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Study on variability, correlation and path coefficient analysis in Sudan grass (*Sorghum sudanense* L.)

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Abstract
Fifty genotypes of Sudan grass were evaluated in a randomized block design with three replications to estimate variability, correlation and path analysis. High heritability estimates were observed for all the characters studied, except L: S ratio. High estimates of heritability (b.s) accompanied by high genetic advance as percentage of means was reported for characters viz., days to 50% flowering, green forage yield, dry matter yield, plant height, crude protein yield, number of tillers, stem thickness, leaf width, crude protein content and leaf length. Correlations studies showed that green forage yield was significantly and positively associated with plant height, number of tillers, leaf length, stem thickness, dry matter yield and crude protein yield. Path analysis revealed that leaf width exhibited highest positive direct effect on green forage yield as well as it showed significant and positive correlation with green forage yield. Stem thickness showed highest negative direct effects on green forage yield which was followed by leaf: stem ratio, plant height, leaf length, crude protein content and dry matter yield. The pair of genotypes viz., IS-700 and cofs-29 (D^2= 1523.39) was most divergent from one another and genotypes like, IS-3236, IS-3284, IS-700 and cofs-29 for improvement in green forage yield of Sudan grass.

Keywords: Sudan grass, genetic diversity, correlations, path coefficient and direct and indirect effects

Introduction

Sudan grass (*Sorghum sudanense* L.) is a species of grass raised for forage and grain native to tropical and subtropical regions of Eastern Africa. In recent years, the interest in this crop is growing globally since sustainable yields can be produced in the condition of water deficit and high temperature stress (Swith and Frederiksen 2000) [14]. It can be grown in annual temperature range of 7.8 to 27.5^{0}C and pH 4.9 to 8.2. Most favorable temperature for growth ranges from 25-30^{0}C. Adapted to wide range of soil from heavy clay's to sand but requires fertile land to give heavy yields. It does not tolerate saline and alkaline condition of soils. It can be harvested as pasture, green chop, hay or silage. It can be ready for harvest in about 45 days after planting. Sudan grass can be grazed any time after the plant has reached a height of 18 inches which is usually 5 to 6 weeks after planting. To avoid HCN poisoning Sudan grass should not be pastured until it is 45-60 cm high. Sudan grass is nutritious and contains 6.5 to 23 per cent crude protein. (James and Duke 1983) [6]. Information on genetic variability, character association of these characters with forage yield is most essential for formulating effective selection schemes in any crop improvement programme. Hence, the present investigation was undertaken to determine genetic variability, association between forage yield and its contributing components in various genotypes of Sudan grass.

Materials and Methods

The experimental material used for the study consists of 50 diverse genotypes of Sudan grass. These genotypes of Sudan grass were evaluated in a Randomized Block Design with three replications at Forage Project, MPKV, Rahuri during July 2012 to Dec. 2012. Each genotype was sown in single row of 3.0 m length with 30 cm line sowing. Observations on various characters except green forage yield and dry matter yield were recorded on five randomly selected plants in each experimental plot for first three cuts and average value were worked out for remaining character and used for statistical analysis. The genotypic and phenotypic variances were calculated by using respective mean squares from analysis of variance table (Johnson *et al.* 1955) [7].

The phenotypic and genotypic coefficients of variation were computed, as per the formulae given by Burton (1952) [3]. Heritability in broad sense for each character was estimated as suggested by Hanson *et al.* (1956) [5]. Genetic advance (at 5 % selection intensity) was estimated using the formula given by Allard (1960) [1]. Analysis of covariance was carried out by taking two characters at a time. The genotypic and phenotypic co-variances were calculated as per Singh and Chaudhari (1979) [11] and correlation coefficients as suggested by Dewey and Lu (1959) [4].

