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Genotype by Environment (G X E) Interaction on Yield and its Component of Sorghum (*Sorghum bicolor* L. Moench) Genotypes of some selected States in North-Western Nigeria

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Ten Sorghum (Sorghum bicolor L. Moench) lines were evaluated during the 2010 rainy season at Usmanu Danfodiyo University, teaching and research farm, Sokoto, Sokoto State, and during 2011 rainy season at Bubuche, Augie Local Government Area, Kebbi State, in North-Western Nigeria. The objective of the study was to determine the influence of Genotype by Environment interaction on yield of Sorghum. The materials used in the study consisted of ten indigenous grain sorghum genotypes representing the types grown in North-Western Nigeria, which were collected by the National Center for Genetic Resources and Biotechnology (NACGRAB), Moor plantation, Ibadan, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, each pot size was 6m x 3m, with 75cm as inter row spacing, 30 cm intra-row spacing and a total of 240 plants per plot after thinning were used. Study revealed that genotype by environment interaction (G X E) had significant (p ≥ 0.01) influence for flag leaf area (821.07**), indicating that selection for the trait is not possible at one location. In contrast there was no significant genotype by environment interaction influence on leaf number (3.28), leaf length (36.58), plant height (271.01), leaf area index (0.22) straw weight (5.52), 100-seed weight (38.95), and total grain yield (1.32). Suggesting that selection for these traits can be done at one location simultaneously.

Key words: Genotype, environment, yield, Sorghum, influence.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) Moench is unique because it can consistently produce high yield even in certain semi-arid and arid areas where rice, wheat and corn are not well adapted (Ezeaku *et al*., 1997). The crop productivity is, however, constrained by the use of low yielding varieties and poor crop management (Hassan and ELasha, 2008). Although, sorghum has better drought tolerance than most other field crops, significant variation exists within species (Walulu *et al*., 1994). Thus sorghum improvement efforts particularly in the development of cultivars and hybrids with high grain yield under diverse environmental conditions are needed (Faisal, 2011) and Ezeaku and Muhammad (2005). However, the prevalence of environmental causes of variation over the genetic effects does not suggest that the importance of genotype on crop performance should be minimized (Faisal, 2011). An estimated 55721588 tonnes of sorghum were produced worldwide, harvested from 40935896 hectares in 2010, with an average yield of 13612kg/ha, the African total production for the year 2010 was 211107724 tonnes harvested from 24837754 hectares at a yield per hectare of 8498kg/ha. In Nigeria the total production was 4784100 tonnes, harvested from4736730 hectares at an average yield of 10100kg/ha (FAOSTAT, 2010). Genotype by environment interaction (G X E) study is of great interest to plant breeders because of their progress from selection, the term "G x E interaction" refers to instances where the joint effects of genetic and environmental are significantly greater or significantly reduced, than would be predicted from the sum of the separate effects **(**Andrew *et al.,* 1998) and Asfaw, (2007). The study objective was to investigate the influence of genotype by environment interaction (G X E) on yield and its component of Sorghum.

MATERIAL AND METHODS

A field experiment was conducted during the rainy seasons 2010 and 2011 at two locations, ten Sorghum (*Sorghum bicolor* L. Moench) lines were evaluated during the 2010 rainy season at Usmanu Danfodiyo University, teaching and research farm, Sokoto, Sokoto State, and during 2011 rainy season at Bubuche, Augie Local Government Area, Kebbi State, in North-Western Nigeria. Sokoto is located in the Sudan Savanna agro-ecological zone of Nigeria on latitude 13^0 01 N; longitude 5^0 15 E and altitude of about 350m above sea level (ASL). Mean annual rainfall is about 752 mm. The minimum and maximum temperatures are 26^0 and 35^0, respectively, and relative humidity of 23-41%. The area is characterized by long dry season with cool air during Hammattan (November – February), dry air during hot season from March – May followed by a short rainy season, (Bello, 2006) and Bubuche is located in Augie local government area of Kebbi State on latitude 13^0 05 N ; longitude $4^0$12 E and altitude of 345m above the sea level, temperature ranges from 27^0-34^0 and relative humidity of 24-44% with mean annual rainfall of 6700-7600mm (Anon, 2009). The texture of the soil was loamy sand and the soil is deep, loose and well drained, chemical analysis shows that the soil is slightly acidic, low to medium in organic carbon, low total nitrogen, low exchangeable cat ions low in cat ions exchange capacity (CEC), very low available P and K Ca and Mg contents and low Bulk density.

