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Effect of spacing and nitrogen fertilization on growth, yield and economics of fodder maize (*Zea mays* L.)

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Abstract
A field experiment was carried out during *rabi* season of 2017-18 on medium black soil at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat) to study the effect of spacing and nitrogen levels on growth and yield of fodder maize. Twelve treatment combinations consisted of three spacing *viz*., S_1:20cm, S_2:30cm and S_3:40cm; and four levels of nitrogen *viz*., N_1:00 kg N ha^{-1}, N_2:80 kg N ha^{-1}, N_3: 100 kg N ha^{-1} and N_4: 120 kg N ha^{-1} were tested under split plot design with four replications. The experimental results revealed that sowing of fodder maize at wider row spacing of 40 cm recorded significantly higher values of number of leaves plant^{-1}, number of internodes plant^{-1}, stem thickness and length of internodes. Whereas, narrow row spacing of 20 cm produced higher green and dry fodder yields along with higher gross and net returns. Almost all the growth and yield attributes, green and dry fodder yields were found significantly higher when crop was fertilized with 120 kg N ha^{-1} followed by 100 kg N ha^{-1}. Maximum gross and net return as well as B:C ratio were observed under 120 kg N ha^{-1}.

Keywords: Fodder maize, *rabi*, crop geometry, nitrogen levels

Introduction
India has the largest livestock population of 520 million heard which is about 15 per cent of the world's livestock. Whereas, India has only two per cent of the world's geographical area under fodder crops (Shah *et al.*, 2011a) [30]. Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and successful cultivation in diverse seasons and ecologies for various purposes. Globally, maize is known as "Queen" of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 million hectares in about 160 countries having wider diversity of soil, climate, biodiversity and management practices. In modern maize production systems, enhanced plant-to- plant variability often results from increased competition among individual plants at progressively higher plant densities for limiting resources. The present feed and fodder resources of the country can meet only 47 per cent of the requirements with a vast deficit of 61 and 22 per cent of green and dry fodder, respectively (Shah *et al.*, 2011b) [29]. There are two major approaches to increase fodder production *i.e.* horizontal and vertical improvement. Firstly, the production of fodder can be increased by increasing the area under fodder crops, which is not feasible as the country is already facing hardship in feeding its human population which is increasing at the rate of more than 1% per annum. Thus, the only way left out is vertical enhancement of fodder production by increasing the yield of fodder per unit area per unit time.

Among the various agronomic factors, proper row spacing and nitrogen are of prime importance for enhancing fodder yield of better quality. Plant spacing is one of the important factors that determine the efficient use of land, light, water and nutrients. The number of plants required per unit area is one of the prime considerations for higher biomass production which depends upon the nature of the crop, growth habit and environment. Among different nutrients, nitrogen is the most commonly deficient nutrient in the soil and gives considerable response in forage maize. Nitrogen is an essential element for both fodder quantity and quality as it is a component of protein and chlorophyll. It is thus, essential for photosynthesis, vegetative and reproductive growth and it often determines yield of maize. Maize can be grown to produce fodder in *rabi* season to solve the problem of livestock feed shortage during this period. Therefore, present experiment was planned to evaluate the effect of spacing and nitrogen levels on growth, yield and economics of fodder maize (*Zea mays* L.) under Saurashtra region.

Materials and Methods

The field experiment entitled "Effect of spacing and nitrogen levels on growth, yield and quality of fodder maize (*Zea mays* L.)" was conducted in *rabi* season of the year 2017-18 at Instructional Farm College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The soil of experimental field was medium black in texture, medium in available nitrogen, phosphorus and potassium with alkaline in reaction (pH of 7.67). Twelve treatment combinations consisted of three spacing *viz*., S_1:20cm, S_2:30cm, S_3:40cm and four levels of nitrogen *viz*., N_1:00 kg N ha^{-1}, N_2:80 kg N ha^{-1}, N_3: 100 kg N ha^{-1} and N_4: 120 kg N ha^{-1} were tested under split plot design with four replications. Furrows at 20cm, 30cm and 40cm distance were opened by bullock drawn cultivar in the whole experimental field before sowing the crop. The full dose of phosphorus in the form of DAP and half quantity of nitrogen in the form of urea were applied in previously opened furrows as basal application at the time of sowing and remaining half quantity of nitrogen was applied as top dressing at knee height stage (30 DAS) in the form of urea. Herbicide Pendimethalin 30 EC @ 0.9 kg ha^{-1} was applied as pre-emergence with irrigation water. Two manual weeding was done in between the rows at 20 and 35 DAS of crop. The first common irrigation was applied immediately after sowing. Second common irrigation was given 7 DAS for proper germination and establishment of the seedlings. Total seven irrigations were given to fodder maize crop. Other cultural operations were carried out as per recommendations made for the fodder maize in the Saurashtra region of Gujarat.

