GENETIC VARIABILITY AND TRAIT ASSOCIATION FOR RELATIVE GROWTH RATE AND GREEN FODDER YIELD IN *SORGHUM BICOLOR* L

AWAN ZK[1], MASOOD SA[1*], NASEEM Z[1], FAZAL A[1], ASLAM N[1], TAHIR MHN[1] AND ALI Q[1, 2]

1: Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan

2: Centre of Excellence in Molecular Biology, University of the Punjab Lahore Pakistan

*Corresponding author: s.ahtisham01@gmail.com

ABSTRACT

Demand of sorghum forage is increasing day by day, so it is necessary to make efforts for the development of high green forage yielding sorghum. This research was conducted to determine the effect of seed weight on seedling traits, relative growth rate, green forage yield and its components. Higher heritability was recorded for days to 50% flowering, plant height, number of leaves, green fodder yield and root-shoot length ratio. The magnitude of genotypic correlation coefficients was higher than phenotypic coefficients for the most of the traits indicating that these traits are under genetic control rather than environment. Green forage yield showed highest positive phenotypic correlation with seed weight and days to 50% flowering and number of leaves/plant has the second highest positive phenotypic correlation. Relative growth rate, dry shoot weight, days to 50% flowering, plant height and number of leave/plant also exhibits positive and significant phenotypic correlation with seed weight. The result of correlation is of great value in the evaluation of the most effective procedures for selection of superior genotypes. It was suggested from the higher heritability and positive association of major yield traits that breeding would be very effective and selection on the basis of positive correlation may be useful to improve green fodder yield of sorghum.

 Keywords: **genetic variability,** *Sorghum bicolor***, green fodder, relative growth, association**

INTRODUCTION

Sorghum bicolor L. is regarded as a vital food and fodder crop of dry land agriculture. Having diploid (2n=2X=20) genome of 735 Mbp and is a self-pollinated crop. Genus sorghum contains many species and subspecies, and it has quite a few types like grass sorghums, grain sorghums, broomcorn and sweet sorghums. But *Sorghum bicolor* or grain sorghum is of main importance. Its grains are important due to its usage as food and livestock feed. Whereas, stem serves as fuel and building material and foliage are utilized as hay, silage, pasture and green fodder. Sorghum flour is used to make various foods and unleavened bread, dough is fermented and porridge is made by boiling its grains. Further, it is an ingredient in various bakery products and Africans also prepare beer from its grains. In Pakistan, the shortage of green fodder is about 40-50 percent which reaches up to 75 percent in fodder lean period. Government of Pakistan is spending Rs.261 million for ongoing schemes and Rs.739 million for new schemes in livestock sector [1] to meet the requirements. There are two green fodder lean periods in Pakistan; first when summer season forages are at their completion stage and winter forages are being sown, second when winter forages (mid may-mid july) complete their life cycle and summer forages are being sown. During mid to late summer, there is a need of good quality forage in excessive amount to maintain the meat and milk production of livestock. Green fodder crops provide 51% of the nutrients to the livestock in Pakistan [2] and its demand for rapidly expanding livestock industry are increasing day by day [3]. Because of its competition with other cash crops, the fodder crop sector remains neglected and growing area under fodder crops is reducing up to 2% in each decade [2]. So, it is important to produce high quality, high yielding and multicut fodder varieties, and their consumption at maximum nutritive stage has to be ensured to fulfill the growing demand of forage for livestock [4]. Livestock production can be increased up to 50% by increasing the yield of quality forage [5].

