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Original Research Article

Performance of Fodder Maize (*Zea mays* L.) Under Varying Plant Densities and Fertility Levels

D. Panwar*, D. Chouhan, D. Singh, R. P. Singh and V. Nepalia

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan- 313001, India

**Corresponding author*

A B S T R A C T

A field experiment entitled "Performance of Fodder Maize (*Zea mays* L.) Under Varying Plant Densities and Fertility Levels" was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *kharif* 2015 and 2016 with objective to evaluate production potential of fodder maize under varying plant densities and fertility levels. The treatment consisted combinations of four plant densities (1,33,333, 1,66,666, 2,22,222 and 3,33,333 plants ha^{-1}) and four fertility levels (90 + 30, 110 + 40, 130 + 50 and 150 + 60 kg N + P_2O_5 ha^{-1}). The plant density of 2,22,222 plants ha^{-1} recorded significantly higher green and dry fodder yield, net return and B C ratio over 1,66,666 and 1,33,333 plants ha^{-1} and proved economically profitable compared to rest of the densities. Increasing plant density from 1,33,333 to 3,33,333 plants ha^{-1} decreased crude protein content, however, failed to influence total digestible nutrient and crude fiber content significantly. The green fodder yield, net return and B C ratio recorded under application of 130 kg N + 50 kg P_2O_5 ha^{-1} were significantly higher over 110 kg N + 40 kg P_2O_5 and 90 kg N + 30 kg P_2O_5 ha^{-1} and proved economically beneficial. Increasing fertility level significantly increased crude protein, crude fiber and total digestible nutrient content significantly.

Keywords

Fodder maize plant densities, Fertility, Fodder yield, Quality and Economics

Introduction

An increase in population leads to a sharp increase in the demand of animal product such as milk, eggs and the meat. The increase in demand for livestock products has given impetus to greater livestock population within the existing farming system and also emphasizing the need of feed and fodder security in country. At present, the country faces a net deficit of 61.1 per cent green fodder, 21.9 per cent of dry crop residue and 64 per cent feeds (Chaudhary *et al.,* 2012). Thus fulfilling the demand for feed and fodder will be major challenge for the livestock sector of the country. Maize (*Zea mays* L.) is most ideal and suitable crop for fodder as well as silage because of its high yielding ability, excellent nutritional profile, its quick growing nature, succulence, palatability and excellent quality without any anti-nutritional factor, when harvested at any stage of crop growth (Kumar *et al.,* 2018). The climate of the southern Rajasthan is very favourable for maize crop. In this zone it is mainly grown as rainfed crop during monsoon season. In recent past development of composite fodder maize "Pratap Makka Chari-6" has opened a new avenue for exploiting higher green fodder for livestock. Thus identification and development of production technology *i.e.* plant density and fertility level for fodder maize "Pratap Makka Chari-6" as per crop growing situation is

considered to be the first and foremost step for enhancing its green fodder production.

Materials and Methods

The field experiment was carried out during *kharif* 2015 and 2016 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan which is situated at 23°34'N latitude and 73°42'E longitude at an altitude of 582.17 meter above the mean sea level. The soil of the experiment site was clay loam having pH 7.2 & 7.3, organic carbon 0.65 & 0.67, available nitrogen 278.1& 272.3 kg ha^{-1}, phosphorus 18.1 & 18.4 kg ha^{-1} and potassium 302.3 & 301.5 kg ha^{-1} in the plough layer. The well distributed rainfall of 474.1 & 664.3 mm was recorded during crop growth period, respectively. The treatment consisted combinations of four plant densities (30 x 25cm = 1,33,333, 30 x 20 cm = 1,66,666, 30 x 15 cm = 2,22,222 and 30 x 10 cm = 3,33,333 plants ha^{-1}) and four fertility levels (90 + 30 , 110 + 40, 130 + 50 and 150 + 60 kg N + P_2O_5 ha^{-1}). These sixteen treatment combinations were evaluated under factorial randomized block design with three replications during both the years. Fodder maize variety 'Pratap Makka Chari-6" release by MPUAT, Udaipur was used as test variety. During both the years the crop was sown manually on first week of July placing seeds at a depth of 4-5 cm maintaining rows and plants spacing as per treatment. The experimental plot size was 15 m^2. The green crop was harvested at 100 per cent tasseling stage. Phosphorus as per treatments was applied as basal, whereas nitrogen was applied in 3 equal splits *viz.*, 1/3 as basal, 1/3 at knee high stage and remaining 1/3 at initiation of tassel. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg ha^{-1} followed by one hoeing and earthing up at 20 days after sowing was carried out. Net returns B C ratio was calculated on basis of prevailing market prices of inputs and green fodder rate. LAI, chlorophyll, protein content, nutrient uptake, CGR and RGR and other quality parameters were worked out by using standard methods of analysis and formula. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