Results and Discussion

A. Effect of spacing

The data presented in Table-1 revealed that plant height, nnumber of leaves $plant^{-1}$, number of internodes $plant^{-1}$, stem thickness, length of internode and Periodical dry matter accumulation at 40, 60 DAS and at harvest were recorded higher in wider row spacing of 40 cm as compared to narrow row spacing. This might be due to efficient utilization of growth resources like sunlight, moisture and nutrients under wider spacing. These results are conforms the findings of Muniswamy *et al.* (2007) [20], Boomsma *et al.* (2009) [6], Dar *et al.* (2014) [9], Dutta *et al.* (2015) [11], Chavan *et al.* (2017) [8], Kumari *et al.* (2017) [14] and Neelam and Dutta (2018) [21]. The significant reduction in plant growth with reduction in row spacing seems to be the resultant effect of natural shading due to overcrowding of plants which might have reduced the availability of light within the crop canopy and inhibited elongation of lower internodes. Fodder maize sown at 40 cm spacing produced significantly more number of leaves these might be due to lesser inter row competition for light and have adequate space to extend its leaf and intercept more light with less competition. The results obtained in present study are in close agreement with those reported by Emine *et al.* (2010) [12], Verma and Tomar (2014) [32], Bairagi *et al.* (2015) [4], Devi and Ghosh (2017) [10]. Fodder maize sown at wider row spacing of 30 and 40 cm were at par with each other except, at 40 DAS and recorded significantly higher dry matter accumulation $plant^{-1}$ than closer row spacing of 20 cm. Dense population under closer plant geometry reduced dry matter production might be due to less availability of space for each plant which increased competition among the plants for resources. The results corroborates with the findings of Singh and Singh (2006) [30], Suryavanshi *et al.* (2009) [31], Verma and Tomar (2014) [32], Dutta *et al.* (2015) [11], Kumari *et al.* (2017) [14] and Kurne *et al.* (2017) [15]. Non-significant effect of row spacing on leaf: stem ratio and days to 50% flowering were observed.

The data presented in Table-2 revealed that fodder maize sown at closer row spacing of 20 cm produced significantly higher green and dry fodder yields of 40809 and 12180 kg ha^{-1}, respectively than crop sown at 40 cm row spacing and it was at par with row spacing of 30 cm. The magnitude of increase in green and dry fodder yields under 20 cm were to the tune of 32.5 and 31.2 per cent, respectively over 40 cm row spacing. This mainly attributed to the fact that this spacing acquired 82.8 per cent higher plant population than 40 cm row spacing. The findings are in close conformity with the results reported by Moosavi *et al.* (2012) [19], Shafi *et al.* (2012) [27], Golada *et al.* (2013) [13], Massey *et al.* (2014) [17], Mandic *et al.* (2015) [16] and Sangtam *et al.* (2017) [25].

Table 1: Effect of spacing and nitrogen levels on growth and yield attributes of *rabi* fodder maize

Treatments	Plant height (cm)			No. of leaves $plant^{-1}$			No. of internodes $plant^{-1}$	Length of internode (cm)	Stem thickness (cm)
	40 DAS	60 DAS	Harvest	40 DAS	60 DAS	Harvest			
Spacing (cm)									
S_1-20	99.3	135.4	145.1	5.0	6.9	9.2	11.7	13.2	1.6
S_1-30	105.0	147.2	154.5	5.9	8.7	10.3	13.6	15.6	1.9
S_1-40	109.7	151.4	158.9	6.5	8.8	10.6	14.5	16.5	2.0
S.Em.±	1.95	2.87	3.48	0.15	0.18	0.24	0.29	0.36	0.09
C.D. at%	6.75	9.93	NS	0.53	0.62	0.84	1.02	1.23	0.30
CV %	7.45	7.94		10.51	8.84	9.68	8.87	9.44	18.92
Nitrogen levels (kg ha^{-1})									
N_1-00	77.1	121.8	133.8	4.9	7.5	8.6	12.2	13.9	1.5
N_2-80	105.4	143.9	144.2	5.7	8.0	9.7	13.1	14.9	1.8
N_3-100	114.4	154.6	164.6	6.3	8.3	10.8	13.7	15.5	1.9
N_4-120	121.8	158.4	168.7	6.4	8.6	11.1	14.2	16.0	2.1
S.Em.±	1.74	2.51	3.44	0.13	0.20	0.20	0.22	0.38	0.07
C.D. at 5%	5.06	7.27	9.99	0.37	0.58	0.58	0.63	1.12	0.21
CV %	5.77	6.00	7.80	7.54	8.49	6.86	5.66	8.81	13.92
Interaction									
S.Em.±	3.02	4.34	5.96	0.22	0.34	0.34	0.38	0.67	0.13
C.D. at 5%	NS	NS	17.30	NS	NS	NS	NS	NS	NS

Table 2: Effect of spacing and nitrogen levels on yield attributes and economics of rabi fodder maize

