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Estimation of Genetic Variability for Yield and Its Component Traits among Some Selected Sorghum (*Sorghum bicolor* L. Moench) Accessions

[1]Akinyele, M. O., * [2]Oyewale, R. O., [3] Idowu, G. A., [2]Bolajoko, M. H and [2]Ishaya, E.B.

[1]National Biotechnology Development Agency, Abuja, Nigeria

[2]Department of Crop Production, Federal University of Technology, Minna, Niger state, Nigeria

[3]National Agricultural Seed Council, Abuja, Nigeria

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Abstract: A field experiment was conducted to evaluate nineteen accessions of sorghum grown for two cropping seasons of 2015 and 2016 at the Teaching and Research Farm of Department of Crop Production, Federal University of Technology, Minna, Niger state to characterize 19 sorghum accessions base on their morph-agronomic traits and determine yield with its component traits. A randomized complete block design with three replications was used for the experiment. Data were collected on plant height, number of leaves/plant, leaf length, leaf width, number of nodes, days to 50 % flowering, days to 95 % maturity, panicle length, panicle width, grain weight and 1000 seed weight and were subjected to individual and combined analysis of variance (ANOVA). Based on the finding of this study, highly significant differences among accessions were found except for leaf width and number of nodes for all characters. Phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) and high phenotypic and genotypic variability were observed between the nineteen sorghum accessions. The highest value of heritability was observed in grain weight (99 %), and the most high yielding accession was AKV11 (Kaura) with grain weight of 614g in 2015 and 514.33g in 2016. High genetic advance was recorded in grain yield and panicle length. Combined correlation coefficient for the two cropping seasons revealed that the yield components exhibited varying trends of correlation relationship between themselves, The most outstanding performance accessions for grain weight are: AKV11 (Kaura), AKV9

(Shawimpe) and AKV14 (Farafara), which could be used for Sorghum improvement programmed and recommend for farmers in the Southern Guinea Zones of Nigeria.

Keywords: Sorghum, Accessions, Variability, Genotypic, Phenotypic, Correlation

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is an important staple food crops and provide bulk of raw materials for the livestock and many agro-allied industries in the world[1]. It had been reported that, area under sorghum cultivation in Sub- Sahara Africa has steadily increased over the years but the average yield trends are downwards[2] .There are collections of sorghum genotypes in some research institutes and most of these collections lack information on its morphology- agronomic traits that could be used by researchers to improve sorghum production in Nigeria. However, breeding for high yield crops require information on the nature and magnitude of variation in the available materials and the relationship of yield with other agronomic characters[1] grain yield in sorghum is quantitative in nature and polygenically controlled, effective yield improvement and simultaneous improvement in yield components are imperative [1]. Selection on the basis of grain yield character alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and dependable[3] Around the world, Sorghum is grown for the production of dense grain panicles; for food, and energy[4] .Sorghum in Africa is processed into a wide variety of attractive and nutritious traditional foods, such as semi-leavened bread, couscous, dumplings and fermented and non-fermented porridges. It is the grain of choice for brewing traditional African beers[5].

Genetic variability studies provide the basic information regarding the genetic properties of the population based on which the breeding methods are formulated for further crop improvement. For any progress in plant breeding, there is the need to study the genetic variability which cannot be easily quantified. Genetic improvement for quantitative traits depends on the nature and amount of variability present in any genetic stock and the extent to which the desirable traits are heritable[6] .Knowledge of association between yield and its component traits and among the component parameters themselves can improve the efficiency of selection in plant breeding. Therefore, there is the need to characterize as much as possible sorghum genotypes available in Nigeria to identify traits for yield against future sorghum improvements for better food production and security. Therefore the aim of this present study is to characterise sorghum accessions base on their morph-agronomic traits and determine yield with its component traits in different sorghum accessions.

MATERIALS AND METHODS

Study Area: The trial was conducted in 2015 and 2016 cropping seasons at the Teaching and Research Farm of Department of Crop Production, Federal University of Technology, Gidan kwano campus Minna, Niger state. The site is located in the Southern Guinea Savanna of Nigeria, with Global Positioning System (GPS) co-ordinates of (Latitude 9.52335N, and Longitude 6.44791E).Minna is located in the Southern Guinea Savanna agro-ecological zone of Nigeria with a mean annual rainfall of 1200mm[7]. The rainfall which has its peaks in September and it usually begins in April and ends in the first week of October. The temperature ranges between 35 and 37.5^{o}C, with relative humidity between 60 and 80 % in the month of July and 40 and 60 % in January. The agro- metrological data during the years of experimentation is shown in appendix 3.

Planting Materials: The Sorghum germplasm used in this study comprised nineteen sorghum accessions **(Table 1**) collected from Institute for Agricultural Research (IAR) Ahmadu Bello University Zaria.

