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CORRELATION ANALYSIS AMONG FORAGE YIELD AND QUALITY COMPONENTS IN SORGHUM SUDANGRASS HYBRIDS UNDER WATER STRESS CONDITIONS

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ABSTRACT
Coming food security threat can be reduced by improving the nutritional components of feed stuff of livestock. Forages are directly involved in significant gain of milk and meat yield for the malnourished people of developing countries. Fifty fodder hybrids of sorghum and sudangrass along with fifteen parents were evaluated for their genetic potential against water stress in the field. Correlation among forage yield components; plant height (PH), number of leaves/plant (NOL^{-P}), number of tillers/plant (NOT^{-P}), leaf area (LA), green forage yield (GFY) and forage quality parameters; crude protein (CP), crude fibre (CF) , nitrogen free extracts (NFE), Ether Extracts (EE), total ash contents (TA), sugar contents (SC) were determined under normal and water deficit conditions. Under both environmental conditions, GFY was positively correlated with all forage yield and forage quality components except NFE under normal and SC, CP and TA under water stress. Plant height had positive correlation with all traits except $NOT\text{-}^{P}$, SC and NFE under stress conditions. Leaf area was positively correlated with all yield and quality traits except NOT^{-P} and NFE under both conditions. Number of leaves per plant was positively correlated with all yield and quality traits under normal environmental conditions except NFE but it had negative correlation with SC, CF and NFE under stress conditions. LA and $NOL\text{-}^{P}$ was found to be significant morphological trait contributing positively to fodder yield and quality.

KEY WORDS: Genetic analysis, correlation, forage yield, quality, drought.

INTRODUCTION
People of developing countries endure from malnourishment; milk and meat are too costly or out of stock. Drought is one of foremost causes for malnourishment and water scarcity in the entire world due to which the availability of animal feed and food of human being is affected persistently. Water scarcity has demanded drought tolerant cultivars of all cultivated crops (Ali *et al*., 2011b, c). Forage sorghum [*Sorghum bicolor* (L). Moench] has become popular crop of water deficient areas of the world where most of the farmer's earnings has obtained through products of live stocks (Mohammed and Maarouf, 2009, Tariq *et al*., 2012). Sorghum (*Sorghum bicolor* L.) is an important crop cultivated for fodder and grain under irrigated as well as rainfed areas. It is flourishing fodder crop in rainfed areas due to its drought tolerance ability. It has higher genetic variability in terms of genetic and germplasm resources to develop new cultivars adapted to different agro-ecological regions of world (Zhang *et al*., 2010). Worldwide, livestock use 3.4 billion hectares of grazing land as well as the production from about a quarter of the land in crops. This amounts to more than two-thirds of total agricultural land area and a third of total land area. Forage species are thus an important aspect of agricultural landscapes in the region of the world (Michael, 2011). Random and insufficient amount of rainfall has negative effect over the crop growth and yield all over the world (Rauf and Sadaqat, 2008; Bibi *et al*., 2010). Furthermore, diminishing level of ground water table and boost in cost of energy affect the production of all crops in all cultivated areas. So, selection of drought tolerant genotypes is requirement of the plant breeders. The inequity water accessibility at different growth stages directly effects the crop yield because it agitate various plant physiological processes and phenotypic expressions (Kramer and Boyer, 1995; Miyashita *et al*., 2005; Bibi *et al*., 2010; Ali *et al*., 2011b, c) under water stress in sorghum. The average fodder production in Pakistan is less than the potential of 50 to 100 tons per hectare (Chaudhry *et al*., 2006). Sorghum perform better even under rainfed conditions and is significantly correlated with plant height (Habyarimana *et al*., 2004). Green fodder yield showed positive and significant correlation with plant height. This indicated that any selection based on this trait may be helpful for the improvement of forage sorghum. Higher genotypic and phenotypic variances were recorded for fodder yield and plant height that indicated additive gene action for these traits (Godbharle *et al*., 2010). Improvement in green sorghum fodder yield depends upon the nature and degree of heritability, genetic variability and genetic advance in the base population (Mahajan *et al*., 2011, Ali *et al*. 2011, e,f). A positive genotypic correlation between two desirable traits makes it easy to improve both the traits under consideration at once (Khairwal *et al*., 1999, Ali *et al*., 2011a, d). The present study was conducted to evaluate the significance of genetic correlation among

various quality traits in Sorghum-Sudangrass hybrids under water stress conditions.

MATERIALS & METHODS

Genetic material used was already developed through screening against water stress (Bibi *et al.,* 2010a; Bibi *et al.,* 2010b). Parental materials were crossed in line x tester fashion (10 x 5) to develop 50 F_1 hybrids. These hybrids along with parental genotypes were evaluated under normal and water deficit conditions for different forage yield and quality parameters along with local varieties. Genetic analysis and correlation were performed to check the worth of developed genetic material. 10 Seeds of each parents and F_1 hybrids were grown in research field keeping plant to plant and row to row distances of 15cm and 75cm, respectively. The experiment was laid out in a randomized complete block design with three replications under normal as well as under water stress. At the emergence of heads five plants of each genotype were marked randomly in each replication and data recorded for the following plant traits.

