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RESEARCH PAPER

Evaluation of pop sorghum germplasm for productivity and popping traits

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Abstract: The experimental material consisting of 44 genotypes involving 39 pop-sorghum germplasm lines and five checks including special variety for popping KMJ-1 was evaluated for popping and productivity traits. During *Rabi* 2019 in a replicated trial at RARS, Vijayapura. Significant treatment variances were observed for traits days to 50% flowering, plant height and panicle length. The grain weight per plant, panicle weight, grain number per plant, popping expansion ratio and flake size recorded high estimates of phenotypic coefficient of variation (PCV). Moderate estimates of PCV for panicle length, hundred grain weight and popping yield and low estimates for days to 50% flowering and plant height were recorded. Promising genotypes identified for popping traits were SPGT-2, SPGT-12 and SLR 211-142; for both popping and yield traits were GRPM-362-28 and GRPM362-352, and for yield traits were GRPM362-5, GRPM36217 and SPGT-1.

Key words: Expansion ratio, Pop sorghum, Popping, Variances

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench], the "King of millets", is one of the most important cereal crops in the world because of its adaptation to a wide range of ecological conditions, suitability for low input cultivation and diverse uses. It is the fifth most important cereal crop globally after wheat, maize, rice and barley in terms of production and utilization, and is the dietary staple of more than 500 million people in 30 countries. Africa and India account for the largest share (70 %) of global sorghum area, while USA, Mexico, Nigeria, Sudan and Ethiopia are the major sorghum producers (Anon., 2020).

Sorghum in India is grown in both *kharif* anf *Rabi* seasons. *Rabi* sorghum (post-rainy) being grown under residual moisture situation is characterized by excellent grain quality and tasty grains and fetches high price in the market unlike *kharif* sorghum grains. Hence, Rabi sorghum is exclusively used for human consumption. Sorghum produced in India is consumed mostly in the form of roti (unleavened bread) and *sankati* (thick porridge). To some extent it is also eaten as parched and popped grain. Traditionally, farmers have consciously selected landraces of sorghum for the special purposes. The special food purpose sorghums are expected to be having distinct grain properties.

In parts of Africa and Asia, sorghums that pop like popcorn can be found. Popped sorghum is already a favorite in central India, and it is starting to find favor in several other countries as well. In India, people sprinkle a handful of dry grain onto a bed of hot sand or a hot sheet of metal. The popped kernels are brushed off as they form (Anon., 1996). Popping can be an economic and effective method for processing millets for food and industrial uses. The popped sorghum grains can be used in weaning and supplementary food formulations. Utilization of sorghum in the form of ready-to-eat pops improves its consumption significantly (Sailaja, 1992). When popped, the grains lose moisture and the nutrients get concentrated (Sajjanar *et al*., 2009).

Pop sorghum belongs to Roxburgii group of sorghum and is cultivated and consumed next only to grain sorghum because of their economic and nutritive value (Mallinath *et al*., 2004). As with popcorn, the best popping types usually have small grains with a dense, "glassy" (corneous) endosperm that traps steam until pressure builds to explosive levels. Utilization of these popping sorghums in breeding programs aimed at improved popping quality might be rewarding (Rao and Murty, 1981).The present study was aimed at evaluation of Pop-sorghum genotypes in Rabi sorghum for yield and popping traits.

Material and methods

The experimental material consisting of 44 genotypes involving 39 pop-sorghum germplasm lines and five checks including special variety identified for popping (KMJ-1) were used to study their performance for popping and productivity traits. The seed material of these genotypes was collected from germplasm pool being maintained at AICSIP, RARS, Vijayapur. Field evaluation of these genotypes was taken up for productivity traits during *rabi* 2019-20 in a Randomized Block Design (RBD) with two replications. Each entry was planted in two rows of 4 m length, with a spacing of 45 x 15 cm. The experimental material was sown during first fortnight of October 2019. Recommended package of practices were followed. The plant protection measures were taken up to avoid pest incidence.