Table 1: Nineteen Sorghum Accessions used in the study

S/NO	Identity	Local name	Status
1	AKV12	ADAMU MAKIWA	LANDRACE
2	AKV8	BOG FARWA	LANDRACE
3	AKV13	BUKWAKANA	LANDRACE
4	AKV4	CHAKE ILARE	LANDRACE
5	AKV17	CHAM	LANDRACE
6	AKV15	CSRO2	IMPROVED
7	AKV5	DANYANA	LANDRACE
8	AKV1	FALA FATE	LANDRACE
9	AKV14	FARA FARA	LANDRACE
10	AKV3	HARJU	LANDRACE
11	AKV11	KAURA	LANDRACE
12	AKV18	MORI	LANDRACE
13	AKV6	NDUVORI	LANDRACE
14	AKV7	PANPARA	LANDRACE
15	AKV19	PAUL NOEL	LANDRACE
16	AKV2	SAMSORG 40	IMPROVED
17	AKV9	SHAWIMPE	LANDRACE
18	AKV10	WAGO FARI	LANDRACE
19	AKV16	YIMSHI	LANDRACE

Source: Institute for Agricultural Research (IAR). Ahmadu Bello University Zaria.

Soil Sampling and Analysis: Surface soil (0-15 cm) samples were collected from the Teaching and Research Farm of Federal University of Technology, Minna using an auger. The sample was air dried, gently crushed, passed through a 2 mm sieve and thoroughly mixed together to determine the physical and chemical analysis. Some were further passed through 0.5 mm sieve to determine the total nitrogen. The soil samples were analysed using standard methods as described by Agbenin[8]. Particle size distribution was determined by Bouyocous hydrometer method. Soil pH was determined in a 1: 2.5 soil to water using a glass electrode pH meter. Total Nitrogen was determined by micro Kjeldahl method. Available phosphorus (P) was extracted by Bray P1 method. Colour was developed in soil extract using ascorbic acid blue method. Exchangeable K^+ was extracted with 1N neutral ammonium acetate (NH_4OAc) solution and amounts of K^+in solution were determined using a flame photometer. Results of the analysis are shown in Appendix 1.

Experimental Design and Field Layout: The experiment was laid out in a Randomized Complete Block Design (RCBD) with three (3) replications. The gross plot size was 4m by 2m ($8m^2$); 5 ridges of 2m long each. The net plot size was 2.4m by 2m ($4.8m^2$); 3 ridges of 2m long each. Gross plots were separated by a distance of 0.5m each while a distance of 1m separated one replication from the other.

Cultural Practices

Land Preparation: The total land area of $658m^2$ was measured, ploughed, harrowed mechanically and was ridged manually.

Sowing: Three to four seeds were sown per hill and each stand was later thinned to one plant per stand.

Fertilizer Application: NPK fertilizer was applied at the rate of 60 kg N ha^{-1}, 30 kg ha^{-1} of phosphorus (P_2O_5) and10kgha^{-1} Potassium (K_2O) at 3 weeks and Nitrogen was split at 6 weeks after sowing (WAS).

Weeding: In each year, 1.5L/ha of Atrazine was applied as pre emergence, followed by supplementary hoe weeding at 6 WAS and ridge remolding at 9 WAS.

Harvesting: Harvesting was done manually.

Data Collection: In each net plot, five plants were tagged and used to obtain the following parameters:

Plant height: Plant height was measured with a meter rule from the base of the plant to the tip at 4, 6, 8, 10 and 12 weeks (WAS) the mean was obtained, recorded and expressed in centimeters (cm)

Number of leaves: Number of leaves were counted at 4, 6,8,10 and 12 WAS and the mean recorded.

Leaf length: This was measured with metre rule from leaf base to the tip of leaf plants at 4, 8, 10 and 12 WAS and expressed in cm.

Leaf width: It was measured with metre rule from the middle region of the leaf at 4, 8, 10 and 12 WAS and expressed in cm.

Number of nodes: Numbers of nodes were counted at 4, 6, 8, 10 and 12 WAS and the mean recorded.

Days to 50 % flowering: The date when 50 percent of the plants produced flowers was recorded and converted in number of days from date of planting up to date of heading

Days to 95 % maturity: The date when 95 percent of the plants are physically matured counting in days taken from sowing up to physiological maturity.

Panicle length: This was measured with meter rule from the base of the panicle to the tip at maturity and expressed in cm.

Panicle width: It was measured in the widest diameter at maturity and expressed in cm.

Grain yield: After harvest, was dried threshed then weighed in gram to determine grain yield and the mean recorded.

1000 Seed weight: 1000 grains were counted from each net plot, weighed and the mean recorded in gram.

Statistical Analysis: Data collected were subjected to analysis of variance (ANOVA) using SAS 9.1.3 software statistical package. The means were separated by Student- Newman-Keuls (SNK) test at 5 % level of significant. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), genotypic and phenotypic variances, heritability and genetic advance were estimated. Pearson Correlation coefficient was estimated for every pair of trait using the PROC CORR procedure.