Results and Discussion

a) Correlation Studies

The correlation studies (Table 1) revealed that, the characters *viz.,* Days to 50% flowering showed significant positive genotypic correlation with stem thickness (0.280), Pooranchand (2000) [10] observed positive association of days to 50% flowering with stem thickness, while Plant height showed significant positive genotypic correlations with number of tiller's (0.620), crude protein yield (0.576), dry matter yield (0.562), green forage yield (0.526) and crude protein contents (0.251). Anup and Vijaykumar (2000) [2] noticed significant and positive genotypic correlations of plant height with green forage yield in forage sorghum. Zhan Qiuwen *et al.,* (2004) [15] also noticed similar result in sorghum-Sudan grass hybrid. Number of tiller's showed significant positive genotypic correlations with dry matter yield (0.726), crude protein yield (0.713) and green forage yield (0.729), while it showed significant and negative genotypic correlations with leaf width (-0.331). Zhan Qiuwen *et al.,* (2004) [15] obtained significant positive association of number of tiller's with green forage yield in sorghum- Sudan grass hybrid while leaf length showed significant and positive correlations with dry matter yield (0.240), crude protein yield (0.265) and green forage yield (0.230). Zhan Qiuwen *et al.,* (2004) [15] observed positive association of leaf length with green forage yield in sorghum Sudan grass hybrid which is in confirmation with finding of present investigation. Leaf width showed significant positive genotypic correlations with leaf: stem ration (0.326) and stem thickness (0.507). Paroda *et al.,* (1976) [9] observed significant positive genotypic association of leaf width with stem thickness which is in confirmation with results of present investigation. Leaf: stem ratio showed significant negative genotypic correlation with stem thickness (-0.501), crude protein content (-0.217) and green forage yield (-0.195), while it was having significant negative correlations with plant height. Stem thickness showed significant positive genotypic correlation with dry matter yield (0.273), crude protein yield (0.287) and green forage yield (0.265). Zhan Qiuwen *et al.,* (2004) [15] observed positive association of stem thickness with green forage yield, where as crude protein content (%) showed significant positive genotypic correlation with crude protein yield (0.230) and plant height. Sunky *et al.,* (2000) [13] observed significant association of crude protein content with plant height in Sudan-grass which is in confirmation with the findings of present study. Dry matter yield showed significant positive correlations with crude protein yield (0.995), green forage yield (0.995). Manickam *et al.,* (1994) observed that the dry matter yield of Sorghum Sudan grass hybrid was significantly affected by green forage yield which is in confirmation with result of present investigation. Crude protein yield showed significant positive genotypic correlation with green forage yield (0.990). Anup and Vijaykumar (2000) [2] observed positive association of crude protein yield with green forage yield which is in confirmation with result of present investigation.

b) Path coefficient analysis

The direct and indirect contributions of each character as revealed by path coefficient analysis are presented in Table 2. The present investigation revealed that days to 50% flowering showed positive direct effect on green forage yield (0.946). This may be due to its positive indirect effect via number of tiller's. Contradictory result was obtained by Paroda *et al.,* (1976) [9] as they noticed negative direct effect of days to 50% flowering on green forage yield in forage sorghum. Plant height showed negative direct effects on green forage yield (-0.340). This may be due its high positive indirect effect via number of tiller's (1.068). Contradictory result was obtained by the Paroda *et al.,* (1976) [9] who noticed direct positive effect of plant height on green forage yield in forage sorghum. Sukhchain *et al.,* (2008) [12] noticed positive indirect effect of plant height on green forage yield in forage sorghum. The number of tiller's showed positive direct effect on green forage yield (1.723). This may be due to its high positive indirect effects via leaf: stem ratio (0.362). This result is in confirmation with the findings of Manickam *et al.,* (1994) who observed direct effect of number of tiller's on green forage yield in Sorghum-Sudan grass hybrid. Leaf length showed negative direct effects on green forage yield (-0.285). Contradictory result was obtained by Paroda *et al.,* (1976) [9] who noticed direct positive effects of leaf length on green forage yield in forage sorghum. Anup and Vijaykumar (2000) [2] observed direct positive effect of leaf length on green forage yield in forage sorghum. Leaf width exhibited positive direct effects on green forage yield (2.733) accompanied by its significant association with green forage yield. This result is in confirmation with the findings of Parod *et al.,* (1976) [9] who noticed positive direct effect on leaf width with green forage yield accompanied by is significant positive association with green forage yield in forage sorghum. Anup and Vijaykumar (2000) [2] observed direct positive effect of leaf width on green forage yield in forage sorghum. Leaf: stem ratio exhibited negative direct effects and significant negative correlations with green forage yield (-2.197) which may due to its positive indirect effects via stem thickness. Stem thickness showed negative direct effect on green forage yield (-2.567). Contradictory result was obtained by Zhan Qiuwen *et al.,* (2004) [15] who noticed positive direct effect of stem thickness on green forage yield in sorghum-Sudan grass hybrid. Paroda *et al.,* (1976) [9] observed positive direct effect of stem thickness on green forage yield in forage sorghum. Crude protein content (%) showed low negative direct effects on green forage yield (-0.114) but is association with green forage yield was significant positive which may be due to its positive indirect effect via leaf: stem ratio. Dry matter yield showed low negative direct effect on green forage yield (-0.047). This may be due to high positive indirect effects via number of tiller's (1.250). Contradictory result was obtained by Manickam *et al.,* (1994) as they noticed strong positive direct effects of dry matter yield on green forage yield and it was significant positively correlated with green forage yield in sorghum-Sudan grass hybrid. Crude protein yield showed low positive direct effects on green forage yield (0.014).

