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SOWING DATE, CROP GEOMETRY AND FERTILIZER LEVELS INFLUENCED YIELD, PRODUCTIVITY AND ECONOMICS OF FODDER MAIZE

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SUMMARY

The field investigation was conducted at Forage Research Farm, CCS HAU, Hisar (India) during *Kharif* 2021 and 2022. The soil of the experimental field was slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in split-plot design with three sowing dates (June 10, June 25 and July 10) and two crop geometries (30 cm × 10 cm and 45 cm × 10 cm) in main plots and five fertilizer levels (Control – No N and P, 40 kg N+20 kg P_2O_5/ha, 60 kg N+30 kg P_2O_5/ha, 80 kg N+40 kg P_2O_5/ha and 100 kg N+50 kg P_2O_5/ha) in sub-plots with three replications. Among sowing dates, the maximum green fodder yield (39.62 and 44.06 t/ha) and dry matter (10.90 and 12.38 t/ha), respectively during first and second year were recorded in the crop sown on July 10, which was at par to that sown on June 25. Maximum B:C was obtained in the fodder maize sown on June 25 (2.16 and 2.40) being at par with July 10 sowing (2.09 and 2.34). Among crop geometries, significantly highest yield of green fodder and dry matter, (39.48 and 43.96, 10.86 and 12.35 t/ha, respectively during first and second year) were recorded in the crop sown with 30 cm × 10 cm geometry. Numerically better B:C was achieved with crop geometry of 30 x 10 cm crop geometry, although it was at par with the crop geometry 45 cm x 15 cm. With increasing NP fertilizer dose, fodder maize responded up to the maximum level of 100 kg N+50 kg P_2O_5 ha^{-1} for yield (46.02 and 12.80 t/ha, two year mean green fodder and dry matter, respectively) were on a par with 80 kg N+40 kg P_2O_5/ha level. Maximum B:C (2.30 and 2.54 during first and second year, respectively) was fetched with the fertilizer application of 80 kg N+40 kg P_2O_5/ha level. It can be concluded that fodder maize crop may be sown from June 25 to July 10 with a spacing of 30 cm x 10 cm and fertilizer application 80 kg N+40 kg P_2O_5 per hectare for high fodder yield and quality along with economical production.

Key words: Fodder maize, fodder yield, per day productivity of fodder and economics

Worldwide, maize is cultivated over an area of 205.87 mha with a record production and grain productivity of 1210 mha and 58.7 q/ha, respectively. In India, acreage under maize is 9.9 mha for grain with an average productivity of 31.3 q/ha (FAO, 2021) and 0.9 mha for fodder with an average green fodder yield of 350.5 q/ha. In Haryana, area under grain maize in *kharif* season is only about 6200 ha with average productivity of 27.4 q/ha (Anonymous, 2020). Being a C_4 plant, maize requires less water than other C_3 cereals. Maize gives higher fodder productivity even in a shorter period than any other cereal fodder crop (Satpal *et al.*, 2023). The maize fodder is rich in essential nutrients and can be fed at any stage of growth without any risk to animals as it is free from anti-nutritional constituents. It can be fed as green or dry and is most favorable for silage making also. it contains 9-10% crude protein CP), 60-64% neutral detergent fiber (NDF), 38-41% acid detergent fiber (ADF), 23-25% hemi-cellulose, and 28-30% cellulose on the dry matter basis at milk to the early dough stage (Chaudhary *et al.*, 2012).

Production potential of forage maize can be altered with changes in agronomic practices *viz.*, sowing date, crop geometry and nutrient management. Time of sowing is very critical for grain as well as fodder yield in maize (Van Roekel and Coulter, 2012) and therefore, farmers' are concerned about the yield response of maize to sowing date (Abendroth *et al.*, 2017). However, optimum maize sowing date may vary from area to area due to differences in climate and the length of the growing season where the crop is produced (Bruns and Abbas, 2006).

