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COMPARISON OF SORGHUM GENOTYPES FOR FORAGE PRODUCTION AND QUALITY

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ABSTRACT

In the present study seven locally available advance lines of sorghum were investigated for their performance in term of forage material and nutritional profile of dry matter. The genotypes Hegari, Noor, F-214, JS-2002, F-207, PC-1 and F-9917 were compared in randomized complete block design. The significant variations in fresh and dry forage material as well as their nutritional values were noted among the genotypes. The genotype Hegari was the best performer for forage material and next to follow was Noor. The genotypes Hegari produced dry matter (22.53 t ha^{-1}) with crude protein (8.29 %) and ash contents (9.60). Furthermore, its dry matter has the lowest value for crude fibre. The higher values produced by Hegari for more dry matter and nutritive values can be attributed to higher leaf area. The genotypes F-214 and F-9917 had been very poor for crude protein and ash contents, respectively. The genotype F-9917 must not be recommended for forage purposes due to its lower ash and higher crude fibre contents in dry matter. Taking a better variety in respect to dry matter and nutritional contents, the Hegari should be preferred over the tested varieties for forage purpose.

Key words: Genotypes, Forage potential, Nutritional value.

INTRODUCTION

The forage crops are the cheapest source of animals feed and therefore, taken as foundation of livestock industry throughout the world. The demand for livestock products is continuously rising due to their most frequent use in human diets. Besides, that it also seems to re-emergence of animals for draught power especially for small farmers due to sky touching prices of fuel. The share of livestock in GDP of Asian and Pacific countries is increasing (ESCAP, 2008) whereas feed resources are not enough to satisfy the projected livestock population. The reduction in area under fodder crops and rangelands as well as cultivation of forage crops on marginal lands are principle factors responsible for forage shortage. It has been estimated that need for forage crops will increase two to three fold in Asian countries upto 2050 (Devendra and Leng, 2011). Therefore, it is imperative to combine all approaches including the genetic improvement, use of better agronomic practices, forage preservation and efficient resource utilization to ensure substantial amount of fodder to growing population of livestock.

The urbanization, ecological pressure and rising prices of basic inputs compel the breeders to introduce new varieties having ability to produce more with available resources. The use of varieties with higher productivity potential and ideal nutritional values, on one hand will make the livestock industry more profitable and on other hand ensure the availability of livestock products at low prices to the consumers. As sorghum can perform the best at higher temperature and dry land ecologies, it serves as to provide substantial amount of fodder of outstanding quality during summer season. It produce a tonnage of dry matter having digestible nutrients (50 %), crude protein (8 %), fat (2.5 %) and nitrogen free extracts (45 %) (Azam *et al*., 2010). It can be used fresh as well as can be stored in form of silage and hay for future use.

As a result of crop improvement programme, a number of promising strains of plants with diversified morphological and quality traits are available for general cultivation (Hussain *et al*., 1995). The changes in genetic material of crops resulted wide variations in the morphological and forage quality traits (Bukhsh *et. al.*, 2010 and Ullah *et al.*, 2007). The interaction between genotype and environment has been an important factor while selecting the variety for the area (Nawaz *et al.*, 2004) and it might be the basic reason for great variability of outcome of same variety in various growing conditions (Kamal and Tariq, 1995; Mohammed and Mohamed, 2009). Therefore, genetic improvement of crop is basically aimed to enable the crop to survive in vagary of environmental conditions. The planned study was conducted with the objective to refine the available genetic material of sorghum for forage production and quality under given agro climatic conditions.