The materials used in the study consisted of ten indigenous grain sorghum genotypes representing the types grown in North-Western Nigeria, which were collected by the National Center for Genetic Resources and Biotechnology (NACGRAB), Moor plantation, Ibadan, Nigeria (Table, 1). The experiment was laid out in a Randomized Complete Block Design (RCBD) in three replications. Each plot size was 6m x 3m, with 75cm as inter row spacing and 30 cm intra-row spacing and a total of 240 plants per plot after thinning were used. Before sowing, seeds were treated with Apron-plus 3g/kg seed against soil fungi and insects. Sowing was on 10Th of June, 2010 and 2011. Five seeds were sown in each hole. Seedlings were thinned to three plants per hole after three weeks from sowing. Hand hoeing weeding practiced trice, the first one was two weeks after sowing and the subsequent weeding were carried out at three weeks interval.

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Table 1. Sorghum landraces used in the study

S/No	Genotypes	Area Collected	Grain Colour	Major Use
1	YOR RAGADO (EX-CHARANCHI)	Kano State	Brown	Food
2	EX-RIMI	Kano State.	White	Food
3	AREWA (EX-KAITA)	Katsina State	White.	Food
4	RED (EX-FUNTION)	Katsina State	White	Food
5	K-5912 (I AR -ZARIA)	Kaduna State	White	Food
6	RED (EX-RUGARGIWA)	Sokoto State	Red	Food
7	RIBOLAHU (EX-ACHIDA)	Sokoto State	White	Food
8	TALANKWASHE (EX-BODINGA)	Sokoto State	White	Food
9	JANJARE(EX-SAIDAWA)	Zamfara State	Red	Medicine
10	NG/SA/07/182	Kebbi State	Red	Food

Table 2. Mean performance of Sorghum genotypes evaluated at Usmanu Danfodiyo University Sokoto teaching and research farm during 2010 rainy season

Sorghum genotypes	Leaf number	Leaf Length (CM)	Plant height (CM)	Leaf area index (M^2)	Flag leaf area (m^2)	Flag leaf length (CM)	Straws weight (kg/ha)	100-seed weight (g)	Total grain yield (kg/ha)
YOR RAGADO	13.42a	77.91ab	18.37a	0.56b	41.08ab	32.20a	2.17b	14.99ab	492b
EX-RIMI	13.02a	74.60b	18.43a	1.00ab	44.91ab	28.30a	6.01ab	4.83 b	464 b
AREWA (EX-KAITA)	12.98a	78.99ab	192.90a	1.obal	34.72b	28'56a	4.81ab	4.28 b	3.216a
RED (EX-FUNTION)	13.26a	71.97b	188.66a	1.00 b	46.06ab	31.6oa	4.14ab	17.32a	4957b
K-5912 (I AR -ZARIA)	14.46a	70.83b	192.139	1.13ab	36.46b	28.64a	4.59ab	9.20ab	608b
RED (EX-NIGARGIWA)	14.43a	75.21b	173.07a	0.86 b	56.56a	34.03a	4.93ab	14.07ab	468b
RIBOLAHU (EX-ACHIDA)	14.33a	74.02b	187.17a	1.50 b	49.60a	28.18a	4.61ab	9.13ab	429b
TALANKWASHE	13.47a	75.89b	182.67a	1.66a	40.63ab	32.71a	8.40a	14.99ab	148b
JANJARE(EX-SAIDAWA)	13.42a	75.07b	184.20a	0.96ab	44.63ab	28.69a	5.36ab	4.83b	100b
NG/SA/07/182	12.31a	85.47a	194.09a	1.23ab	30.1b	28.83a	2.10b	4.28b	192b

Mean with the same letter(s) in a column are not significantly different at 5% level of significance according to DMRT (Duncan's multiple range tests).