Maize in general is responsive to applied nutrients irrespective of the source either organic or inorganic. However, the rate of nutrient application depends mainly on soil nutrient status/balance and cropping system (Parihar *et al*., 2011). Fertilizer application is one of the important factor that influence the fodder yield and quality. An adequate supply of nutrients at each growth stage is highly essential for good yield and quality of fodder maize. Fertilization application is one of the most important agronomic practices and therefore, there are several studies conducted with different fertilizer levels suggests that optimum rate of fertilizer for maize cultivation depends on many variable factors such as environmental factors, soil fertility and management factors including plant density and time of planting. Higher plant density may require more fertilizer (Emine *et al*., 2010). However, the *kharif* maize as fodder crop in Haryana is new and the information on its response to fertiliser levels with reference to sowing time and planting density is limited. Therefore, to exploit the fodder potential of maize; suitable date of sowing, ideal crop geometry and optimum fertilizer dose need to be standardized. Keeping the above facts in view, present study has been planned with following objectives.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 2021 and 2022 at Forage Section Research Area, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar (29°10' N of 75°46' E, at an average elevation of 215.2 m above mean sea level) having semi-arid and sub-tropical climate with hot dry summer and severe cold winters and receives 450 mm precipitation per annum. The soil of the experimental site was slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in split-plot design with three sowing dates (June 10, June 25 and July 10) and two crop geometries (30 cm × 10 cm and 45 cm × 10 cm) in main plots and five fertilizer levels (Control – No N and P, 40 kg N+20 kg P_2O_5 ha^{-1}, 60 kg N+30 kg P_2O_5 ha^{-1}, 80 kg N+40 kg P_2O_5 ha^{-1} and 100 kg N+50 kg P_2O_5 ha^{-1}) in sub-plots with three

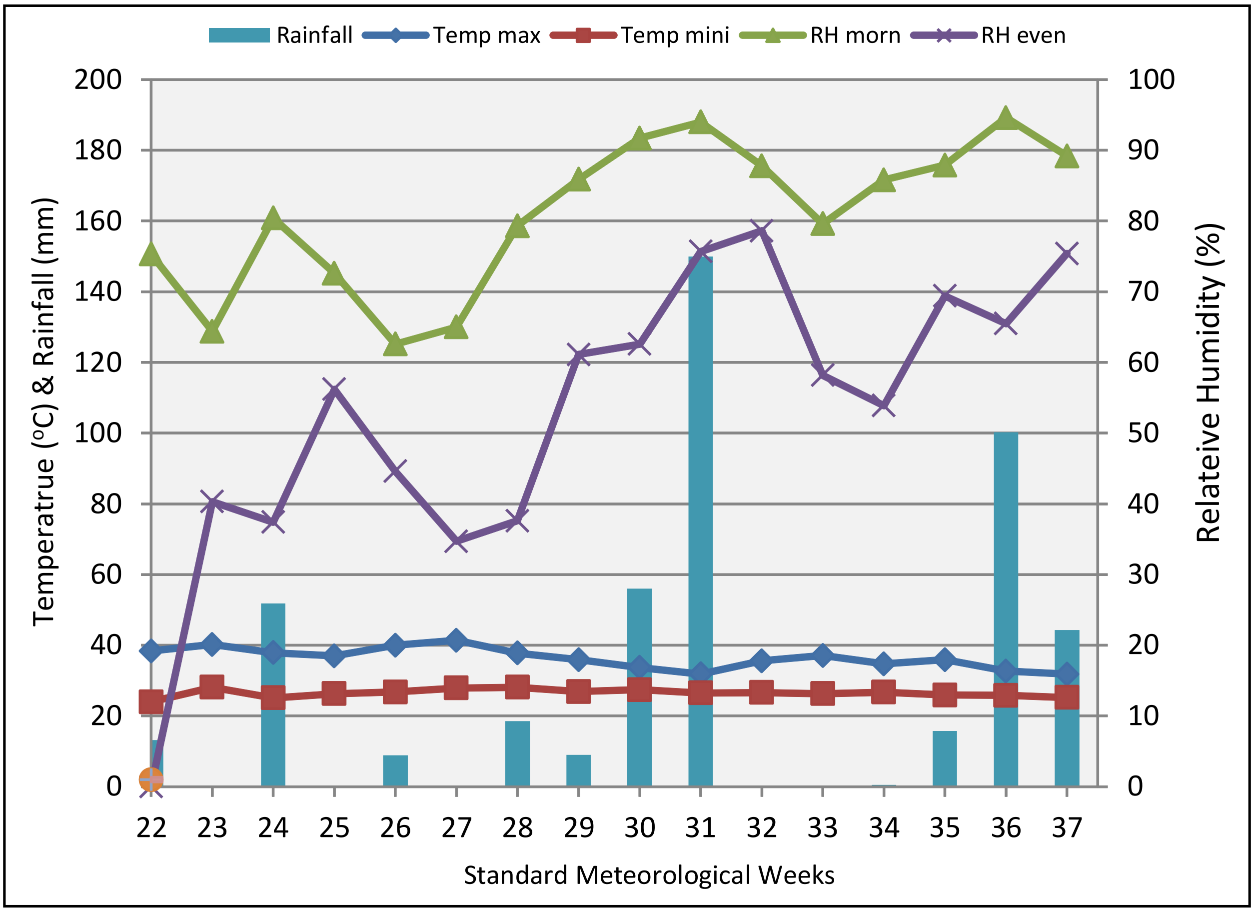

Fig. 1. Mean weekly meteorological data recorded during crop season (2021).

