it is essential to develop appropriate agro-techniques to increase the seed production of forage maize. The aim of this study was to evaluate effects of the nitrogen levels and planting geometry on growth parameters of African tall fodder maize (*Zea mays* L.) *viz.* plant height, stem girth, number of internodes plant^{-1}, dry matter accumulation plant^{-1}, days taken to 50% silking and physiological maturity which directly will lead towards seed production of fodder maize in order to determine the suitable nitrogen level and planting geometry.

Materials and Methods

The experiment was conducted at instructional cum research farm, Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.) with adequate facilities for irrigation and drainage. The soil was neutral in reaction (pH -7.09) with electrical conductivity (EC) in the safer range (0.19dSm^{-1}), medium in organic carbon (0.60%) and available nitrogen (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 comprising of 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 in 6 x 4 m net plot area. The crop was irrigated at 15 days interval as per need during growing season. Other agronomic and plant protection measures were adopted as and when crop needed. Fodder maize was harvested when crop attained full maturity which is considered to be ideal stage for quality fodder maize seeds. For phenological observations five plants were randomly selected in each net plot area and measurements were taken based on growth and yield attributing parameters. The height of the plant was measured in centimeters from the base of the stem just above the soil up to the base of terminal leaf bud of the main shoot. Stem girth was measured with the help of venires caliper. Number of internodes was counted at every 15 days interval after 45 DAS. For dry matter accumulation the whole above ground portion of the plant was taken, sun dried and oven dried at 60^o±2^{o}C till constant weight was obtained. The weight was recorded in grams and expressed as g plant^{-1}. The number of days taken from sowing to the day when 50 percent of the population initiates silking in each net plot was counted to calculate days to 50 percent silking. The seed yield of each plot was recorded after shelling the cobs in q ha^{-1}. The weight of seeds obtained from five plants used for post harvest studies in each plot was then added to the seeds of respective plots. The crop in each net plot was harvested separately as per treatment and the values were converted into hectare basis and expressed in quintals. The data were statistically analysed as per standard procedure given by Gomez and Gomez 1984 [7].

Results and Discussion

Growth parameters: The maximum plant height was recorded under 160 kg N ha^{-1} at each successive growth stages, which was at par with 120 kg N ha^{-1} followed by 80 kg N ha^{-1}. Among the treatments, lowest plant height (25.9 cm) was significantly observed under control. The maximum plant height was recorded with planting geometry of 75cm x 20cm followed by 60cm x 20cm and 50cm x 20cm (Table 1). Among the different planting geometries the differences were non-significant at all successive growth stages. The results revealed that the stem girth of fodder maize plant was discernibly influenced by manipulating the N levels and was significantly improved with increase in nitrogen dose from 0 to 160 kg ha^{-1} during the period of experimentation. However, the application of 120 and 160 kg N ha^{-1} showed at par in stem girth with each other but was significantly superior to control (Table 1). At initial stage the stem girth were similar with all planting geometry and started increasing upto 80 DAS. However, stem girth was found maximum with planting geometry 75 x 20 cm (3.5 cm) which was on par with 60 x 20 cm (3.4 cm) at all growth stages. The number of internodes increased significantly with the application of nitrogen from 0 to 160 kg ha^{-1} with wider planting geometry of 75 x 20 cm at 60 and 75 DAS. The improvement in plant height, stem girth and number of internodes with each successive increment of nitrogen might be attributed to the fact that nitrogen is an integral part of protein, the building blocks of plant and it also helps in maintaining higher auxin level, which might have resulted in better growth parameters reported by Singh *et al* (2000b) [14]. The availability of nitrogen sources increases the protoplasmic constituents, and accelerate the process of cell division and elongation, which, in turn increases the values of growth attributes (Hadda and Arora, 2006) [8]. It also encourages the shoot growth. Therefore, higher doses of nitrogen increased the chlorophyll content which increased the rate of photosynthesis and extension of stem resulting increased plant height, stem girth and number of internodes plant^{-1}. Similar results were found by Adamu *et al.* (2015) [1], Amanullah *et al* (2007) [2], Kumar (2009) [9]. These findings were also reported by Okumura *et al* (2011) [10] and Santos *et al* (2002) [12]. Contrasting results were also reported by Cruz *et al*. (2008) [5].

