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Pummy Kumari
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Satywan Arya
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Su Mon Thant
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Vinod Kumar
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Bajrang Lal Sharma
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Dalbir Singh Phogat
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Pummy Kumari
Forage Section, Department of Genetics and Plant Breeding, Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Assessment of quality biomass production potential of forage sorghum hybrids in semi-arid conditions of Haryana

Pummy Kumari, Satywan Arya, Su Mon Thant, Vinod Kumar, Bajrang Lal Sharma and Dalbir Singh Phogat

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Abstract
Sorghum being a C_4 crop has diverse uses as food, feed, fodder and fuel. But among *kharif* forages sorghum has great potential to provide quality forage and fodder for animal use. It is best suited in semi-arid regions due to its drought tolerance nature as compared to fodder maize. By keeping these points in consideration, we have planned an experiment to evaluate eleven CMS based forage sorghum hybrids for green and dry biomass potential along with their fodder quality along with two checks. The most productive hybrids among them were SHH 1836 (GFY: 673.5 and DFY: 161.2 q/ha); SHH 1911 (GFY: 645.0 and DFY: 159.0 q/ha); SHH 1903 (GFY: 642.0 and DFY: 159.3 q/ha); SHH 1812 (GFY: 631.5 and DFY: 154.6 q/ha); SHH 1513 (GFY: 627.3 and DFY: 153.3 q/ha) and SHH 1916 (GFY: 624.3 and DFY: 148.3 q/ha) having 18.2, 13.0, 12.7, 10.8, 10.1 and 9.6 % increase for green biomass yield and 15.1, 14.0, 14.1, 10.7, 9.8 and 6.2 % increase for dry matter yield, respectively. As far as quality of these hybrids are concerned SHH 1836 was best among all hybrids having crude protein content 11.37% and 61.2% IVDMD clubbed with highest green biomass yield and tolerance to foliar disease and insect pest attack.

Keywords: Biomass, fodder quality, hybrids and livestock sustainability

Introduction
Arid and semi-arid tropics of the world faces food security threats due to abrupt climate changes, weather variability and needs immediate attention especially in those geographic regions of the world where agriculture is highly dependent on rainfall (Sarkar *et al.*, 2020) [9]. Recent climatic changes are of global concern for availability of sufficient and healthy plant based food not only for humans but also for animals (Wheeler and Von Braun, 2013) [13]. Livestock sector contributes a lot in GDP especially in agriculture based countries of the world like India. It is major concerned and focus area to produce grain/field crops for human consumption and forage crops as animal feed and fodder and become challenging task in years to come.
Mostly, cereal crops have been used over centuries as an animal feed and green fodder due their high dry matter production potential. Various cereal crops like maize, wheat, sorghum, pearl millet etc. are used as green fodder, dry fodder and left over residues also used for livestock production. Cultivation of cereal fodder along with legume crops, also improves yield as well as protein content and other quality parameters of fodder (Zhang *et al.*, 2015) [14].
From decades various forage sorghum breeders are doing efforts to enhance biomass yield and quality of forage crops by conventional breeding approaches. Subsequently many improved single-cut and multicut varieties were developed like SSG 59-3 (Multicut), HC 136, HC171, HC 260, HC 308, Pant Chari 3, Pant Chari 4, Pant Chari 5 etc. In 1977, multicut forage sorghum variety SSG 59-3 was developed through pedigree selection of a cross between JS 263 (a sweet forage sorghum variety) sudan grass (with multicut traits). This variety had desirable multicut traits such as early vigour, synchronous tillers, faster growth, potential to give 4-5 cuts without significant reduction of forage yield in subsequent cuts, very high and best quality fodder with desirable level of resistance against foliar diseases, and insect pests. Later on in 1980s, Pusa Chari-23 was released as multicut variety of forage sorghum, but it was highly susceptible to foliar diseases.