MATERIALS AND METHODS

The experiment was conducted under irrigated conditions of Faisalabad at Agronomic Research Farm, University of Agriculture, Faisalabad (31^0.40" N, 73^0.11"

E) during the year 2008. The soil of the experimental site was medium sandy loam and calcareous with pH (7.5), Ec (1.27 dsim^{-1}) and O.M (0.73 %). The soil was twice cross ploughed with cultivator upto 30 cm depth and was leveled to ensure uniform distribution of irrigation water over the field. For entire period of growth, 13 acre inches irrigation water was used. The rouni irrigation consumed 4 acre inches water, while the remaining three irrigations were applied with 3 acre inches at germination completion (20 DAS), seedling elongation stage (40 DAS) and heading stage (60 DAS). The seven sorghum genotypes (Hegari, Noor, F-214, JS-2002, F-207, PC-1 and F-9917) were compared for forage yield and selected quality traits in Randomized Complete Block Design (RCBD). The seeds were sown during first week of June in 30 cm apart rows with single row hand drill. The total plot size was 10.8 m^2 (1.8m x 6 m). The seed rate used was 80 kg ha^{-1}. The phosphorus and nitrogen was applied at the rate of 58 and 80 kg ha^{-1} in form of urea and single super phosphate, respectively. All the recommended dose of phosphorus and half of nitrogen were broadcasted at time of seed bed preparation and remaining half of nitrogen was top dressed with second irrigation. All the other agronomic practices like sowing time and methods, irrigation, nutrient and weed management etc. were kept normal and uniform for all the plots. The weeds were manually controlled after first irrigation by using sickle. The morphological traits like plant density (m^{-2}), plant height (cm), stem diameter (cm), no. of leaves and leaf area per plant (cm^{-2}), fresh and dry matter yield (t ha^{-1}) were recorded at 50 % flowering. Whereas, the forage quality was determined by the crude protein, crude fibre and ash contents in dry matter. The crop was manually harvested above ground level at 70 days after sowing with sickle. The plant height, stem diameter, leaf area and no. of leaves per plant were counted by taking ten plots randomly from individual plot. The plant density was measured by selecting two rows, each having one meter length at three different places from each plot and was converted to no. of plants per unit area (1m^2). The plant height of ten randomly selected plants was measured with the help of measuring tape right from base to the highest leaf tip. The stem diameter was recorded at base, middle and top portion of plants with vernier caliper and then average was calculated. For the leaf area measurement, whole leaves of selected plants were removed and weighed. The sub sample of 5 g leaves were used for leaf area measurement and then were converted to leaf area per plant by unity method. The leaf area was calculated using leaf area meter model LI-3000. The forage yield was recorded by measuring the weight of total mass of individual plot and was then converted on hectare basis. The dry matter yield was recorded by the dry matter % age of the respective plot by using formula suggested by Herrera (2006).

Dry matter yield=(Fresh forage yield x % Dry matter)/100

The samples from chopped fodder were oven dried at 72 ^{0}C for 48 hours to determine the dry matter % age. The small portion of dry matter was well grinded and preserved in polythene bags for further quality analysis. The nutritional components of forage material like crude protein, crude fibre and ash contents were determined by using procedures recommended by AOAC (1990). The nutritional value of dry matter was determined in analytical lab of Department of Agronomy, University of Agriculture, Faisalabad. The data recorded on various morphological, yield and quality parameters was statistically analyzed by Fischer' s analysis of variance techniques and the significance of treatment means were evaluated by using LSD test at 0.05 % probability level (Steel *et al*., 1997).

Average daily weather data

Period	Temperature (^{0}C)	Relative Humidity (%)	Rainfall (mm)
01-15th June	33.73	40.66	0.86
15-30th June	33.06	55.33	1.91
01-15th July	32.08	55.93	2.16
15-31st July	33.61	50.18	3.07
01-15th August	29.85	70.40	12.85

Source: Agricultural metrological cell, Department of Crop Physiology, University of Agriculture, Faisalabad

RESULTS AND DISCUSSION

Morphological and yield traits: The analysis of variance showed that differences among selected genotypes were significant for agronomic traits, fresh forage and dry matter yield (Table 1). The highest mean value for plant density was observed for PC-1 and it was followed by F-214. However, the values recorded for plant density of genotype F-207 and F-214 were statistically at par. The highest value for plant density of PC-1 may be due to its lower 1000 grains weight, thus more number of seeds dropped in unit area. The minimum plant density was recorded for F-9917 but it did not differ significantly from JS-2002. The significant differences among genotypes for plant density suggested that seeds of genotypes have different seed viability and weight of individual seed. Our findings are comparable to those of Naeem *et al*. (2004) and Kainth *et al*. (2004) where a significant variation among sorghum cultivars were documented for plant density.