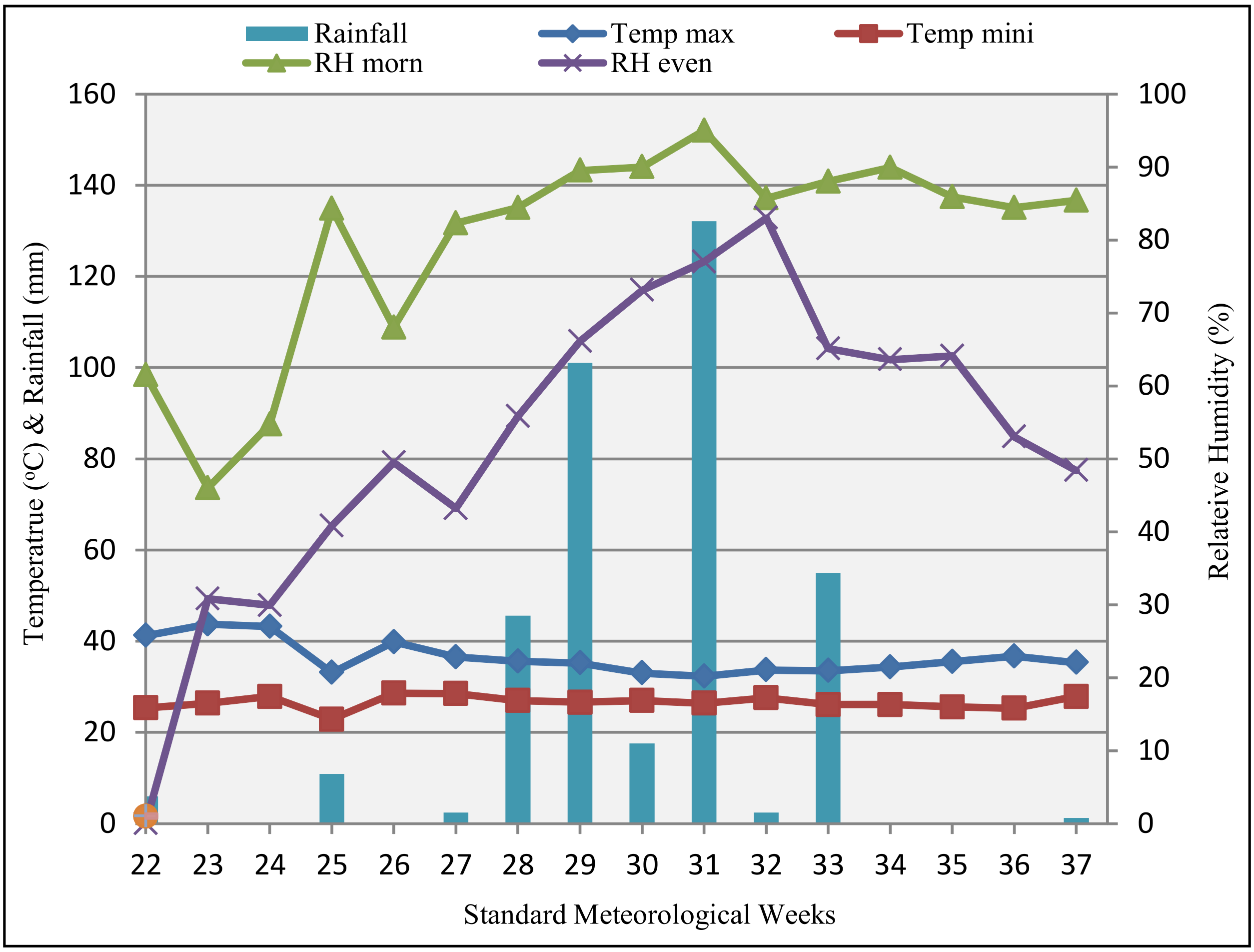

Fig. 2. Mean weekly meteorological data recorded during crop season (2022).

