Electronic Journal of Plant Breeding, 3(2): 806-810 (June 2012)
ISSN 0975-928X

Research Note

Genetic variability and heritability studies for different quantitative traits in sweet sorghum [*Sorghum bicolor* (L.) Moench] genotypes

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(Received: 6 Jan 2012; Accepted: 27 Apr 2012)

Abstract
A field experiment was conducted during summer 2011 under irrigated situation at Department of Millets, Tamil Nadu Agricultural University to assess genetic variability and heritability of 52 sweet sorghum genotypes. The observations were recorded for 17 quantitative traits. The phenotypic co-efficient of variation (PCV) was greater than genotypic co-efficient of variation (GCV) for most of the characters studied indicating influence of the environmental effect on the characters. But the GCV was near to PCV for the characters like days to fifty per cent flowering, days to physiological maturity, plant height, juice yield and sucrose yield, indicating a highly significant effect of genotype on phenotypic expression for these traits with very little effect of environment. The genotypes under study showed high heritability for sixteen characters and moderate heritability for only one character i.e. number of leaves. High heritability combined with high genetic advance (as per cent of mean) was observed for sucrose yield, juice yield, cane yield, juice extraction per cent, sucrose per cent, juice volume, juice weight, millable cane weight, fresh cane weight, stay green trait, stem girth and plant height. High heritability estimates along with high GA indicates that variation for these characters is due to additive gene effects and consequently the scope for improving sucrose and cane yield through selection is more.

Key words
Sweet sorghum, Heritability, PCV, GCV, Genetic advance

Sorghum bicolor (L.) Moench is an important crop in the semi-arid tropics of Africa and southern Asia, and grown substantially by marginal farmers. This crop requires less water and nutrient and hence is widely cultivated in the semi-arid tropics in Sub-Saharan Africa and India (Rooney *et al*., 2000). Compared to grain sorghum, sweet sorghums feature more rapid growth, higher biomass production, wider adaptation, and have greater potential for ethanol production (Reddy *et al*., 2007). Like other sorghums, sweet sorghums are tolerant to drought, water-logging conditions and saline/alkali soils (Reddy and Reddy, 2003; Ali *et al*., 2008). Sorghum is closely related to sugarcane (Tarpley and Vietor, 2007), and the commercial value of these crops is based on exploiting their stems which contains high amount of sugars (Billa *et al*., 1997).

Many characteristics such as millable cane weight, juice extraction percentage, cane yield, juice yield, sucrose yield and grain yield have been proved as major contributors to its economic superiority (Bala *et al*., 1996; Almodares *et al*., 2006, 2008). However, inheritance of these traits are polygenic (quantitative) in nature and hence, very difficult to be manipulated directly in breeding procedure. Cultivar development is, however, firstly based on the exploitation of genetic variability of the genotypes with the traits of interest (Makanda *et al*., 2009). Quantitative traits are highly influenced by environment condition. Progress of breeding in such characters are primarily conditioned by the magnitude and nature of variation and interrelationship among them (Ghandhi *et al*., 1964). Progress in any crop improvement venture depends mainly on the magnitude of genetic variability and heritability present in the source material. The extent of variability is measured by GCV and PCV which provides information about relative amount of variation in different characters. Hence, an attempt was made to estimate genetic variability, heritability and genetic advance in the available germplasm of sweet sorghum [*Sorghum bicolor* (L.) Moench].

For this study 52 accessions of sweet sorghum (Table 1) were selected from sorghum gene bank at Department of Millets, Tamil Nadu Agricultural University, Coimbatore, India. All the genotypes were evaluated during *summer* 2011. The experiment was laid out in a randomized block design (RBD) with two replications. Each genotype was sown in single row of 4 m length with a spacing of 60 × 15 cm. The data were recorded on five random plants from each genotype in each replication for seventeen characters *viz.*, days to fifty per cent flowering, days to physiological maturity, plant height, stem girth, internode length, number of leaves, stay green trait, brix content, fresh cane weight, millable cane weight, juice weight, juice volume, sucrose percentage, juice extractability percentage, cane yield, juice yield, sucrose yield.

Phenotypic and genotypic variances were estimated according to the formula given by Lush (1940), PCV and GCV were computed based on the methods given by Burton (1952). The coefficients of variation were categorized as proposed by Sivasubramanian and Madhava Menon (1973). The heritability was computed based on the methods given by Falconer (1960). Genetic advance and genetic advance as percentage of mean were estimated according to the formula given by Johnson *et al*. (1955) and Hanson *et al.* (1956).Statistical analysis were done by using INDOSTAT software.

