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Estimates of heritability and genetic advancement through mutation breeding for *rabi* parching sorghum yield

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Abstract
Increasing knowledge of sorghum nutrition has lead to investigation of parching sorghum (Hurda) varieties by mutation studies. The present work was carried out to study the high yielding parching sorghum mutants of the genotypes Gulbhendi and Sakari Mokari. The experiment was carried out at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and Agricultural Research Station, Ekarjuna in collaboration with the BARC, Mumbai during the years 2015-16 to 2017-18 in 49 Gulbhendi and Sakari Mokari mutants each, along with the check Gulbhendi and Sakari Mokari, respectively. As compared to the Gulbhendi check maximum hurda yield per panicle for Gulbhendi mutant was recorded in mutants Gulbhendi Mutant 300 Gy selection No.-16-6-3-2 followed by Gulbhendi Mutant 300 Gy selection No.-26-1-5-2, Gulbhendi Mutant 300 Gy selection No.-35-3-3-1, Gulbhendi Mutant 300 Gy selection No.-19-2-3-1 and Gulbhendi Mutant 300 Gy selection No.-42-4-1-1 and for the Sakari Mokari mutants the maximum seed weight per panicle was observed by Sakari Mokari Mutant 300 Gy selection No.-18-1-2-1 followed by Sakari Mokari Mutant 300 Gy selection No.-51-1-4-1, Sakari Mokari Mutant 300 Gy selection No.-43-4-1-2 and Sakari Mokari Mutant 300 Gy selection No.-32-3-2-1 in comparison to Sakari Mokari check. Phenotypic coefficient of variance was recorded higher than genotypic coefficient of variance for both the genotypes under study indicating a preferential influence of environment on the genotype. The variability studies showed the heritability of 68.57% for Gulbhendi mutants and 52.54% for Sakari Mokari mutants seed yield per panicle which was observed to be moderate for both the genotypes mutants.

Keywords: Sorghum, hurda, mutation breeding, yield

Introduction
Sorghum is the fifth major cereal crop having huge nutritional importance. Roughly, developing countries contribute about 90% of the world's sorghum area and 95% of the world's millet area, mainly Africa and Asia. This tropical grass is grown mostly in semi-arid parts of the world (Léder, 2004) [1]. Sorghum apart from being used as food, feed, fiber, and bioenergy crop it is also used as feedstock for cellulosic ethanol (Wang *et al.*, 2016). One of the special ready to use snack of sorghum popularly known as hurda is obtained in early January of Rabi sorghum and is very juicy and tender. Sorghum food needs to be popularized due to its high minerals and fiber content and low or slow starch digestibility making it a perfect food for diabetic and obese people. Nowadays due to hike in the agro-tourism business in the rural area aided with supply of sorghum hurda as a niche encourage more of agro-tourism business and earn a greater profit to the farmer/producer (Chavan *et al.*, 2013) [3]. To gain a variety which is having sweeter juicy and tender hurda mutation studies are on their way. Mutation is the sudden heritable change in the genotype of the species. However, mutation breeding is generally used when the desired variation is not present in the population and when we need to have more diverse studies in the specified crop species. One of the main reasons for this has been the tremendous amount of unexploited natural variation present in the species. Even though large amount of genetic variability is present in sorghum, but it does not always satisfy the needs of plant breeders for varietal improvement (Hanna. 1982) [4]. This study focuses on the genetic improvement of the sorghum varieties for obtaining a delicious and sweet sorghum snack.

Material and Methods

The present study was carried out at Sorghum Research Station, Dr. Panjabrao Deshmukh, Krishi Vidyapeeth, Akola and at Agricultural Research Station, Ekarjuna. The variety Gulbhendi and Sakari Mokari were used in the study for mutagenic treatment and to study various characters.

Mutagenic treatment

The selfed seeds were treated with physical mutagen (gamma rays) and chemical mutagen (EMS) separately or in combination. Dry Seeds were irradiated with gamma rays (300 Gy) at BARC, Trombay and half of the seeds were treated with EMS @ 0.1 and 0.2% in the year 2015-16.

