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Influence of balanced nutrition, seed rate and plant geometry on fodder maize in south-eastern Rajasthan

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Abstract
A field experiment was conducted during summer season of 2009 and 2010 at Borkhera farm, Kota, Rajasthan to find out the effect of row spacing, seed rate and balanced nutrition on fodder maize. Plant height, leaf area index, green and dry fodder yield, crude protein content, nitrogen, phosphorus, potassium and zinc uptake was significantly increased as the row spacing increased from 30 to 45 cm. Maximum green fodder (45.10 t/ha) and dry fodder (11.96 t/ha) yields were obtained with the row spacing of 45 cm, which was significantly superior to row spacing of 30 cm. Seed rate 60 and 75 kg/ha being at par, registered significantly highest plant height, leaf area index, green and dry fodder yield over seed rate 45 kg/ha. Significantly highest green and dry fodder yields (48.06 and 12.70 t/ha) were recorded with application of N 100 kg + P 30 kg + K 30kg + Zn 5kg /ha. This nutrient combinations also significantly increased nitrogen, phosphorus, potassium and zinc uptake and their content in fodder maize.

Keywords: Balanced fertilization, Fodder maize, Nutrient uptake, Row spacing, Seed rate

Maize (*Zea mays* L.) is an important fodder crop of India. Its greater production potential, wider adaptability, quick growing nature, palatability and excellent fodder quality makes it an ideal fodder crop. Maize fodder is free from toxicants and can be safely fed to animals at any stages of crop growth. In south eastern Rajasthan, farmers holding lands under Chambal command area or having irrigation facility through tube wells are growing maize as green fodder in *Zaid* and *Kharif* seasons. The productivity of fodder maize in this region is very low due to multiple constraints; of which imbalanced plant nutrition, improper plant geometry and inadequate seed rate are the important ones. At present, the country faces a net deficit of 61.1 % green fodder, 21.9% dry crop residues and 64% feeds (Anonymous, 2011). In India the cropped area under cultivated forage is only 4.9 % of the total cropped area, which is almost static since last few decades (Kumar *et al*., 2012) and there is hardly any scope of expansion due to increasing pressure on agricultural lands for food and cash crops. Therefore, there is a need to increase production of quality fodder in per unit area and time (Hazra, 2014). Being a highly exhaustive crop, maize demands good nutrient management. High yielding varieties respond not only to heavy doses of nitrogen but also equally to phosphorus and potassium applications and give the highest yields when balanced dose of fertilizers are adequately applied. Among micronutrients, zinc deficiency appears to be most wide spread due to intensive agriculture, use of high analysis fertilizers and limited or no zinc application by farmers. Maize is also the most susceptible to zinc deficiency and is used as an indicator plant for zinc. Among cereals, maize ranks third in zinc demand after rice and wheat. Besides improving photosynthesis and regulation of auxin concentration, zinc plays an important role in nitrogen metabolism and protein synthesis (Alloway, 2008). Its application reduces fibrous carbohydrate contents in fodder thereby increases digestibility. Maintenance of optimum plant stand with the use of optimum seed rate and appropriate sowing method are of prime importance for exploiting available resources towards yield formation. Even distributions of plants facilitate greater availability of growth inputs with least intra and inter plant competition, which consequently results in realization of higher productivity. Therefore, the present study was conducted to assess the effect of balanced fertilization, seed rate and row spacing on yield and quality of fodder maize.

