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Evaluation for Morphological and Biochemical Traits Related to Quality Biomass Production among MS Based Forage Sorghum Hybrids

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ABSTRACT

Livestock is a major component of Indian agriculture. With the increase in livestock population during past few years there is huge gap in demand and supply of green as well as dry fodder, hence forage crops improvement programme needs to be strengthened. Keeping this in view hybrid evaluation experiments were conducted during *kharif* 2013 and 2014 at Research area of forage farm at CCS HAU, Hisar and material was sown in randomized block design to estimate overall performance of hybrids for two successive years. Fifteen MS based hybrids were developed for two successive years and then evaluated for two years for various agronomic traits that affect the biomass production directly or indirectly. Out of these hybrids HH 602, HH 561, HH 529 and HH 619 showed higher green and dry fodder yield for two successive years as compared to best check SSG 59-3 (*GFY: 737.6* q/ha and DFY: 137.7 *q/ha*). As far as their quality is concerned they have low HCN than toxic limit (200 micro g/g) crude protein more than 8% and *in vitro dry matter digestibility* more than 50% in HH 529 and HH 619. Thus, on the basis of this evaluation programme we can say that these hybrids are promising for green fodder productivity. They may also help to fill the gap between demand and supply of green as well as dry fodder for livestock industry.

Keywords: Sorghum, biomass, hybrid, quality and fodder.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is the gifted genera of the tropical regions that provide food, feed, stover (dry straw) and fuel to millions of poor farmer families and their livestock's (Shinde *et al.,* 2015) Single-cut and multi-cut sorghum varieties/ hybrids are also cultivated for green fodder (forage). Sorghum has a wider range of adaptability and is more widely grown. Forage sorghum hybrids are commonly grown in areas where rainfall is insufficient for corn (*Zea mays* (L.) production and may be utilized as silage, greenchop, pasture, dry hay or fodder (Dhalberg *et al.,* 2011).

India is predominantly an agricultural country and has the largest livestock population in the world. Livestock sector plays a critical role in livelihood security and the welfare of India's rural population. It contributes 9 % to GDP and employs 8% of the labour force. This sector is emerging as an important growth leverage of the Indian economy. It is sub-sector of agriculture which adds almost 32% of agriculture output in India. India supports 20% of the livestock population of the world on 2.3% geographical area only. The country face a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% feeds (Vision 2030, IGFRI). There is a large gap between requirement and availability of feed at the national level. It is matter of prime concern to bridge this gap. Most of the deficient regions lie in the arid and semi-arid agro-ecological zones.

Animal feed is the most crucial input in livestock production. Empirical studies in India have shown that enhancing quality and quantity of feed input has greater impact than breed improvement on increasing milk productivity (Gaddi & Kunal, 1996). Although India is the highest milk producer country but per capita milk production is very low due to the huge deficit in the availability of feed stuffs. This is also to note that area under forage production has not increased considerably in the last few decades and our natural grazing lands and pastures are fast degrading and decreasing. Hence, efforts should be directed to intensify forage production per unit area per unit time, which can be achieved through improved high yielding varieties/hybrids and better management practices. Sorghum has a significant role in livestock production, particularly in tropical zone where feed stuffs could not meet animal requirements due to many factors such as poor soil fertility and drought (Pholsen & Suksri, 2007).

Along with this forage quality is paramount to palatability or acceptability and animal intake. Plant morphology, anatomical components, digestibility, protein, mineral, cellulose and lignin contents, and anti-nutritional factors like hydrocyanic acid in sorghum determine animal performance like milk and meat production, (Hanna 1993). Lignin concentrations in brown-midrib (bmr) mutants are consistently lower than their normal counterparts in sorghum (by 21.8%). The *in vitro digestibility* of bmr sorghum (642 g kg^{-1} dry matter) was higher than the normal genotypes of sorghum (568 g kg^{-1} dry matter) (Cherney *et al.,* 1988).

To realizing forage potential of sorghum there is an urgent need to develop multi-cut, intra-specific, single-cross, forage hybrids. These hybrids provide a better alternative to forage varieties grown during the summer and kharif season. So, present study was planned with the object to screen no. of hybrids for various morphological and biochemical parameters that determines forage yield and quality.

Materials and Methods

Hybrid evaluation experiments were conducted during *kharif* 2013 and 2014 at Research area of forage farm at CCS HAU, Hisar. Research material consisted of fifteen forage sorghum hybrids and check SSG 59-3 (a multicut variety) was sown in randomized block design to estimate overall performance of hybrids for two successive years. Fifteen MS based hybrids have been developed for two successive years and then evaluated for two years for various agronomic traits that affect the biomass production directly or indirectly.

