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Response of Pop Sorghum Genotypes to Row Spacings and Fertilizer Levels*

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Abstract: .An experiment on effect of row spacings and fertilizer levels on yield and popping quality of pop sorghum genotypes was carried out during *kharif* 2002 at Main Agricultural Research Station, UAS, Dharwad, Karnataka. Of the three genotypes tested, Pudakalakatti out yielded all other genotypes, but Shiggaon produced superior quality pops. Higher grain yield (1410 kg ha^{-1}) and stover yield (23.40 t ha^{-1}) were recorded with 45 cm row spacing followed by 60 cm rows and the lowest values were recorded in 37.5 cm rows. Good popping quality was obtained in medium to wider row spacings (45 cm and 60 cm). Application of 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} significantly increased the yield attributes, grain yield, stover yield and net returns, whereas the B:C ratio was higher with the application of 40:20:20 kg N, P_2O_5 and K_2O ha^{-1}.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is a premier crop of the semi-arid tropics and a major staple food in several parts of the world. It is a dry land crop grown in *kharif* and *rabi* seasons for the utility as food, feed, forage and industrial raw material. However, it is considered less economical and the production is relegated to marginal lands and low fertile soils with reduced input use. Sorghum grains are consumed in different forms in India namely, unleavened food, dumpling and boiled rice like products. Popped sorghum is a popular traditional snack food in central and south India which has market potential. Popping improves quality by reducing antinutrients, increasing the grain protein, carbohydrate digestibility and soluble dietary fibre. Since not much information is available on production of pop sorghum, an experiment was conducted using potential genotypes with higher grain as well as quality pop.

Material and Methods

A field experiment was conducted during *kharif* season 2002 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad in medium deep black soil having 228, 29.2 and 322 kg ha^{-1} of total N, available P_2O_5 and K_2O with soil pH of 7.6 and organic carbon of 0.52 per cent. The treatments consisted of three genotypes (Pudakalakatti, Shiggaon and Kanavi locals), three row spacings (37.5 cm, 45 cm and 60 cm) and two fertilizer levels (80:40:40 and 40:20:20 kg N, P_2O_5 and K_2O ha^{-1}). The experiment was laid out in a Randomized Block Design (RBD) with three replications. Half the dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose and remaining half of nitrogen was top dressed at 30 days after sowing. The observation on yield and yield components were recorded at harvest. Popping percentage, popping expansion volume, net returns and B:C ratio were also worked out.

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Results and Discussion

Amongst the genotypes Pudakalakatti recorded higher grain yield (1505 kg ha^{-1}) followed by Shiggaon (1294 kg ha^{-1}), while Kanavi produced 1137 kg yield ha^{-1} (Table 2). The higher yield in Pudakalakatti was the consequence of higher total dry matter production, number of raches per ear, grain number per ear, grain weight per ear and 1000-grain weight (Table 1). The stover yield also exhibited similar trend as that of grain yield. Superior performance of Pudakalakatti over Shiggaon was also reported by Naganagouda (2001). The quality parameters differed significantly among the genotypes and the genotype Shiggaon recorded higher popping percentage and expansion volume than Pudakalakatti and Kanavi (Table 2).Similar results were obtained in the earlier studies at Dharwad (Naganagouda, 2001 and Anon., 2002).

Higher grain yield of 1410 kg ha^{-1} and stover yield of 23.4 t ha^{-1} were recorded with 45 cm rows (medium). Closer row (37.5 cm) was comparable with medium row spacing while wider (60 cm) row spacing decreased the grain yield and stover yield. The decrease in wider row spacing was mainly due to lower overall population. The higher grain yield and stover yield in case of 45 cm row spacing could be attributed to least intra specific competition for growth resources compared to 37.5 cm row spacing as evident from yield attributes. Results are in conformity with earlier findings (Anon., 2002 and Chittapur *et al.*,2002). However, the interaction effects were not significant. The popping percentage and expansion volume increased with increase in row spacing. The higher popping percentage and expansion volume were recorded with 45 cm and 60 cm row spacings. The increase in popping percentage and popping expansion volume with wider row spacings could be attributed to development of bold seeds *viz.,* 1000-grain weight. Increasing level of fertilizer application from 40:20:20 kg N, P_2O_5 and K_2O ha^{-1} to 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} increased the grain yield as well as stover yield. The higher yield of grain and stover at higher fertilizer level was due to improved yield attributes and total dry matter production. Such improvements with increasing fertilizer levels were also reported by Chouhan and Dighe (1999) in grain sorghum and Negalur (2000) in pop sorghum. Application of 40:20:20 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher popping percentage and expansion volume over 80:40:40 kg N, P_2O_5 and K_2O ha^{-1}. These results are in conformity with the findings of Negalur (2000).