A field experiment was conducted at Krishi Vigyan Kendra, Kota (Rajasthan) during summer season of 2009 and 2010. The soil of experimental field was clay loam in

texture and slightly alkaline in reaction (pH 7.9), medium in organic carbon (7.0 g/kg), available nitrogen (257 kg/ha), phosphorus (15.8 kg/ha), high in potassium (470 kg/ha), low in zinc (0.71mg/kg soil). The experiment was laid out in split plot design, comprising two row spacing (30 and 45 cm), three seed rate (45, 60 and 75 kg/ha) in main plots and four nutrient combinations (N 100 kg/ha, N+P 30 kg/ha, NP+K 30 kg/ha and NPK+ Zn 5kg/ha) in sub plots and was replicated thrice. Nitrogen was applied through urea, phosphorus through single super phosphate, potassium through murate of potash and zinc through ZnSO4. Fodder maize cv. J-1006 was sown on 25th March during 2009 and 28th March during 2010. As per treatments; the total quantity of phosphorus, potassium, zinc and half dose of nitrogen were drilled in furrows before sowing. The remaining half of nitrogen was top dressed at knee height stage. Crop was harvested at 75% silking stage. Plant height of five randomly tagged plants of each plot were recorded and averaged to height/plant. Leaf area index was recorded with canopy analyzer. The crop from each net plot (leaving boarder) was harvested and immediately weighed for green fodder yield. Sample of fodder maize collected at harvest were oven dried at 65 ^{0}C to a constant weight for determination of moisture/dry matter content. Standard methods were employed for determination of nutrient concentration in plant samples, *i.e.* Nesler's reagent colorimetric method for N (Lindner, 1944), Vanadomolybdo phosphoric yellow color method for P, Flam photometer for K and Atomic absorption spectrometer for zinc. The N content of sample was multiplied by a factor 6.25 to obtain crude protein content. The uptake was determined by multiplying their contents with respective dry fodder yield at harvest.

Plant height and leaf area index of maize recorded during both the years of study varied significantly from row spacing of 30 cm to 45 cm (Table 1). Maize sown at 45 cm row spacing resulted highest green fodder (45.10 t/ha) and dry fodder (11.96 t/ha) yields which were significantly superior to yields of 30 cm row spacing. Singh *et al* (2012) also observed highest green fodder yield of maize with 60 x 15 cm row and plant spacing. Wider row spacing enhanced the fodder yield due to better crop canopy development which resulted in more efficient utilization of resources. Crude protein content (7.98 and 7.88 %) was significantly increased with increased row spacing of 45 cm (Table 2). Increase in row spacing of 45 cm significantly increased uptake of nitrogen, phosphorus, potassium and zinc, and their contents in the biomass. The present finding was in agreement with that of Mundra *et al.* (2002).

Table 1. Effect of row spacing, seed rate and different nutrient combinations on plant height, leaf area index, green and dry fodder yields of maize

Treatment	Plant height (cm)		Leaf area index		Green fodder yield (t/ha)			Dry fodder yield (t/ha)		
	2009	2010	2009	2010	2009	2010	Mean	2009	2010	Mean
Row spacing (cm)										
30	190.11	191.00	5.66	5.81	42.71	42.60	42.66	11.17	11.16	11.17
45	195.27	196.44	6.13	6.26	44.68	45.52	45.10	11.81	12.09	11.96
SEM	1.59	1.57	0.105	0.097	0.369	0.371	0.262	0.125	0.092	0.077
CD (P=0.05)	5.02	4.96	0.331	0.308	1.165	1.170	0.773	0.394	0.290	0.229
Seed rate (kg/ha)										
45	188.79	189.58	5.47	5.61	39.99	39.74	39.86	10.47	10.52	10.5
60	194.12	194.41	5.95	6.10	45.29	45.64	45.47	11.92	12.05	11.99
75	195.16	197.16	6.26	6.41	45.80	46.80	46.30	12.10	12.30	12.2
SEM	1.54	1.32	0.128	0.119	0.452	0.454	0.320	0.153	0.112	0.095
CD (P=0.05)	4.86	4.16	0.405	0.378	1.427	1.433	0.946	0.483	0.355	0.28
Fertilization (kg/ha)										
N100	184.38	184.61	5.25	5.26	40.11	39.25	39.71	10.37	10.37	10.38
N100 +P30	189.94	190.94	5.62	5.83	42.40	42.80	42.60	11.16	11.25	11.21
N100+P30+K30	195.38	196.5	6.07	6.33	44.70	45.58	45.14	11.87	12.06	11.97
N100+P30+K30+Zn5	201.05	202.83	6.65	6.73	47.50	48.62	48.06	12.56	12.82	12.70
SEM	3.25	2.92	0.083	0.094	0.791	0.912	0.604	0.227	0.242	0.166
CD (P=0.05)	9.33	8.38	0.240	0.270	2.270	2.616	1.702	0.653	0.695	0.469