Observations were recorded on days to 50% flowering, plant height (cm), panicle length (cm), panicle breadth (cm), panicle weight (g), grain weight per plant (g/plant) and hundred grain weight (g). All the observations were recorded on five randomly selected plants in each entry except days to flowering (recorded on plot basis).

The germplasm lines were also observed for popping traits using harvested bulk seed of each entry. Popping was carried out using conventional method of popping. The cooking pan was heated by using LPG burner and the pretreated grains

(hot water treatment followed by seed drying overnight). Gas control knob of the burner was set at the same level during popping and it was covered. The heating was continued until complete popping took place. The popping observations were recorded on Popping yield, expansion ratio and flake size. Popping yield (%) was calculated by dividing no. of popped grains by total number of grains and expressed in percentage. Expansion ratio (ml/g) was determined by the ratio of bulk volume of popped sample (ml) to the weight of raw sample. Flake size (ml) Flake size is obtained by the ratio of popped grain volume to that of number of seeds per gram.

Results and discussion

Analysis of variance

The analysis of variance for various characters studied is presented in Table 1. The mean sum of squares due to genotypes was significant for days for 50 (%) flowering, plant height and panicle length among all the characters studied indicating genotypic differences existed for these traits among the genotypes tested. The variability estimates (mean, range and phenotypic coefficient of variation) are presented in Table 2.

The mean number of days to 50 (%) flowering was 72.55 days with a range of 61.0 to 84.0 days. The genotype GRPM362-28 was earliest to flower at 61.00 days, while the genotype GRPM362-39 flowered late at 84.00 days. The phenotypic coefficient of variability was 7.09. The variability study showed relatively lower phenotypic coefficient of variation for days to 50 % flowering. Similar observations were reported earlier by Patel *et al.* (1980) and Nimbalkar *et al.* (1988).

The mean plant height recorded was 242.28 cm with a range of 151.50 to 274.0 cm. The analysis of variance revealed highly significant differences among the genotypes with respect to plant height. The maximum height of 274.0 cm was recorded by line GRPM362-39 and the lowest plant height was recorded by line GRPM362-28 (151.50 cm).The variability study showed relatively low estimates of coefficient of phenotypic coefficient of variation (9.14 %) for plant height. Similar observations were reported earlier by Dhimer and Desai (1978) and Negash *et al.* (2005).

Panicle length varied significantly among the genotypes with a mean of 14.10 cm and range of 12.60 to 25.20 cm. The line

Table 1. Mean sum of squares for productivity and popping traits in 44 *rabi* sorghum genotypes evaluated during *Rabi* 2019 at RARS, Vijayapur

Traits	Replication	Treatment	Error
Days to 50 % flowering	8.28	51.84**	1.12
Plant height (cm)	3228.28	804.93**	177.60
Panicle length (cm)	14.33	10.23**	2.47
Panicle breadth (cm)	1.76	0.27	0.10
Panicle weight (g)	285.04	81.23	23.08
Grain weight per plant (g)	151.77	70.45	8.94
100 seed weight (g)	0.67	0.16	0.03
Number of grains per plant	884.55	123213.99	20095.25
Fodder yield per plant (g)	426.53	114.00	48.08
Popping (%)	4.11	322.57	7.28
Expansion ratio(ml/g)	40.90	52.41	10.73
Flake size	0.00082	0.02361	0.00153

Note: ** Significance at 1 % probability level
* Significance at 5 % probability level

Table 2. Promising genotypes identified and estimates of variability parameters for productivity and popping traits among *rabi* sorghum genotypes evaluated during *Rabi* 2019, at RARS Vijayapur

