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Correlation analysis of some agronomic traits for biomass improvement in sorghum (*Sorghum Bicolor* L. Moench) genotypes in North-Western Nigeria

Lawali Abubakar[1]* and T. S. Bubuche[2]

[1]Department of Crop Science, Faculty of Agriculture, Usmanu Danfodiyo University, P. M. B. 2346, Sokoto State, Nigeria.
[2]Department of Agricultural Education, College of Education, P. M. B. 1012, Argungu, Kebbi State, Nigeria.

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Ten Sorghum (*Sorghum bicolor* L. Moench) land races of North Western, Nigerian origin were evaluated during 2010 at Usmanu Danfodiyo University, teaching and research farm, Sokoto, Sokoto State and during the 2011 rainy season at Bubuche in Augie Local Government Area, Kebbi State in North-Western Nigeria. The objective of the study was to determine the correlation between the traits of sorghum that have direct bearing with biomass improvement. The procedure outlined in the IBGR/ICRISAT sorghum descriptor was used to measure each trait. Results obtained revealed that, leaf number (LN) has significant positive correlation with plant height (r=0.275), leaf area index (LAI) (r=0.308), and straw weight (STRW) (r=0.433) but negative significant correlation with flag leaf area (FLA) (r= -0.401). Leaf length (LL) had significant positive correlation with flag leaf length (FLL) (r= 0.299) and straw weight (STRW) (r=0.516). Plant height (PH) recorded significant positive correlation with leaf number (LN) (r=0.275) and STRW (r=0.360) but negatively correlated with FLL (r=0.118) and total grain yield (TGY) (r=0.102). LAI has significant positive with LN (r=0.308), PH (r=0.274) and negatively correlated with hundred grain weight (HUNDGWT) (r= -0.158) and TGY (r= -0.190). FLA had significant positive correlation with only FLL (r=0.266) and significantly negatively correlated with LN (r= -0.401), and STRW (r= -0.540). STRW has the significant and positive correlation with LN (r=0.433), with LL (r=0.516) and PH (r=0.360) but significantly and positively correlated with only FLA (r= -0.540). Selection for straw weight can therefore be carried out simultaneously with plant height, leaf length and leaf number.

Key words: Correlation, agronomic, traits, biomass, sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is one of the most important food crops of the world (Mahajan et al., 2011), and provide bulk of raw materials for the livestock and many agro-allied industries in the world (Dogget, 1970). It is drought tolerant which allows farmers to use one third less water than similar crops in its cultivation (Kumar et al., 2012). Sorghum is indigenous to Africa, and many of today's varieties originated on that continent. Sorghum was also grown in India before recorded history and in Assyria as early as 700 BC. The crop reached China during the thirteenth century and the Western Hemisphere much later (Undersander et al., 2013).

Sorghums in general can be classified into two types: Forage types (mainly for forage or animal feed) and grain

*Corresponding author. E-mail: dr.lawaliabubakar@yahoo.com. Tel: +2348039657021.

types (mainly for human consumption). The forage sorghums are further grouped into four types: (a) hybrid forage sorghum, (b) sudangrass, (c) sorghum x sudan hybrids (also known as sudan hybrids), and (d) sweet sorghum. The latter is used mainly for molasses but more recently for biofuel production as well (Newmann et al., 2010).

The estimated world production of grain sorghum in 2011 was 4,198,010 tonnes, with an average yield of 15, 274 kg/ha produced over 35,482,800 ha (FAOSTAT, 2011). In Africa 20,780,959 tonnes were produced at an average yield of 10,623 kg/ha across 19,561,929 ha during the same period. Nigeria was ranked second in sorghum production worldwide after India in 2011 (FAOSTAT, 2011), with production of 6,897,060 tonnes, harvested from 4, 891,150 ha at with an average yield of 14,101 kg/ha.

Yield is a complex character, which depends upon many independent contributing characters. Knowledge on type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield, information on the nature of association between yield and its components help in simultaneous selection for many characters associated with yield improvements (Kumar et al., 2012).
To determine relationships, correlation analyses are used such that the values of two characters are analyzed on a paired basis, results of which may be either positive or negative. When there is positive association of major yieldcharacters component breeding would be very effective but when these characters are negatively associated, it would be difficult to exercise simultaneous selection for them in developing a variety (Nemati et al., 2009).