Among the kharif forage crops sorghum is an important one that have a wide range of ecological adaptability because of its xerophytic characteristics [6]. It is more tolerant to drought, alkali or salts than most of cultivated crops. It covers more than 50 % of the requirement of the rain-fed region of the country. Properly cured sorghum fodder, with a little protein supplement maintains cattle in good condition and is a good substitute of corn silage for better milk production of cattle

[7-9]. Its feeding value is equal to that of corn and it is suitable as green fodder, hay, silage and feed for almost each class of livestock as its fodder contains 12% protein, 70% carbohydrates, 50% digestible nutrients with 8% protein, 45% nitrogen-free extract and 2.5% fat and is juicy with good palatability and is liked by livestock [10,12.13]. So there is need to produce high yielding sorghum varieties to overcome such issues. Genetic variability in the germplasm is a great option for improving yield, quality and adaptability related traits [11]. Breeding programs with valuable information on genetic variability lead to greater success in making decision about the breeding procedure to be followed and selecting better types than the others. Whereas, genetic potential of a trait is measured by heritability which is used as a selection criteria. Burton [14] stated that estimates of heritability can be used to get better knowledge about selection efficiency.

The present study was focused on the evaluation of genetic variability and heritability among sorghum accessions for forage yield and its components. And development of a criterion on the basis of interrelation among various traits can be established.

MATERIAL AND METHODS

The germplasm comprised of 18 accessions; 009947, 009950, 009942, 009915, 009994, 009978, 009993, 009913, 009925, 009964, 009912, 009940, 009989, 009946, 009963, 009953, 009958, 009918 and four commercial verities; of fodder sorghum, collected from Fodder Research Program of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The 100 seeds of each accession were weighed in grams before conducting the experiments. The research was carried out in two experiments. First experiment was conducted in the wire house of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad from in 2014 and the second experiment was conducted at the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad in the month of during same year. All eighteen accessions and four commercial varieties were sown in sand filled polythene bags at the depth of 1.25 cm following a completely randomized design (CRD) with three replications. Four seeds per bag were sown and six bags of each accession in each replication were used. Data were recorded on data were recorded for emergence percentage (%), emergence rate index (ERI), fresh root length (cm), fresh shoot length (cm), fresh root/shoot ratio, fresh root weight (g), fresh

shoot weight (g), fresh total weight (g), dry root weight (g), dry shoot weight (g), dry root/shoot ratio and relative growth rate. In 2nd phase all eighteen accessions and four commercial varieties were sown following a randomized complete block design (RCBD) with three replications. Plant to plant and row to row distances was kept 25 cm and 75 cm, respectively. Sowing was done with the help of a dibbler. Di ammonium phosphate (DAP) at the rate of 50 Kg per acre and urea 25 Kg per acre was applied at the sowing time. Another 25 Kg of Urea was applied with second irrigation. Total five irrigations were applied during entire crop season. All the recommended crop husbandry practices were applied uniformly to all the experimental units. Ten randomly selected plants of each accession per replication at 50 % flowering stage were tagged to record the data on days to 50 % flowering, plant height (cm), number of leaves/ plant, leaf area (cm^2), leaves/stem ratio, green forage yield (Kg/plant). Data were analyzed for genotypic and phenotypic coefficient of variability, genotypic and phenotypic correlation, heritability and path coefficient using normal methodologies proposed by Burton [14], Al-Jibouri, *et al*. [15], Johnson, *et al*. [16] and Dewey and Lu [17], respectively.

RESULTS AND DISCUSSION

Results pertaining to the analysis of variance showed highly significant differences for emergence percentage and emergence rate index among all the accessions (Table 1). All the traits except fresh root weight, dry root weight, dry shoot weight and dry root shoot weight ratio showed significant differences among accessions. Root length had highly significant differences among all the accessions. Highly significant differences were found for all the traits across the harvests among the accessions. Results for analysis of variance of seedling traits for first harvest showed highly significant differences among all the accessions except dry root weight, fresh root shoot weight ratio and dry root shoot weight ratio while dry shoot weight had significant differences among all the accessions (Table 2). Whereas, non-significant differences among all the accessions for all the traits in second harvest were observed for all traits except root length and root shoot length ratio whereas root length and root shoot length ratio had highly significant differences among all the accessions (Table 3). The results pertaining to the analysis of variance of sorghum accessions in third harvest were significant for root length, fresh root shoot weight ratio and dry root shoot weight ratio (Table 4). Moreover, root shoot length ratio showed

highly significant differences among all the   accessions.