Table 2. Effect of row spacing, seed rate and different nutrient combinations on crude protein content and nutrient uptakes in fodder maize

Treatment	Crude protein content (%)		N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)		Zn uptake (g/ha)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Row spacing (cm)										
30	6.92	6.91	124.03	124.64	37.47	37.44	112.79	118.02	535.58	540.88
45	7.98	7.88	153.04	155.00	44.98	46.26	115.31	127.74	577.36	613.86
SEM	0.07	0.06	1.62	1.74	2.10	2.30	0.799	2.92	12.12	18.78
CD (P=0.05)	0.23	0.26	5.11	5.48	6.62	7.27	2.51	9.22	38.22	59.19
Seed rate (kg/ha)										
45	7.38	7.23	124.70	123.04	35.45	35.44	102.84	110.09	508.91	494.70
60	7.59	7.55	145.62	147.89	41.9	42.53	115.39	136.38	578.29	584.37
75	7.36	7.39	145.29	148.52	46.33	47.58	123.92	137.18	582.20	653.04
SEM	0.09	0.10	1.92	2.13	1.62	1.99	3.63	2.81	14.85	23.00
CD (P=0.05)	NS	NS	6.26	6.71	5.12	6.28	11.46	8.85	46.81	72.50
Fertilization (kg/ha)										
N100	5.99	6.06	99.84	101.05	20.82	20.82	65.32	79.70	420.27	409.50
N100 +P30	7.03	7.18	125.70	127.85	44.92	44.10	74.81	85.48	470.05	480.27
N100+P30+K30	8.12	7.89	155.38	155.65	44.30	44.86	141.65	143.81	486.33	509.72
N100+P30+K30+Zn5	8.65	8.44	173.24	174.72	54.86	57.62	174.42	202.54	849.22	910.00
SEM	0.10	0.15	3.80	4.60	3.31	3.49	8.96	5.47	22.66	30.30
CD (P=0.05)	0.31	0.45	10.92	13.20	9.51	10.03	25.71	15.70	65.00	86.91

Seed rate of 60 kg and 75 kg/ha being at par, recorded significantly highest plant height and leaf area index than seed rate of 45 kg/ha during the both year of study (Table 1). It was the effect of high plant population on vegetative growth and development. Green fodder and dry fodder yields were increased significantly as the seed rate was increased from 45 to 60 kg/ha. Significantly highest green fodder (46.30 t/ha) and dry fodder (12.20 t/ha) yields were recorded with seed rate of 75 kg/ha compare to 45 kg/ha seed rate and it was at par with 60 kg/ha seed rate. These findings were also in agreement with Mahdi *et al.* (2012). Crude protein content was not significantly influenced by the seed rate. Highest crude protein contents (7.59 and 7.55%) were recorded in 60 kg/ha seed rate during first and second year of study. The reduction in crude protein content with increased seed rate might be due to inadequate availability of nitrogen as a result of competition. Similar observations were made earlier (Mahdi *et al*., 2012). Increase in seed rate from 45 to 75 kg/ha significantly increased nitrogen, phosphorus, potassium and zinc uptake but it was at par in case of 60 and 75 kg/ha seed rate (Table 2) . The higher nutrient uptake with aforesaid treatment might be due to higher total biomass yield and nutrient content. Nitrogen, phosphorus, potassium and zinc contents in fodder maize were also found significant with increasing seed rate from 45 to 75 kg/ha but it was again at par in case of 60 and 75 kg/ha seed rate (Table 3).