Hisar is located at 29.09°N 75.43°E in western Haryana. Hisar has very hot summers and relatively cool winters. The maximum day temperature during the summer varies between 40 to 46°C. Relative humidity varies from 5 to 100 per cent. The average annual rainfall is around 350 mm most of which occurs during the months of July and August. Meteorological data of both the years during growing period was given in Table 1. The hybrid evaluation trial was sown in randomized block design having plot size 20$m^2$with row to row and plant to plant spacing 45cm and 30 cm, respectively for evaluating them along with check for various yields and forage quality related traits. Data were recorded on five randomly chosen plants for early vigor, TSS%, regeneration potential, plant height, number of tillers per plant, green (GFY) and dry fodder yield (DFY) after 1st and 2nd cut. First cut was taken after 60 days and then 2nd cut was taken after 45 days. For DFY, 500 g of green fodder was dried and then weighed to calculate DFY q/ha. For quality estimation samples of green fodder harvested from the field then heads were cut from the stalks and 500 g sample was weighed, and was dried to constant weight at 60 ºC for dry matter determination. Then dried sample was passed through a small chopper, mixed thoroughly, and sampled for dry matter determination and laboratory analyses. HCN µg/100g was estimated on fresh wt. basis by Gilchrist *et al.*, 1967 method, crude protein (% N X 6.25) was estimated via modified Kjeldahl *et al.*, 1883 procedure and IVDMD% was determined by the two-stage technique of Tilley and Terry, 1963 and expressed as a percentage. Data collected over the 2 years were subjected to analysis of variance, GCV, PCV, heritability and simple correlations using the appropriate software.

Results and Discussion

The means and ranges for all fodder yield and quality traits, plus the level of significance for the 16 sorghum genotypes studied, are reported in Table 2. Highly significant (P<0.001) differences among genotypes were ob-served for early vigor, TSS%, regeneration potential, plant height, number of tillers per plant, green (GFY) and dry fodder yield (DFY) after 1st and 2nd cut for both seasons. This indicates the prevalence of enough genetic variability in the material under study for selection and improvement of genotypes for biomass production. It also shows its suitability for further statistical analysis for all the characters under study. Among all hybrids HH 530, HH 561 had shown more plant height as compared to check SSG 59-3. All the hybrids under study had shown good early vigor except HH 520 having early vigor score only one. HH 602 and HH 551 had shown good regeneration potential. Maximum no. of tillers per plant was observed in HH 676 and HH 561. In all the hybrids HCN content was below 200 µg/100g on fresh wt. basis (toxic limit is 200 µg/100g). Crude protein range from 6.9 (HH 520) to 9.8% (HH 619) and IVDMD % was from 39.9 (HH 539) to 55.6 (HH 619).

Similar results of outperformance of hybrids as compared to local checks and the commercial hybrids for forage yield were reported by (Mohammad *et al.,* 2012) although some morphological traits like number of tillers/plant, leaf length, leaf breadth, stem girth and number of leaves/plant all hybrids have almost equivalent to the checks. Pothisoong & Jaisil 2011 had evaluated twenty sweet sorghum F_1 hybrids for yield potential, heterosis and ethanol production and observed significant improvement for all traits in hybrids as compared to their parents. Akabri *et al.,* 2012; Goyal *et al.,* 2013 developed two hybrids Surat-1 x C-10-2, Surat-4 x UP Chari and 94002A x RSSV-9 and NSS1007A x Ramkel respectively showing high green fodder yield over commercial cultivars and checks. Pahuja *et al.,* 2014 observed outperformance of hybrids as compared to local checks in forage yield for all traits like number of tillers/plant, leaf length, leaf breadth, stem girth and number of leaves/plant. They had reported that hybrid 56A X COFS29 was unique in achieving high forage yield and choice of parents involved in hybrid production, especially female parent used should have good combining ability for forage yield.