Analysis of variance showed significant differences among the accessions for all the characters studied. The extent of variability in respect of range, mean, phenotypic and genotypic coefficients of variation, heritability and genetic advance is given in Table 2. From our study, six genotypes (K05 27, K05 30, S03 146, K05 199, K05 SS 1143 and K05 SS 1173) were found to be earlier than general mean (65.16 days). But totally twenty three genotypes were found to be earlier for days to fifty per cent flowering than the check variety SSV 84 (69.50 days). In case of days to physiological maturity, six genotypes (K05 27, K05 30, S03 146, K05 199, K05 SS 1143 and K05 SS 11730 were found to be earlier than general mean (100.29 days). Although, nineteen genotypes were found to be earlier than the check variety SSV 84 (106.00 days). In sweet sorghum, tall and thick stems contribute more towards the millable cane yield and juice yield. From this, study genotypes K05 278, K05 192, K05 156, K05 176 and S03 281 were identified as significantly taller with thick stems. High brix is essential for maximizing the amount of sucrose and ethanol produced per unit area cultivated. K05 244, K05 240, K05 311, K04 144, K05 176, K05 181, K05 242 and K05 247 showed significantly higher brix value than the general mean (21.55 %). Fifteen genotype had higher brix value than the mean of SSV 84 (19.10 %). Genotypes K05 154, K05 156, K05 199, K05 289, K05 184, S03 238, S03 479 showed higher value for sucrose yield than the general mean (0.64 t/ha). However, none of the genotype had higher sucrose yield than the mean of SSV 84 (1.85 t/ha).

The present investigation revealed considerable amount of variation for all the characters studied. The maximum range of variation was observed for plant height, fresh cane weight, millable cane weight, juice extractability percentage, cane yield, juice yield, and sucrose yield.

The high coefficients of phenotypic (PCV) and genotypic (GCV) variances were obtained for traits like stay green, fresh cane weight, millable cane weight, juice weight, juice volume, sucrose percentage, juice extraction percentage, cane yield, juice yield, and sucrose yield, revealing that the genotypes have a broad base genetic background as well as good potential that will respond positively to selection for cane and sucrose yield. Similar results were obtained by Wu *et al*. (2010) and Kachapur *et al.* (2009). The lowest PCV and GCV were for days to first flowering, which was in conformity with the findings of Kachapur *et al.* (2009). PCV was larger as compared to GCV for most of the traits indicating the influence of environmental effect. But the GCV was near to PCV for the characters like days to fifty per cent flowering, days to physiological maturity, plant height, juice yield and sucrose yield, indicating a highly significant effect of genotype on phenotypic expression for these traits with very little effect of environment.

Heritability estimates observed for the characters ranged from 56.02 (Number of leaves) to 96.45 per cent (Sucrose per cent). The genotypes under study showed high broad sense heritability values for sixteen characters and moderate heritability for only one character (Number of leaves).High heritability estimates shows that variation for these characters is due to high additive gene effects and consequently the scope for improving yield through selection is more.

The effectiveness of selection depends upon genetic advance of the character selected along with heritability. Characters which showed high heritability with high genetic advance as percentage of mean (GAM %) were sucrose yield (93.14 percent and 126.98 percent), juice yield (91.22 per cent and 81.82 per cent), cane yield (79.22 per cent and 60.42

per cent), juice extraction per cent (83.66 per cent and 49.95 per cent), sucrose per cent (96.45 per cent and 98.18 per cent), juice volume (92.88 per cent and 81.83 per cent), juice weight (91.12 per cent and 81.82 per cent), millable cane weight (79.21 per cent and 62.49 per cent), fresh cane weight (75.55 per cent and 49.36), stay green trait (88.72 per cent and 57.66 per cent), stem girth (81.59 per cent and 32. 91 per cent) and plant height (71.52 per cent and 27.59 per cent). Kachapur *et al.* (2009) observed higher broad sense heritability value for days to fifty per cent flowering and higher heritability value coupled with high GAM % for juice yield.

High heritability with moderate genetic advance as percentage of mean were observed for days to fifty per cent flowering (86.67 per cent and 16.01 per cent), internode length (71.67 per cent and 18.12) and brix (60.97 and 16.86). Moderate heritability with moderate genetic advance was observed for number of leaves (56.02 and 11.32). High heritability along with low genetic advance attributable to non-additive gene action was noticed for days to physiological maturity (71.75 and 7.92).