Procedure

During the first year, screening of M1 plants of Gulbhendi and Sakari Mokari was done for checking the physical injuries and estimating the number of pants germinated or survived. Normal package of practices was followed to raise a healthy crop. Selfed panicles of individual plants were harvested separately and advanced to the M2 generation. In the second year, selection was done for earliness, panicle area, seed size and grain yield per plant as well as for shootfly tolerance. Best IPS (20%) were harvested separately and advanced to M3 generation. During third year, M3 populations were planted in plant to row progeny method and ideal plant type and high grain yield mutants were selected at ARS, Ekarjuna and PDKV, Akola. Based on the morphological, yield related and biochemical analysis, 10% of the elite mutants were chosen for large scale farm trials.

During rabi 2015-16, mutation breeding material developed in collaboration with BARC, Mumbai was sown at ARS farm, Ekarjuna. The M_1 population were planted and normal package of practices were followed to raise the healthy crop till maturity and M_1 seed of Gulbhendi and Sakari Mokari were harvested in bulk. IPS from M_1 generation were harvested at Akola. Total 507 individual plant selections were made in Gulbhendi and Sakari Mokari under M_2 generation for boldness, earliness, shootfly tolerance, higher grain yield and good grain quality and M_2 seed were harvested.

The $M_{2:3}$ seeds of Gulbhendi and Sakari Mokari were planted at ARS, Ekarjuna during rabi 2016-17 and normal package of practices were followed to raise the healthy crop till maturity. Total 54 individual plant selections were made in Gulbhendi and Sakari Mokari for boldness, earliness, shootfly tolerance, higher grain yield and good grain quality. During the same year, $M_{2:3}$ seeds were also replicated at Sorghum Research Unit, Akola. Total 344 individual plant selections were made in Gulbhendi and Sakari Mokari each for boldness, earliness, shootfly tolerance, higher grain yield and good grain quality and M_3 seed were harvested.

During the year 2017-18, $M_{3:4}$ seeds were planted at Sorghum Reaesrch Unit, Akola and ARS farm, Ekarjuna. Total 157 individual plant selections were made in Gulbhendi and Sakari Mokari under M_4 generation for boldness, earliness, shoot fly tolerance, higher grain yield and good grain quality and M_4 seed were harvested.

Results

From the study it was observed that (Table 1) (Figure 1) highest seed yield per panicle for Gulbhendi mutants were recorded in Gulbhendi Mutant 300 Gy selection No.-16-6-3-2 (49.00 gm) followed by Gulbhendi Mutant 300 Gy selection No.-26-1-5-2 (48.00 gm), Gulbhendi Mutant 300 Gy selection No.-35-3-3-1 (46.00 gm), Gulbhendi Mutant 300 Gy selection No.-19-2-3-1 (45.3 gm) and Gulbhendi Mutant 300 Gy selection No.-42-4-1-1 (44.00 gm) on the other hand, lowest seed yield per panicle was recorded by Gulbhendi Mutant 300 Gy selection No.-55-1-1-2 (28.64 gm), Gulbhendi Mutant 300 Gy selection No.-17-2-2-1 (27.40 gm) and Gulbhendi Mutant 300 Gy selection No.-23-7-3-1 (27.00 gm) as compared to the Gulbhendi check (32.35 gm).

In the Sakari Mokari mutants the highest seed weight per panicle (Table 1) (Figure 2) was observed by Sakari Mokari Mutant 300 Gy selection No.-18-1-2-1 (52.75 gm) followed by Sakari Mokari Mutant 300 Gy selection No.-51-1-4-1, Sakari Mokari Mutant 300 Gy selection No.-43-4-1-2 and Sakari Mokari Mutant 300 Gy selection No.-32-3-2-1 (50.00 gm each) and on the other hand, lowest seed yield per panicle was recorded in Sakari Mokari Mutant 300 Gy selection No.-38-2-1-1 (34.57 gm), Sakari Mokari Mutant 300 Gy selection No.-51-8-2-1 (34.20 gm) and Sakari Mokari Mutant 300 Gy selection No.-5-5-3-1 (33.99 gm) as compared to the Sakari Mokari check (39.20 gm).

The variability studies indicated that Gulbhendi mutants (Table 2) recorded a mean seed yield per panicle of 36.43 gm with genotypic and phenotypic co-efficient of variation of 10.09 and 14.72, respectively and broad sense heritability of 68.57%. On the other hand, Sakari Mokari mutants (Table 2) recorded a mean seed yield per panicle of 41.66 gm with genotypic and phenotypic co-efficient of variation of 6.71 and 12.76 respectively with the broad sense heritability of 52.54%.