replications. As per treatment, full dose of phosphorus and half dose of nitrogen were applied as basal dose. Remaining half dose of nitrogen was top dressed at knee high stage. Urea (46% N) and DAP (18% N + 46% P) were used as source of N and P. Fodder maize variety African tall was sown as per treatment on June 10, June 25 and July 10 in opened furrows at two crop geometries (30 cm × 10 cm and 45 cm × 10 cm). Seed rate of 80 and 55 kg/ha was used for 30 cm x 10 cm and 45 cm x 10 cm crop geometry, respectively to obtain the optimum plant population. The amount of total rainfall received during the crop period was 294.1, 242.8, 394.1 and 367.0, 356.1, 354.9 mm for D_1 (First date of sowing – 10 June), D_2 (Second date of sowing – 25 June) and D_3 (Third date of sowing – 10 July), respectively, during 2021 and 2022, respectively. Weekly weather parameters *i.e.* temperature (°C), relative humidity (%) and rainfall (mm) during the crop duration are given in Fig 1 and 2. For GFY data, harvested green fodder from each plot was weighted in-situ in kg per plot and then converted into t/ha. For DMY data, random sample of green fodder of 500 g was taken separately from each plot at the time of harvesting, after sun drying, it was oven dried till constant a weight was achieved, on the basis of final weight of these samples, the green fodder yield was converted into dry matter yield (t/ha). The local market's prevailing input and product prices were used to calculate economics of the treatments. Data were analyzed by using OPSTAT software available at CCS Haryana Agricultural University website (Sheoran *et al.*, 1998). The results are presented at five per cent level of significance (p=0.05) for making comparison between treatments.

RESULTS AND DISCUSSION

Effect of sowing date

The plant population (Number of plants/m^2) recorded at harvest did not differ significantly under different date of sowing. Maximum plant height at harvest (212.0 cm during 2021 and 215.2 cm during 2022, respectively) was recorded in July 10 which

TABLE 1
Effect of sowing dates, crop geometry and fertilizer levels on plant population and plant height of fodder maize

Treatments	Number of plants/ m^2 at harvest		Plant height at harvest (cm)	
	2021	2022	2021	2022
Sowing date				
10th June	23.0	25.0	206.0	209.2
25th June	22.9	24.6	210.3	213.5
10th July	22.5	24.3	212.0	215.2
SEm±	0.6	0.5	0.8	1.1
C. D. at 5%	NS	NS	2.5	3.3
Crop geometry				
30 cm × 10 cm	27.2	29.5	207.6	210.8
45 cm × 10 cm	18.4	19.7	211.3	214.4
SEm±	0.5	0.4	0.7	0.9
C. D. at 5%	1.6	1.3	2.1	2.7
Fertilizer level				
Control (No N and P)	22.2	24.1	180.6	183.7
40 kg N+20 kg P_2O_5/ha	22.5	24.6	200.1	203.2
60 kg N+30 kg P_2O_5/ha	23.4	25.1	214.4	217.7
80 kg N+40 kg P_2O_5/ha	23.1	24.7	224.9	228.0
100 kg N+50 kg P_2O_5/ha	22.8	24.7	227.3	230.5
SEm±	1.37	1.1	2.7	2.8
C. D. at 5%	NS	NS	7.5	7.8
C. V.%	5.47	5.56	5.37	5.5

was on a par with June 25 sown crop At harvest (milk stage), maximum green fodder and dry matter yields (39.62, 10.90, and 44.06, 12.38, t ha^{-1} during 2021 and 2022, respectively) were recorded in July 10 sowing which were on a par with June 25 sowing during both the years. Data presented in Table 3 revealed that maximum per day productivity of green fodder yield (0.602 and 0.681 t/ha during 2021 and 2022, respectively) was recorded in July 10 sowing which was significantly higher over other dates of sowing during both the years. Maximum per day productivity of dry matter yield (0.165 and 0.192 t/ha during 2021 and 2022, respectively) was recorded in July 10 sowing which was at par with June 25 sowing during first year but significantly higher over other dates of sowing during second year of experimentation. The reason for lower fodder yield in June 10 sown crop might be due to stressed conditions created by prevailed higher mean maximum temperature (40.5 and 37.6 °C during 2021 and 2022, respectively) along with low relative humidity (RH of morning 68 and 78 and RH of evening 41 and 55 % during 2021 and 2022, respectively).