Results and Discussions

Plant densities

The pooled basis results of the experiment revealed that increasing plant densities from 1,33,333 to 3,33,333 plants ha^{-1} significantly increased plant density of fodder maize recorded at harvest of crop. The plant height recorded under 2,22,222 plants ha^{-1} was significantly higher over 1,66,666 and 1,33,333 plants ha^{-1}. Further increase in plant density from 2,22,222 to 3,33,333 plants ha^{-1} failed to record significant variation in plant height at harvest. Increase in plant height seems to be the resultant of mutual shading due to overcrowding of plants which force plants to grow with faster rate (Parik *et al.*, 2019). Shivalakshmi *et al.*, (2012) described this as a "cooperative movement" wherein smaller plants tend to catch-up with taller plants by means of it and compete more on even terms and conditions. The maximum LAI was recorded under 3,33,333 plants ha^{-1} which was significantly higher over rest of the plant densities. The increase in LAI with increasing plant densities was in close accordance with findings of Bhatt, (2012). Days taken to 50 per cent tasseling, chlorophyll content, number of leaves and number of inter node did not vary significantly under increasing plant densities from 1,33,333 to 3,33,333 plants ha^{-1}. However, maximum dry matter $plant^{-1}$, leaves weight, stem girth and diameter was recorded under 1,33,333 plants ha^{-1} and increasing plant densities decrease these growth parameters to varying extents (Table 1 and 2).

Table.1 Effect of plant densities and fertility levels on growth of fodder maize (Pooled of two years)

Treatments	Density (Lakhs ha^{-1}) at harvest	Plant height (cm)	Dry matter plant^{-1} (g)	LAI	Days to 50% tasseling	Chlorophyll **(mg g^{-1})**	Green leaves		Inter node plant^{-1}	Stem	
							No. plant^{-1}	Weight plant^{-1}		Girth (cm)	Diameter (cm)
Plant densities											
1,33,333 plants ha^{-1}	1.32	276.04	84.62	9.55	45.96	2.30	16.7	53.0	16.16	1.63	5.11
1,66,666 plants ha^{-1}	1.62	287.73	68.74	11.36	46.50	2.31	16.6	44.8	16.09	1.55	4.88
2,22,222 plants ha^{-1}	2.20	303.21	56.54	15.86	46.21	2.32	16.6	34.3	16.07	1.51	4.73
3,33,333 plants ha^{-1}	3.28	312.51	41.51	17.41	46.42	2.32	16.7	23.0	16.16	1.43	4.48
S.Em.±	0.02	2.96	0.55	0.09	0.36	0.01	0.09	0.48	0.20	0.02	0.06
C.D.(P=0.05)	0.05	8.38	1.55	0.26	NS	NS	NS	1.36	NS	0.06	0.18
Fertility levels ($N + P_2O_5$ kg ha^{-1})											
090+ 30	2.11	276.28	55.89	13.10	47.8	2.26	16.6	35.8	16.07	1.45	4.56
110 + 40	2.09	295.09	61.98	13.53	46.6	2.33	16.6	39.0	16.03	1.52	4.78
130 + 50	2.08	301.87	66.23	13.73	46.2	2.33	16.6	40.5	16.10	1.59	4.98
150 + 60	2.14	306.26	67.31	13.83	44.5	2.34	16.8	39.8	16.27	1.56	4.88
S.Em.±	0.02	2.96	0.55	0.09	0.4	0.01	0.09	0.48	0.20	0.02	0.06
C.D.(P=0.05)	NS	8.38	1.55	0.26	1.0	0.02	NS	1.36	NS	0.06	0.18

* **LAI**-Leaf area index

Table.2 Effect of plant densities and fertility levels on growth, fodder yield, quality and economics of fodder maize (Pooled of two years)