Genotypic and Phenotypic Coefficients of Variation: The genotypic and phenotypic coefficients of variation were calculated according to Burton and Devane[9] (1953).

Genotypic Coefficient of Variation (GCV) = $\frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$

Phenotypic Coefficient of Variation (PCV) =$\frac{\sqrt{\sigma^2 ph}}{\bar{X}} \times 100$

Where:

σ^2g = genotypic variance

σ^2ph = phenotypic variance

$\bar{X}$= general mean of trait

The PCV and GCV values were ranked as low, moderate and high Siva Subramanian and Monon[10], as stated below:

0-10 % Low

10-20 % Moderate

Greater than 20 % High

Heritability (h^2B): The heritability (broad sense) values were estimated according to the suggestion made by Johnson *et al*., [11]

$h^2B = \frac{\sigma^2 g}{\sigma^2 ph} \times 100$

Where:

σ^2g = genotypic variance

σ^2ph = phenotypic variance

The heritability percentage was categorized as low, moderate and high according to Robinson *et al*.[12], as follows:

0-30 % Low

31- 60 % Moderate

60 % and above High

Genetic Advance (GA): Genetic advance was estimated with the method suggested by Allard[13]; Singh and Chaudhury[14].

GA = K. σph.h^2B

K: Constant = 2.06 at 5 % selection intensity

σph = Square root of phenotypic variance

h^2B = Heritability

GAM = GA as % of mean

GAM = (GA/mean value) * 100

RESULTS

Growth Phonology and Yield Components for 2015: Result in **Table 1** showed there were significant differences in plant height among the Sorghum accessions. AKV19 gave the tallest height (247cm) and was significantly different from all others. The number of leaves/plant revealed significant differences among the accessions. AKV19 had the highest number of leaves (19) but not significantly different from 12 others. Also leaf length showed significant differences among the accessions. AKV8 had the longest leaf length (141.3cm) and was not significantly different from eleven others. Five others (AKV12, AKV5, AKV3, AKV4 and AKV6) had the same ranking and therefore, not significantly different. Leaf width indicated that there were no significant differences among the accessions.

Result of numbers of nodes showed that AKV19 and AKV4 having the same number (9) were significantly different from other accessions. Days to 50 % flowering showed there were significant differences among the accessions. AKV19 had the longest days to 50 % flowering (119days) and was significantly different from others. Also days to 95 % maturity showed significance differences among accessions. AKV5 had the longest days to maturity (155days) and was significantly different from 18 others. There were significant differences among accessions for panicle length.

AKV18 had the longest length (47.07cm) but not significantly different from AKV5. Result revealed significant differences among accessions for panicle width. AKV11 had the highest diameter for panicle width (3.4cm) but not significant difference from AKV15 and AKV3. The result of grain yield showed significant differences among accessions. AKV11 had the highest grain yield (614g) and was significantly different from 18 others. There were significant differences among accessions for 1000 seed weight. AKV11, AKV17 and AKV11 had the highest weights (35g) and were significantly different from other accessions.

Growth Phonology and Yield Components for 2016: Result in **Table2** showed significant differences in plant height among the Sorghum accessions. AKV12 gave the tallest height (165cm) and was significantly different from all others. There was no significant difference among the other eighteen accessions. The numbers of leaves were also significantly different among the accessions. AKV19 had the highest number of leaves (18) but not significantly different from AKV18, AKV6, AKV11, AKV14 and AKV5. There were no significant differences among the thirteen others accessions. Leaf length also showed significant differences among the accessions.

AKV8 had the longest leaf length (135.67cm) and was not significantly different from eleven others. Result of Leaf width showed no significant differences among the accessions. For the number of nodes, AKV19 and AKV4 (8) were significantly similar and different from others. Days to 50 % flowering showed significant differences among the accessions. AKV19 had the longest days to 50 % flowering (128days) and was significantly different from all others. The result on days to 95 % maturity revealed significance differences among the accessions. AKV5 had the longest days to 95 % maturity (160days) and was significantly different from all others.

There were significant differences among accessions for panicle length. AKV18 had the longest length (45.4cm) and was significantly different from others. Also panicle width showed significant differences among the accessions. AKV11 had the highest diameter for panicle width (3.2cm) but not significantly different from AKV15 and AKV3. Grain yield also revealed significant differences among accessions. AKV11 had the highest grain yield (514.33g) and was significantly different from all others. There were significant differences among accessions for 1000 seed weight.AKV11, AKV17 and AKV11 had the highest weights (35g) and were significantly different from other accessions.