PH (cm)

Plant height was recorded from ground level to the last node of the randomly marked plant with the help of a meter rod graded in centimeters. Mean of five observations of each genotype in each replication was calculated separately from normal and water stress trail.

NOL^{-P}: The total number of leaves per plant (NOL^{-P}**)** were counted from each marked plant from each genotype in each replication and mean number of leaves per plant of one genotype in one replication was calculated separately from normal and water stress trial.

NOT^{-P}: The total number of tillers per plant (NOT^{-P}) were counted from each marked plant in each genotype in each replication and mean number of tillers per plant of one genotype in one replication was calculated separately from normal and water stress trial.

LA (cm^2): Leaf area of randomly selected five plants was measured with the help of measuring tape in centimeters by taking the width of leaf blade from three different places, tip, mid and base. While the length of the leaf was taken from base to tip and then leaf area was recorded separately from normal and water stress trial by using the following formula

Leaf Area = Average of the Leaf width x Leaf length

GFY (kg/2m): To determine the green forage yield, two meter row of each genotype in each replication was harvested and fresh weight of the forage was recorded with the help of a weighing balance separately from normal and water stress trial.

Evaluation for forage quality components

The fresh plant samples of the parents, hybrids and local varieties were collected from each replication and data recorded for the forage quality parameters. The plant samples were chopped and mixed thoroughly and ground to fine powder and divided into three groups for estimations of the following quality components by using proximate analysis (Bibi *et al.,* 2012).

Sugar Contents (%)

Syrup was extracted from randomly marked five plants from each replication and their brix value was calculated with the help of brix refractometer (Bibi *et al.,* 2012). Then average value was calculated separately from normal and stress treatment.

Crude Protein (%)

Crude protein contents were determined thorough Kjeldahl method following the formula (Bibi *et al*., 2012).

*Crude Protein %=100*6.25 {(ml N/10 H_2SO_4 neutralized by NH_3 x 0.0014 x Total diluted volume) / (Weight of sample x ml of dil. digested material distilled)}*

Nitrogen Free Extract (NFE)

The nitrogen free extract, was determined by difference formula (Bibi *et al*., 2012).

NFE %= 100 - (% crude protein + % ether extract + % crude fibre + % ash)

Crude Fibre (%)

Crude fibre contents were determined with the help of following formula (Bibi *et al.,* 2012)

Crude fibre % =100{(Weight of dried residue – weight of ash)/Weight of moisture free sample}

Ether Extract (%)

Ether extract % = 100 (Weight of residue / Weight of the sample)

Total Ash (%)

The mineral elements were determined by burning off the organic matter and weighing the residue (Bibi *et al.,* 2012)

Ash % = 100 (Weight of ash / Weight of sample)

RESULTS & DISCUSSION

Correlation among forage yield components

Correlation studies increases the possibility of indirect selection for different traits. This provides information to the breeder about importance of any trait. Results pertaining to correlations among various forage yield components are presented in the Table 1 under normal and water stress conditions. Green forage yield had positive correlation with all forage yield components i.e. plant height, number of leaves per plant, number of tillers per plant and leaf area under both normal and water stress conditions. Green forage yield was positively and significantly correlated with NOL^{-P}, and NOT^{-P} under normal as well as water stress conditions. Positive and significant correlation of green forage yield with forage yield components has also been reported by Jayamani and Dorairaj (1993); Mohammad *et al*. (1993); Manickam and Das (1994); Desai *et al*. (1999); Anup and Vijaykumar (2000); Chand, (2000); Yadav *et al*. (2003); Sinde *et al*., 2012; Tariq *et al*. (2012) and Amare *et al*. (2015). Plant height (PH) was positively correlated with NOT^{-P} and LA under both conditions, while PH was negatively correlated with NOL^{-P} under water stress conditions. Number of leaves per plant was positively correlated with all yield traits under both environmental conditions but it had significant and positive correlation with GFY under normal and LA and GFY in stress conditions. Laynar *et al*. (2010) also reported positive and significant correlation of PH on GFY. Number of tillers per plant had significant and positive correlation with PH and GFY under both conditions. Leaf area had significant positive correlation with PH under normal whereas under stress conditions, it is positively correlated with PH and NOT-P. Yadav *et al*. (2003) and Ali *et al*. (2011c, d, e) and Tariq *et al*. (2012) also reported positive and significant correlation of plant height with leaf area.