Effect of crop geometry

Among crop geometries, the plant population (Number of plants/m^2) recorded at harvest differed significantly. Maximum plant population (27.2 and 29.5 plants/m^2 during 2021 and 2022, respectively) was recorded with 30 cm × 10 cm which was significantly higher over 45 cm × 10 cm crop geometry. Maximum plant height at harvest (211.3 and 214.4 cm during 2021 and 2022, respectively) was recorded with 45

TABLE 2
Sowing dates, crop geometry and fertilizer levels effect on fodder yield of maize

Treatments	Green fodder yield (t/ha)			Dry matter yield (t/ha)		
	2021	2022	Mean	2021	2022	Mean
Sowing time						
10th June	36.36	40.88	38.62	10.00	11.49	10.75
25th June	38.45	42.97	40.71	10.58	12.07	11.33
10th July	39.62	44.06	41.84	10.90	12.38	11.64
SEm±	0.43	0.44	-	0.12	0.12	-
C. D. at 5%	1.36	1.38	-	0.38	0.39	-
Crop geometry						
30 cm × 10 cm	39.48	43.96	41.72	10.86	12.35	11.61
45 cm × 10 cm	36.81	41.31	39.06	10.12	11.61	10.87
SEm±	0.35	0.36	-	0.10	0.10	-
C. D. at 5%	1.11	1.12	-	0.31	0.32	-
Fertilizer level						
Control (No N and P)	27.87	32.33	30.10	7.67	9.09	8.38
40 kg N+20 kg P_2O_5/ha	35.31	39.81	37.56	9.70	11.20	10.45
60 kg N+30 kg P_2O_5/ha	40.55	45.05	42.80	11.20	12.70	11.95
80 kg N+40 kg P_2O_5/ha	43.21	47.71	45.46	11.90	13.40	12.65
100 kg N+50 kg P_2O_5/ha	43.77	48.27	46.02	12.00	13.60	12.80
SEm±	0.64	0.64	-	0.18	0.18	-
C. D. at 5%	1.81	1.82	-	0.50	0.51	-
C. V.%	7.09	6.38		7.26	7.02	

TABLE 3

Sowing dates, crop geometry and fertilizer levels effect on the per day productivity of fodder of fodder yield in maize

Treatments	Per day productivity of GFY (t/ha)			Per day productivity of DMY (t/ha)		
	2021	2022	Mean	2021	2022	Mean
Sowing time						
10th June	0.530	0.602	0.566	0.145	0.163	0.154
25th June	0.577	0.656	0.617	0.159	0.183	0.171
10th July	0.602	0.681	0.642	0.165	0.191	0.178
SEm±	0.008	0.007	-	0.002	0.002	-
C. D. at 5%	0.024	0.022	-	0.007	0.005	-
Crop geometry						
30 cm × 10 cm	0.586	0.661	0.624	0.161	0.183	0.172
45 cm × 10 cm	0.553	0.631	0.592	0.152	0.175	0.164
SEm±	0.006	0.006	-	0.002	0.001	-
C. D. at 5%	0.019	0.018	-	0.006	0.004	-
Fertilizer level						
Control (No N and P)	0.408	0.480	0.444	0.112	0.134	0.123
40 kg N+20 kg P_2O_5/ha	0.522	0.597	0.560	0.142	0.166	0.154
60 kg N+30 kg P_2O_5/ha	0.606	0.683	0.645	0.167	0.188	0.178
80 kg N+40 kg P_2O_5/ha	0.651	0.729	0.690	0.179	0.202	0.191
100 kg N+50 kg P_2O_5/ha	0.661	0.742	0.702	0.182	0.207	0.195
S. Em±	0.010	0.010	-	0.003	0.003	-
C. D. at 5%	0.027	0.028	-	0.008	0.008	-

TABLE 4

Economics of fodder maize cultivation as influenced by different sowing dates, crop geometry and fertilizer levels

