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Studies on Genetic Variabilty in Some Sweet Sorghum (*Sorghum bicolor* L Moench) Genotypes

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Abstract

*Sorghum is of paramount importance as a cereal crop around the world as such there is a need to study the genetic variation existing among sorghum germplasms which is necessary for improving the crop. Studies were carried out to estimate the extent of genetic variability in some cultivated genotypes of sweet sorghum (Sorghum bicolor L Moench). Thirty genotypes were evaluated in 2011 rainy season cross two locations, to obtain more information on their genetic and morphological diversities. Significant mean squares were obtained for 10 traits in the individual analysis and also for the combined analyses across locations, suggesting that this sweet sorghum population was highly variable for some of the characters and as such will respond to selection. Mean performances for the combined analyses identified are: ICSV 93046, (SW DAURA 06-5-2 &ICSV700), SPV 422, ICSV700, (SW DAURA 06-5-2 & 38A x NR71182), SW DAURA 06-5-2, (SW DAURA 06-5-4 & E36-1), 38A*NR71182, and (SW KEBBI 07-5 & SPV 422) which served as the best genotypes in terms of days to 50% flowering, plant height, stem thickness, number of nodes, number of leaves, panicle weight, 1000 grain weight, grain yield and sugar content. Analysis of variance revealed significant difference existing among the genotypes in respect of all the characters studied indicating high degree of variability and diversity among the genotypes. Environmental influence was less on the expression of characters like days to 50% flowering, number of leaves, number of nodes, plant height, grain yield and sugar content was evidenced by narrow gap between genotypic and phenotypic coefficient of variation.*

Keywords: Genotypes, Sorghum, Sweet sorghum, Variance, Variability

INTRODUCTION

Sorghum grain is the fifth most important cereal in the world after wheat, rice, maize and barley (Ritter et al., 2007). In Africa it comes second after maize in terms of production (Young and Long, 2000). Over 61 million metric tons of sorghum were produced in 2013, top producers were the United States, Nigeria, Mexico, India and Sudan with majority of the sorghum produced from Africa having 41%, America followed closely with 38% and then Asia having 18% (Deb et al., 2004, Nedumaran et al., 2013). Sweet sorghum (*Sorghum bicolor* (L) Moench) belongs to the same species as grain sorghum, grass sorghum and broom sorghum (Doggett, 1970). Sweet sorghum is similar to commonly grown grain sorghum with an increased potential to accumulate sugars in the stalk but less in grain yield. The global energy demand and volatile prices of fossil fuels has forced nations to search for new alternative energy sources. Sweet sorghum, with its short growing period (four months), low water requirement, high biomass and alcohol production potential and greater income potential from cultivation, is thus a preferred raw material for generating energy. Genetic

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variation exists crop species as a gift of nature which may arise as a result of geographical separation or due to genetic barriers (Sinha and Kumaravadivel, 2016). Therefore the first step in any breeding program is the study of the genetic variability present. This cannot easily be measured as the phenotypic expression reflects non-genetic as well as genetic influences. The genetic basis must be inferred from the phenotypic observations which are the results of interactions of genotype and environment. Wide diversity is usually found within and among the sorghum cultivars at both phenotypic and genotypic level (Hart et al., 2001). Therefore in developing suitable breeding programs knowledge of genetic variability of a crop usually aids in selecting desirable parents for gene introgression from distantly related germplasm. The more diverse the genotypes/ varieties, the more they can be crossed to produce superior hybrids resistant to biotic and abiotic stresses. As such having a clear understanding of the genetic diversity in sweet sorghum will aid the genetic improvement of this crop (Jayaramachandran et al., 2011).