Sl. No.	Traits	Mean	Range		PCV (%)	Top five genotypes
			Min.	Max.		
1	Days to 50 % flowering	72.55	61.00	84.00	7.09	(GRPM362-28, GRPM362-47, SPGT-17, SPGT-72, SPGT-9) (for earliness)
2	Plant height (cm)	242.28	151.50	274.00	9.14	GRPM362-39, GRPM362-289, SPGT-17, GRPM362-30, SPGT-7 (for tall height)
3	Panicle length (cm)	14.1	12.60	25.20	17.87	GRPM362-28, SPGT-15, SPGT-72, GRPM362-17, KMJ-1, SPGT-5
4	Panicle breadth (cm)	4.33	3.35	5.40	10.15	(GRPM362-289, GRPM362-281, GRPM362-352, GRPM362-187, SPGT-1)
5	Panicle weight (g)	32.41	18.03	47.15	22.34	(SPGT-1, GRPM362-5, SPGT-18, GRPM362-289, GRPM362-19)
6	Grain yield per plant	21.33	10.29	34.33	29.52	RSJ-1 , GRPM362-5, SPGT-1, GRPM362-17, M 35-1, SPGT-18, SPGT-17
7	Test weight(g)	2.07	1.41	2.56	15.14	(GRPM362-30, GRPM362-187, GRPM362-352, GRPM362-39, SPGT-11)
8	Grain number per plant	1052.89	380.50	1771.00	25.24	(SPGT-1, SPGT-15, GRPM362-17, SLR211-169, GRPM362-5)
9	Fodder yield per plant (g)	36.4	14.02	53.65	24.73	(GRPM362-19, GRPM362-5, AKJ-1, SPGT-26, GRPM362-289, GRPM362-17)
10	Popping yield (%)	69.05	0.00	83.61	18.59	(SLR211-142, GRPM362-167, SPGT-72, GRPM-362-352, GRPM362-183)
11	Expansion ratio (ml/g)	17.21	2.12	27.00	32.65	(SPGT-2, GRPM362-352, SPGT-12, GRPM362-30, GRPM362-28)
12	Flake size	0.41	0.00	0.63	27.36	(GRPM362-28, SPGT-17, SPGT-2, SPGT-12, GRPM362-352, SLR211-142)

GRPM362-28 showed highest panicle length where as lowest panicle length was recorded by the line SPGT-13. The variability study showed moderate phenotypic coefficient of variation (17.87 %). Similar observations were reported earlier by Dhimer and Desai (1978), and Negash *et al.* (2005).

Mean panicle breadth was 4.33; maximum was 5.40 and minimum of 3.35 cm. The line GRPM362-289 showed highest panicle breadth and line GRPM362-28 showed lowest panicle breadth. The variability study showed relatively moderate phenotypic coefficient of variation (10.15 (%). Similar results were recorded by Lonc (1969).

Panicle weight showed a mean value of 32.41 g with a range of 18.03 g to 47.15 g and PCV (22.34 %). The line SPGT-1 showed highest panicle weight and line GRPM362-28 showed lowest panicle weight. The variability study showed high phenotypic coefficient of variation were also reported by Khanure (1993).

Grain weight varied significantly from 10.29 to 33.53g with a mean of 21.33 g. The lowest grain yield was recorded by line GRPM362-28 and highest grain yield was recorded by line SPGT-1. Relatively hig estimates (29.52 %)of phenotypic coefficient of variability were observed for this trait Similar observations were reported earlier by Rao and Patil (1996) and Prabhakar (2001)The lines differed significantly for 100 seed weight. The values ranged between 1.41 g to 2.56 g with a mean of 2.07 g. The lowest 100 seed weight was recorded by line GRPM362-28 whereas highest weight was exhibited by line GRPM362-19. Moderate estimates the phenotypic co-efficient of variability for this trait was (15.14 %). Observations for high variability have been reported earlier by Nguyen *et al.* (1999) and Prabhakar (2001).

