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Research Communication

Comparison of sorghum (*Sorghum bicolor*) cultivars for productivity and nitrogen-use efficiency under different fertilizer levels in rainfed condition

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ABSTRACT

Response of 9 sorghum [*Sorghum bicolor* (L.) Moench] cultivars, viz. 4 hybrids ('SPH 1820', 'SPH 1849', 'CSH 25', 'CSH 30') and 5 improved varieties ('SPV 2433', 'SPV 2437', 'SPV 2438', 'CSV 27' and 'CSV 31'), to 3 fertility levels [75, 100 and 125 % recommended dose of fertilizer (RDF)] under rainfed conditions was studied during the rainy (*kharif*), season of 2018 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The experiment was laid out in a factorial randomized block design, comprising 27 treatment combinations, each replicated thrice. Results revealed that, fertilization with 125% RDF recorded significantly higher plant height (249.42 cm), dry- matter accumulation pea plant (164.43 g) at harvesting, yield-attributing characters, grain and stover yields (4.06 and 11.12 t/ha respectively) and N-use efficiency than 100% RDF and 75% RDF. Among the hybrids, 'SPH 1849' gave the highest grain yield (4.85 t/ha) and among the varieties 'CSV 31' showed the highest grain yield (4.08 t/ha). Thus, sorghum genotype 'SPH 1849' with 125% RDF application (100 kg N + 50 kg P_2O_5 + 50 kg K_2O/ha) showed better performance under rainfed condition in southern Rajasthan.

Key words: Sorghum, Hybrid, Variety, Productivity, N use efficiency

Sorghum [*Sorghum bicolor* (L.) Moench], being fifth most important cereal crop in India, is traditionally grown for food, animal feed and fodder. Sorghum has drough-adaptation capability; hence it is preferred over other cereals in warmer and semi-arid drought-prone regions of the world with high temperature and water stress (Mishra *et al.,* 2017). Moreover, sorghum can be an important crop for future food security under changed climate (Hadebe *et al.,* 2016). Rajasthan is a major sorghum producing state in the country, which recorded 0.30 million tonnes grains from 0.52 million ha area during 2019–20. However, sorghum productivity in the state (583 kg/ha) is far below than the national average (780 kg/ha) (ICAR, 2020). Such low productivity of sorghum can be attributed to lack of suitable genotypes at field level, cultivation under poor soil-fertility condition and inadequate application of major plant nutrients. Hence, we hypothesized that higher productivity of sorghum could be achieved with suitable combination of improved genotype and fertilizer-management practice.

Adequate supply of the primary nutrients, viz. N, P and K, is considered to be of prime importance owing to their profound effect on growth, development and productivity of input-responsive improved and hybrid sorghum genotypes. Selection of N-use efficient genotype is of paramount importance, as farmers invest on fertilizer application based on credit and rainfall availability, particularly in arid and semi-arid regions. Therefore, it is necessary to assess the performance of sorghum genotypes (improved vs hybrid) with different fertility levels under rainfed conditions in southern Rajasthan.

A field experiment was carried out at the Instructional Farm, Rajasthan College of Agriculture, Udaipur (24° 35' N latitude, 73° 42' E longitude and 582.17 m above mean sea level) during the rainy season (*kharif*), 2018, to find out suitable combination of sorghum genotype and fertility level for achieving higher growth attributes, yield components, productivity, nutrient-use efficiency and profitability in rainfed sorghum-production system. The experimen-

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tal soil was clay loam in texture, moderately alkaline (pH 8.1) with medium organic carbon (0.71 %) and phosphorus (21.6 kg/ha), low available nitrogen (249.2 kg/ha), high available potassium (378.7 kg/ha) and electrical conductivity of 0.76 dS/m. During the crop growing season, the minimum and maximum temperature ranged from 12.1 to 25.5°C and 24.0 to 35.6°C, respectively, and the minimum and maximum relative humidity ranged from 16 to 100% and 46 to 100%, respectively. Total rainfall received during crop growing season was 455.6 mm.