MATERIALS AND METHODS

Thirty genotypes of sweet sorghum genotypes/varieties were used for this study: seven of these genotypes obtained from India, eleven were locally collected across Nigeria, nine genotypes of what resulted from crosses done and three non-sweet varieties were included from the Institute for Agricultural Research (IAR), Samaru, Zaria as shown on Tables 3 and 4. All 30 genotypes/varieties s shown on the Tables 3 and 4 were planted during the 2011 rainy seasons at two locations for evaluation in replicated trials. The Research Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU) Samaru Zaria located at (11 011′N, 07 0 38′E, 686 m above sea level) in the northern Guinea Savanna ecological zone of Nigeria; and the Irrigation Research Station, Kadawa of IAR/ABU (11 0 39′, 080 027′ E and 500 m above sea level), in the Sudan Savanna ecological zone of Nigeria. At each location, the 30 genotypes/varieties were grown in a randomized complete block design with three replications. Each of the 30 plots consisted of 4 ridges each of which measured 5m long and were spaced 0.75m apart with 0.25m within row spacing. Proper local agronomic practices for sorghum were carried out. The two inner rows were used for data collections and observation for each plot.

The data collected include: Days to 50% flowering, Number of leaves, Plant height, Stem thickness, Number of nodes, Panicle length, Panicle weight, Grain yield/plot, 1000g grain weight, Percentage sugar content. The genotypes used for this study are listed in Table 3 and 4.

The data obtained were subjected to analysis of variance for each location based on plot means followed by combined analysis of data across the two locations; these were done according to methods described by (Singh and Chaudhary, 1985). Mean separation was carried out according to Duncans multiple range test (DMRT) described by (Duncan, 1955).

RESULTS

Analysis of variance

The combined analysis of variance across the two locations is presented in Table 1. The location mean square values combined across the locations showed significance for all the traits except panicle length while the genotype mean square values showed significant variation for all the traits studied. Also the genotype x location interaction effect was highly significant for all the traits studied.

Table 1: Mean squares from combined ANOVA for ten traits in 30 Sorghum genotypes across locations.

Source of variation	Df	DTF	PHT	STH	NON	NOL	HWT	PAL	TWT	GYD	PSS
Rep	2	14.27	76.42	0.07	0.01	0.04	0.0007	0.72	2.42	0	0.14
Location	1	96.8*	58056.42**	8.49**	68.45**	72.20**	113.21**	0.78	1496.75**	52.08**	68.76**
Genotype	29	319.99**	12331.95**	3.69**	17.58**	18.82**	1.54**	232.09**	40.81**	0.74**	28.39**
Location X Genotype	29	95.25**	884.0**	0.49**	1.54**	1.41**	0.63**	2.58**	21.44**	0.34**	1.38**
Pooled Error	116	8.27	131.48	0.13	0.07	0.07	0.01	0.92	2.55	0.005	0.05

Df=degree of freedom, DTF= Days to 50% flowering, PHT=plant height, STH=stem thickness, NON=no of nodes, NOL=no of leaves, HWT=head weight, PAL=panicle length, TWT=1000 grain weight, GYD=grain yield, PSS=% stem sugar, ** significant at 1%, * significant at 5 %

MEAN PERFORMANCE

The mean performance of the genotypes across locations showed a clear indication of superiority of some of the cultivars over others for SW bungudu 07-6, SW bungudu 07-1, SPV 422 and E 36-1 as shown on Table 4.6 SW bodinga 07-3 (60days) and 64 DTN (62 days) were the earliest to flower while, SW daura 06-5-2 (82 days) and ICSV 93046 (91 days) were the last to flower among the local and exotic varieties respectively. SW daura 06-5-2 (304.81cm) among the local collections and ICSV 700 (303.67cm) among the exotic varieties were the tallest while the shortest was SW daura 06-5-1 (158.78cm). SPV 422 (7.58cm) had the thickest girth while SW daura 06-5-1 (4.78cm) was the thinnest. ICSV 700 (13) and SW bodinga 07-3 (11) had the highest number of nodes while SW daura 06-2 (5) had the lowest number of nodes. SW bodinga 07-3 (13) and ICSV 700 (15) had the highest number of leaves. SW daura 06-5-2 (7.35g) had the heaviest head while ICSV 700 had lightest weight. For panicle length, SW daura 06-5-2 (32.23cm) had the longest panicle while SW makarfi 06-3 (10.8cm) had the shortest panicle length. SW daura 06-5-4 (29.81g) and E 36-1 (29.24g) had the highest grain weight while the lowest grain weight was shown in the hybrid ICSA 344 x ICSV 111 (20.9g). Among the exotic varieties, SPV 422 had the highest (7.49%) sugar content while SW daura 06-5-4 (7.53) showed the highest sugar content among the local varieties.