Average grain number per plant observed was 1052.89. The maximum number recorded was 1771. The line SPGT-1 showed highest gain number per plant of 1771, while the line GRPM362-28 showed the lowest gain number per plant of 380. The variability study showed high phenotypic coefficient of variation (25.24 %). Similar results were reported by Shinde *et al.,* (2010). Average fodder weight observed was 36.40g. The maximum recorded was 53.65 g (GRPM362-19) while the line GRPM362-28 showed the lowest fodder weight of 20.3 g. High estimates of PCV (24.73 %) was observed for fodder weight per plant. Similar results were obtained by Halalli *et al.* (1983).

For the trait popping yield, the range was found to be from 54.89 per cent (GRPM362-47) to 83.61 per cent (SLR211-142), showing a high PCV of 18.59 (%). The mean observed was 69.05 (%). The mean expansion ratio was 17.21 (ml/g) with a range of 27.00 to 2.12 (ml/g). The line GRPM362-19 was the lowest (8.5 ml/g), while the line SPGT-2 (27.00 ml/g) was the highest. The phenotypic coefficient of variability was 32.65. Overall mean of genotypes for flake size was 0.41. Highest flake size observed was 0.63 and the least reading was 0.28. Highest flake size was recorded in the line GRPM362-28 and lowest by the line SPGT-72. The phenotypic coefficient of variability for this trait was 27.35 (%).

Identification of promising genotypes for popping and yield traits

Regarding popping traits, the top five entries identified were: popping yield (SLR211-142, GRPM362-167, SPGT-72, GRPM-362-352, GRPM362-183), expansion ratio (SPGT-2, GRPM362-352, SPGT-12, GRPM362-30, GRPM362-28) and flake size (GRPM362-28, SPGT-2, SPGT-12, GRPM362-352, SLR211-142) (Table 2). Promising genotypes identified for both popping traits and yield traits were GRPM-362-28 (expansion ratio, flake size, panicle length and earliness), GRPM362-352 (popping yield, panicle breadth, test weight) and SPGT-72 (popping yield, panicle length, earliness). Promising genotypes identified for yield traits were GRPM362-5 (grain weight, panicle weight, grain number and fodder weight, charcoal rot), GRPM36217 (grain weight, grain number, panicle length and fodder weight), SPGT-1 (grain weight, panicle weight, panicle breadth, grain number).

The pop-sorghum genotype GRPM362-352 recorded high grain weight, panicle weight, panicle length, panicle breadth and all popping traits popping yield, expansion ratio and flake size. It recorded with low grain size (1.79 g/100 seeds). This genotype may be subjected for further detailed analysis for its use in development of mapping population. SMJ-1 that recorded with no popping yield and GRPM362-352 that recorded with high popping yield these may be crossed to develop mapping population for mapping QTLs for popping traits and also for genetic analysis of popping traits in sorghum.

Days to 50% flowering ranged between 61-84 days among popping genotypes. Top five pop-sorghum genotypes identified for earliness were GRPM362-28, GRPM362-47, SPGT-17, SPGT-72, SPGT-9. Promising genotypes identified for various yield traits are: grain weight per plant (GRPM362-5, SPGT-1, GRPM362-17, SPGT-18, SPGT-17), grain number per plant (SPGT-1, SPGT-15, GRPM362-17, SLR211-169, GRPM362-5), test weight (GRPM362-30, GRPM362-187, GRPM362- 352, GRPM362-39, SPGT-11) and fodder weight (GRPM362-19, GRPM362-5, AKJ-1, SPGT-26, GRPM362-289, GRPM362-17).

Conclusion

Rabi sorghum offers stable source of high quality grain for novel and traditional food uses, providing choices to end users in terms of taste and nutrition.

Promising genotypes identified for popping traits were SPGT-2 and SPGT-12 for high expansion ratio and flake size, SLR 211-142 for popping yield and flake size. Promising genotypes identified for both popping traits and yield traits were GRPM-362-28 (expansion ratio, flake size, panicle length and earliness), GRPM362- 352 (popping yield, panicle breadth, test weight) and SPGT-72 (popping yield, panicle length, earliness).

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