The experiment comprising of 27 treatment combinations including 3 fertility levels [75, 100 and 125% of recommended dose of fertilizer (RDF)] and 9 genotypes (Hybrids, viz. 'SPH 1820', 'SPH 1849', 'CSH 25', 'CSH 30' and varieties, viz. 'SPV 2433', 'SPV 2437', 'SPV 2438', 'CSV 27' and 'CSV 31') was laid out in a factorial randomized block design, each replicated thrice. Seeds of all genotypes were line-sown @ 10 kg/ha at a spacing of 45 cm (row to row). Thinning was done around 15 days after sowing (DAS) to maintain plant-to-plant distance of 15 cm. The recommended dose of fertilizer (RDF) for the study region is 80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha (ICAR, 2017). The entire amount of phosphorus and potassium along with one-third of nitrogen dose was applied basal. Phosphorus, potassium and nitrogen were supplied through (diammonium phosphate), muriate of potash and urea (for rest amount of N after diammonium phosphate application), respectively. The remaining dose of nitrogen was applied in 2 splits (one-third N in each split) by urea top-dressing at 35 and 47 DAS.

Pre-emergence herbicide atrazine was sprayed @ 0.50 kg a.i./ha to control all types of weeds during initial stages of crop growth. Hoeing and earthing up were done at 30 DAS with the help of spade (manually) to control weeds, maintain proper aeration and conserve soil moisture. Phorate 10 G was applied @ 20 kg/ha in furrows at sowing to prevent the infestation of sorghum shoot fly. Harvesting

Table 1. Effect of fertilizer levels and genotypes on growth and yield attributes, yield, harvest index (HI) and partial factor productivity of sorghum during *the3 rainy season of* 2018

Treatment	Plant height (cm) at harvest	DMA (g/plant) at harvest	Days to 50% flowering	Panicles/m²	Length of panicle (cm)	Grain weight/panicle (g)	Test weight (g)	Yield (t/ha)			HI (%)	PFP_N (kg grain/kg N applied)
								Grain	Stover	Biological		
Fertilizer levels												
75% RDF	229.92	127.65	66.63	13.37	25.08	32.09	30.06	3.42	9.66	13.08	26.07	57.01
100% RDF	235.19	152.77	64.70	13.70	27.17	36.91	32.10	3.84	10.45	14.29	27.17	47.95
125% RDF	249.42	164.43	64.19	14.00	28.13	39.22	33.09	4.06	11.12	15.18	26.99	40.61
SEm±	2.87	2.94	0.28	0.26	0.39	0.84	0.26	0.08	0.22	0.24	0.60	0.98
CD (P=0.05)	8.14	8.35	0.78	NS	1.11	2.38	0.75	0.23	0.63	0.67	NS	2.79
Genotypes												
'SPH 1820'	190.01	129.12	61.44	13.67	29.15	40.85	31.93	4.38	8.93	13.31	32.92	56.51
'SPH 1849'	192.80	142.75	62.00	14.00	30.54	45.04	33.13	4.85	9.21	14.06	34.59	62.94
'CSH 25'	207.89	168.78	64.89	14.67	29.35	41.94	33.06	4.70	10.67	15.37	30.77	61.59
'CSH 30'	208.45	122.02	57.22	13.56	30.72	36.44	29.56	3.99	8.81	12.80	31.31	51.09
'SPV 2433'	237.56	161.65	69.78	13.89	21.84	33.14	34.37	3.46	11.25	14.70	23.37	44.06
'SPV 2437'	285.92	190.59	66.22	13.67	26.35	34.57	33.23	3.67	11.88	15.54	23.63	47.38
'SPV 2438'	314.71	153.07	70.11	13.33	21.81	23.93	31.56	2.14	12.51	14.65	14.42	26.58
'CSV 27'	263.98	125.51	69.56	12.56	23.90	30.16	28.84	2.69	10.33	13.02	20.91	34.71
'CSV 31'	242.27	141.05	65.33	13.89	27.46	38.55	30.08	4.08	10.11	14.19	28.81	51.85
SEm±	4.97	5.10	0.48	0.45	0.68	1.46	0.46	0.14	0.39	0.41	1.03	1.71
CD (P=0.05)	14.11	14.47	1.36	NS	1.92	4.13	1.30	0.41	1.09	1.16	2.94	4.84
Hybrid	199.79	140.67	61.39	13.98	29.94	41.07	31.92	4.48	9.40	13.88	32.40	58.03
Variety	268.89	154.37	68.20	13.47	24.27	32.07	31.62	3.21	11.21	14.42	22.23	40.92