The plant height is an important morphological trait of crop plant and mostly shows the relative vigor and growth of the crop. The maximum figure for plant height (257.83 cm) was recorded for F-214 but it did not differ significantly with Hegari, Noor and PC-1. The genotype F-207 produced the shortest plants. The differences among genotype F-9917, JS-2002 and F-207 were not significant for plant height. The earlier studies conducted by Nabi *et al*. (2006) and Ayub *et al.,* (2010) for sorghum cultivars also supported our findings for plant height.

The data presented in table 1 also reveals that genotypes have significant effect on stem thickness. The maximum stem thickness (1.16 cm) was recorded in JS-2002 whereas F-214 and F-207 produced the lowest stem diameter but statistically similar to stem thickness of PC-1. Our results for stem diameter has also been confirmed by the findings of Nabi *et al.* (2006) and Naeem *et al.* (2002) where a range of stem diameter was observed for cultivars.

The genotype Noor registered the highest value (14.17) for number of leaves per plant but it did not differ significantly from Hegari, JS-2002 and F-9917. The variety F-207 produced the lowest number of leaves per plant but it did not differ significantly from F-214 and PC-1. The lowest no. of leaves per plant of genotype F-207 is the result of its lowest plant height (table 1). The significant difference among sorghum cultivars has also been previously reported by Naeem *et al*. (2002) and Nabi *et al*. (2006) which probably due to genetic make of genotypes under investigation.

The substantial differences among sorghum genotypes had also been observed for leaf area per plant (Table 1). The leaf area is function of leaf number per plant and leaf area of individual leaf. It is clear from the data that leaf area per plant is particularly affected by leaf expansion. The genotype Hegari proved to be superior over tested varieties for leaf area per plant and its leaf area was 2939 cm^2 per plant. Therefore, the genotype Hegari seems to be leafier and it can also be estimated its dry matter should have higher nutritional value. All the tested genotypes did not produced significantly different values for leaf area per plant except Hegari. The lowest value for leaf area per plant was observed in variety PC-1. The comparison made by Naeem *et al*. (2002) and Kainth *et al.* (2004) also reported significant variations among sorghum genotypes for leaf area per plant.

The genotypes performance for fresh forage material is presented in table 1. It is quite obvious that genotype Hegari was the best producer of fresh forage (69.39 t ha^{-1}) among the other genotypes. However, the variety Hegari could not produce statistically higher value for fresh forage material over the genotype Noor which produced 62.48 tons fresh forage. The higher forage production by Hegari can be attributed toward its taller plants with more leaves per plant. The yield differences among the genotypes might be result of significant variations in their respective morphological attributes. The significant differences in green forage yield among sorghum cultivars have also been undertaken by Naeem *et al.* (2002) and Chughtai *et al*. (2007).

As for as dry matter production is concerned, the genotype Hegari ranking first among the selected genotypes. The dry matter yield produced by the variety Hegari (22.53 t ha^{-1}) remained statistically at par with those obtained from F-207 and PC-1. The absence of significant differences among genotypes Hegari, F-207 and PC-1 suggested relatively higher dry matter contents in F-207 and PC-1. The performance of variety JS-2002 regarding dry matter production was poor and its dry matter yield did not vary significantly from F-214 and F-9917. The significant variations among sorghum genotypes for dry matter production have already been reported in studies conducted by Yousef *et al*. (2009), Palta and Karadavut, (2011) and Panwar *et al.* (2000) for maize genotypes.

Quality parameters: The crude protein contents in dry matter are of utmost importance in forage crop as it determines the palatability and digestibility of forage crops. The data presented in table 2 showed that likewise higher fresh and dry matter yield the genotype Hegari exhibited the highest value (8.29 %) for crude protein. It was followed by JS-2002 which produced 7.46 % crude protein. The genotype F-214 proved to be the lowest in crude protein than other genotypes. The significant differences among the genotypes can be attributed to the variation their respective leaf to stem ratio (data not given). The higher protein contents in dry matter ultimately will result higher protein yield on unit area. The significant differences in crude protein contents in dry matter of various genotypes have also been confirmed by Nabi *et al*. (2006), Filho *et al*. (2004) and Tauqir *et al*. (2009). The difference among genotype may be due to relative contribution of leaves to total biomass and concentration of protein in dry matter.

