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Genetic variability, heritability and genetic advance studies in the land races of *kharif* sorghum for seed quality parameters (*Sorghum bicolor* (L.) Moench)

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Abstract
Fifty-five landraces of *kharif* sorghum were evaluated for six seed quality parameters. The study revealed that the characters electrical conductivity and threshed grain mold rating showed high GCV and PCV values indicating thereby large amount of variation in these characters. All the characters showed close GCV and PCV values indicating less influence of environment of these characters. The high heritability estimates were observed for all the characters indicating that these characters would respond positively to selection. The high values of expected genetic advance over mean were recorded for the characters like electrical conductivity, threshed grain mold rating and vigour index. The electrical conductivity and threshed grain mold rating exhibited high heritability along with high value of expected genetic advance per cent over mean which indicated the importance of these traits for selection. High values of heritability along with low value of expected genetic advance were observed for the characters like seed hardness, germination percentage of seed and specific gravity of seed and heterosis breeding can be fruitfully exploited improving these characters.

Keywords: variability, GCV, PCV, genetic advance, heritability, sorghum

Introduction
Sorghum is one of the important crops of dry land agriculture. In a systematic breeding programme, collection and evaluation of germplasm is the first step. The adequacy of germplasm collection is determined by the amount of genetic variability with their nature and magnitude in it. Variability is the prerequisite for the effective selection in breeding of crop plants. In order to broaden the genetic base, there is need to exploit the unused germplasm and the land races. The land races are the varieties nurtured and cultivated by the farmers though traditional method of selection by over the decades. The land race is a primitive cultivar grown by the farmers and their successors since ancient times. These land races are store houses of the genetic variability and ordinarily are adapted to local soil types, and varying ranges of climatic conditions etc. They are sources of many valuable genes including those for adaptation. So, there is need to conserve and study the characteristic of land races and their further utilization in the breeding programme. Therefore, the present study was undertaken to study the genetic parameters such as variance, coefficient of variation, heritability and genetic advance in the *kharif* sorghum land races.

Material and Methods
Fifty-five land races of *kharif* sorghum comprising of 40 hybrids of *kharif* sorghum developed by crossing 4 lines and 10 testers in line × tester fashion along with one check CSH-35. The crossing program was carried out at the Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during rabi 2019-2020. The seed parental lines was provided by Sorghum research unit, Dr. PDKV, Akola. Experiment was conducted during kharif 2020-2021. Material was sown in randomized block design with 3 replications. Observations were recorded on the six characters like seed hardness (kg/cm^2), threshed grain mold rating (%), specific gravity of seed (g/ml), germination percentage of seed, vigour index of seed and electrical conductivity (dsm^{-1}). Seed hardness was measured as the physical strength required in kg/cm2 to break the kernel using kiya hardness tester. Grains of same moisture content were used for observations.

Five kernels of each genotype were tested for their strength to break and mean was calculated and hardness is expressed in kg/cm^2. Electrical conductivity of the grain leachates was measured using the method of Fatonah *et al.* (2017) [11]. Analysis of variance was done as per the method suggested by Panse and Sukhatme (1967) [8]. Genotypic and phenotypic coefficients of variation were estimated as per formulae given by Burton (1951) [2]. Heritability and genetic advance were estimated as per Johnson *et al*. (1955) [12].

Results and Discussion

The analysis of variance indicated highly significant differences among the genotypes for all the characters under study. High magnitude of variation in the experimental material was also reflected by wider range for all the characters under study (Table 1).

Seed hardness ranged from 5.82 to 9.07 kg/cm^2 (Table 1). Lowest seed hardness of 5.82 kg/cm^2 was observed in genotype AKMS-30-A and highest seed hardness was exhibited by the genotype AKMS-733-A × IVT-4121 (9.07 kg/cm^2). Threshed grain mold rating ranged from 11.66 to 32.00%. The lowest threshed grain mold rating of 11.66% was recorded in genotype AKMS-733-A × IVT-4121 and highest rating was recorded in genotype ICSR-1048 Sel.-2 (32.00%). Specific gravity of seed varied from 0.97 to 1.12 g/ml. Maximum specific gravity of seed was shown by the genotype AKMS-90-A × STR-293 × 426-2 (1.12 g/ml) and minimum specific gravity of seed was shown by the genotype ICSR-91016 (0.97 g/ml). Germination percentage of seed ranged from 68.00 to 86.00. Lowest germination was observed in the genotype ICSR-91016 (68.00%) and the highest germination was observed in the genotype AKMS-90-A × STR-293 × 426-2 (86.00%). Vigour index of seed varied from 1263.77 to 2512.92. Minimum vigour index of seed was observed in the genotype IVT-3004 (1263.77) and maximum vigour index of seed was observed in the genotype AKMS-733 × IVT-4121 (2512.92). Electrical conductivity ranged from 1.25 to 2.72 dsm^{-1}. Lowest electrical conductivity was observed in the genotype AKMS-733 × IVT-4121 (1.25 dsm-1) and highest electrical conductivity was observed in the genotype IVT-3004-1 (2.72 dsm^{-1}).

The Genotypic coefficient of variation, Phenotypic coefficient of variation, Heritability in broad sense and Expected Genetic Advance per cent over mean for various characters are presented in Table 2.

The genotypic coefficient of variation (GCV) ranged from 3.32 to 23.58% for different character under study (Table 2). The highest order value of genotypic coefficient of variation was observed for electrical conductivity (23.58%) followed by threshed grain mold rating (22.15%), vigour index of seed (18.11%), seed hardness (10.67%), germination percentage of seed (6.07%) and specific gravity of seed (3.32%).