The interaction effects due to genotypes X row spacings X fertilizer levels for the parameters under study (Table 1 and 2) were not significant. The gross and net returns were significantly higher with genotype Pudakalakatti at 45 cm row spacing supplied with 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} (Rs.34,874/- and Rs.21,966/- per ha, respectively) (Table 3). This was mainly due to higher grain and stover yields. However, B:C ratio was higher in Pudakalakatti under 45 cm row spacing supplied with 40:20:20 kg N, P_2O_5 and K_2O ha^{-1} (2.00). Similar trend was noticed for pop making. But the pop making was found more economical than grain production.

Thus, the analysis of factors under study revealed superiority of cultivar Pudakalakatti under genotypes closely followed by Shiggaon. A 45 cm row spacing among the spacings and a fertilizer dose of 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} among the fertility levels were optimum. The quality of pops with Shiggaon was particularly superior and was more attractive also.

Table 1. Total dry matter (g plant^{-1}), number of raches ear^{-1}, grain number ear^{-1}, grain weight ear^{-1} (g) and 1000-grain weight (g) at harvest of pop sorghum genotypes as influenced by row spacings and fertilizer levels

Treatments		Total dry matter (g plant^{-1})				Number of raches ear^{-1}				Grain number ear^{-1}				Grain weight ear^{-1} (g)				1000-grain weight (g)			
Genotypes (G)	Fertilizer level (F)	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
G_1	F_1	144.50	162.59	164.16	157.42	32.8	36.1	34.0	34.3	1039.5	1130.2	1118.3	1096.0	15.78	18.40	18.42	17.53	15.17	16.26	16.49	15.97
	F_2	163.48	179.16	180.52	174.39	35.1	42.6	36.4	38.0	1070.4	1141.5	1150.6	1120.8	17.66	20.04	20.75	19.48	16.51	17.56	18.00	17.36
G_2	F_1	171.47	190.61	188.96	183.68	32.1	37.4	35.2	34.9	1063.3	1129.5	1132.4	1108.4	16.33	18.61	18.66	17.86	15.33	16.50	16.48	16.10
	F_2	184.96	204.25	204.41	197.87	38.7	43.5	38.2	40.1	1090.8	1160.6	1170.3	1140.5	17.97	21.08	21.48	20.18	16.49	18.15	18.41	17.68
G_3	F_1	113.43	130.85	127.75	124.01	30.4	30.0	33.9	31.5	975.3	1040.6	1053.7	1023.2	13.39	15.15	16.03	14.86	13.75	14.54	15.22	14.50
	F_2	124.34	145.18	144.61	138.04	31.2	34.7	36.1	34.0	1004.2	1075.3	1085.4	1055.0	14.97	17.73	17.88	16.86	14.89	16.48	16.42	15.93
Genotype	G_1	153.99	171.38	172.34	165.90	34.0	39.3	35.2	36.2	1054.9	1135.9	1134.5	1108.4	16.72	19.22	19.58	18.51	15.84	16.91	17.24	16.67
	G_2	178.21	197.43	196.69	190.78	35.4	40.5	36.7	37.5	1077.0	1145.0	1151.4	1124.5	17.15	19.84	20.07	19.02	15.91	17.32	17.45	16.89
	G_3	118.89	138.02	136.18	131.03	30.8	32.4	35.0	32.7	989.7	1057.9	1069.5	1039.1	14.18	16.44	16.96	15.86	14.32	15.51	15.82	15.22
Fertilizer level	F_1	143.13	161.68	160.29	155.04	31.8	34.5	34.4	33.6	1026.0	1100.1	1101.5	1075.9	15.17	17.39	17.70	16.75	14.75	15.77	16.06	15.53
	F_2	157.60	176.20	176.51	170.10	35.0	40.3	36.9	37.4	1055.1	1125.8	1135.4	1105.4	16.87	19.62	20.03	18.84	15.96	17.40	17.61	16.99
Mean		150.36	176.51	168.40		33.4	37.4	35.7		1040.6	1112.9	1118.5		16.02	18.50	18.87		15.36	16.58	16.84	