Grain yield and fodder production in sorghum are complex characters controlled by many genes, therefore their improvement will lead to increased overall productivity in sorghum production (Sadia et al., 2001). To exploit the potentiality of sorghum therefore several crop improvement programmes have been undertaken (Mahajan et al., 2011). There is therefore the need to study the relationship of sorghum characters for all breeding objectives, as this will facilitate selection.

The objective of the study was therefore to determine the correlation between the traits of Sorghum land races of North Western Nigerian origin that have direct bearing with biomass improvement, with a view of using the result as a basis for selection in conventional breeding programmes.

MATERIALS AND METHODS

Ten local sorghum varieties were evaluated during 2010 the Usmanu Danfodiyo University, teaching and research farm, Sokoto, Sokoto State and during the 2011 rainy season at Bubuche in Augie Local Government Area of Kebbi State all in North-Western Nigeria. Sokoto is located in the Sudan Savanna agro-ecological zone of Nigeria on latitude 13° 01 N; longitude 5° 15 E and altitude of about 350 m above sea level (ASL). Mean annual rainfall is about 752 mm. The minimum and maximum temperatures are 26 and 35°, respectively, and relative humidity of 23 to 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 Kebbi State on latitude 13° 05 N; longitude 4° 12 E and altitude of 345 m above the sea level, temperature ranges from 27 to 34° and relative humidity of 24 to 44% with mean annual rainfall of 6700 to 7600 mm (Kebbi State, 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 (Table 1).

Planting materials

The materials used in this study consisted of ten indigenous grain sorghum genotypes representing the widely grown Sorghum types in North-Western Nigeria (Table 2) which were collected by National Center for Genetic Resources and Biotechnology (NACGRAB), Moor plantation, Ibadan, Nigeria.

The experiment was laid out in a Randomized Complete Block Design (RCBD) in three replications. Each pot size was 6 × 3 m, 75 cm as inter row spacing and intra-row spacing of 30 cm and a total of 240 plants per plot after thinning. Before sowing, seeds were treated with Apron-plus 3 g/kg seed against soil fungi and insects. Sowing was on 10th of June, 2010 and 2011 respectively. Five seeds were sown in each hole. Seedlings were thinned to three plants per hole after three weeks from sowing. Hand hoeing weeding was done thrice; the first one at two weeks after sowing and the subsequent weeding were carried out at three weeks interval each.

Data collection

Data were collected on days to 50% flowering (DF), plant height (PH), leaf length (LL), leaf number (LN), leaf area index (LAI), flag leaf area (FLA), flag leaf length (FLL), total grain yield (TGY), 100-grain weight (HGW) and total biomass weight (STRAW) were recorded at both locations and during both seasons. The data was collected according to standard procedures described in the IBPGR/ICRISAT (1993) Sorghum descriptor. LAI was calculated on the basis of the length and width of the third top leaf multiplied by the coefficient of 0.71 (Krishnamurthy et al., 1974).

Statistical analysis

Data were subjected to analysis of variance using SAS ver. 9.1 (SAS, 2004) to estimate variance for all traits. All factors (accession, block, and environment) were treated as random variables. The Pearson correlation coefficient was calculated for every pair of traits using the PROC CORR procedure.

Correlation

The correlation estimate was carried out using the formulae described by (Wright, 1921). Phenotypic correlation:

$$rp_{xy} = \frac{\sigma p_{xy}}{\sqrt{(\sigma^2 p_x)(\sigma^2 p_y)}}$$

Table 1. Physical and chemical properties of the soil at two experimental sites (Sokoto, 2010; Bubuche, 2011) cropping seasons.

S/N	Properties	Sokoto (2010)	Bubuche (2011)
	Physical properties		
1	Sand (g kg^{-1})	890	517
2	Silt (g kg^{-1})	45	377
3	Clay (g kg^{-1})	43	103
4	Textural class	Sand	Sandy loam
	Chemical properties		
4	Soil pH (H_2O) 1:2	5.90	5.80
5	Soil pH ($CaCl_2$) 1:2	5.40	5.30
6	Organic carbon (g kg^{-1})	2.40	1.76
7	Total Nitrogen (g kg^{-1})	0.40	0.66
8	Available P (mg kg^{-1})	0.80	0.76
9	Exchangeable K (Cmol kg^{-1})	0.44	0.58
10	C.E.C. (Cmol kg^{-1})	5.50	11.80
11	Na (Cmol kg^{-1})	0.43	0.50
12	Ca (Cmol kg^{-1})	0.35	0.31
13	Mg (Cmol kg^{-1})	208	0.51

Source: Agric. Chemical Lab. UDUS.