RDF, Recommended does of fertilizer, DMA, Dry-matter accumulation; HI, harvest index; PFP_N, partial factor productivity
NS, Non-significant

was done on different dates according to maturity (when panicles turned yellow) of the genotypes. Plant height, dry-matter accumulation, and yield attributes, viz. length of panicle, grain weight/panicle and test weight were recorded from 5 randomly selected plants in each plot at time of harvesting. Grain and stover yields were recorded plot-wise and then converted into kg/ha. The biological yield, harvesting index and partial factor productivity (PFP_N) were calculated using the following formulae.

Biological yield (kg/ha), Grain yield + stover yield

$$\text{Harvest index (\%)}, \frac{\text{Grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

$$PFP_N, \frac{\text{Grain yield (kg/ha)}}{\text{Nitrogen applied (kg/ha)}}$$

Observed data were analysed statistically by the method analysis of variance (ANOVA) as per the procedure outlined for factorial randomized block design (Panse and Sukhatme, 1985). Statistical significance was tested by P-value at 0.05% level of probability and critical difference (CD) was worked out wherever the effects were significant.

Both fertilizer levels and genotype factors exerted significant effect on all yield- attributing traits of sorghum, except number of panicles/m^2 (Table 1). Application of 125% ensured higher panicle length, grain weight/panicle, grains/panicle and test weight than the values obtained with 75% RDF and 100% RDF. Sorghum grain yield was significantly higher with 125% RDF, accounting 12.84 and 18.72% more than that of 100% RDF and 75% RDF respectively (Table 1). Similarly, the stover yield of sorghum was found to be significantly higher with 125% RDF than that of 100% RDF and 75% RDF application. Our findings confirm the findings of Meena *et al.* (2020). The higher productivity of sorghum under 125% RDF indicates that, the current level of fertilizer recommendations must be revised according to the varietal nature. The higher rates of NPK application improved the vegetative and reproductive growth, as well as production and translocation of photosynthates to grain. The variation in harvest index was non-significant due to fertilizer levels and genotypes. The partial factor productivity of nitrogen (PFP_N) was significantly higher with 75% RDF, registering 18.89 and 40.39% more than 100% RDF and 125% RDF application respectively.

Among the genotypes, 'SPH 1849' produced higher grain weight/panicle whereas 'CSH 30' recorded the highest panicle length, followed by 'SPH 1849'. In terms of test

Table 2. Interaction effect of fertilizer levels and genotypes on grain yield, straw yield and partial factor productivity (PFP_N)

	Grain yield (t/ha)			Straw yield (t/ha)			PFP_N (kg grain/kg N applied)		
	75% RDF	100% RDF	125% RDF	75% RDF	100% RDF	125% RDF	75% RDF	100% RDF	125% RDF
'SPH 1820'	4.05	4.48	4.61	8.53	9.19	9.07	67.44	55.95	46.15
'SPH 1849'	4.67	4.86	5.03	8.75	9.29	9.59	77.83	60.71	50.27
'CSH 25'	4.84	4.64	4.61	10.07	10.61	11.33	80.66	58.03	46.10
'CSH 30'	3.58	3.86	4.54	8.14	8.44	9.84	59.60	48.26	45.40
'SPV 2433'	2.95	3.51	3.91	9.96	12.06	11.72	49.17	43.89	39.12
'SPV 2437'	3.40	3.79	3.81	11.14	11.40	13.08	56.67	47.40	38.07
'SPV 2438'	1.39	2.47	2.57	11.47	12.64	13.41	23.22	30.86	25.67
'CSV 27'	2.42	2.94	2.71	9.68	11.00	10.32	40.28	36.71	27.14
'CSV 31'	3.49	3.98	4.76	9.19	9.42	11.72	58.22	49.76	47.58
SEm±	0.25			0.67			2.95		
CD (p≤0.05)	NS			NS			8.38		