Table 1: Seed yield per panicle of Gulbhendi and Sakari Mokari mutants.

Gulbhendi Mutants (300 Gy)	Seed yield/Panicle	Sakari Mokari Mutants (300 Gy)	Seed yield/Panicle
GBM - 17-2-2-2	33.28	SKM - 18-1-1-1	48.62
GBM - 16-6-3-2	49.00	SKM - 51-5-1-1	44.00
GBM - 29-3-1-1	39.00	SKM - 51-3-1-2	41.00
GBM - 42-5-2-2	40.00	SKM - 22-1-1-1	42.00
GBM - 26-1-5-2	48.00	SKM - 13-3-3-1	36.00
GBM - 26-1-8-1	37.25	SKM - 52-2-1-2	40.00
GBM - 27-3-3-1	39.00	SKM - 22-1-2-1	39.00
GBM - 42-4-1-1	44.00	SKM - 51-1-4-1	50.00
GBM - 19-2-3-1	45.83	SKM - 51-1-3-2	40.66
GBM - 19-2-2-1	42.76	SKM - 43-4-1-2	50.00
GBM - 23-1-4-2	35.88	SKM - 18-1-2-1	52.75
GBM - 66-7-3-2	37.44	SKM - 67-4-4-1	36.00
GBM - 23-7-3-1	27.00	SKM - 23-3-4-1	36.00
GBM - 27-2-5-1	35.36	SKM - 34-5-3-1	44.00
GBM - 32-2-7-1	37.23	SKM - 34-3-3-1	41.90
GBM - 32-2-8-2	33.57	SKM - 32-4-1-1	37.65
GBM - 32-2-8-3	38.20	SKM - 63-1-3-1	38.00
GBM - 35-6-2-1	39.88	SKM - 27-1-3-1	47.33
GBM - 23-2-3-1	36.12	SKM - 53-1-2-1	40.66
GBM - 35-3-2-1	33.10	SKM - 59-3-1-1	45.00
GBM - 29-1-3-1	36.80	SKM - 67-5-3-1	43.48
GBM - 66-8-3-1	33.00	SKM - 67-10-2-1	43.00
GBM - 32-2-7-2	32.11	SKM - 34-4-1-1	43.00
GBM - 55-1-1-2	28.64	SKM - 43-3-1-1	44.03
GBM- 35-3-3-1	46.00	SKM - 57-4-2-1	47.00
GBM - 10-2-1-1	37.53	SKM - 38-3-1-1	43.00
GBM - 35-2-1-1	40.00	SKM - 32-3-2-1	50.00
GBM - 35-6-7-1	36.03	SKM - 22-6-3-1	43.00
GBM - 42-3-1-2	35.54	SKM - 27-4-1-1	46.16
GBM - 29-2-1-1	31.62	SKM - 34-5-4-1	40.50
GBM - 32-2-2-1	31.75	SKM - 51-1-5-1	36.43
GBM - 32-1-2-1	34.80	SKM - 50-2-1-1	35.00
GBM - 42-6-2-1	38.99	SKM - 53-2-2-1	35.66
GBM - 7-1-2-1	38.00	SKM - 49-1-2-1	39.75
GBM - 66-7-2-1	41.53	SKM - 53-2-1-1	37.50
GBM - 42-6-1-1	34.22	SKM - 13-3-2-1	35.00
GBM - 14-2-1-1	32.85	SKM - 34-4-3-1	44.42
GBM - 66-7-1-1	37.26	SKM - 5-5-3-1	33.99
GBM - 43-9-1-1	30.72	SKM - 38-2-1-1	34.57
GBM - 35-7-2-1	32.55	SKM - 61-1-2-2	48.00
GBM - 42-3-1-1	42.02	SKM - 61-1-2-1	41.00
GBM - 66-7-2-2	36.09	SKM - 51-8-2-1	34.20
GBM - 27-2-1-1	33.14	SKM - 34-5-2-1	44.50
GBM - 66-2-1-1	35.63	SKM - 22-4-1-1	41.43
GBM - 17-2-2-1	27.40	SKM - 48-3-1-1	39.75
GBM - 16-1-1-1	34.67	SKM - 27-6-2-1	42.83
GBM - 16-3-2-2	32.00	SKM - 38-1-1-1	42.66
GBM - 23-7-6-1	31.19	SKM - 51-1-1-1	45.83
GBM - 17-2-1-1	35.00	SKM - 31-1-3-1	37.80
Gulbhendi Check	32.35	Sakari Mokari Check	39.20
	2.25		2.61
	10.71		10.86
	6.32		7.32