Table 2. Sorghum landraces used in the study.

S/N	Name	Area collected	Grain colour	Major use
1	Zago.Ex-BATSARI	Katsina State	Brown	Food
2	NG/SA/07/005	Niger State.	White	Food
3	NG/SA/07/125	Zamfara State	White.	Food
4	NGB/06/001	Kaduna State	White	Food
5	NG/SA/DEC/07/0049	Niger State	White	Food
6	NG/SA/DEC/07/0108	Niger State	White	Food
7	NG/SA/DEC/07/0213	Kaduna State	White	Food
8	NG/SA/DEC/070123	Kano State	White	Food
9	NG/SA/DEC/07/0036	Niger State	White	Food
10	EX-ARGUNGU (Kaura)	Kebbi State	Red	Food

Where, rp_{xy} = Phenotypic correlation coefficients between traits x and y; σp_{xy} = phenotypic variance of traits x and y; σp_x = Phenotypic variance of trait x; σp_y = Phenotypic variance of trait y.

Genotypic correlation

$$rg_{xy} = \frac{\sigma g_{xy}}{\sqrt{(\sigma^2 g_x)(\sigma^2 g_y)}}$$

Where, rg_{xy} = Genotypic correlation coefficients between traits x and y; σg_{xy} = genotypic covariance of traits x and y; σg_x = genotypic variance of traits x and y; σg_y = genotypic variance of trait y.

Environmental correlation

Environmental correlation (r_e)= $\frac{S^2_e X,Y}{\sqrt{(S^2_e X)(S^2_e Y)}}$

Where, S^2_e X.Y =environmental correlation between traits x and y; S^2_e X = environmental variance of the traits x; S^2_e Y = environnemental variance of traits y.

RESULTS AND DISCUSSION

Knowledge of the relationship among yield components is essential for the formulation of breeding programmes aimed at achieving the desired combinations of various components of yield. The estimates of correlation

Table 3. Performance of sorghum varieties evaluated at Usmanu Danfodiyo University Sokoto teaching and research farm during 2010 rainy season..

Genotypes	LN (cm)	LL (cm)	PH (cm)	LAI (cm2)	FLA (cm^2)	FLL (cm)	STRW (kg/ha)	100-SWT (g)	TAY (kg/ha)
Zago Ex-Batsari	14.357^{a}	76.793^{ab}	124.84^{b}	0.8667^{ab}	41.433^{a}	32.980^{ab}	5.203^{bc}	4.533^{b}	381.9^{b}
NG/SA/07/005	14.183^{a}	75.533^{ab}	184.60^{a}	2.0333^{a}	45.810^{a}	29.237^{b}	7.693^{ab}	5.867^{ab}	353.^{ab}
NG/SA/07/125	13.130^{a}	80.180^{a}	194.55^{a}	0.7667^{c}	35.970^{a}	29.370^{b}	7.207^{ab}	9.767^{ab}	1154.10^{ab}
NGB/06/001	14.267^{a}	75.733^{a}	183.17^{a}	1.9000^{ab}	46.003^{a}	35.673^{ab}	8.473^{a}	12.667^{ab}	528.5^{ab}
NG/SA/DEC/07/0049	14.690^{a}	79.267^{a}	185.38^{a}	1.2000^{abc}	38.370^{a}	32.233^{ab}	7.493^{ab}	12.067^{ab}	1629.2^{a}
NG/SA/DEC/07/0108	14.707^{a}	74.700^{ab}	190.02^{a}	0.7667^{c}	41.267^{a}	31.087^{ab}	7.170^{ab}	14.863^{a}	400.2^{ab}
NG/SA/DEC/07/0213	12.767^{ab}	78.133^{ab}	171.27^{ab}	1.6833^{abc}	38.727^{a}	34.943^{ab}	7.000^{ab}	8.213^{ab}	419.3^{ab}
NG/SA/DEC/07/0123	13.433^{a}	71.833^{b}	173.94^{ab}	1.6000^{abc}	46.447^{a}	34.883^{ab}	4.233^{c}	8.513^{ab}	280.2^{b}
NG/SA/DEC/07/ 0036	14.400^{a}	75.500^{ab}	181.90^{a}	1.2000^{abc}	39.367^{a}	33.363^{ab}	7.890^{a}	13.370^{ab}	314.7^{b}
EX-Argungu (Kaura)	10.633^{b}	72.733^{b}	175.93^{ab}	1.2333^{abc}	44.867^{a}	38.633^{a}	3.357^{c}	10.288^{ab}	387.3^{b}