Phenological characters

The treatment combination of 160 kg N ha^{-1} and 75 x 20 cm planting geometry produced highest dry matter (12.57, 55.60, 137.93 and 856.33 g plant^{-1} respectively) which were found superior over other remaining treatment combinations at all growth stages (Table 4). The result might be due to the better growth and development of the crop with higher dose of nitrogen along with wider planting geometry. Optimum planting geometry might have promoted better light interception by the leaves enhanced photosynthesis and carbon dioxide assimilation leading to higher dry matter production as was noticed in the present study corroborates with earlier findings of Sheraz (2010) [13] and Patel *et al* (2010) [11]. Control took 85.44 days for 50% silking followed by treatments receiving 80 kg N ha^{-1} (86.78 days) followed by 120 kg N ha^{-1} (87.11 days) and 160 kg N ha^{-1} (92.22 days). The results are in confirmation with the findings of Umair (2015) [3]. They reported that maximum number of days taken by plants for silking was due to increase in nitrogen level from 0 kg ha^{-1} to higher level of nitrogen**.** Planting geometries were ineffectual to the crop on days taken for 50% silking. The longest number of days to physiological maturity was recorded under 160 kg N ha^{-1} (138.56 days) and the shortest number of days to physiological maturity was seen under control (Table 4). The highest number of days to physiological maturity was observed with the planting geometry of 50 × 20 cm might be ascribed due to an inter plant competition existed for space and nutrient within the community which in turn increased vegetative growth and hence the total number of days to physiological maturity. The plots with treatment combination of 160 kg N ha^{-1} along with 50 x 20 cm planting geometry took the maximum days for maturity (140 days). Different nitrogen levels coupled with planting geometry of 50 x 20 cm took comparably maximum days for maturity. This is due to higher nitrogen dose and narrow planting geometry triggered the vegetative growth of plant instead of reproductive growth of crop (Table 5).

Yield

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 *i.e.*10.4 q ha^{-1}. The maximum seed yield was noted with 75 x 20 cm planting geometry (24.0 q ha^{-1}) which was significantly superior over other planting geometries tried. 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 (31.0 qha^{-1}). Although the lowest seed yield was observed under control combinations as compared to other remaining treatment combinations (Table 6). 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 followed by planting geometry of 60 cm x 20 cm (13.27%) and least (9.96%) under planting geometry of 50cmx20cm (Table6).

Table 1: Plant height, stem girth, number of internodes plant^{-1}, dry matter accumulation plant^{-1}as influenced by different levels of nitrogen and planting geometry

Treatments			Plant height (cm)					Stem girth (cm)					Number of internodes plant^{-1}	
			20 DAS	40 DAS	60 DAS	80 DAS	At harvest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	60 DAS	75 DAS
Nitrogen	N_1	0	11.5	25.9	56.2	138.4	182.1	1.1	1.4	2.2	2.4	3.2	3.2	4
level (kg ha^{-1})	N_2	80	12.4	30.6	70.2	174.2	234	1.2	2.1	2.6	3.2	3.4	3.4	4.9
	N_3	120	12.7	34.3	79.8	192	268.4	1.2	2.4	2.8	3.3	3.5	4.2	5.6
	N_4	160	13.0	35.0	83.7	200.6	301.1	1.2	2.6	2.9	3.5	3.5	4.5	6.5
		S.Em ±		0.9	2.6	5.9	5.8		0.03	0.06	0.05	0.06	0.04	0.1
		CD(P=0.05)	NS	2.7	7.5	17.3	17.2	NS	0.09	0.17	0.14	0.17	0.13	0.29
Planting	S_1	50	12.1	29.3	63.9	166.2	233.5	1.2	2	2.4	2.9	3.3	3.5	4.6
geometry	S_2	60	12.4	31.5	73.4	173.5	243.1	1.2	2.1	2.6	3.1	3.4	3.9	5.5
(cm)	S_3	75	12.7	33.5	80.1	189.3	262.7	1.2	2.3	3	3.3	3.5	4.1	5.7
		S.Em ±		0.8	2.2	5.1	5.1		0.03	0.05	0.04	0.05	0.04	0.09
		CD(P=0.05)	NS	2.3	6.5	15	14.9	NS	0.08	0.15	0.12	0.15	0.11	0.25
Interaction	NXS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	S

Table 2: Number of internodes plant^{-1} of fodder maize as influenced due to interaction effect of nitrogen level and planting geometry

Number of internodes plant^{-1}								
	60 DAS				75 DAS			
Nitrogen level (kg ha-1)	Planting geometry (cm)				Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean	50 x 20	60 x 20	75 x 20	Mean
0	3.1	3.1	3.3	3.16	3.3	4	4.7	4.02
80	3.3	3.5	3.6	3.44	4.6	4.9	5.1	4.89
120	3.4	4.5	4.5	4.16	4.6	6	6.1	5.56
160	4.1	4.7	4.8	4.53	5.8	6.9	6.7	6.47
Mean	3.47	3.93	4.07		4.58	5.47	5.65	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS		Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.04	0.04	0.07		0.1	0.09	0.17	
CD(P=0.05)	0.13	0.11	0.22		0.29	0.25	0.51	

Table 3: Dry matter accumulation of fodder maize as influenced due to interaction effect of nitrogen level and planting geometry