For comparison of	S.Em±	CD (0.05)	S.Em±	CD (0.05)	S.Em±	CD (0.05)	S.Em±	CD (0.05)	S.Em±	CD (0.05)
Genotype (G)	1.92	5.52	1.08	3.11	11.66	33.51	0.33	0.96	0.23	0.66
Row spacing (S)	1.92	5.52	1.08	3.11	11.66	33.51	0.33	0.96	0.23	0.66
Fertilizer level (F)	1.57	4.50	0.88	2.54	9.52	27.36	0.21	0.78	0.19	0.54
G x S	3.32	NS	1.88	NS	20.19	NS	0.58	NS	0.40	NS
G x F	2.71	NS	1.53	NS	16.49	NS	0.47	NS	0.32	NS
F x S	2.71	NS	1.53	NS	16.49	NS	0.47	NS	0.32	NS
G x S x F	4.70	NS	2.65	NS	28.56	NS	0.81	NS	0.56	NS

Note:
Genotype — G_1 - Shiggoan local; G_2 - Pudakalakatti local; G_3 - Kanavi local
Spacing — S_1 - 37.5 x 10 cm; S_2 - 45 x 10 cm; S_3 - 60 x 10 cm
Fertilizer — F_1 - 40:20:20 kg N, P_2O_5 & K_2O ha^{-1}; F_2 - 80:40:40 kg N, P_2O_5 & K_2O ha^{-1}
NS - Non-significant

Table 2. Grain yield (kg ha^{-1}), stover yield (t ha^{-1}), harvest index, popping percentage and popping expansion volume (ml g-1) at harvest of pop sorghum genotypes as influenced by row spacings and fertilizer levels

Treatments		Grain yield (kg ha^{-1})				Stover yield (t ha^{-1})				Harvest index				Popping percentage				Popping expansion volume (ml g^{-1})			
Genotype	Fertilizer	Row spacing (S)																			
(G)	level (F)	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
G1	F_1	1067	1320	1238	1208	19.4	23.0	21.6	21.4	0.053	0.056	0.055	0.055	78.54	81.21	81.97	80.57	8.01	10.66	10.18	9.62
	F_2	1219	1538	1383	1380	20.3	25.8	23.6	23.2	0.057	0.057	0.056	0.056	79.24	83.05	82.85	81.17	8.81	10.80	10.89	10.17
G2	F_1	1373	1517	1503	1464	21.7	26.1	25.0	24.2	0.061	0.055	0.057	0.058	72.89	75.90	76.05	74.95	5.12	8.25	8.45	7.27
	F_2	1474	1619	1546	1546	23.4	29.3	27.5	26.7	0.060	0.052	0.054	0.055	74.21	77.32	77.15	76.23	6.79	9.41	9.39	8.53
G3	F1	960	1184	1096	1080	14.5	16.9	15.8	15.7	0.063	0.066	0.065	0.065	66.10	69.97	70.15	68.74	4.98	6.81	6.95	6.25
	F_2	1073	1281	1231	1195	15.6	19.6	17.8	17.7	0.064	0.063	0.065	0.064	67.05j	71.19	71.25	69.83	5.09	8.24	7.89	7.07
Genotype	G_1	1143	1429	1311	1294	19.9	24.4	22.6	22.3	0.055	0.056	0.055	0.056	78.89	82.13	82.41	81.14	8.41	10.73	10.54	9.89
	G_2	1423	1568	1524	1505	22.5	27.7	26.2	25.5	0.061	0.054	0.055	0.057	73.55	76.61	76.60	75.59	5.95	8.83	8.92	7.90
	G_3	1016	1233	1163	1137	15.0	18.3	16.8	16.7	0.064	0.065	0.065	0.064	66.57	70.58	70.70	69.28	5.04	7.53	7.42	6.66
Fertilizer level	F_1	1133	1340	1279	1251	18.5	22.0	20.8	20.4	0.059	0.059	0.059	0.059	73.50	77.19	77.08	75.92	6.90	9.48	9.39	8.59
	F_2	1255	1479	1386	1374	19.8	24.9	23.0	22.5	0.060	0.057	0.058	0.059	72.51	75.69	76.06	74.75	6.04	8.58	8.53	7.71
Mean		1194	1410	1333		19.1	23.4	21.9		0.060	0.058	0.059		73.01	76.44	76.57		6.47	9.03	8.96	
For comparison of		S.Em±		CD (0.05)		S.Em±		CD (0.05)		S.Em±		CD (0.05)		S.Em±		CD (0.05)		S.Em±		CD (0.05)	
Genotype (G)		33.30		95.70		0.61		1.74		0.002		0.006		0.34		0.97		0.11		0.31	
Row spacing (S)		33.30		95.70		0.61		1.74		0.002		NS		0.34		0.97		0.11		0.31	
Fertilizer level (F)		27.19		78.14		0.49		1.42		0.002		NS		0.28		0.79		0.09		0.25	
G x S		57.67		NS		1.05		NS		0.004		NS		0.58		NS		0.19		NS	
G x F		47.09		NS		0.86		NS		0.003		NS		0.48		NS		0.15		NS	
F x S		47.09		NS		0.86		NS		0.003		NS		0.48		NS		0.15		NS	
G x S x F		81.56		NS		1.48		NS		0.005		NS		0.83		NS		0.26		NS	