Other single cut forage sorghum varieties which are popular until 2000s at farmer's field were HC 136, HC171 and HC 260 etc.
Although there is no quantum jump in production, productivity and quality of fodder using pedigree breeding approaches. With the discovery of workable cytoplasmic-nuclear male-sterility in sorghum and initiation of the accelerated sorghum project in 1962 CMS based hybrid breeding was given due emphasis (Reddy and Reddy, 2019). During 1962-1969, out of temperate x temperate and temperate x tropical crosses, three hybrids i.e. CSH 1, CSH 2 and CSH 3 were released. Later on, CSH 13 and CSH 14 were released and CSH 13 has 40% more green fodder yield over CSH 9 although its grain yield is marginally improved and forage sorghum hybrid development starts from here. Later on, CSH 20MF in 2005 and CSH 24MF in 2010 were released at national level as multicut hybrids and revolutionized the fodder yield potential of hybrids leading a quantum jump in green biomass production, productivity and quality. To strengthen our breeding programme and to identify a suitable hybrid with high biomass and quality for semi-arid region of Haryana following study was conducted.

Material and Method

a) Experimental Material

The experimental treatments consisted of 11 sorghum experimental hybrids developed by using different CMS lines at Research Farm of Forage Section, CCS Haryana Agricultural University, Hisar, Haryana along with two standard checks. We evaluated the green fodder yield at 50% flowering of the following hybrids: SHH 1902, SHH 1903, SHH 1904, SHH 1906, SHH 1908, SHH 1911, SHH 1912, SHH 1916, SHH1513, SHH 1812 and SHH 1836 along with two checks HJ 541 and HJ 513. The hybrids were evaluated in a randomized-block design with 3 replicates.
Seeds were manually sown in 5.0 m^2 (5m x 5 rows) plots with 25 cm between rows and 15cmplant to plant spacing. Thinning was performed 30 days after planting to maintain a density of 12 plants per linear meter. The crop was raised following package and practices as per recommendation. The crop was grown only under rainfed conditions.
The crop was harvested at 50% flowering of these hybrids viz., 70 to 88 days and experimental hybrids reached harvest stage at different days and maximum at 88 days we have cut all hybrids. The green fodder cut was performed manually 10 cm above the ground level with knives. Morphological data was recorded from five randomly selected plants from the each plot of each replication. Green biomass yield was calculated from whole plot in kg/plot and converted in q/ha for further analysis. For dry matter calculation we have harvested 500 gm sample from every plot and air dried and then oven dried and weighted dry matter yield. From dried sample quality analysis was carried out and crude protein % and *invitro* dry matter digestibility was estimated using Micro-Kjeldhal's method and Tilley and Terry (1963) [11] method, respectively. TSS % was estimated using Refractometer.
Data for various foliar diseases was recorded based visual observations according to scale of 1-9 (1 = complete resistant and 9= highly susceptible). Shoot fly and stem borer dead hearts were counted at 28 days and 45 days after sowing, respectively. Data for stem tunneling was recorded based on tunneling caused by stem borer upto 50% flowering and measured by meter scale after vertical cut in sorghum stem. Mean ± standard deviation and coefficient of variation was also calculated for all the traits and it is within acceptable limit (<25.0).