Dry matter accumulation (g plant^{-1})																
40 DAS					60 DAS				80 DAS				At harvest			
Nitrogen level (kg ha^{-1})	Planting geometry(cm)				Planting geometry(cm)				Planting geometry(cm)				Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean	50 x 20	60 x 20	75 x 20	Mean	50 x 20	60 x 20	75 x 20	Mean	50 x 20	60 x 20	75 x 20	Mean
0	2.53	3.40	4.58	3.50	27.26	29.72	30.65	29.21	65.74	72.53	83.93	74.07	321.81	330.04	413.80	355.22
80	2.35	4.84	6.84	4.68	33.43	35.60	38.32	35.78	106.41	109.29	118.06	111.25	365.21	394.89	489.67	416.59
120	7.76	8.44	9.82	8.67	38.76	39.71	46.47	41.65	110.45	116.92	119.44	115.60	438.26	537.41	655.23	543.63
160	11.07	12.14	12.57	11.93	51.31	53.15	55.60	53.35	128.04	134.66	137.93	133.54	599.00	690.67	856.33	715.33
Mean	5.92	7.20	8.45		37.69	39.55	42.76		102.66	108.35	114.84		431.07	488.25	603.76	
	Nitrogen level (N)	Planting Geometry (S)	Interaction NXS		Nitrogen level (N)	Planting Geometry (S)	Interaction NXS		Nitrogen level (N)	Planting geometry (S)	Interaction NXS		Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	0.14	0.12	0.25		0.38	0.33	0.65		0.52	0.45	0.90		13.76	11.92	23.84	
CD(P=0.05)	0.42	0.37	0.73		1.10	0.95	1.91		1.53	1.33	2.65		40.37	34.96	69.92	

Table 4: Days to 50% silking and days to physiological maturity as influenced by different levels of nitrogen and planting geometry

Treatments			Days to 50% silking	Days to physiological maturity
Nitrogen	N_1	0	85.44	116.11
level (kg ha^{-1})	N_2	80	86.78	128.56
	N_3	120	87.11	132.67
	N_4	160	92.22	138.56
		S.Em ±	0.75	1.02
		CD(P=0.05)	2.21	2.99
Planting	S_1	50	89.17	131.08
geometry	S_2	60	87.42	128.17
(cm)	S_3	75	87.08	127.67
		S.Em ±	0.65	0.88
		CD(P=0.05)	1.91	2.59
Interaction	NXS		NS	S

Table 5: Days to physiological maturity of fodder maize as influenced due to interaction effect of nitrogen levels and planting geometry

Days to physiological maturity				
Nitrogen level (kg ha^{-1})	Planting geometry (cm)			
	50 x 20	60 x 20	75 x 20	Mean
0	116.00	116.33	116.00	116.11
80	136.67	123.33	125.67	128.56
120	131.67	134.00	132.33	132.67
160	140.00	139.00	136.67	138.56
Mean	131.09	128.17	127.67	
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS	
S.Em ±	1.02	0.88	1.77	
CD(P=0.05)	2.99	2.59	5.18	

Table 6: Yield, harvest index and shelling percentage of fodder maize as influenced by nitrogen levels and planting geometry

Treatments			Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Harvest index (%)
Nutrient	N_1	0	10.4	92.6	10.3
level	N_2	80	17.1	131.1	11.7
(kg ha^{-1})	N_3	120	24.8	140.4	15.2
	N_4	160	28.6	147.4	16.5
		S.Em ±	0.6	2.5	0.3
		CD(P=0.05)	1.7	7.3	1.0
Planting	S_1	50	16.3	143.4	9.96
geometry	S_2	60	20.3	128.5	13.27
(cm)	S_3	75	24.0	111.8	17.02
		S.Em ±	0.5	2.2	0.30
		CD(P=0.05)	1.5	6.3	0.88
Interaction	NXS		S	NS	S

Table 7: Seed yield and Harvest Index of fodder maize as influenced due to interaction effect of nitrogen level and planting geometry

Nitrogen level (kg ha^{-1})	Seed yield (q ha^{-1})				Harvest index (%)				
	Planting geometry (cm)				Planting geometry (cm)				
	50 x 20	60 x 20	75 x 20	Mean	50 x 20	60 x 20	75 x 20	Mean	50 x 20
0	8.7	10.7	12.0	10.5	8.0	10.3	12.5	10.3	8.0
80	15.0	17.7	18.7	17.1	9.1	12.0	14.0	11.7	9.1
120	18.3	25.0	31.0	24.8	10.4	15.0	20.3	15.2	10.4
160	23.3	28.0	34.3	28.5	12.4	15.7	21.3	16.5	12.4
Mean	16.3	20.4	24.0		10.0	13.3	17.0		10.0
	Nitrogen level (N)	Planting geometry (S)	Interaction NXS		Nitrogen level (N)	Planting geometry (S)	Interaction NXS		Nitrogen level (N)
S.Em ±	0.58	0.50	1.00		0.35	0.30	0.60		0.35
CD(P=0.05)	1.69	1.47	2.93		1.02	0.88	1.76		1.02

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