The application of balance nutrition (NPK Zn) significantly improved the yield component. Maximum plant height (201.05 and 202.83 cm) was recorded with application of N 100+P 30+K 30+Zn5 kg/ha during the both year of study, which was significantly higher over N 100 and N 100 + P30 kg/ha (Table 1). Leaf area index significantly increased with the application of *each* additional nutrient of N 100+P 30+K 30+Zn5 kg/ha. It was well emphasized that balanced nutrition with NPK +Zn markedly improved overall growth of the crop by virtue of its impact on morphological and photosynthetic components along with accumulation of nutrients. This provided opportunity for availability of nutrients and metabolites for growth and development, which ultimately resulted in realization of higher yield. The highest green fodder (48.06 t/ha) and dry fodder (12.70 t/ha) yields were obtained with the combined application of N 100+P 30+K 30+Zn5 kg/ha which was significantly superior to rest of the treatments (Table 1). Increase in green and dry fodder yields were due to enhancement in the growth attributes, which led to photosynthates partitioning as nitrogen, phosphorus and potassium play vital role in different plant metabolic activities and in improving nutritional status of plants.

Table 3. Effect of row spacing, seed rate and different nutrient combinations on nutrient contents of fodder maize

Treatment	N (%)		P (%)		K (%)		Zn (ppm)	
	2009	2010	2009	2010	2009	2010	2009	2010
Row spacing (cm)								
30	1.10	1.10	0.33	0.32	0.94	1.02	47.55	47.88
45	1.27	1.26	0.37	0.37	0.99	1.11	48.00	50.11
SEM	0.0118	0.013	0.012	0.013	0.011	0.014	0.142	0.460
CD (P=0.05)	0.037	0.041	0.037	0.040	0.034	0.061	0. 449	1.456
Seed rate (kg/ha)								
45	1.16	1.15	0.33	0.33	0.94	0.95	46.91	46.50
60	1.20	1.19	0.36	0.37	0.96	1.17	50.28	50.84
75	1.21	1.20	0.37	0.37	0.97	1.20	50.92	52.25
SEM	0.011	0.012	0.009	0.011	0.006	0.023	0.96	1.22
CD (P=0.05)	0.034	0.037	0.028	0.034	0.018	0.072	3.02	3.88
Fertilization (kg/ha)								
N100	0.96	0.97	0.20	0.19	0.63	0.77	40.44	40.66
N100 +P30	1.12	1.13	0.40	0.39	0.67	0.76	42.11	42.55
N100+P30+K30	1.30	1.27	0.37	0.38	1.19	1.19	41.00	42.33
N100+P30+K30+Zn5	1.38	1.37	0.42	0.42	1.36	1.54	67.55	70.44
SEM	0.017	0.025	0.025	0.024	0.055	0.025	1.63	1.980
CD (P=0.05)	0.049	0.072	0.073	0.071	0.158	0.074	4.68	5.681

Whereas, Zn is involved in protein synthesis, and biosynthesis of indole 3-acetic acid (a growth hormone, involved in cell division and cell elongation), which increased growth of the plant and ultimately yield. Highest crude protein contents (8.65 and 8.44%) were recorded with the application of nutrient N 100+P 30+K 30+Zn 5 kg/ha (Table 2). Improvement in crude protein content under N and Zn application was expected as N and Zn are the key constitutes of protein, enzymes and chlorophyll. Jaliya *et al* (2008) reported a significant increase in crude protein content of maize with Zn application. Application of N 100+P 30+K 30+Zn 5 kg/ha significantly increased the nitrogen, phosphorus, potassium and zinc uptake. The improvement in uptake of nutrient in soil and in dry matter was probably achieved by the synergistic effect of N and Zn on P and K. The NPK and Zn nutrient contents in maize were also significantly influenced by the application of N 100+P 30+K 30+Zn 5 kg/ha (Table 3) .

It was concluded that for maximum nutritious green and dry fodder yields in south-eastern Rajasthan, maize should be sown at row spacing 45 cm with seed rate of 60 kg/ha and fertilized with N 100kg + P 30kg + K 30kg + Zn 5 kg/ha.

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