In order to get enhanced performance of animals, the quality of fodder being fed to them is of utmost importance. The main quality attributes in forage sorghum are protein, IVDMD, NDF, ADF and toxic substances like HCN and tannin. Out of these proteins, IVDMD and toxic substances are most important. Like other straws, the nutritive value of sorghum fodder is also low due to presence of high content of above mentioned cell wall constituents as well as lignin and low content of protein and minerals. Crude protein (CP) content is often considered a good determinant of quality. Good quality forage generally will have higher protein content. Average 20% of crude protein is unavailable to ruminants due to tannin. Goal in breeding programme is to improve CP more than 9 %. IVDMD (*in vitro dry matter digestibility*) is a measure of plant quality index. Findings of present investigation is in close conformation with the findings of Grewal *et al.,* 1996 who revealed that protein and IVDMD varied from 3.01 to 8.75 and 40.40 to 66.16 %, respectively. Kumar *et al.,* 2011 reported that protein content in single cut (SC) and multicut (MC) genotypes ranged from 5.24 to 10.06 and 4.81 to12.47 per cent, respectively. Range, genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (h^2bs) and genetic advance as percent of mean have been presented in Table 2.

Information on the nature and magnitude of genetic variability is of immense importance for initiating any breeding programme, because presence of considerable variability in the base material ensures better chances of evolving desired plant types. The estimates of PCV, GCV, heritability and genetic advance as per cent of mean are useful in determining the method of selection to improve a particular population for a specific trait. It is clear from Tables 1 that it was always not necessary for high heritability to be associated with high genetic advance. The genetic constants for the characters revealed that the magnitude of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the traits denoting environmental factors influencing their expression to some degree or other. Wide difference between PCV and GCV implied their susceptibility to environmental fluctuation, whereas narrow difference suggested their relative resistance to environmental alteration. High magnitude of GCV and PCV suggested greater scope for selection of superior genotypes for these traits. In the material under study, wide range of variation, high coefficient of variation, heritability and genetic advance as per cent of mean were recorded for early vigor, no. of tillers per plant, regeneration potential, dry fodder yield, green fodder yield, and HCN. It may be due to the presence of additive gene action for these characters and hence, simple selection would be the most appropriate breeding method for their improvement. Similar results were also reported by Jain *et al.,* (2009) for number of leaves per plant, green fodder yield and dry fodder yield. Our results are in agreement with findings of Kumar & Sahib (2003) and Bello *et al.,* (2007). Tariq *et al.,* (2012) studied 25 sorghum genotypes and found high GCV and PCV for green fodder yield whereas our result are contrary to this in respect of no. of tillers, green fodder yield, dry fodder yield and HCN had high heritability estimates along with high genetic advance. Traits like plant height, crude protein and IVDMD%, revealed high heritability associated low genetic advance as percent of mean. This may be due to presence of both additive as well as non additive type of gene action. Similarly Saini & Paroda (1975) reported high heritability for protein and medium heritability for IVDMD.

Most of the agronomic traits evaluated in this study showed positive and significant ($P<0.05$) correlation among themselves (Table 3). For instance, there was also a positive and significant correlation between number of tillers per plant and plant height (0.575), plant height and green fodder yield (0.657), green fodder yield and regeneration potential (0.549), green fodder yield and dry fodder yield (0.903), dry fodder yield and plant height (0.609) and IVDMD and CP was 0.707. The significant positive correlation among these traits suggests that these traits could be simultaneously improved without any compensatory negative effects. However, negative and significant correlation was observed among regeneration potential and IVDMD% (-0.554). The negative relationship between these traits suggests that they should be improved independently. Because forage sorghum breeding program should aim for improvement of important fodder quality traits, such as digestibility and protein content, in addition to forage yield. Similar results for the association of significant correlation between number of days to flowering, number of grains per panicle, number primary panicles, number of days to maturity, panicle weight and biological yield was reported by Nyadanu & Dikera (2014). Mahajan *et al*., 2011 and Millinath *et al*. 2004 also reported that days to 50% flowering, panicle length, plant height and number of grains/panicle were associated among themselves in sorghum.

Considering morphological characters, both green and dry fodder yield are equally important, however, we have evaluated hybrids thus we consider green fodder yield as important trait. Thus, in present investigation, path coefficient analysis was performed considering green fodder yield as dependent character. Residual effect calculated was 0.0938 (Table 4). This indicates that a considerable magnitude of variation was presented for association of green fodder yield with dependent traits. Path coefficient analysis was carried out among six variables including morphological and quality traits which revealed that plant height, dry fodder yield and CP% exhibited high positive and direct effect on green fodder yield. While number of tillers per plant had positive but indirect effect on green fodder yield *via* plant height.