Correlation Coefficients for quantitative traits of sorghum evaluated during the 2015 cropping season in Minna Southern Guinea Savanna of Nigeria: Correlation coefficient for the quantitative traits of sorghum for 2015 cropping season presented in Table 3. The result revealed that plant height was positive (r = 0.46388) and exhibited significant relationship with number of leaves/plant, positive but not significant with other variables. Number of leaves/plant was positive (r = 0.70485) and highly significant with days to 50 % flowering, positive and significant with leaf length (r = 0.55432), days to 95 % maturity (r = 0.46164), panicle length (r = 0.48108) and panicle width (r = 0.502938).Leaf length showed positive and significant relationship with days to 50 % flowering (r = 0.54094), panicle width (r = 0.52167), grain yield (r = 0.51551) and 1000 seed weight (r = 0.4519). Leaf width showed positive but non-significant relationship with days to 50 % flowering, days to 95 % maturity, panicle length, panicle width and grain yield.

Number of nodes exhibited positive but non- significant relationship with days to 50 % flowering, days to 95 % maturity, panicle length, and panicle width but showed negative (r = -0.0827) and non-significant relationship with grain yield. Days to 50 % flowering showed high and positive significant relationship with days to 95 % maturity (r = 0.90054), panicle length (r = 0.81241) and panicle width (r = 0.64095), but showed positive and non-significant relationship with grain yield. Days to 95 % maturity showed highly significant and positive relationship with panicle length (r = 0.84865), positive and significant with panicle width (r = 0.50106) but positive and non- significant with grain yield (r = 0.01268). Panicle length showed positive but non- significant relationship with panicle width and grain yield. Panicle width showed positive and significant relationship with grain yield (r = 0.53526). Grain yield showed positive and significant relationship with 1000 seed weight (r = 0.49443).

Correlation Coefficients of quantitative traits of sorghum evaluated during the 2016 cropping season in Minna, Southern Guinea Savanna of Nigeria : Correlation coefficients for the quantitative traits of sorghum for 2016 cropping season was presented in Table 4 The result revealed that plant height showed positive but non-significant relationship with 7 variables and negative relationship with others. Number of leaves/plant was positive (r = 0.60165) and highly significant with days to 50 % flowering, positive and significant(r = 0.52435) with leaf length and panicle width (r = 0.44831) but positive and non-significant with other characters. Leaf length was positive (r = 0.57323) and significant with days to 50 % flowering, panicle width (r = 0.46932), grain yield (r = 0.49873) and seed weight (r = 0.4685). Leaf width showed positive but non-significant relationship with most variables and negatively with two.

Number of nodes showed positive but non-significant relationship with most variables and negative with grain yield. Days to 50 % flowering showed high and positive (r = 0.92836) relationship with days to 95 % flowering, panicle length (r = 0.80076) and panicle width (r = 0.62061), but showed positive and non-significant relationship with grain yield. Days to 95 % maturity showed positive (r = 0.82839) and high significant relationship with panicle length, positive (r = 0.51093) and significant with panicle width, positive but non-significant with grain yield. Panicle width showed positive (r = 0.4704) and significant with grain yield. Grain yield showed positive (r = 0.5112) relationship with 1000 seed weigh.

Table 1: Mean Values for agronomic traits (quantitative) of nineteen sorghum accessions evaluated in Minna southern guinea of Nigeria for 2015