Treatments	Cost of cultivation (Rs./ha)		Gross returns (Rs./ha)		Net returns (Rs./ha)		B:C	
	2021	2022	2021	2022	2021	2022	2021	2022
Sowing time								
10th June	39083	39083	72729	81757	33646	42674	1.86	2.09
25th June	39083	39083	76901	85935	37818	46852	1.97	2.20
10th July	39083	39083	79233	88122	40150	49039	2.03	2.25
SEm±	-	-	866	874	866	874	0.03	0.02
C. D. at 5%	-	-	2728	2753	2728	2753	0.08	0.08
Crop geometry								
30 cm × 10 cm	41600	41600	78953	87924	37353	46324	1.90	2.11
45 cm × 10 cm	40066	40066	73623	82620	33557	42554	1.84	2.06
SEm±	-	-	707	714	707	714	0.02	0.02
C. D. at 5%	-	-	2227	2248	2227	2248	NS	NS
Fertilizer level								
Control (No N and P)	38558	38558	55737	64668	17179	26110	1.45	1.68
40 kg N+20 kg P_2O_5/ha	40368	40368	70624	79620	30256	39252	1.75	1.97
60 kg N+30 kg P_2O_5/ha	41094	41094	81107	90105	40013	49011	1.97	2.19
80 kg N+40 kg P_2O_5/ha	41821	41821	86422	95420	44601	53599	2.07	2.28
100 kg N+50 kg P_2O_5/ha	42323	42323	87548	96546	45225	54223	2.07	2.28
S. Em±	-	-	1275	1283	1275	1283	0.04	0.04
C. D. at 5%	-	-	3626	3648	3626	3648	0.1	0.1

cm × 10 cm crop geometry which was significantly higher over 30 cm × 10 cm. At harvest (milk stage), maximum green fodder and dry matter yields (39.62, 10.90, and 44.06, 12.38, t ha^{-1} during 2021 and 2022, respectively) were recorded in 30 cm × 10 cm crop geometry which was significantly higher over 45 cm × 10 cm. The results are in conformity with Bhadre *et al*. (2015) and they also concluded that sowing of fodder maize at 30 cm × 10 cm geometry was a suitable agro-technique for achieving higher productivity of fodder maize. Data presented in Table 3 revealed that maximum per day productivity of green fodder and dry matter yields (0.586, 0.161 and 0.661, 0.183 t/ha during 2021 and 2022, respectively) were recorded in 30 cm × 10 cm crop geometry which was significantly higher over 45 cm × 10 cm.

Effect of fertilizer levels

Among fertilizer levels, the plant population (No. of plants/m^2) recorded at harvest did not differ significantly. Maximum plant height at harvest (227.3 cm during 2021 and 230.5 cm during 2022, respectively) was recorded with the application of 100 kg N+50 kg P_2O_5 ha^{-1} which was on a par with 80 kg N+40 kg P_2O_5 ha^{-1}. Maximum green fodder and dry matter yield at harvest (43.77, 12.00 and 48.27, 13.60 t ha^{-1} during 2021 and 2022, respectively) was recorded with the application of 100 kg N+50 kg P_2O_5 ha^{-1} which was on a par with 80 kg N+40 kg P_2O_5 ha^{-1}. Data presented in Table 3 revealed that maximum per day productivity of green fodder and dry matter (0.661, 0.182 and 0.742, 0.207 t ha^{-1} during 2021 and 2022, respectively) were recorded with the application of 100 kg N+50 kg P_2O_5 ha^{-1} which was on a par with 80 kg N+40 kg P_2O_5 ha^{-1}. Satpal *et al.* (2022) and Kumar *et al.* (2012) also reported increase in yield of fodder maize with increasing N dose 120 kg N and 80-100 kg N+40 kg P_2O_5 ha^{-1}, respectively. Satpal *et al.* (2023) also reported that improved varieties of fodder maize responded up to 120 kg N/ha.

ECONOMICS

Perusal of the data from Table 4 revealed that among sowing dates, maximum values of gross returns and net returns were obtained in 10 July sown crop (Rs.79233 ha^{-1}, Rs. 40150 ha^{-1} and Rs. 88122 ha^{-1}, Rs. 49039 ha^{-1}, respectively during first and second year) followed by June 25. Maximum B:C was also fetched in July 10 sown fodder maize (2.03 and 2.25) which were at par with June 25 sowing. Numerically better B:C (1.90 and 2.11 during 2021 and 2022, respectively) was achieved with crop geometry of 30 cm x 10 cm, although it was at par with the crop geometry 45 cm x 15 cm. Benefit cost ratio was significantly influenced by different fertilizer levels. Maximum B:C (2.07 and 2.28 during first and second year, respectively) was fetched with the fertilizer application of 80 kg N+40 kg P_2O_5/ha level which was same as that with 100 kg N+50 kg P_2O_5/ha.

CONCLUSION

It can be concluded that fodder maize crop may be sown from June 25 to July 10 with a spacing of 30 cm x 10 cm and fertilizer application 80 kg N+40 kg P_2O_5 per hectare for high fodder yield and quality along with economical production. For realizing maximum BC ratio, application of 80 kg N+40 kg P_2O_5/ha was sufficient in fodder maize.

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