Table 3. Mean performance of Sorghum genotypes evaluated at Bubuche Augie local government, Kebbi State during 2011 rainy season

Sorghum Genotypes	Leaf Number	Leaf Length (cm)	Plant Height (cm)	Leaf Area Index (cm^2)	Flag Leaf Area (cm^2)	Flag Leaf Length (cm)	Straws Weight (kg/ha)	100-Seed Weight (g)	Total Grain Yield (kg/ha,)
YOR RAGADO	16.63a	7299ab	146.37 a	1.34 a	226.07ab	38.55ab	2.20c	13.59a	2933a
EX-RIMI	15.88a	72.6ab	152.83 a	1.27ab	213.27ab	39.71a	2.77bc	3.43a	663a
AREWA (EX-KAITA)	16.60a	72.6ab	152.83 a	1.22abc	234.01a	35.81c	1.78c	11.18a	3126a
RED (EX-FUNTION)	15.53abc	77.14a	157.33 a	1.18abc	160.37d	36.85bc	3.85bc	9.13 a	449a
K-5912 (I AR -ZARIA)	15.31abc	64.26b	158.33 a	1.12abc	198.07bc	38.37a	2.93bc	8.90bc	408a
RED (EX-NIGARGIWA)	15.08abc	65.88ab	155.83 a	0.96cd	196.38bc	39.76a	4.06abc	14.88a	371a
RIBOLAHU (EX-ACHIDA)	15.60abc	74.98ab	124.80 a	0.99cd	213.64abc	35.77c	6.92a	10.66a	286a
TALANKWASHE	13.3bc	68.83ab	137.93 a	1.14abcd	198.77bc	38.52ab	1.78c	8.26a	456a
JANJARE(EX-SAIDAWA)	13.46bc	74.11ab	164.17 a	1.09acd	204.39abc	38.50ab	3.89abc	7.28a	299a
NG/SA/07/182	15.63ab	74.55ab	163.17 a	1.11abd	180.26cd	36.76bc	4.33abc	11.56a	2715a

Mean with the same letter(s) in a column are not significantly different at 5% level of significance according to DMRT (Duncan's multiple range tests).

Table 4. Combine mean performance of Sorghum genotypes evaluated across the locations during 2010 and 2011 rainy seasons

Sorghum Genotypes	Leaf Number	Leaf Length (cm)	Plant Height (cm)	Leaf Area Index (cm^2)	Flag Leaf Area (cm^2)	Flag Leaf Length (cm)	Straws Weight (kg/ha)	100-Seed Weight (g)	Total Grain Yield (kg/ha,)
YOR RAGADO	14.54a	17.45ab	163.55a	0.95a	133.57a	35.37a	2.13c	14.29ab	1713 b
EX-RIMI	14.45a	73.50ab	1170.88a	1.13a	129.09a	34.01a	4.39bc	6.65 c d	563 b
AREWA (EX-KAITA)	14.74a	75.81ab	172.87a	1.34a	32.80 a	3.29bc	7.73bc	7.73bcd	17646a
RED (EX-FUNTION)	14.40a	74.55b	170.50a	1.09a	103.46c	34.22a	3.99bc	13.22a	2963b
K-5912 (I AR -ZARIA)	14.89a	67.54c	176.73a	1.12a	117.26abc	33.50a	3.76bc	9.07abcd	508b
RED (EX-NIGARGIWA)	14.75a	70.55bc	164.45a	0.91a	126.47a	36.90a	4.49ab	1448 a	419b
RIBOLAHU (EX-ACHIDA)	14.96a	160.30a	124.ooa	1.31a	31.97a	31.97a	5.67a	9.89abcd	358b
TALANKWASHE	13.44a	74.59ab	174.18a	1.40a	119.70abc	35.51a	7.03a	11.62abc	302b
JANJARE(EX-SAIDAWA)	13.97a	80.01a	178.63a	1.17a	124.51ab	33.59a	4.76abc	6.06d	200b
NG/SA/07/182	13.90a	76.10ab	161.50a	1.05a	107.63bc	32.80a	3.4bc	7.92abd	1454b