ACCESSIONS	PLHT (cm)	NOF	LVT (cm)	LVW (cm)	ND	DFL	DM	PL (cm)	PW (cm)	GY (g)	SW (g)
AKV12	195.66^{b}	15^{abc}	121.47^{bc}	8.07^{a}	7^{b}	105^{cd}	140^{c}	43.33^{bc}	2.60^{cdefg}	363.67^{c}	30.00^{d}
AKV8	183.33^{bc}	15^{abc}	141.3^{a}	8.53^{a}	7^{b}	95^{efgh}	125^{d}	31.33^{i}	2.80^{bcd}	294.67^{ef}	32.00^{c}
AKV13	132^{cd}	15^{bc}	130.27^{ab}	7.57^{a}	7^{b}	102^{de}	140^{c}	38.33^{def}	2.73^{bcd}	264.33^{gh}	27.00^{f}
AKV4	166.23^{bcd}	14^{bc}	118.33^{bc}	7.40^{a}	9^{a}	101^{def}	140^{c}	43.07^{bc}	2.83^{bc}	186.00^{j}	25.00^{g}
AKV17	179.80^{bc}	16^{abc}	126.27^{abc}	7.20^{a}	7^{b}	92^{gh}	125^{d}	19.50^{k}	2.67^{bcde}	325.00^{d}	35.00^{a}
AKV15	194.67^{b}	16^{abc}	132.33^{ab}	9.37^{a}	7^{b}	113^{b}	145^{b}	35.27^{fgh}	3.37^{a}	355.00^{c}	23.00^{i}
AKV5	141.33^{bcd}	16^{abc}	119.2^{bc}	7.80^{a}	7^{b}	110^{bc}	155^{a}	44.67^{ab}	2.63^{bcdef}	257.00^{h}	32.00^{c}
AKV1	116.33^{d}	14^{bc}	112.33^{c}	7.63^{a}	8^{b}	101^{def}	140^{c}	38.53^{def}	2.33^{g}	244.67^{h}	24.00^{h}
AKV14	178.00^{bc}	16^{abc}	134.37^{ab}	8.73^{a}	7^{b}	101^{def}	140^{c}	36.33^{efg}	2.50^{defg}	388.00^{b}	30.00^{d}
AKV3	160.33^{bcd}	15^{abc}	118.67^{bc}	8.97^{a}	7^{b}	104^{cd}	140^{c}	40.07^{cde}	3.20^{a}	254.67^{h}	24.00^{h}
AKV11	112.33^{d}	16^{abc}	134.8^{ab}	8.37^{a}	7^{b}	93^{gh}	125^{d}	35.33^{fgh}	3.40^{a}	614.00^{a}	35.00^{a}
AKV18	129.00^{cd}	17^{ab}	131.8^{ab}	8.20^{a}	7^{b}	112^{b}	140^{c}	47.07^{a}	2.80^{bcd}	266.00^{gh}	23.00^{i}
AKV6	141.33^{bcd}	16^{abc}	117.27^{bc}	7.77^{a}	7^{b}	103^{d}	140^{c}	36.47^{efg}	2.90^{bc}	188.00^{j}	25.00^{g}
AKV7	112.00^{d}	15abc	132.37ab	9.03^{a}	7^{b}	102^{def}	140^{c}	38.13^{def}	2.43^{efg}	285.00^{fg}	28.00^{e}
AKV19	247.00^{a}	19^{a}	132.93^{ab}	8.267^{a}	9^{a}	119^{a}	140^{c}	40.67^{cd}	2.93^{b}	305.67^{e}	35.00^{a}
AKV2	131.67^{cd}	13^{c}	88.00^{d}	8.67^{a}	7^{b}	63^{i}	95^{e}	12.30^{l}	1.50^{i}	165.33^{k}	24.00^{h}
AKV9	138.00^{cd}	15^{bc}	126.97^{abc}	7.67^{a}	7^{b}	94^{fgh}	125^{d}	24.00^{j}	2.80^{bcd}	389.67^{b}	32.00^{c}
AKV10	150.67^{bcd}	14^{bc}	128.23^{ab}	9.03^{a}	7^{b}	98^{defg}	140^{c}	33.60^{ghi}	2.37^{fg}	267.00^{gh}	28.00^{e}
AKV16	132.67^{cd}	15^{abc}	130.43^{ab}	7.37^{a}	7^{b}	89^{h}	125^{d}	32.60^{hi}	1.83^{h}	210.00^{i}	34.00^{b}
±SE	11.80	0.69	3.41	0.45	0.25	1.68	0	0.88	0.07	5.96	0
CV%	13.2	7.7	4.7	9.5	5.9	2.9	0.0	4.3	4.5	3.5	0.0

Means with the same letter(s) are not significantly different at ($p<0.05$) by Student-Newman-Keuls Test (SNK). PLHT=Plant Height, NOF=Number of Leaves/Plant, LVT=Leaf Length, LVW=Leaf Width, ND=Number of Nodes, DFL= Days to 50 % Flowering, DM=Days to 95 % Maturing, PL=Panicle Length, PW= Panicle Width, GY=Grain Yield, SW=1000 Seed Weight

Table 2: Mean values of agronomic traits (quantitative) of nineteen Sorghum accessions evaluated in Minna southern guinea zone of Nigeria for 2016