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). LN, leaf number; LL, leaf length in cm; PH, plant height in cm; LAI, leaf area index cm^2; FLA, flag leaf area in cm^2; 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 .

coefficients among different characters indicate the extent and direction of association. The correlation co-efficients provide a reliable measure of association among the characters and help to differentiate vital associations useful in breeding from those of the non-vital ones (Falconer, 1981).

Results of the evaluation at Sokoto during the 2010 rainy season indicated that there was significant (P ≤ 0.05) differences between the varieties with respect to leaf number/plant, leaf length, plant height, leaf area index, flag leaf length, straw weight, 100 seed weight and total grain yield (Table 3). There was however, non significant difference between the varieties in terms of flag leaf area. Evaluation of the sorghum varieties in Bubuche during 2011 rainy season showed significant (P ≤ 0.05) difference between the varieties in terms of leaf number/plant, leaf length, plant height, flag leaf area, flag leaf length and 100 seed weight. However, with non significance difference in leaf area index, straw weight and total grain yield (Table 4). Evaluation of the sorghum varieties in Bubuche during 2011 rainy season showed significant (P ≤ 0.05) difference between the varieties in terms of leaf number/plant, leaf length, plant height, flag leaf area, flag leaf length and 100 seed weight. However, with non significance difference in leaf area index, straw weight and total grain yield (Table 4).

The combined analysis of the results across season and locations indicated significant difference (P ≤ 0.05) between the varieties in all the characters studied (Table 5). The result is not surprising as Maarouf and Moataz (2009) had reported variation among sorghum genotypes developed for forage production.

Correlation analysis of the combined results revealed that leaf number (LN) has significant positive correlation with plant height (r=0.275), leaf area index (LAI) (r=0.308), and highly significant positive correlation with straw weight (STRW) (r=0.433) but negative significant correlation with flag leaf area (FLA) (r= -0.401) (Table 6). This suggests selection for leaf number, plant height, leaf area index and straw weight can be carried out simultaneously, with however, an inverse selection pattern between leaf number and flag leaf area. Tesso et al. (2011) reported that, leaf number, leaf length and leaf area index had high significant and positive correlation with straws weight, plant height had high negative correlation with days to 50% flowering and 100-grain weight.

The study also revealed that straws weight have highly significant and positive correlation with plant height (0.360), leaf length (0.516), indicating that selection for the traits can be carried out simultaneously. Also Kumar et al. (2012) reported that days to 50% flowering showed positive significant correlation with stover yield per plant, and plant height showed positive significant association with 100- seed weight and stover yield per plant.

Leaf length (LL) had significant positive correlation with only flag leaf length (FLL) (r= 0.299) and highly significant positive correlation with straw weight (STRW) (r=0.516). El Naim et

Table 4. Mean performance of Sorghum genotypes evaluated at Bubuche Augie local government, Kebbi State during 2011 rainy season.