Treatments	Dry matter accumulation (g plant^{-1})			Leaf: stem ratio	Days to 50% flowering	Green fodder yield (kg ha^{-1})	Dry fodder yield (kg ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
	40 DAS	60 DAS	Harvest							
Spacing (cm)										
S_1-20	27.7	58.1	87.9	0.87	60.1	40809	12180	81618	62846	4.35
S_1-30	30.1	62.4	92.2	0.89	60.9	39449	11835	78898	61403	4.51
S_1-40	32.7	64.2	93.9	0.90	62.7	30740	9285	61480	44624	3.65
S.Em.±	0.65	0.93	1.84	0.01	1.41	1341	354	-	-	-
C.D. at%	2.26	3.20	NS	NS	NS	4642	1225	-	-	-
CV %	8.64	6.01		5.72	9.19	14.50	12.75	-	-	-
Nitrogen levels (kg ha^{-1})										
N_1-00	20.9	50.9	80.6	0.83	49.5	30507	9235	61014	46073	4.08
N_2-80	29.0	59.0	88.7	0.88	58.2	35860	10758	71720	53683	3.98
N_3-100	33.6	67.1	94.6	0.90	67.3	39933	11897	79866	61530	4.36
N_4-120	37.3	69.5	101.4	0.94	69.8	41697	12509	83394	64760	4.48
S.Em.±	0.67	0.92	1.61	0.01	1.04	1078	307	-	-	-
C.D. at 5%	1.93	2.66	4.66	0.02	3.03	3129	892	-	-	-
CV %	7.64	5.16		3.11	5.91	10.10	9.59	-	-	-
Interaction										
S.Em.±	1.15	1.59	2.78	0.01	1.81	1868	533	-	-	-
C.D. at 5%	NS	NS	8.07	NS	NS	5419	1545	-	-	-

B. Effect of nitrogen

The data presented in Table-1 revealed that among the growth parameters studied, plant height, number of leaves plant^{-1} and dry matter accumulation plant^{-1} increased with increase in nitrogen levels from 0 to 120 kg N ha^{-1}. Also, maximum number (14.2), thickness (2.1 cm) and length (16.0 cm) of internode were produced with the application of 120 kg N ha^{-1}.The increase in growth parameters like plant height, number of leaves, dry matter accumulation, number of internodes, thickness and length with increase in nitrogen levels could be attributed to favourable effect of nitrogen in increasing cell wall material resulted in increased size of cell. It contributes to cell division and cell elongation. These results are in accordance with the findings of Emine *et al.* (2010) [12], Aslam *et al.* (2011) [3], Patil (2013) [23], Ali and Muhammad (2017) [1] and Patel *et al.* (2017) [22]. Green and dry fodder yields were significantly influenced by different nitrogen levels. Application of 120 kg N ha^{-1} to fodder maize produced significantly higher green and dry fodder yields of 41697 and 12509 kg ha^{-1}, respectively and which was found at par with 100 kg N ha^{-1}. The increasing trend observed in green and dry fodder yields were evidently due to cumulative effects of increasing trend observed on major growth parameters which ultimately resulted in increased green and dry fodder yields. The result confirms the findings of Budakli *et al.* (2010) [7], Aslam *et al.* (2011) [3], Patil (2013) [23], Patel *et al.* (2017) [22] and Meena *et al.* (2021) [18].

C. Interaction Effect

Interaction effect between row spacing and nitrogen levels was found significant for plant height at harvest, dry matter accumulation plant^{-1}, green fodder yield, dry fodder yield. The results more or less collaborates the findings of Emine *et al.* (2010) [12], Bhatt *et al.* (2012) [5] and Verma and Tomar (2014) [32].

D. Economics

The maximum gross and net realization of ₹ 81,618 and ₹ 62,846 ha^{-1}, respectively were obtained under spacing S_1 (20 cm) followed by S_2 (30 cm). This could be due to more number of plants per unit area in narrow row spacing which leads to higher green and dry fodder yields which leads to higher gross and net returns. These results are in close vicinity with those obtained by Kumari *et al.* (2017) [15]. Data further showed that fodder maize fertilized with 120 kg N ha^{-1} (N_4) recorded maximum gross and net returns of ₹ 83,394 and ₹ 64,760 ha^{-1}, respectively with B: C ratio of 4.48. This might be due to sufficient availability and more uptake of nitrogen by crop ultimately resulted in better vegetative growth that leads to higher fodder yield and hence higher gross and net returns as well as B: C ratio. The results more or less collaborates the findings of Sankaran *et al.* (2005) [26] and Reddy and Bhanumurthy (2010) [24].

Conclusion

On the basis of one year field experimentation, it seems quite logical to conclude that under medium black soil of South Saurashtra Agro-climatic zone for getting higher fodder yield, fodder maize should be sown at row spacing of 20 cm with the application of 120 kg N ha^{-1} along with other recommended package of practices.

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