High GCV along with high heritability and genetic advance provide better information than
other parameters alone. On the basis of the present study, sucrose yield, juice yield, cane yield, juice extraction per cent, sucrose per cent, juice volume, juice weight, millable cane weight, fresh cane weight, stay green trait, stem girth and plant height are the most important quantitative characters to be taken into consideration for effective selection in sweet sorghum [*Sorghum bicolor* (L.) Moench] genotypes.
Per se performance of the parents is one of the simplest selection criteria for identification of superior genotypes. The genotypes with high *per se* performance would be much useful as parent for producing better offspring in any breeding programme (Rai *et al*., 1999). Parents with significant *per se* performance are expected to yield recombinants in the segregating generations. It is worthwhile using them in hybrid breeding programmes which would result in some good hybrids. Thus, the various genotypes which recorded outstanding mean performance for different traits, may be used as potential parents and could be utilized in hybridizing programme of sweet sorghum for improving the yield and performance of trait of interest. For developing varieties and hybrids with high cane yield, juice yield, high brix , high sucrose content genotypes such as K05 154, K05 144, K05 176, K05 156, K05 242, K05 278, K05 291, S03 281 S03 479 can be used.

Acknowledgement: The authors are grateful to Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, for providing facilities to conduct the research work.

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Table 1. List of sweet sorghum accessions used in the research

S.No	Accessions No.	S.No	Accessions No.
1.	K05 22	27.	K05 235
2.	K05 27	28.	S03 238
3.	K05 29	29.	K05 244
4.	K05 30	30.	K05 240
5.	K05 51	31.	K05 242
6.	K05 53	32.	K05 247
7.	K05 56	33.	K05 264
8.	K05 60	34.	S03 263
9.	K05 69	35.	SS 265
10.	K05 144	36.	K05 267
11.	S03 146	37.	K05 273
12.	K05 154	38.	K05 278
13.	S03 155	39.	S03 281
14.	K05 156	40.	K05 289
15.	S03 173	41.	K05 291
16.	K05 176	42.	K05 296
17.	K05 181	43.	K05 302
18.	K05 183	44.	K05 303
19.	K05 184	45.	K05 311
20.	K05 190	46.	K05 312
21.	K05 192	47.	K05 365
22.	K05 199	48.	K05 SS 1143
23.	K05 200	49.	K05 SS 1173
24.	K05 201	50.	S03 479
25.	K05 224	51.	RSSV 9
26.	K05 226	52.	SSV 84

Table 2. Estimates of variability and genetic parameters for seventeen characters in sweet sorghum

Characters	Mean	Range	$\sigma^2 p$	$\sigma^2 g$	PCV (%)	GCV (%)	h^2 (%)	GAM
Days to 50% flowering	65.16	49.50 -77.00	34.17	29.61	8.97	8.35	86.67	16.01
Days to maturity	100.29	86.00 - 111.50	28.89	20.73	5.36	4.54	71.75	7.92
Plant height (cm)	259.17	118.25 - 302.27	1284.08	1244.16	13.82	13.60	96.89	27.59
Stem width (cm)	1.58	1.07 - 2.18	0.09	0.08	19.58	17.69	81.59	32.91
Internode length (cm)	17.76	13.50 - 20.87	4.75	3.41	12.28	10.39	71.67	18.12
Number of leaves	10.63	6.86 - 12.02	1.08	0.60	9.80	7.34	56.02	11.32
Stay green trait	2.43	1.10 - 4.50	0.59	0.52	31.55	29.71	88.72	57.66
Brix	18.46	11.2 - 22.90	6.15	3.75	13.43	10.48	60.97	16.86
Fresh cane weight (kg)	0.61	0.28 -1.03	0.037	0.028	31.71	27.56	75.55	49.36
Millable cane weight (kg)	0.39	0.14 - 0.81	0.02	0.02	38.30	34.09	79.21	62.49
Juice weight(kg)	0.13	0.04 - 0.28	0.003	0.003	43.59	41.61	91.12	81.82
Juice volume (Litre)	0.14	0.04 – 0.29	0.003	0.003	42.77	41.22	92.88	81.83
Sucrose %	5.81	0.95 - 11.6	8.25	7.95	49.41	48.52	96.45	98.18
Juice extractability %	32.27	12.44 - 66.74	87.52	73.21	28.98	26.51	83.66	49.95
Cane yield (t/ha)	33.26	11.16 - 67.51	161.90	128.26	38.25	34.05	79.22	60.42
Juice yield (t/ha)	10.61	3.00 - 67.51	21.39	19.49	43.59	41.61	91.12	81.82
Sucrose yield (t/ha)	0.633	0.12 – 1.63	0.17	0.16	66.18	63.87	93.14	126.98