ACCESSIONS	PLHT (cm)	NOF	LVT (cm)	LVW (cm)	ND	DFL	DM	PL (cm)	PW (cm)	GY (g)	SW (g)
AKV12	165.00^{a}	14^{b}	116.17^{bcdef}	7.93^{a}	6^{b}	115^{c}	145^{d}	41.33^{bc}	2.53^{bcde}	298.00^{c}	30.00^{d}
AKV8	127.33^{b}	14^{b}	135.67^{a}	8.37^{a}	6^{b}	100^{e}	130^{g}	29.67^{j}	2.63^{bc}	246.00^{d}	32.00^{c}
AKV13	103.97^{b}	14^{b}	125.27^{abcde}	7.50^{a}	6^{b}	112^{c}	145^{d}	36.33^{efg}	2.63^{bc}	213.00^{e}	27.00^{f}
AKV4	115.00^{b}	13^{b}	113.00^{cdef}	7.43^{a}	8^{a}	111^{cd}	142^{e}	40.97^{bcd}	2.73^{b}	125.00^{f}	25.00^{g}
AKV17	134.00^{b}	15^{b}	122.47^{abcde}	7.40^{a}	6^{b}	102^{e}	130^{g}	17.93^{l}	2.57^{bcde}	278.33^{cd}	35.00^{a}
AKV15	133.00^{b}	15^{b}	128.83^{abc}	9.47^{a}	6^{b}	123^{b}	150^{b}	33.33gh^{i}	3.17^{a}	279.67^{cd}	23.00^{i}
AKV5	105.67^{b}	15^{ab}	114.00^{cdef}	7.83^{a}	6^{b}	120^{b}	160^{a}	43.00^{b}	2.53^{bcde}	201.00^{e}	32.00^{c}
AKV1	109.67^{b}	14^{b}	106.67^{f}	7.63^{a}	7^{b}	111^{cd}	146^{c}	36.50^{efg}	2.13^{f}	208.33^{e}	24.00^{h}
AKV14	115.00^{b}	15^{ab}	127.97^{abcd}	8.70^{a}	6^{b}	111^{cd}	145^{d}	34.33^{gh}	2.40^{cdef}	332.33^{b}	30.00^{d}
AKV3	123.67^{b}	14^{b}	110.33^{ef}	8.77^{a}	6^{b}	114^{c}	145^{d}	38.17^{def}	3.10^{a}	205.00^{e}	24.00^{h}
AKV11	102.67^{b}	15^{ab}	129.43^{abc}	8.27^{a}	6^{b}	99^{e}	130^{g}	33.33^{ghi}	3.20^{a}	514.33^{a}	35.00^{a}
AKV18	124.33^{b}	16^{ab}	128.13^{abcd}	8.27^{a}	6^{b}	122^{b}	145^{d}	45.40^{a}	2.70^{bc}	204.67^{e}	23.00^{i}
AKV6	109.00^{b}	15^{ab}	112.17^{def}	7.60^{a}	6^{b}	110^{cd}	145^{d}	34.87^{fgh}	2.80^{b}	121.67^{f}	25.00^{g}
AKV7	103.33^{b}	14^{b}	127.13^{abcd}	8.97^{a}	6^{b}	112^{c}	142^{f}	36.57^{efg}	2.30^{def}	251.67^{d}	28.00^{e}
AKV19	132.00^{b}	18^{a}	131.83^{ab}	8.33^{a}	8^{a}	128^{a}	145^{d}	38.67^{cde}	2.83^{b}	262.67^{d}	35.00^{a}
AKV2	126.67^{b}	13^{b}	83.07^{g}	8.50^{a}	6^{b}	63^{f}	95^{h}	12.30^{m}	1.53^{g}	121.67^{f}	24.00^{h}
AKV9	135.67^{b}	14^{b}	121.23^{abcde}	7.60^{a}	6^{b}	104de	130^{g}	22.70^{k}	2.60^{bcd}	334.67^{b}	32.00^{c}
AKV10	102.67^{b}	13^{b}	123.57^{abcde}	8.90^{a}	6^{b}	108^{cd}	145^{d}	31.63^{hij}	2.27^{ef}	208.67^{e}	28.00^{e}
AKV16	110.33^{b}	14^{b}	125.83^{abcde}	7.53^{a}	6^{b}	98^{e}	130^{g}	30.87^{ij}	1.73^{g}	143.33^{f}	34.00^{b}
±SE	**6.23**	**0.66**	**3.29**	**0.44**	**0.27**	**1.61**	**0.08**	**0.82**	**0.07**	**8.93**	**0.00**
CV%	**9.0**	**7.9**	**4.7**	**9.3**	**7.3**	**2.6**	**0.1**	**4.2**	**4.8**	**6.5**	**0.0**

Means with the same letter(s) are not significantly different at ($p<0.05$) by Student-Newman-Keuls Test (SNK). PLHT=Plant Height, NOF=Number of Leaves/Plant, LVT=Leaf Length, LVW=Leaf Width, ND=Number of Nodes, DFL= Days to 50 % Flowering, DM=Days to 95 % Maturing, PL=Panicle Length, PW= Panicle Width, GY=Grain Yield, SW=1000 Seed Weight**.**

Table3: Correlation Coefficients for quantitative traits of sorghum evaluated during the 2015 cropping season in Minna Southern Guinea Savanna of Nigeria

	PLHT	NOF	LVT	LVW	ND	DFL	DM	PL	PW	GY	SW
NOF	0.46388*										
LVT	0.24722	0.55432*									
LVW	0.13915	-0.02305	0.11892								
ND	0.42874	0.30839	-0.03717	-0.22542							
DFL	0.42489	0.70485**	0.54094*	0.0787	0.34207						
DM	0.18441	0.46164*	0.41581	0.04007	0.18942	0.90054**					
PL	0.08793	0.48108*	0.37025	0.02173	0.29706	0.81241**	0.84865**				
PW	0.28532	0.502938*	0.52167*	0.16315	0.2193	0.64095**	0.50106*	0.44195			
GY	0.05104	0.29501	0.51551*	0.19144	-0.0827	0.11122	0.01268	0.01842	0.53526*		
SW	0.25213	0.38071	0.4519*	0.31056	0.12814	-0.04337	-0.13175	-0.1788	0.02529	0.49443*	

PLHT=Plant Height, NOF=Number of Leaves/Plant, LVT=Leaf Length, LVW=Leaf Width, ND=Number of Nodes, DFL= Days to 50 % Flowering, DM=Days to 95 % Maturing, PL=Panicle Length, PW= Panicle Width, GY=Grain Yield, SW=1000 Seed Weight.