Our results are similar to Iyanar and Khan (2005) who has found plant height had highest direct effect on green fodder yield followed by leaf breadth. Jadhav *et al.*, 2009 found only green fodder yield/plant had high direct contribution on dry fodder yield. Whereas, leaf length, leaf width, plant height and stem thickness had high positive indirect contribution on dry fodder yield through green fodder yield. Hence, the present investigation emphasized that male sterility based hybrids may help in formulation of breeding strategies for improvement of forage sorghum for the green as well as dry fodder yield along with quality traits viz., protein, digestibility and for low HCN. Thus efforts should, therefore, be directed at designing forage sorghum varieties/hybrids that tiller, grow tall and ensure multi-cuts. For that there is an urgent need to develop a multidisciplinary approach and multi-institutional alliances of crop scientists, chemical technologists, and animal health and nutrition experts having a major role in good quality forage research and cultivar development.

Table 1. Meteorological data during the growing periods.

Year and Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
2013	**Max**	**Min**	**Morning**	**Evening**	**Total**
July	36.1	26.9	83.4	61.8	147.7
August	33.4	25.7	89.2	70.2	299.7
September	34.3	23.8	84.8	54.7	144.4
2014					
July	37.64	27.7	71.4	50.6	49.9
August	36.5	26.2	78.7	50.2	1
September	34.9	23.7	83.0	50.7	81.5

Table 2. Overall mean, range, GCV, PCV, heritability and genetic advance as per cent of mean for different characters among MS based hybrids

S. No.	Variables	Mean	Range	Coefficient of variations (%)		Heritability (%)	Genetic advance as % of mean
				GCV	PCV		
1	Early Vigor	3.0	1.0-4.0	31.98	31.98	100	65.5
2	TSS	3.8	3.0-5.0	17.49	18.53	89	33.5
3	Regeneration	2.9	1.0-5.0	47.3	47.3	100	96.5
4	Plant Height (cm)	223.6	166.3-267.0	15.48	15.93	93.5	30.5
5	No. of tillers	3.5	2.0-5.8	36.64	40.67	78	67
6	Green fodder yield (q/ha)	649.8	400.0-879.5	20.49	20.56	98.5	41.5
7	Dry fodder yield (q/ha)	147.8	89.8-243.8	28.55	29.18	94.5	57
8	HCN	8.1	11.8-124.7	60.97	62.61	94	121.5
9	Crude protein%	47.8	6.9-9.8	11.43	12.53	82.5	21
10	IVDMD%	50.5	39.9-55.6	9.25	11.98	59	14

Table 3. Correlation coefficient analysis observed among various morphological traits among MS based hybrids

Variables	Early vigour	TSS%	Regeneration	Plant Height (cm)	No. of tillers	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Crude protein%	IVDMD %
IVDMD%									1
Crude protein%								1	0.707**
Dry fodder yield (q/ha)							1	0.437^{NS}	0.186^{NS}
Green fodder yield (q/ha)						1	0.903**	0.450^{NS}	0.110^{NS}
No. of tillers					1	0.411^{NS}	0.320^{NS}	0.233^{NS}	0.021^{NS}
Plant Height (cm)				1	0.575*	0.657**	0.609*	0.418^{NS}	0.365^{NS}
Regeneration			1	0.039^{NS}	0.149^{NS}	0.549*	0.302^{NS}	-0.113^{NS}	-0.554*
TSS %		1	-0.039^{NS}	0.758**	0.163^{NS}	0.402^{NS}	0.315^{NS}	0.370^{NS}	0.376^{NS}
Early vigour	1	0.146^{NS}	0.243^{NS}	0.217^{NS}	-0.003^{NS}	0.401^{NS}	0.366^{NS}	0.362^{NS}	0.151^{NS}

Table 4. Showing direct (In diagonal) and indirect effect among MS based hybrids for various morphological traits (Residual effect: 0.0938)

Variables	Plant Height (cm)	No. of tillers	Green fodder yield (q/ha)	Crude protein%	IVDMD%	Dry fodder yield (q/ha)
Plant Height (cm)	0.464	0.27687	0.00338	0.00338	0.20277	0.28556
No. of tillers	0.46366	-0.063	-0.01976	-0.01976	-0.01342	-0.021
Green fodder yield (q/ha)	-0.03753	-0.06285	1	0.24846	0.07369	0.0648
Crude protein%	0.00181	0.07813	0.24846	0.248	-0.32855	-0.0324
IVDMD%	-0.14369	-0.07016	-0.09744	-0.09744	-0.329	0.6094
Dry fodder yield (q/ha)	0.37532	0.20367	0.15893	0.15893	0.06009	0.609

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