Mean with the same letter(s) in a column are not significantly different at 5% level of significance according to DMRTCOMBINED

Table 5: Combine analysis of variance showing mean squares (M.S) and coefficients of variation of ten sorghum genotypes evaluated during 2010 and 2011

Source of Variation	Replication	Environment (E)	Genotype (G)	GXE	Error	CV (%)
LN	0.65	51.02**	2.04	3.28	2.17	10.23
LL (cm)	4.86	266.87**	65.87	36.58	33.82	7.87
PH (cm)	197.29	16854.53	330.11	271.01	432.15	12.31
LAI	0.36	0.03	0.12	0.22	0.2	39.97
FLA (cm)	25.95	382096.76**	685.05**	821.07**	239.01	12.59
FLL (cm)	57.5	885.43**	14.76	6.31	22.82	14.04
STRAW-WT	5.82	13.54	10.94*	5.52	4.85	51.04
100-GWT	58.35	5.52	59.01	38.95	32.66	56.59
TGY (kg/ha)	90774101	116079368	171980744	1.32	1.16E+08	421.37

** Significant at $p<0.01$, *Significant at $p<0.05$

Note: LN (leaf number), LL (leaf length in cm), PH (plant height in cm), LAI (leaf area index cm2), FLA (flag leaf area in cm2), FLL (flag leaf length in cm), STRW (straw weight in kg), 100-SWT (100-seed weight in g), TGY (total grain yield in kg/ha)

Data Collection

Data were collected on days to 50% flowering (DF), plant height (PH), and leaf characteristics including leaf length (LL), leaf number (LN), leaf area index (LAI), flag leaf area (FLA) and flag leaf length (FLL). At maturity, total grain yield (TGY), 100-grain weight (HGW) and straw weight (STRAW-WT0 were recorded at both locations and during both seasons in accordance with the procedure outlined in the IBGR/ICRISAT sorghum descriptor (IBPGR and ICRISAT 1993). Leaf area (LA) per plant was calculated on the basis of the length and width of the third top leaf multiplied by the total number of leaves and a coefficient of 0.71 (Krishnamurthy *et al*., 1974).

Statistical analysis

Data were subjected to analysis using SAS ver. 9.1 (SAS, 2004) was used to estimate variance for all traits. All factors (genotype, environment and their interaction) were treated as random variables.

RESULT AND DISCUSSION

Result of the study indicated the mean performance of the genotypes across the two locations (Table 2 &3), and the combined mean performance across the locations (Table 4) showed variation among the genotypes. The study revealed that genotype by environment interaction (G X E) had significant ($P \geq 0.01$) influence on only flag leaf area (821.07**) (Table 5), this showed that selection for the trait is not possible at one location because of high environmental influence, this result was supported by the findings of Pham and Kang (1988), whom reported that significant G x E for a quantitative trait is known to reduce the usefulness of the genotype means over all locations or environments for selecting and advancing superior genotypes to the next stage of selection. However, there was non significant G x E interaction effect with respect to leaf number (3.28), leaf length (36.58), plant height (271.01), leaf area index (0.22) straw weight (5.52), 100-seed weight (38.95), and total grain yield (1.32), and therefore indicates that selection for these traits can be done at one location. The results were supported by Basford and Cooper, (1998), that stated that, if there were no genotype by environment (G x E) associated with the genotype and environment, selection would be greatly simplified because the 'best' genotype in one environment would also be the 'best' genotype for all target environments. Furthermore, variety trials would be conducted at only one location to provide universal results (MARC, 2007).

Conclusion

The result of the study indicates that all characters studied with the exception flag leaf area can be selected for at one location. This is because there was no Genotype by Environment interaction (G X E) effect on them. These characters are leaf number, leaf length, plant height, leaf area index and flag leaf length, straw weight, 100-seed weight, and total grain yield.

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