RDF, Recommended does of fertilizer

Table 3. Correlation coefficient and regression equation between grain yield (Y) and independent (X) variables on mean basis in sorghum genotypes

Dependent (Y)	Independent (X)	R	r^2	Regression equation Y = a + bX
Grain yield	Plant height at harvesting	–0.720**	0.519	Y = 7514.02 – 15.71 X
	DMA at harvest	0.167	0.028	Y = 2924.04 + 5.72 X
	Number of panicles/m^2	0.502**	0.252	Y = –3223.30 + 510.97 X
	Length of panicle	0.794**	0.631	Y = –1389.54 + 192.67 X
	Grain weight/panicle[1]	0.951**	0.905	Y = –674.93 + 123.30 X
	Test weight	0.285	0.081	Y = 718.13 + 96.20 X
	Stover yield	–0.365	0.133	Y = 6197.88 - 0.23 X

DMA, Dry-matter accumulation

weight, 'SPV 2433' proved to be superior to the other genotypes. The higher grain yield, stover yield and biological yield were obtained from 'SPH 1849', 'SPV 2438' and 'SPV 2437', respectively. Further, 'SPH 1849' revealed the highest harvest index of 34.59% (Table 1). Significantly higher PFP_N was observed in 'SPH 1849' than other genotypes. The interaction effect of fertilizer levels and sorghum genotypes on PFP_N was found to be significant (Table 2). Application of 75% RDF to hybrid 'CSH 25' resulted in the highest PFP_N, while the lowest PFP_N was observed with the application of 75% RDF in 'SPV 2438'. On an average, the hybrids gave 39.70% higher grain yield than the improved varieties and they were found to be more responsive to NPK application. Furthermore, to explore the important yield attributing traits that govern the variability in sorghum grain yield, linear regression equations were fitted, as shown in Table 3. A significant ($p \leq 0.05$) positive correlation existed between grain yield and yield attributes namely, number of panicles/m^2 (0.502), length of panicle (0.794) and grain weight/panicle (0.951). Hence, grain weight per panicle was found to be the most important yield determining trait which must be focused on future breeding programmes for development of high yielding genotypes.

Summarily, the better performance of sorghum can be obtained with the genotype 'SPH 1849' and 125% RDF application (100 kg N + 50 kg P_2O_5 + 50 kg K_2O/ha) under rainfed condition in southern Rajasthan. In general, hybrids are to be preferred over improved varieties with a higher dose of NPK fertilizers (beyond present recommendation) to achieve higher productivity of sorghum.

REFERENCES

Hadebe, S.T., Modi, A.T. and Mabhaudhi, T. 2016. Drought tolerance and water use of cereal crops: A focus on sorghum as a food security crop in sub-Saharan Africa. *Journal of Agronomy and Crop Science* **203**: 177–191.

ICAR. 2020. *Agricultural Research Data Book.* ICAR-Indian Agricultural Statistics Research Institute, New Delhi.

Mishra, J.S., Kumar, R., Ravikumar, S., Kumar, R., Prakash, V., Rao, K.K. and Bhatt, B.P. 2017. Production potential of improved grain sorghum cultivars (*Sorghum bicolor*) under staggered plantings in non-traditional areas of eastern India. *Indian Journal of Agronomy* **62**(1): 74–80.

Meena, K., Kaushik, M.K., Verma, A. and Bairwa, D.D. 2020. Effect of fertility level on growth and yield of sweet sorghum [*Sorghum bicolor* (L). Moench] genotypes. *Journal of Pharmacognosy and Phytochemistry* **9**(5): 740–743.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*, Edn 4, Indian Council of agricultural Research, New Delhi.