The phenotypic coefficient of variation (Table 2) ranged from 23.88 to 3.51 percent for various characters under study. Highest phenotypic coefficient of variation was observed for the character electrical conductivity (23.88%) followed by threshed grain mold rating (22.61%), vigour index of seed (18.89%), seed hardness (11.93%), germination percentage of seed (7.63%) and specific gravity of seed (3.51%).

The characters electrical conductivity and threshed grain mold rating showed high GCV and PCV values indicating thereby large amount of variation for these characters. Low GCV and PCV values were found for the characters germination parentage of seed and specific gravity of seed indicating small amount of variation. For electrical conductivity similar results were obtained by Bongale (2000) [1]. For threshed grain mold rating Rathod (2005) [9] and Dhutmal *et al.* (2020) [3] recorded the similar results. Low GVC and PCV for germination percentage of seed and specific gravity of seed were reported by Rathod (2005) [9]. All the characters showed close GCV and PCV values indicating less influence of environment of these characters.

With the genotypic coefficient of variation, it is difficult to determine the relative amounts of heritable and non heritable components of variation present in the population. Estimates of heritability and genetic advance would supplement this parameter. The heritability in broad sense ranged from 63.20 to 97.50 percent (Table 2). The highest heritability estimate in broad sense was observed for electrical conductivity (97.50%) followed by threshed grain mold rating (96.00%), vigour index of seed (91.90%), specific gravity (89.90%) seed hardness (79.90%) and germination percentage of seed (63.20%) (Table 2). These characters would respond positively to selection because of their high broad sense heritability. High heritability estimates for electrical conductivity were reported by Rathod (2005) [9]. For threshed grain mold rating and seed hardness high heritability estimates were reported by Rathod (2005) [9] and Dhutmal *et al.* (2020) [3]. For the character germination percentage of seed, similar results were reported by Thorat *et al*. (2005) [10]. High heritability estimates in broad sense for the character specific gravity of seed, was reported by Rathod (2005) [9] and Khade *et al.* (2020) [7].

Expected genetic advance over mean ranged from 6.49 to 47.98% (Table 2). The high values of expected genetic advance over mean were recorded for the characters electrical conductivity (47.98%) followed by threshed grain mold rating (44.71%) and vigour index (35.78%). For the character electrical conductivity results were in conformity with results of Rathod (2005) [9] and Khade *et al*. (2020) [7]. For threshed grain mold rating similar results were obtained by Rathod (2005) [9] and Dhutmal *et al*. (2020) [3].

In general high heritability accompanied with high expected genetic advance for characters suggest that the genes governing these character may have additive effect. It can be mentioned here that characters electrical conductivity, threshed grain mold rating and vigour index of seed exhibited high heritability values along with high values of expected genetic advance. The phenotypic expression of these characters may be governed by the gene acting additively and thereby indicating the importance of these characters for selection. For electrical conductivity similar finding were reported by Kathalkar (2017) [6] for high heritability estimates along with high values of expected genetic advance. For threshed grain mold rating similar findings were reported by Rathod (2005) [9].

Moderate values of expected genetic advance percent over mean was observed for the character seed hardness (19.65%) while low values for germination percentage of seed (9.94%) and specific gravity of seed (6.49%). For the character specific gravity of seed, similar results were reported by Rathod (2005) [9] and Khade *et al*. (2020) [7].

High values of heritability along with low value of expected genetic advance were observed for the characters like germination percentage of seed and specific gravity of seed. Regarding these characters, the heritability is mainly due to non additive gene effect (dominance and epitasis) hence the expected genetic advance would be low. Since the characters are mainly governed by non additive component of variation which is non fixable, heterosis breeding can be fruitfully

exploited improving these characters. Kathalkar (2017) [6] reported high value of heritability along with low values of expected genetic advance for germination of seed and specific gravity of seed.

Table 1: Range, mean and the best genotype for different characters

S N	Character	Range	Mean	Best genotype
1	Seed hardness (kg/cm^2)	5.82-9.07	7.05	AKMS-733-A × IVT-4121
2	Threshed grain mold rating (%)	11.66-32.00	21.67	AKMS-733-A × IVT-4121
3	Specific gravity of seed (g/ml)	0.97-1.12	1.04	AKMS-90-A × STR-293 × 426-2
4	Germination% of seed	68.00-86.00	75.23	AKMS-90-A × STR-293 × 426-2
5	Vigour index of seed	1263.77-2512.92	1752.99	AKMS-733-A × IVT-4121
6	Electrical conductivity (dsm^{-1})	1.25-2.72	2.04	AKMS-733-A × IVT-4121

Table 2: Estimation of genetic parameters –GV, PV, GCV, PCV, h^2 and EGA

S N	Character	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	$h^{2\%}$	EGA as% over mean
1	Seed hardness (kg/cm^2)	0.57	0.71	10.67	11.93	79.90	19.65
2	Threshed grain mold rating (%)	23.04	24.00	22.15	22.61	96.00	44.71
3	Specific gravity of seed (g/ml)	0.00	0.00	3.32	3.51	89.90	6.49
4	Germination% of seed	20.85	32.98	6.07	7.63	63.20	9.94
5	Vigour index of seed	100830.40	109672.30	18.11	18.89	91.90	35.78
6	Electrical conductivity (dsm^{-1})	0.23	0.24	23.58	23.88	97.50	47.98

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