Table 2: Mean performance of the 30 sorghum genotypes taken across locations

GENOTYPES	DTF	PHT	STH	NON	NOL	HWT	PAL	TGW	GYD	PSS
Local varieties										
SW bungudu 07-1	69^{jk}	200.24^{de}	5.52^{j}	7^{i}	9^{i}	4.33^{a-d}	17.46^{jk}	23.27^{h-j}	0.94^{kl}	7.14^{a-d}
SW daura 06-5 2	82^{bc}	304.81^{a}	6.42^{d-f}	10^{c}	12^{c}	7.35^{a}	32.23^{a}	24.86^{e-h}	0.90^{l}	6.90^{a-d}
SW samaru 06-4	80^{cd}	187.4^{ef}	6.32^{e-g}	9^{d}	11^{d}	5.35^{a-d}	18.63^{i-k}	21.59^{jk}	1.54^{bc}	7.33^{a-c}
SW daura 06-5-1	69^{n}	158.78^{hi}	4.78^{k}	5^{l}	6^{m}	4.96^{a-d}	19.51^{h-j}	26.01^{e-h}	1.00^{jk}	5.76^{k}
SW daura 06-2	67^{kl}	161.42^{hi}	5.00^{k}	7^{i}	9^{i}	6.03^{a-d}	24.74^{b-g}	24.99^{e-h}	1.05^{j}	6.68^{h-j}
SW kebbi 07-5	65^{lm}	209.25^{d}	4.83^{k}	6^{k}	8^{k}	4.22^{a-d}	17.14^{jk}	22.05^{i-k}	0.94^{kl}	7.52^{a}
SW daura 06-5-4	67^{kl}	210.25^{d}	4.83^{k}	5^{l}	9^{i}	6.15^{b-d}	25.04^{b-g}	29.81^{a}	0.62^{o}	7.53^{a}
SW dansadau 07-2	79^{c-f}	182.81^{fg}	5.58^{ij}	8^{f}	9^{i}	3.79^{b-d}	11.37^{l}	26.01^{d-g}	1.00^{jk}	7.14^{b-e}
SW bodinga 07-3	60^{n}	255.08^{b}	6.27^{e-g}	11^{b}	13^{b}	6.13^{a-d}	26.64^{b-f}	26.01^{d-g}	0.95^{kl}	6.84^{f-i}
SW makarfi 06-3	73^{h-j}	161.95^{hi}	5.73^{h-j}	7^{i}	10^{f}	3.63^{cd}	10.80^{l}	28.02^{a-c}	1.26^{gh}	7.37^{ab}
SW bungudu 07-6	81^{bc}	237.72^{c}	5.50^{j}	9^{d}	11^{d}	5.49^{a-d}	24.92^{b-g}	26.01^{c-f}	0.51^{p}	7.37^{ab}
Exotic varieties										
SPV 422	73^{hi}	236.00^{c}	7.58^{a}	11^{b}	13^{b}	6.46^{a-d}	26.04^{b-f}	28.23^{ab}	1.04^{j}	7.49^{a}
NTJ 2	67^{kl}	158.78^{hi}	6.67^{c-e}	9^{d}	11^{d}	5.50^{a-d}	19.95^{h-j}	26.33^{b-e}	1.20^{hi}	7.36^{ab}
E 36-1	79^{c-f}	161.53^{hi}	6.25^{e-g}	8^{f}	10^{f}	5.94^{a-d}	23.55^{e-h}	29.24^{a}	1.58^{bc}	7.26^{a-d}
ICSR 93034	69^{jk}	206.42^{d}	6.63^{c-e}	9^{d}	11^{d}	6.19^{a-d}	23.00^{e-h}	28.09^{a-c}	1.6^{b}	6.5^{j}
64 DTN	62^{mn}	169.03^{gh}	6.92^{c}	9^{d}	11^{d}	5.18^{a-d}	19.52^{h-j}	28.28^{ab}	1.17^{i}	5.96^{k}