TABLE 1. Correlation coefficients among forage yield components under normal as well as water stress (Upper diagonal for normal and lower for water stress)

	Plant Height	Number of leaves per plant	Number of tillers per plant	Leaf area	Green forage yield
Plant Height	1	0.163	0.383**	0.383**	0.204
Number of leaves per plant	-0.021	1	0.220	0.155	0.481**
Number of tillers per plant	0.274**	0.076	1	0.004	0.390**
Leaf area	0.296**	0.312**	-0.092	1	0.107
Green forage Yield	0.221	0.287**	0.505**	0.149	1

Correlation among forage quality components

Table 2 revealed correlations among various forage quality components under normal as well as under water stress conditions. Sugar content (SC) had positive and significant correlation with CP, EE and TA and negatively correlated with NFE under normal environmental conditions while it had positive and significant correlation with CP and TA and negatively correlated with CF, NFE and EE under water stress conditions. Crude protein was positively correlated with EE and TA under normal conditions while under water stress it was positively correlated with only TA. Nitrogen free extract had negative correlation with all other quality components (SC, CP, CF, EE and TA) under normal conditions, and all quality components except EE under water stress conditions. Crude fibre was negatively correlated with SC, CP and NFE under water stress conditions whereas it was positively correlated with all quality components under normal environmental conditions except NFE.

TABLE 2. Correlation coefficients among forage quality components under normal as well as water stress (Upper diagonal for normal and lower for water stress)

	Sugar Content	Crude Protein	Crude Fibre	Nitrogen free extract	Ether Extract	Total Ash
Sugar Content	1	0.648**	0.190	-0.679**	0.647**	0.776**
Crude Protein	0.684**	1	0.108	-0.659**	0.508**	0.507**
Crude Fibre	-0.026	-0.087	1	-0.745**	0.200	0.182
Nitrogen free extract	-0.435**	-0.625**	-0.793**	1	-0.597**	-0.52**
Ether Extract	-0.088	0.086	0.100	0.174	1	-0.697**
Total Ash	0.642**	0.538**	0.003	-0.501**	0.069	1

Correlation between forage yield components and forage quality components

Table 3 and Table 4 showed the correlation between forage yield and quality components under normal as well as water stress conditions respectively. Table 3 shows that PH was negatively correlated with all quality components except CF and TA. While NOL-P had positive correlation with all forage quality components except NFE under normal conditions. Similarly NOT-P had positive and significant correlation with NFE while negative correlation with all other components. Leaf area had significant positive correlation with SC and TA whereas significantly negative correlation with NFE. Green forage yield had positive correlation with all quality components. So increase in green forage yield will increase the quality of the forage.

TABLE 3. Correlation coefficients among forage quality and yield components under normal conditions

	Sugar Content	Crude Protein	Crude fibre	Nitrogen free extract	Ether extract	Total Ash
Plant height	-0.004	-0.274**	0.199	-0.056	-0.001	0.103
Number of leaves per plant	0.04	0.021	0.179	-0.208	0.156	0.225
Number of tillers per plant	-0.61**	-0.648**	0.179	0.484**	-0.458**	-0.368**
Leaf area	0.365**	0.101	0.154	-0.264*	0.199	0.333**
Green forage yield	0.067	0.039	0.052	-0.125	0.194	0.188

Table 4 showed positive correlation of plant height with crude fibre. Mohammad *et al*., (1993) also concluded that PH had positive correlation with CF. Plant height had negative correlation with SC and NFE. Number of leaves per plant had negative correlation with SC, CF and NFE. While under water stress conditions, NOT-P was negatively correlated with SC, CP and TA. Leaf area had negative correlation with NFE while all other remaining components like CP, CF, EE and TA had positive correlation with LA under water stress conditions. Green forage yield had negative correlation with SC, CP and TA under stress conditions. Similar results were observed by Viana *et al*. (1990) who reported that crude protein and crude fibre were not affected by PH. Maiti *et al*., (1995) reported ash content was not correlated with any morphological trait. Crude protein content significantly negatively correlated with LA. Fibre content had negative correlation with number of leaves. Anup and Vijaykumar (2000) reported positive correlation of green forage yield with crude protein.

TABLE 4. Correlation coefficients among forage quality and yield components under water stress conditions

	Sugar content	Crude Protein	Crude fiber	Nitrogen free extract	Ether Extract	Total Ash
Plant height	-0.10	0.06	0.42**	-0.35**	0.23	0.18
Number of leaves per plant	-0.08	0.17	-0.06	-0.05	0.32**	0.03
Number of tillers per plant	-0.62**	-0.56**	0.01	0.33**	0.32**	-0.45**
Leaf area	0.15	0.38**	0.39**	-0.52**	0.16	0.22
Green forage yield	-0.24	-0.16	0.02	0.060	0.32**	-0.28*

CONCLUSION

Water stress predominately affects green fodder yield and also had negative impacts on its quality parameters. Correlation studies provide information about the importance of different traits for direct and indirect selection. All forage yield components had positive correlation with green forage yield under both conditions so the indirect selection of forage yield components may prove to be helpful in increasing the green forage yield of the crop. Forage quality components showed different correlation coefficients under water stress and normal conditions. Green forage yield had positive correlation with all quality components so increase in the forage yield may improve the quality of forage. Under water stress the indirect selection of traits like sugar content crude protein and total ash will had negative effect on green forage yield.

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