Treatments	RGR (g g^{-1} day^{-1})		CGR (g m^{-2} day^{-1})		Yield (q ha^{-1})		Quality (%)			Economics	
	20-40 DAS	40DAS-harvest	20-40 DAS	40DAS-harvest	Green fodder	Dry fodder	Crude protein	Crude fibre	TDN	Net return (Rs. ha-1)	B C ratio
Plant densities											
1,33,333 plants ha^{-1}	0.401	0.302	16.10	20.41	334.82	83.71	5.68	25.10	96.20	82419	4.57
1,66,666 plants ha^{-1}	0.524	0.392	16.56	21.25	351.70	87.92	5.63	25.33	96.17	87331	4.80
2,22,222 plants ha^{-1}	0.597	0.512	16.41	22.92	376.37	94.09	5.60	25.53	96.14	94584	5.15
3,33,333 plants ha^{-1}	0.984	0.783	19.23	25.45	378.77	94.69	5.54	25.43	96.16	95154	5.14
S.Em.±	0.021	0.013	0.53	0.38	3.42	0.86	0.03	0.16	0.02	1027	0.06
C.D.(P=0.05)	0.060	0.036	1.50	1.09	9.68	2.42	0.09	NS	NS	2905	0.16
Fertility levels ($N + P_2O_5$ kg ha^{-1})											
090+ 30	0.660	0.577	14.31	22.24	328.28	82.07	5.19	23.11	96.61	80825	4.58
110 + 40	0.647	0.503	17.16	22.49	349.56	87.39	5.72	24.09	96.43	86813	4.81
130 + 50	0.603	0.459	18.24	22.67	379.07	94.77	5.75	26.88	95.96	95269	5.16
150 + 60	0.596	0.449	18.58	22.65	384.76	96.19	5.79	27.31	95.51	96580	5.12
S.Em.±	0.021	0.013	0.53	0.38	3.42	0.86	0.03	0.16	0.02	1027	0.06
C.D.(P=0.05)	NS	0.036	1.50	NS	9.68	2.42	0.09	0.45	0.06	2905	0.16

RGR- Relative growth rate **CGR**-Crop growth rate **DAS**- Days after sowing **TDN**- Total digestible nutrient

Despite decrease in length and width of individual leaf with increasing plant density, the recorded LAI increased with increasing plant densities might be on account of higher number of plants and leaves per unit area under high density (Meena *et al.,* 2017 and Parik *et al.,* 2019). The maximum relative crop growth rate and crop growth rate were recorded under 3,33,333 plants ha^{-1} which was significantly higher over rest of the plant densities during 20-DAS and 40 DAS to harvest. Increasing plant densities significantly increased crude protein content, however, failed to record statistical significance in crude fibre and total digestible nutrient content.

Further the results of experiment revealed that green fodder, dry fodder yield, net return and BC ratio were recorded under 2,22,222 plants ha^{-1} which were significantly higher over 1,66,666 and 1,33,333 plants ha^{-1}. Advancing plant densities from 2,22,222 to 3,33,333 plants ha^{-1} failed to record statistical significance in green fodder, dry fodder yield, net return and BC ratio. Despite decrease in growth attributing parameters with increasing plant density, the recorded significant improvement in green fodder yield and dry fodder yield was on account of higher number of plants per unit area under increasing density. These results are in line with the results reported by Shanti *et al.*, (2014), Sandya *et al.*, (2016).

Fertility levels

Increasing fertility levels did not influence plant population recorded at harvest, number of green $leaves^{-1}$ and number of inter node $plant^{-1}$. However, increasing fertility level significantly increased plant height, dry matter accumulation, LAI, chlorophyll content, weight of leaves, stem girth and stem diameter at varying extents. Increasing fertility level significantly reduced days taken to 50 per cent tasseling. The fertility levels were statistically at par in terms of RGR between 20-40 DAS, however, showing decreasing trend between 40 DAS to harvest. The CGR during initial period of 20-40 DAS increased significantly with increasing fertility, however, proved statistically at par during later period of 40 DAS to harvest. Application of 130 kg N + 50 kg P_2O_5 ha^{-1} significantly increased green fodder, dry fodder yield net return and BC ratio over 110 kg N + 40 kg P_2O_5 ha^{-1} and 90 kg N + 30 kg P_2O_5 ha^{-1}. At the same time further increase in fertility level failed to record statistical significance. The crude protein, crude fibre and total digestible nutrient content increased significantly with increasing fertility levels. Increasing fertility level enriched soil with N, P and K to the level of sufficiency which suggests greater availability of metabolites and nutrients and thus reduce competition of these between developing structure consequently improving functional activities of each vegetative structure and caused vigorous growth of individual plant (Meena *et al.*, 2017 and Bharti *et al.*, 2019).

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