ICSV 93046	91^{a}	265.4^{b}	6.92^{c}	11^{b}	13^{b}	3.72^{cd}	15.65^{k}	28.04^{a-c}	0.71^{n}	7.26^{a-d}
ICSV 700	84^{b}	303.67^{a}	6.4^{d-f}	13^{a}	15^{a}	3.13^{d}	10.86^{l}	21.97^{i-k}	0.6^{o}	6.92^{e-h}
Hybrids										
1CSA 24001 X Samsorg 38	73^{h-j}	172.47^{gh}	7.07^{bc}	9^{d}	11^{d}	6.76^{a-c}	27.42^{bc}	24.61^{e-h}	0.79^{m}	7.26^{a-d}
ICSA 344 X Samsorg 38	75^{f-h}	206.36^{d}	5.92^{g-j}	8^{f}	10^{f}	6.98^{a-c}	26.21^{b-e}	24.14^{e-h}	1.31^{fg}	7.02^{d-g}
ICSA 24001 X Samsorg 41	80^{c-e}	163.72^{hi}	7.4^{ab}	9^{d}	11^{d}	6.67^{a-c}	24.06^{c-g}	23.82^{f-i}	1.5^{cd}	6.69^{h-j}
ICSA 344 X Samsorg 41	77^{d-g}	137.2^{k}	6^{f-i}	8^{f}	10^{f}	5.39^{a-d}	22.47^{f-h}	20.94^{k}	0.95^{kl}	7.28^{a-d}
ICSA344 X Samsorg 39	71^{ij}	131.53^{k}	6.08^{f-h}	7^{ij}	9^{i}	6.06^{a-d}	21.68^{g-i}	21.32^{jk}	1.43^{de}	7.03^{c-g}
ICSA24001 X E36-1	81^{bc}	204.78^{d}	6.82^{cd}	9^{d}	10.5^{e}	5.82^{a-d}	23.57^{d-g}	21.37^{jk}	1.25^{gh}	6.62^{ij}
ICSA24001 X NTJ-2	76^{e-h}	195.67^{d-f}	7^{bc}	8^{f}	10^{f}	5.88^{a-d}	26.96^{b-d}	26.02^{d-g}	0.89^{l}	6.94^{e-h}
38A X Samsorg 38	74^{g-i}	228.89^{c}	6.27^{e-g}	8^{f}	10^{f}	7.3^{ab}	26.06^{b-d}	26.15^{b-e}	1.91^{a}	7.07^{b-f}
38A X Samsorg 39	75^{f-h}	151.97^{ij}	7^{bc}	8^{f}	10^{f}	7.51^{a}	28.33^{b}	21.23^{jk}	1.85^{a}	6.75^{g-j}
Samsorg 41 (ICSV111)	77^{d-h}	162.36^{hi}	5.58^{ij}	7^{ij}	9^{i}	6.35^{a-d}	23.81^{c-g}	26.02^{c-e}	1.44^{de}	0.02^{l}
Samsorg 39 (NR71182)	76^{e-h}	139.39^{jk}	6.95^{bc}	9^{d}	11^{d}	5.9^{a-d}	23.93^{c-g}	23.77^{g-i}	1.008^{jk}	0.04^{l}
Samsorg 38 (NR71176)	72^{ij}	197.3^{de}	7.08^{bc}	7^{ij}	10^{f}	6.2^{a-d}	24.45^{c-g}	27.72^{a-d}	1.38^{ef}	0.06^{l}
SE	2.76	43.83	0.04	0.03	0.03	1.54	2.54	0.86	0.001	0.02

Key: DTF= Days to 50% flowering, PHT=plant height, STH=stem thickness, NON=no of nodes, NOL=no of leaves, HWT=head weight, PAL=panicle length, TGW=1000 grain weight, GYD=grain yield, PSS=% stem sugar, ** significant at 1%, * significant at 5 % Means with the same letter are not significantly different