Table 1: Mean squares from analysis of variance for seedling traits of sorghum accessions across the harvests

SOV	Accessions	Harvest	Accessions × harvest	Error
DF	21	2	42	132
RL	89.60**	702.11**	2.80	12.61
SL	31.14*	1271.11**	16.29	17.12
RSLR	0.42**	0.35**	0.021	0.04
FRW	15469.98	703731.20**	5638.87	12009.48
FSW	7400.38*	411797.95**	2119.87	4058.88
DRW	413.96	6273.64**	112.12	339.95
DSW	183.96	22057.39**	58.83	138.52
FRSWR	0.25*	1.69**	0.06	0.12
DRSWR	0.26	7.11**	0.16	0.22

Table 2. Mean squares from analysis of variance of seedling traits of sorghum accessions in first harvest

SOV	DF	RL	SL	RSLR	FRW	FSW	DRW	DSW	FRSWR	DRSWR
Acc	21	22.05**	9.20**	0.24**	2652.39*	2352.22**	112.54	44.14*	0.06	0.37
Error	44	8.68	3.18	0.04	1363.25	884.80	125.94	24.17	0.05	0.54

Table 3. Mean squares from analysis of variance of seedling traits of sorghum accessions in second harvest

SOV	DF	RL	SL	RSLR	FRW	FSW	DRW	DSW	FRSWR	DRSWR
Acc	21	29.61**	45.32	0.094**	11251.013	4628.61	312.24	131.83	0.12	0.11
Error	44	10.62	40.21	0.039	22425.89	4159.82	613.16	103.3	0.22	0.20

Table 4. Mean squares from analysis of variance of seedling traits of sorghum accessions in third harvest

SOV	DF	RL	SL	RSLR	FRW	FSW	DRW	DSW	FRSWR	DRSWR
Acc	21	43.54*	9.20	0.13**	12844.31	4659.29	213.41	125.65	0.20*	0.09*
Error	44	18.53	7.97	0.05	12239.31	7132.03	280.76	288.02	0.09	0.05

Significant at 0.05 probability level   Significant at 0.01 probability level

The range of emergence rate index, emergence percentage , root length, shoot length ,root shoot length ratio, fresh root weight ,fresh shoot weight , dry root weight, dry shoot weight, fresh root shoot weight ratio, dry root shoot weight ratio, seed weight, relative growth rate, days to 50% flowering, plant height, number of leaves, leaf area, leaf/stem ratio and green forage yield in our breeding material was 0.07-0.24, 35%-90%, 15.562-24.636, 18.462-27.733, 0.781-1.536, 130.067 mg-276.38 mg,130.26 mg-412.93 mg, 23.88 mg-45.75 mg, 24.911 mg-39.356 mg, 0.690-1.356, 0.795-1.424, 1.274 mg-3.788 mg, 0.208-0.707, 52-85 days, 7-13, 11.909-16.668 cm^2, 0.164-0.509 and 0.116-0.813 respectively. The range found in the literature was 63-81, 101.11-357 cm, 9-21, 169-447 cm^2, 0.39-1.21, 0.116-0.813 Kg/plant for days to 50% flowering, plant height, number of leaves, leaf area, leaf/stem ratio and green forage yield respectively. Sorghum-2011 and Hegari performed best for maximum traits than all accessions and check varietiesbut accessions 009915, 009913, 000047 and 009912 performed better results for traits like plant height, leaf area, dry root weight, dry shoot weight, fresh root length, fresh shoot length, fresh root shoot length ratio and green forage yield as compared to all other accessions. So breeding material used in this research can be used in breeding program for the enhancement of green forage yields of sorghum. Heritability estimates

(Table 5) is of great importance to plant breeder primarily as a measure of the value of selection for particular characters in various types of progenies and as a special tool for a more accurate separation of variability due to inheritance. All Green forage yield related components except leaves: stem ratio and in seeding traits root shoot length ratio had high heritability which indicates that the presence of high proportion of total variability was due to genetic cause in these traits. The traits having less heritability exhibits the presence of high proportion of total variability was due to environmental cause [18,20,22].