Table 2: Variability study of Gulbhendi and Sakari Mokari mutants

	GBM (Seed yield/panicle)	SKM (Seed yield/panicle)
Genotypic Variance (σ2g)	13.5192	7.805586
Phenotypic Variance (σ2p)	28.7484	28.2726
Mean (X)	36.4266	41.6652
Phenotypic co-efficient of Variation (PCV)	14.7193	12.76173
Genotypic co-efficient of Variation (GCV)	10.0938	6.705471
Heritability (Broad Sense) %	68.5754	52.5436

Fig 1: Wide variation for panicle shape in Gulbhendi Mutants

Fig 2: Genetic variation for panicle shape in Sakari Mokari

Discussion

Maximum seed yield per panicle for Gulbhendi mutants were recorded in mutants Gulbhendi Mutant 300 Gy selection No.-16-6-3-2 followed by Gulbhendi Mutant 300 Gy selection No.-26-1-5-2, Gulbhendi Mutant 300 Gy selection No.-35-3-3-1, Gulbhendi Mutant 300 Gy selection No.-19-2-3-1 and Gulbhendi Mutant 300 Gy selection No.-42-4-1-1 as compared to the Gulbhendi check and from the study of Sakari Mokari mutants the maximum seed weight per panicle was observed by Sakari Mokari Mutant 300 Gy selection No.-18-1-2-1 followed by Sakari Mokari Mutant 300 Gy selection No.-51-1-4-1, Sakari Mokari Mutant 300 Gy selection No.-43-4-1-2 and Sakari Mokari Mutant 300 Gy selection No.-32-3-2-1 as compared to the Sakari Mokari check, such similar kind of increase in seed weight was also reported in the studies of Burow *et al*., (2014) [10] where the mutant plants showed increase in the seed production due to the weight of the panicle even though when the individual seeds in the mutant plants were small, this reduction in seed weight was fulfilled by the increase in seed number.

The variability study indicated that Phenotypic coefficient of variance was higher than genotypic coefficient of variance for both the genotypes under study which was also recorded by Narkhede *et al*., (2000) [6], Ranjith *et al*., (2017) [8] in their studies indicating high environmental influence. On the other hand, Sami *et al*., (2013) [9] reported that GCV was near to PCV for traits like grain yield indicating less influence of environment, but the values of PCV was observed to be high than GCV for rest of the characters under study. The Gulbhendi mutants showed the heritability of 68.57% and 52.54% for seed yield per panicle. Heritability was observed to be moderate for both the genotypes mutant which was also reported by Sami *et al*., (2013) [9], whereas, on the other hand, high heritability was recorded in the studies of Ranjith *et al*., (2017) [8] and moderate to high heritability was recorded by Narkhede *et al*., (2000) [6].

Conclusion

From the study it was observed that as compared to the Gulbhendi check maximum seed yield per panicle for Gulbhendi mutants was recorded in mutants Gulbhendi Mutant 300 Gy selection No.-16-6-3-2 followed by Gulbhendi Mutant 300 Gy selection No.-26-1-5-2, Gulbhendi Mutant 300 Gy selection No.-35-3-3-1, Gulbhendi Mutant 300 Gy selection No.-19-2-3-1 and Gulbhendi Mutant 300 Gy selection No.-42-4-1-1 and for the Sakari Mokari mutants the maximum seed weight per panicle was observed by Sakari Mokari Mutant 300 Gy selection No -18-1-2-1 followed by Sakari Mokari Mutant 300 Gy selection No -51-1-4-1, Sakari Mokari Mutant 300 Gy selection No -43-4-1-2 and Sakari Mokari Mutant 300 Gy selection No -32-3-2-1 as compared to the Sakari Mokari check. The variability study indicated that Phenotypic coefficient of variance was higher than genotypic coefficient of variance for both the genotypes under study which indicated a preferential influence of environment on the genotype. The variability studies showed the heritability of 68.57% for Gulbhendi mutants and 52.54% for seed yield per panicle which was observed to be moderate for both the genotypes mutants. Mutation breeding has potential to create vast genetic variability by augmenting with high grain and fodder yield Proposed project would help genetic improvement of landraces and old popular varieties with enhanced seed qualities.

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