Table 1: Genotypic correlation coefficients for green forage yield and its traits in Sudan grass.

Characters	Days to 50 % flowering	Plant height (cm)	No. of tillers/m^2	Leaf length (cm)	Leaf width (cm)	L:S ratio	Stem thickness (cm)	Crude protein (%)	Dry matter yield (q/ha)	Crude protein yield (q/ha)	Green fodder yield (q/ha)
Days to 50 % flowering	1.000	-0.099	0.065	0.084	-0.087	-0.031	0.280**	0.148	0.120	0.114	0.158
Plant height (cm)		1.000	0.620**	-0.136	-0.217*	-0.324**	0.086	0.251*	0.562**	0.576**	0.526**
No. of tillers/m^2			1.000	0.136	-0.331**	-0.165	0.096	-0.054	0.726**	0.713**	0.729**
Leaf length (cm)				1.000	0.149	0.006	0.090	0.058	0.240*	0.265**	0.223*
Leaf width (cm)					1.000	0.326**	0.507**	0.125	0.101	0.113	0.078
L:S ratio						1.000	-0.501**	-0.217*	-0.166	-0.187	-0.195*
Stem thickness (cm)							1.000	0.188	0.273**	0.287**	0.265**
Crude protein (%)								1.000	0.161	0.230*	0.160
Dry matter yield (q/ha)									1.000	0.995**	0.995**
Crude protein yield (q/ha)										1.000	0.990**

*, ** significant at **5** and **1** %, respectively.

Table 2: Genotypic path coefficients (direct and indirect effect) of forage yield contributing characters in Sudan grass.

Characters	Days to 50 % flowering	Plant height (cm)	No. of tillers/m^2	Leaf length (cm)	Leaf width (cm)	L:S ratio	Stem thickness (cm)	Crude protein (%)	Dry matter yield (q/ha)	Crude protein yield (q/ha)	Genotypic correlation with GFY (q/ha)
Days to 50 % flowering	0.946	0.034	0.112	-0.024	-0.238	0.067	-0.718	-0.017	-0.006	0.002	0.158
Plant height (cm)	-0.093	-0.340	1.068	0.039	-0.593	0.712	-0.221	-0.029	-0.026	0.008	0.526**
No. of tillers/m^2	0.061	-0.211	1.723	-0.039	-0.904	0.362	-0.246	0.006	-0.034	0.010	0.729**
Leaf length (cm)	0.079	0.046	0.234	-0.285	0.407	-0.014	-0.231	-0.007	-0.011	0.004	0.223*
Leaf width (cm)	-0.082	0.074	-0.570	-0.042	2.733	-0.716	-1.302	-0.014	-0.005	0.002	0.078
L:S ratio	-0.029	0.110	-0.284	-0.002	0.890	-2.197	1.286	0.025	0.008	-0.003	-0.195*
Stem thickness (cm)	0.265	-0.029	0.165	-0.026	1.387	1.101	-2.567	-0.021	-0.013	0.004	0.265**
Crude protein (%)	0.140	-0.085	-0.093	-0.017	0.340	0.476	-0.483	-0.114	-0.008	0.003	0.160
Dry matter yield (q/ha)	0.114	-0.191	1.250	-0.068	0.277	0.365	-0.701	-0.018	-0.047	0.014	0.995**
Crude protein yield (q/ha)	0.108	-0.196	1.228	-0.075	0.310	0.412	-0.738	-0.026	-0.047	0.014	0.990**

Residual effect = 0.27, Diagonal –direct effects and above and below diagonal indirect effects.
GFY- green forage yield

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