Table 4: Correlation Coefficients of quantitative traits of sorghum evaluated during the 2016 cropping season in Minna Southern Guinea Savanna of Nigeria

	PLHT	NOF	LVT	LVW	ND	DFL	DM	PL	PW	GY	SW
PLHT											
NOF	0.12332										
LVT	-0.0487	0.52435*									
LVW	0.00969	0.01757	0.17004								
ND	0.06193	0.34122	0.01124	-0.2399							
DFL	0.05316	0.60165**	0.57323*	0.09462	0.3031						
DM	-0.1504	0.40854	0.43921	0.05313	0.1506	0.92836**					
PL	-0.138	0.42725	0.33753	0.03588	0.23479	0.80076**	0.82839**				
PW	0.11442	0.44831*	0.46932*	0.17283	0.23095	0.62061**	0.51093*	0.43396			
GY	0.13571	0.26223	0.49873*	0.21273	-0.05531	0.13778	0.04252	-0.0237	0.4704*		
SW	0.0771	0.37075	0.4685*	-0.2772	0.17545	-0.02344	-0.09439	-0.1938	0.00695	0.5112*	

PLHT=Plant Height, NOF=Number of Leaves/Plant, LVT=Leaf Length, LVW=Leaf Width, ND=Number of Nodes, DFL= Days to 50 % Flowering, DM=Days to 95 % Maturing, PL=Panicle Length, PW= Panicle Width, GY=Grain Yield, SW=1000 Seed Weight.

DISCUSSION

Effort to improve a character by selection would be futile unless a major portion of variation is heritable. The amount of variation existing in a population is of great importance for any successful application of selection procedure used for crop improvement[15]. It is therefore important to get information on both genotypic and phenotypic coefficients of variation to know about the heritability of a character. The information on phenotypic coefficient of variation and heritability will be helpful at predicting the possible genetic advance by selection for the character. Correlation coefficient analysis would assist in setting up selection indices.

There were high significant differences in most of the characters investigated which indicated the presence of wide range of variability, and in agreement with[16] who reported similar result of high significant differences in the characters of 224 genotypes investigated. Jain and Patel (2016) studied 32 sorghum genotypes for yield and yield component traits reported existence of diversity in nine quantitative traits among the genotypes. The phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV) for most of the traits investigated except for days to 50 % flowering and grain yield that both PCV and GCV maintain the same values. High (PCV %) and (GCV %) were observed in some of the characters studied.

Khandelwal *et al.*,[16] studied 224 genotypes of sorghum for genetic parameters and characters association among yield components, the result revealed that phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) for all the traits investigated. The estimate of heritability alone may not indicate the response to selection therefore; the heritability estimate appeared to be more meaningful when accompanied by estimate of genetic advance. High heritability was observed for plant height, leaf length, days to 50 % flowering, days to 95 % maturity, panicle length, panicle width and grain yield.For grain yield similar high broad sense heritability was reported by Jain and Patel [17] who also found similar high heritability investigated in 102 land races of forage sorghum for 50 % flowering, plant height, number of leaves per plant, leaf length and fodder yield

Correlation coefficient analysis helps to determine the nature and degree of relationship between any two measurable characters. It resolves the complex relationships between events into simple forms of association. Association between quantitative characters statistically determined by Pearson's correlation coefficient (r) has been quite useful as basis for selection.

Correlation study provides a measure of association amongst characters; they may also be appreciated when highly heritable traits are positively and closely associated among themselves and with grain yield.Combined correlation coefficients for the two cropping seasons studied revealed that the yield components exhibited varying trends of correlation relationship between themselves. Similar result was obtained by Vijaya *et al*.[18] who conducted an experiment on 25 *rabi* sorghum genotypes to assess the association of grain yield components on grain yield per plant, significant and positively correlated was found with panicle weight, harvest index, 100-seed weight and panicle length[19]. Conducted experiment on twenty sorghum landraces and noticed that positive and highly significant correlation between grains yield per panicle and panicle length, panicle width, thousand seed weight. It was discovered that most of the traits with positive relationship also have high heritability. Therefore characters like grain weight, days to 50 % flowering, days to 95 % maturity, leaf length, panicle length and panicle width that have high heritability could be used in selection programme.