Note:
Genotype — G_1 - Shiggoan local; G_2 - Pudakalakatti local; G_3 - Kanavi local
Spacing — S_1 - 37.5 x 10 cm; S_2 - 45 x 10 cm; S_3 - 60 x 10 cm
Fertilizer — F_1 - 40:20:20 kg N, P_2O_5 & K_2O ha^{-1}; F_2 - 80:40:40 kg N, P_2O_5 & K_2O ha^{-1}
NS - Non-significant

Table 3. Economic analysis of pop sorghum production and pop making as influenced by genotypes, row spacings and fertilizer levels

Treatments	Pop sorghum production			Pop making		
	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Shiggaon + 37.5 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	23050	12380	1.16	59490	41349	2.27
Shiggaon + 37.5 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	25385	12465	0.96	67013	45558	2.12
Shiggaon + 45 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	28000	17342	1.63	73066	53168	2.67
Shiggaon + 45 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	32107	19199	1.49	84614	60940	2.57
Shiggaon + 60 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	26300	15682	1.47	68560	49276	2.55
Shiggaon + 60 x 10 cm + 80:40:40 kg $N:PP_2O_5:K_2O$ ha^{-1}	29078	16210	1.26	76295	53746	2.38
Pudakalakatti + 37.5 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	28015	17345	1.63	74906	54622	2.69
Pudakalakatti + 37.5 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	30109	17189	1.33	80420	57185	2.46
Pudakalakatti + 45 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	31995	21337	2.00	83797	62517	2.93
Pudakalakatti + 45 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	34874	21966	1.70	90175	65929	2.72
Pudakalakatti + 60 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	31369	20651	1.95	82595	61454	2.89
Pudakalakatti + 60 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	33052	20184	1.57	85823	62136	2.62
Kanavi + 37.5 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	19237	8567	0.80	51999	34611	1.99
Kanavi + 37.5 x 10 cm + 80:40:40 kg N: $P_2O_5:K_2O$ ha^{-1}	21201	8281	0.64	57824	37396	1.83
Kanavi + 45 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	23241	12583	1.18	63662	44716	2.35
Kanavi + 45 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	25824	12916	1.00	69542	47669	2.18
Kanavi + 60 x 10 cm + 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}	21624	11007	1.04	59040	40750	2.23
Kanavi + 60 x 10 cm + 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}	24277	11409	0.89	66292	44809	2.09
S.Em±	1235	1235	0.11	3844	3286	0.09
CD (0.05)	3549	3549	0.30	11048	9444	0.25

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