Correlation analysis figures out the intensity of relationship between two traits. The correlation studies give a chance to find the direction and magnitude of inter-relationship of yield and yield related traits, which are essential for making an efficient and effective crop improvement procedure [18-21]. The magnitude of genotypic correlation coefficients was higher than phenotypic coefficients for the most of the traits indicating that these traits are under genetic control rather than environment. While all the genotypic correlation coefficients were non-significant indicating that these traits are under genetic control but this control is non-significant. Green forage yield has highest positive phenotypic correlation with seed weight and days to 50% flowering and number of leaves/plant has the second highest positive phenotypic correlation. Relative growth rate, dry shoot weight, days to 50% flowering, plant height and number of leave/plant also exhibits positive and significant phenotypic correlation with seed weight [22-27]. The result of correlation is of great value in the evaluation of the most effective procedures for selection of superior genotypes (Table 6-8). When there is positive association of major yield characters 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 [28-34].

Table 5: Genotypic and phenotypic coefficients of for various traits of sorghum accessions

1) Traits	δ^2_g	δ^2_p	GCV	PCV	h^2 (B.S)
DTF	109.23	129.31	15.67	17.05	84.47
PH	919.44	1138.06	20.09	22.35	80.79
NOL	3.09	3.55	18.22	19.53	87.03
LA	1.63	3.03	8.93	12.18	53.74
LSR	1.52	15.59	392.78	1258.34	9.74
GFY	0.21	0.30	47.82	57.15	70.00
RL	9.96	22.57	16.61	25.002	44.12
SL	3.46	20.58	8.92	21.76	16.81
RSLR	0.13	0.17	36.52	41.89	76.00
FRW	1718.89	13728.37	20.37	57.56	12.52
FSW	822.26	4881.14	14.41	35.10	16.85

DRW	46.00	385.95	21.47	62.19	11.92
DSW	20.44	158.96	13.70	38.19	12.86
FRSWR	0.03	0.15	17.006	39.22	18.80
DRSWR	0.02	0.28	14.706	50.16	8.59

Table 6. Genotypic and phenotypic correlation coefficients among seedling traits in sorghum accessions

Traits	r	E%	ERI	RGR	RL	SL	RSLR	FRW	FSW	DRW	DSW	FRSWR	DRSWR
SW	G	-0.31	0.30	0.71	0.13	-.05	0.09	0.03	0.16	0.16	0.50	-0.32	-0.20
	P	-0.27	0.28	0.56*	0.13	-.03	0.08	0.02	0.12	0.13	0.40*	-0.10	-0.16
E%	G		-1.02	-.20	-0.32	0.52	-0.47	0.11	0.88	0.16	0.73	-2.06	-0.58
	P		-.96*	-.15	-0.25	0.32*	-0.35*	0.09	0.54*	0.13	0.48*	-0.56*	-0.36*
ERI	G			0.10	0.26	-0.42	0.43	-0.17	-0.77	-0.18	-0.70	1.67	0.52
	P			0.09	0.24	-0.28	0.31*	-0.09	-0.53*	-0.17	-0.51*	0.58*	0.35*
RGR	G				-0.28	-0.11	-0.13	-0.59	-0.22	-0.23	0.48	-1.34	-0.74
	P				-0.17	0.03	-0.13	-0.34*	-0.04	-0.22	0.34*	-0.41*	-0.55*
RL	G					-0.54	1.07	0.90	0.34	0.74	0.31	1.59	0.71
	P					-0.36*	0.92*	0.72*	0.26	0.64*	0.26	0.59*	0.59*
	G						-0.86	-0.53	0.50	-0.30	0.23	-2.46	-0.60
	P						-0.61*	-0.19	0.35*	-0.08	0.31*	-0.52*	-0.36*
RSLR	G							0.77	0.03	0.52	0.04	2.04	0.69
	P							0.59*	0.02	0.44*	0.05	0.64*	0.53*
FRW	G								1.11	1.25	0.41	0.16	1.18
	P								0.60*	0.90*	0.44*	0.55*	0.71*
FSW	G									1.11	1.38	0.19	0.04
	P									0.69*	0.09*	-0.30*	0.07
DRW	G										0.68	0.84	0.64
	P										0.62*	0.34*	0.67*
DSW	G											-2.29	-0.14
	P											-0.37*	-0.16
FRSWR	G												3.35
	P												0.82*