Genotypes	LN (cm)	LL (cm)	PH (cm)	LAI (cm2)	FLA (cm^2)	FLL (cm)	STRW (kg/ha)	100-SWT (g)	TAY (kg/ha)
Zago Ex-Batsari	10.33^{ab}	62.567^{abc}	237.60^{ca}	0.7333^{b}	125.13^{ab}	31.067^{abcd}	3.480^{a}	11.417^{abc}	1751^{a}
NG/SA/07/005	13.433^{a}	47.600^{c}	142.51^{bcde}	0.9333^{b}	88.43^{b}	21.967^{d}	3.117^{a}	9.630^{abc}	362^{a}
NG/SA/07/125	8.567.^{ab}	66.067^{ab}	61.73f	0.9333^{b}	207.43^{a}	40.533^{a}	3.073^{a}	16.177^{a}	3374^{a}
NGB/06/001	9.833^{ab}	70.300^{ab}	199.53^{ab}	1.2333^{b}	142.67^{ab}	33.667^{abc}	3.080^{a}	14.560^{ab}	750^{a}
NG/SA/DEC/07/0049	7.900^{b}	79.133^{a}	94.38^{e}f	0.3333^{b}	191.30^{ab}	39.000^{ab}	4.070^{a}	7.370^{bc}	603^{a}
NG/SA/DEC/07/0108	11.833^{ab}	69.667^{ab}	161.88^{bcd}	2.3000^{a}	223.20^{a}	39.000^{ab}	2.630^{a}	8.590^{abc}	425^{a}
NG/SA/DEC/07/0213	12.533^{ab}	68.767^{ab}	186.58^{abc}	1.1333^{b}	173.60^{ab}	33.733^{abc}	5.297^{a}	4.417^{c}	370^{a}
NG/SA/DEC/07/0123	9.000^{ab}	61.100^{bc}	133.14^{cde}	0.7333^{b}	123.90^{ab}	30.867^{abcd}	2.355^{a}	10.333^{abc}	336^{a}
NG/SA/DEC/07/0036	11.467^{ab}	60.400^{bc}	133.51^{de}f	0.9667^{b}	142.13^{ab}	28000^{cd}	2.963^{a}	9.037^{abc}	401^{a}
EX-Argungu (Kaura)	11.800^{ab}	52.667^{bc}	162.94^{bcd}	1.2333^{b}	124.60^{ab}	30.500^{cbd}	2.263^{a}	8.297^{abc}	1395^{a}

Mean with the same letter(s) in a column are not significantly different at 5% level of significance according to DMRT; LN, leaf number; LL, leaf length in cm; PH, plant height in cm; LAI, leaf area index cm^2; FLA, flag leaf area in cm^2; 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.

Table 5. Combined mean performance of Sorghum genotypes evaluated across the locations during 2010 and 2011 rainy seasons.

Genotypes	LN (cm)	LL (cm)	PH (cm)	LAI (cm2)	FLA (cm^2)	FLL (cm)	STRW (kg/ha)	100-SWT (g)	TAY (kg/ha)
Zago Ex-Batsari	12.345^{ab}	9.680^{bc}	181.22^{ab}	0.8000^{cd}	83.28^{ab}	32.023^{a}	4.3417^{abc}	7.975^{ab}	106.66^{ab}
NG/SA/07/005	13.808^{a}	61.567^{c}	163.56^{abcd}	1.483^{abc}	67.12^{b}	25.602^{b}	5.4050^{a}	7.748^{ab}	358.10^{b}
NG/SA/07/125	10.848^{b}	73.123^{ab}	128.14^{d}	0.8500^{abc}	121.70^{ab}	34.952^{a}	5.1400^{ab}	12.972^{a}	2264.0^{a}
NGB/06/001	12.050^{ab}	73.017^{ab}	191.35^{a}	1.5667e	94.34^{ab}	34.670^{a}	5.7767^{a}	13.613^{a}	639.4^{b}
NG/SA/DEC/07/0049	11.295^{ab}	79.200^{c}	139.88^{cd}	0.7667^{d}	114.84^{ab}	35.983^{a}	5.7817^{a}	9.718^{ab}	1116.2^{ab}
NG/SA/DEC/07/0108	13.270^{ab}	72.183^{ab}	175.95^{abc}	1.533^{ab}	132.23^{a}	35.043^{a}	4.9000^{ab}	11.707^{ab}	472.7^{b}
NG/SA/DEC/07/0213	12.650^{ab}	73.440^{ab}	17.92^{abc}	1.3833^{abcd}	106.16^{ab}	34.338^{a}	6.1483^{a}	6.315^{b}	394.6^{b}
NG/SA/DEC/07/0123	11.217^{ab}	66.467^{ab}	153.54^{abcd}	1.667^{abcd}	85.17^{ab}	32.875^{a}	3.2933^{bc}	9.423^{ab}	808.3^{b}
NG/SA/DEC/07/0036	12.933^{ab}	67.950^{bc}	147.71^{bcd}	1.0833^{abcd}	90.75^{ab}	31.082^{ab}	5.4267^{a}	11.203^{ab}	357.7^{b}
EX-Argungu (Kaura)	10.848^{b}	62.700^{bc}	169.44^{abc}	1.233^{abcd}	84.78^{ab}	34.567^{a}	2.800^{c}	9.290^{ab}	891.3^{ab}

Mean with the same letter(s) in a column are not significantly different at 5% level of significance according to DMRT. LN, leaf number; LL, leaf length in cm; PH, plant height in cm; LAI, leaf area index cm^2; FLA, flag leaf area in cm^2; 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.