The crude fibre in forage material has adverse effect on forage quality as it affects the digestibility. The data presented in table 2 showed that dry matter obtained from genotype F-9917 had the highest figure (31.50 %) for crude fibre than all other. The genotype F-207 was second most important variety for higher crude fibre after F-9917. Whereas, the lowest value for crude fibre contents were recorded in dry matter produced by Hegari and therefore, forage obtained by Hegari is taken as good quality forage. The significant differences sorghum among genotypes has already been confirmed by studies conducted by Mahmud *et al*. (2003) and Nabi *et al*. (2006).

The data presenting the ash contents showed that genotypes exhibited significant variations for ash contents (Table 1). The genotype Hegari proved to be superior having 9.60 % ash contents over all tested genotypes and it was followed by F-207. The ash contents in dry matter produced by JS-2002 were statistically at par with F-207. Similarly, the genotypes Noor and PC-1 did not differed significantly for ash contents. The dry matter obtained from genotype F-9917 exhibited the lowest ash contents. The significant variations in ash contents among tested genotypes suggested differences in nutrient absorption from soil and utilization within the plants. The results are consistent with those of Nabi *et al*. (2006) and Ayub *et al*. (2010).

Conclusion: The genetic variations in genotypes induced significant changes in morphological and yield traits. The data also suggested that new genotypes have potential to serve the forage purposes. Under the light of present study, the genotypes Hegari is recommended for approval for general cultivation as it has better performance for fresh and dry matter yield. Furthermore, the variety Hegari appears to be leafier and therefore its dry matter has the best nutritional value. The future research should consider the growth period and optimum time of sowing of individual genotype to ensure the green forage material during the entire summer season.

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Table 1: Comparison of sorghum varieties for morphological traits, fresh and dry matter yield

Variety	Plant density (m^{-2})	Plant height (cm)	Stem diameter (cm)	No. of leaves ($plant^{-1}$)	Leaf area (cm^2 $plant^{-1}$)	Forage yield ($t\ ha^{-1}$)	Dry matter yield ($t\ ha^{-1}$)
Hegari	42.11 bc	257.80 a	1.02 b	13.53 abc	2939 a	69.39 a	22.53 a
Noor	34.00 cd	257.30 abc	0.98b c	14.17 a	2210 ab	62.48 ab	17.89 b
F-214	49.00 ab	257.83 a	0.85 d	12.17 cd	1744 b	45.99 d	15.9 bc
JS-2002	25.11 d	256.67 bcd	1.16 a	13.27 abc	2197 ab	49.38 cd	12.61 c
F-207	45.55 abc	256.23 d	0.85 d	11.70 d	2284 ab	55.71 bc	18.12 ab
PC-1	56.33 a	257.60 ab	0.87 cd	12.77 bcd	1687 b	47.28 d	19.07 ab
F-9917	24.78 d	256.60 cd	1.03 b	14.00 ab	1985 ab	51.65 cd	14.83 bc
LSD value	**13.04**	**0.9869**	**0.1258**	**1.381**	**1182**	**7.781**	**4.586**

The mean values in columns represented by lower case letters are significantly different at 0.05 % probability level.

Table 2: The proportion of crude fibre, crude protein and ash % age in dry matter of sorghum varieties

Variety	Crude protein (% age)	Crude fibre (% age)	Ash (% age)
Hegari	8.29 a	29.05 g	9.60 a
Noor	7.05 d	29.91 e	8.42 d
F-214	6.62 g	30.63 c	8.83 c
JS-2002	7.46 b	29.25 f	9.31 b
F-207	6.91 e	30.79 b	9.35 b
PC-1	6.86 f	30.22 d	8.30 d
F-9917	7.13 c	31.50 a	7.83 e
LSD value	**0.0563**	**0.0796**	**0.1488**

The mean values in columns represented by lower case letters are significantly different at 0.05 % probability level

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