DISCUSSIONS

Analysis of Variance

The wide range of variation observed for the ten traits evaluated may be attributed to the diverse genetic background of the genotypes studied. The significant mean square values obtained for location in respect of some of the characters indicated that the conditions in the two locations were not similar like the variation observed from location to location and also the differences in grain yield. The significant effects of genotype x location means squares observed for most traits suggests that the genotypes behaved differently in each location, thus suggesting the need to test genotypes over different environments across years to ascertain their stability for use as reliable genetic materials for crop improvement. Similar results were reported by (Bello et al., 2007) in their studies on genetic variability in cultivated sorghum in Adamawa state and also by (Zaveri et al., 1989) in their studies on pearl millet. Thus, indicating that the genotypes under study were genetically diverse.

Mean Performance

Performances of the 30 genotypes across locations for the ten traits studied provide a clear indication of the superiority of some of the some genotypes over others. Good breeding potential therefore exists in SW daura 06-5-2, SW bodinga 07-3, SPV 422, E 36-1, ICSR 93034, ICSV 700 and ICSV 93046, which performed very well in some yield and yield components at both locations. Consequently, there is a range of genotypes from which to choose from depending on the breeding objectives.

Table 3: Description of the Sweet sorghum varieties and the hybrids

Genotypes/ varieties	Source	Description
SPV 422	ICRISAT	High stalk yield, high grain yield and high sugar content.
ICSV 700	ICRISAT	Low stalk production
NTJ-2	ICRISAT	Lowest stalk yield, high yielding in post rainy season. Resistant to leaf diseases.
E 36-1	ICRISAT	High stalk sugar
ICSR 903034	ICRISAT	High yielding post rainy season, high sugar content and late maturing.
64 DTN	ICRISAT	High stalk sugar
ICSV 93046	ICRISAT	Moderate sugar content, tolerant to shoot fly, stem borer and leaf diseases.
ICSV 24001 X Samsorg 38	Hybrid	
ICSA 344 X Samsorg 38	Hybrid	
ICSA 24001 X Samsorg 41	Hybrid	
ICSA 344 X Samsorg 41	Hybrid	
ICSA 344 X Samsorg 39	Hybrid	
ICSA 24001 X E 36-1	Hybrid	
ICSA 24001 X NTJ-2	Hybrid	
38A X Samsorg 39	Hybrid	
38A X Samsorg 38	Hybrid	
Non sweet sorghum varieties.		
Samsorg 41 (ICSV111)		
Samsorg 39 (NR71182)		
Samsorg 38 (NR71172)		

Table 4: Sweet sorghum germplasm collected from five northern states of Nigeria.

s/n	Institute assigned name	Place of collection	State
1	SW daura 06-2	Daura	Katsina
2	SW daura 06-5-1	Daura	Katsina
3	SW daura 06-5-2	Daura	Katsina
4	SW daura 06-5-4	Daura	Katsina
5	SW samaru 06-4	Samaru	Kaduna
6	SW makarfi 06-3	Makarfi	Kaduna
7	SW kebbi 07-1	unguwar lawal	Kebbi
8	SW dansadau 07-2	Dansadau	Kebbi
9	SW bodinga 07-3	Bodinga	Sokoto
10	SW bungudu 07-1	Bungudu	Zamfara
11	SW bungudu 07-6	Bungudu	zamfara

CONCLUSION

Analysis of variance revealed significant difference among the genotypes at both locations in respect of all the characters studied thus indicating a high degree of variability and diversity among the genotypes. Therefore, for the success of any breeding program to be achieved, it will be dependent upon the genetic variation in the materials at hand. The greater the genetic variability, the higher would be the heritability for a particular trait of interest. Hence the better the chances of success to be achieved through selection. There was considerable variability present in the sorghum materials used. As such these results will be useful as a guide for choosing populations when developing new breeding strategies to improve sweet sorghum production. The variations could be effectively utilized with appropriate breeding methods to develop improved varieties, synthetics and hybrids for use by both farmers and industries.

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