CONCLUSION

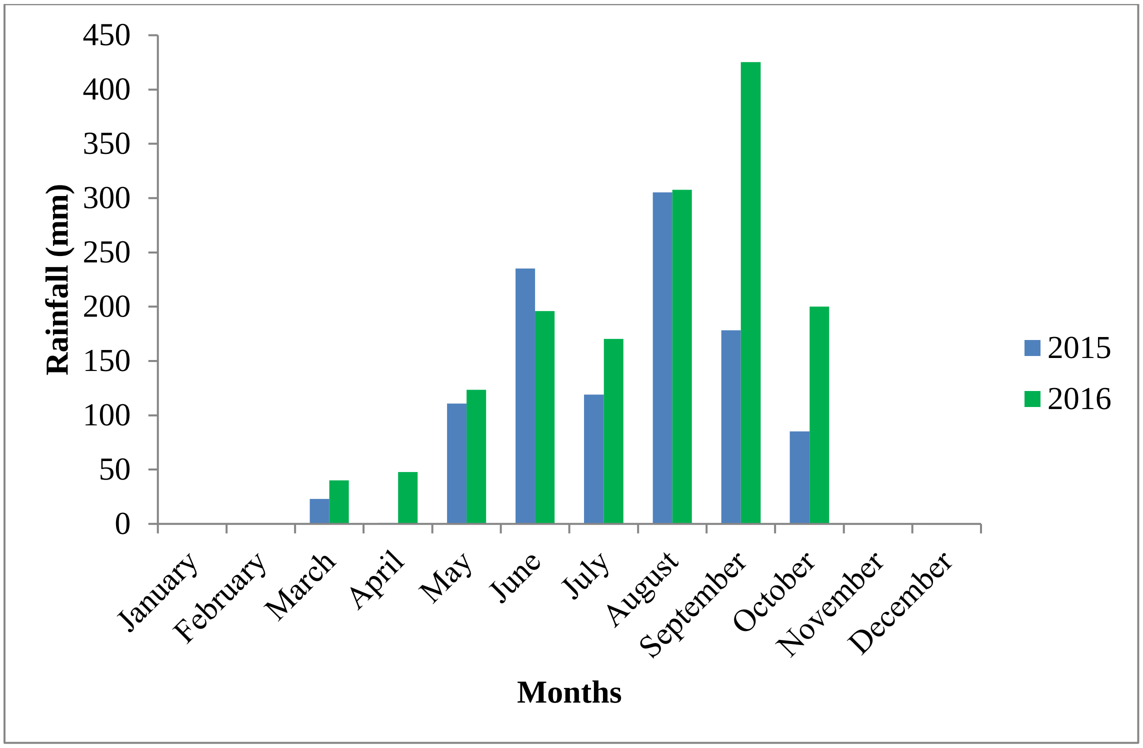
The results of this study revealed that information about components of variance, broad sense heritability, genetic advance, and correlation coefficient in respect of sorghum yield and yield contributing traits obtained could be used as guide for the improvement of sorghum. It can also help farmers to select productive and profitable accessions. The most outstanding performance accessions for grain weight are AKV11 (kaura), followed by AKV9 (shawimpe) and AKV14 (farefare).

RECOMMENDATION

AKV11, AKV9 and AKV14 were recommended for Sorghum improvement programme and for farmers in Southern guinea zones of Nigeria.

APPENDIX I: Temperature and Rainfall distribution during 2015 and 2016 cropping seasons

	2015 Cropping Season			2016 Cropping Season		
	Temperature (ºC)		Rainfall (mm)	Temperature (ºC)		Rainfall (mm)
Month	Max	Min		Max	Min	
January	34	23	0	35.1	20.6	0
February	33	23	0	37.9	22.9	0
March	38	27	22.9	38	25.9	40
April	39	27	0.8	37.2	25.7	47.8
May	35	26	110.7	34	23.8	123.6
June	32	24	235.3	31.1	22.8	196
July	32	24	119.2	30.3	22.4	170.2
August	29	23	305.3	29.8	22.4	307.6
September	30	23	178.3	30.6	21.7	425.2
October	32	25	85.3	33.8	23.1	200
November	35	25	0	33.6	23.4	0
December	33	22	0	0	0	0
Mean	**33.5**	**24.3**	**88.2**	**31**	**21.2**	**125.9**



Appendix 2: Average Rainfall (mm) for 2015 and 2016 cropping seasons
Source: Nigeria metrological centre (NIMET) Minna, Airport Niger state

Appendix 3: Soil physical and chemical properties for the studied period

Parameter	2015	2016
Texture	Sandy loam	Sandy loam
Sand (%)	81.8	75.5
Silt (%)	6.3	11
Clay (%)	11.9	13.5
pH (H_2O)	6.3	6.7
Nitrogen (%)	0.16	0.2
Available Phosphorus (mg/kg)	10.2	27.46
Potassium ($cmolkg^{-1}$)	0.17	0.17

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Corresponding author: Oyewale, R. O

Department of Crop Production, Federal University of Technology, Minna, Niger state, Nigeria

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