Table 7. Genotypic and phenotypic correlation coefficients among seed weight, green forage yield and its related traits in sorghum accessions

Traits	r	PH	NL	LA	L/S ratio	GFY	SW
DTF 50%	G	0.76	0.97	-0.35	0.14	0.86	0.53
	P	0.72*	0.91*	-0.31*	0.10	0.78*	0.52*
PH cm	G		0.91	-0.02	0.02	0.95	0.51
	P		0.85*	-0.01	0.05	0.89	0.49*
NL	G			-0.25	-0.05	0.92	0.53
	P			-0.20	-0.07	0.86*	0.51*
LA	G				-0.39	0.00	-0.25
	P				-0.32*	0.00	-0.22
L/S ratio	G					-0.16	0.17
	P					-0.06	0.14
GFY	G						0.68
	P						0.64*

Table 8. Genotypic and phenotypic correlation coefficients among seedling traits, green forage yield and its related traits in sorghum accessions

Traits	r	DTF 50%	PH	NL	LA	L/S ratio	GFY
E%	G	0.12	0.09	0.15	-0.39	-0.01	0.05
	P	0.11	0.06	0.14	-0.27	0.01	0.04
ERI	G	-0.19	-0.08	-0.17	0.28	-0.11	-0.08
	P	-0.17	-0.07	-0.16	0.22	-0.06	-0.06
RGR	G	0.36	0.34	0.31	0.32	0.06	0.45
	P	0.23	0.245	0.24	0.25	0.04	0.34*
RL	G	0.11	-0.21	-0.03	-0.35	-0.03	-0.08
	P	0.10	-0.20	-0.05	-0.29	-0.00	-0.08
	G	-0.13	0.03	-0.01	-0.23	0.38	-0.20
	P	-0.15	0.01	-0.05	-0.14	0.28	-0.10
RSLR	G	0.15	-0.30	-0.05	-0.20	-0.10	-0.13
	P	0.14	-0.27	-0.06	-0.18	-0.09	-0.11

FRW	G	0.02	-0.24	0.11	-0.55	-0.43	-0.06
	P	0.04	-0.17	0.00	-0.39*	-0.12	-0.01
FSW	G	0.12	0.12	0.24	-0.52	-0.03	0.14
	P	0.07	0.07	0.13	-0.42*	-0.04	0.10
DRW	G	0.03	0.03	0.06	-0.52	0.08	0.20
	P	0.03	0.00	0.01	-0.38*	0.03	0.13
DSW	G	0.43	0.33	0.45	-0.36	0.06	0.50
	P	0.31*	0.24	0.29	-0.28	0.11	0.35*
FRSWR	G	-0.60	-0.90	-0.51	-0.00	-1.18	-0.59
	P	-0.15	-0.26	-0.22	0.00	-0.12	-0.14
DRSWR	G	-0.38	-0.30	-0.38	-0.35	0.06	-0.23
	P	-0.27	-0.24	-0.29	-0.20	-0.04	-0.17

Abbreviations

G   =   Genotypic correlation coefficient
P   =   Phenotypic correlation coefficient
E%   =   Emergence percentage
ERI   =   Emergence rate index
RGR   =   Relative growth rate
RL   =   Root length (cm)
SL   =   Shoot length (cm)
RSLR =   Root shoot length ratio
FRW   =   Fresh root weight (mg)
FSW   =   Fresh shoot weight (mg)

DRW   =   Dry root weight (mg)
DSW   =   Dry shoot weight (mg)
FRSWR   =   Fresh root shoot weight ratio
DRSWR   =   Dry root shoot weight ratio
DTF   =   Days to 50% flowering
PH   =   Plant height (cm)
NL   =   Number of leaves per plant
LA   =   Leaf area (cm^2)
L/S ratio =   Leaf: Stem ratio
DFY   =   Green forage yield (Kg/Plant)

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