al. (2012) reported that Head weight (g) had highly significant and positive correlation with hay weight, plant height, number of head per plot and highly significant negative correlation with days to 50% flowering, 100 grain weight. They reported that hay weight had highly significant positive correlation with plant height, yield weight, number of head per plot, it also had highly significant negative correlation with 100 grain weight. Plant height was also reported by the authors to have highly significant positive correlation with yield /ha. Plant height (PH) was significantly positively correlated with leaf area index (LAI) (r=0.274) and highly significant positive correlation with straw weight (STRW) (r=0.360). Flag leaf area (FLA)

Table 6. Correlation relationship between characters of Sorghum evaluated at Sokoto (Sokoto State) and Bubuche (Kebbi State).

Parameter		LN	LL	PH	LAI	FLA	FLL	STRAW	HUNDGWT	TGY
LN	Pearson correlation	1	0.250	0.275*	0.308*	-0.401**	-0.219	0.433**	-0.051	-0.122
	Sig. (2-tailed)		0.054	0.033	0.017	0.002	0.093	0.001	0.699	0.351
	N		60	60	60	60	60	60	60	60
LL	Pearson correlation	0.250	1	0.196	0.233	-0.127	0.299*	0.516**	0.110	0.055
	Sig. (2-tailed)	0.054		0.133	0.074	0.333	0.020	0.000	0.401	0.675
	N	60	60	60	60	60	60	60	60	60
PH	Pearson correlation	0.275*	0.196	1	0.274*	-0.233	-0.118	0.360**	0.027	-0.102
	Sig. (2-tailed)	0.033	0.133		0.034	0.073	0.368	0.005	0.837	0.439
	N	60	60	60	60	60	60	60	60	60
LAI	Pearson correlation	0.308*	0.233	0.274*	1	0.081	0.234	0.159	-0.158	-0.190
	Sig. (2-tailed)	0.017	0.074	0.034		0.541	0.072	0.226	0.227	0.147
	N	60	60	60	60	60	60	60	60	60
FLA	Pearson correlation	-0.401**	-0.127	-0.233	0.081	1	0.266*	-0.540**	0.021	0.076
	Sig. (2-tailed)	0.002	0.333	0.073	0.541		0.040	0.000	0.876	0.566
	N	60	60	60	60	60	60	60	60	60
FLL	Pearson correlation	-0.219	0.299*	-0.118	0.234	0.266*	1	-0.035	-0.017	0.019
	Sig. (2-tailed)	0.093	0.020	0.368	0.072	0.040		0.791	0.897	0.887
	N	60	60	60	60	60	60	60	60	60
STRAW	Pearson correlation	0.433**	0.516**	0.360**	0.159	-0.540**	-0.035	1	0.022	-0.018
	Sig. (2-tailed)	0.001	0.000	0.005	0.226	0.000	0.791		0.868	0.893
	N	60	60	60	60	60	60	60	60	60
HUNDGWT	Pearson correlation	-0.051	0.110	0.027	-0.158	0.021	-0.017	0.022	1	0.154
	Sig. (2-tailed)	0.699	0.401	0.837	0.227	0.876	0.897	0.868		0.241
	N	60	60	60	60	60	60	60	60	60
TGY	Pearson correlation	-0.122	0.055	-0.102	-0.190	0.076	0.019	-0.018	0.154	1
	Sig. (2-tailed)	0.351	0.675	0.439	0.147	0.566	0.887	0.893	0.241	
	N	60	60	60	60	60	60	60	60	60

*. Correlation is significant at 0.05, ** Correlation is significant at 0.01.

recorded significant positive correlation with flag leaf length (FLL) (r=0.266) and negative significant correlation with straw weight STRAW (r = -0.54) (Table 5). Straw weight can therefore be selected along with leaf length, flag leaf length,flag leaf area, while the length of the flag leaf has an inverse relation with straw weight. Khaliq et al. (2008) reported that flag leaf area was positively correlated with flag leaf length and play a vital role in drought tolerance. Breeding for biomass in sorghum can be carried out based on the character association observed most especially when breeding for livestock.

Conclusions

Results of this study confirmed that several traits are directly or indirectly associated with biomass yield which is important in breeding for biomass yield improvement in sorghum. The study concludes that selection for straw weight is also selection for traits such as plant height, leaf length and leaf number as they add to the final straw weight which is very important in selection for biomass yield improvement.

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