Results and discussion

Ten single cut cytoplasmic male sterlity hybrids were evaluated along with two checks: HJ 541 and HJ 513 for various agro-morphological and biochemical traits. Significant variation was present among all the traits under study and range for all traits is present in Table: 1. As far as their performance for morphological traits are concerned SHH 1836 had maximum plant height (339.5cm) followed by SHH 1903 (324.2cm). Similarly maximum leaf breath, no. of leaves/plant, crude protein % and IVDMD is present in SHH 1836 (as predicted from graph 3). Improvement of green biomass yield and per day productivity is our major breeding objective and for any crop improvement programme consideration of those traits which had strong positive correlation with green biomass production always taken in consideration. Out of these SHH 1836 had given highest green biomass yield as well as dry matter yield *i.e.*, GFY: 673.5 and DFY: 161.2 q/ha followed by SHH 1911 (GFY: 645.0 and DFY: 159.0 q/ha); SHH 1903 (GFY: 642.0 and DFY: 159.3 q/ha); SHH 1812 (GFY: 631.5 and DFY: 154.6 q/ha); SHH 1513 (GFY: 627.3 and DFY: 153.3 q/ha) and SHH 1916 (GFY: 624.3 and DFY: 148.3 q/ha) having 18.2, 13.0, 12.7, 10.8, 10.1 and 9.6 % increase for green fodder and 15.1, 14.0, 14.1, 10.7, 9.8 and 6.2 % increase for dry fodder yield respectively (as shown in graphs 1 and 2). Other promising hybrids were SHH 1912 and SHH 1908. But per day productivity was maximum in SHH 1911 followed by SHH 1906 and SHH 1836. Similar results in forage sorghum hybrids were reported by Vinutha *et al.*, 2017 [12]; Rakić et al., 2013 [7].
Fodder quality plays an important role in palatability and acceptability of green and dry fodder by animal. There are various parameters whose estimation helps in quality determination like HCN, CP%, IVDMD%, ADF, NDF, and Lignin etc. But out of these CP% and IVDMD% are major one. Presence of high IVDMD% in fodder related to its high digestibility in animal rumen and fodder quality is indicated based on presence of dry matter in fodder itself. Animal's feeling of satisfaction after fodder consumption is mainly depend on concentration of dry matter in fodder (Burns, 1994) [4]. In our experimental material crude protein content varied from 8.6 to 11.37 per cent, it was maximum in SHH 1836 followed by SHH 1911 (10.94%). IVDMD% ranged from 50.8 to 61.2 per cent, it was maximum in SHH 1836 followed by SHH 1911 (as shown in graph 4). Similar relation of quality traits with morphological traits in forage sorghum was reported by Pannacci and Bartolini, 2016 [16]; Ayub *et al.*, 2012 [3].
Hisar is hot spot for stem borer and shoot fly also affects sorghum growth and attack of shoot fly on sorghum stem damages main growing point of plant and many side tillers appear in plant after shoot fly damage. All hybrids under study they have moderate level of tolerance for foliar diseases and insect pest attack but SHH 1916, SHH 1836 and SHH 1513, SHH 1519, SHH 1903, SHH 1912 and SHH 1908 were statistically on par with tolerant varieties HJ 541 and HJ 513

(as shown in graph 5 and 6). The result indicated that there is good scope for insect resistant improvement in sorghum through hybrid breeding. Similar results were reported by Agrawal and Abraham, 1984 [1]; Tahir, 2005 [10]; Aruna *et al.*, 2013 [2] and reported that hybrid breeding can contribute to greater extent in breeding of resistant genotypes of forage sorghum.

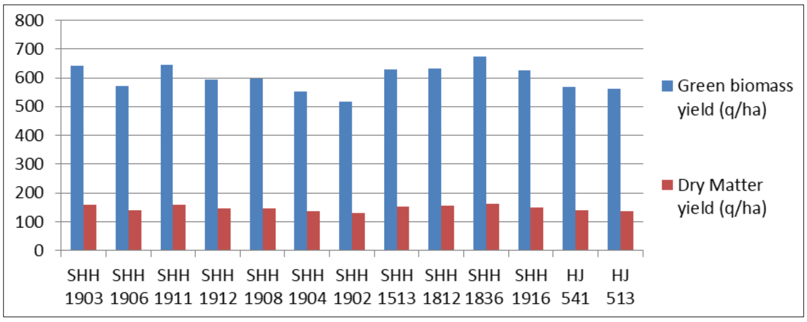
Conclusion and future prospects

In this study we have evaluated CMS based single cut hybrids for various traits and out of all these SHH 1836, SHH 1911, SHH 1903, SHH 1812, SHH 1513 and SHH 1916 performed better then checks with good quality and least incidence of foliar disease and insect pest. These will be tested in large areas in future and hybrids like SHH 1836 surely help to combat the prevailing issue of quality biomass production which majorly affects livestock health especially in developing countries. This type of hybrids might have one more benefit over the others that they are performing better in semi arid regions. Under climate change scenario breeders are continuously doing efforts to develop such type of varieties/hybrids which perform better under biotic and abiotic stresses and cost effective for small dairy farmers and low land holding farmers.

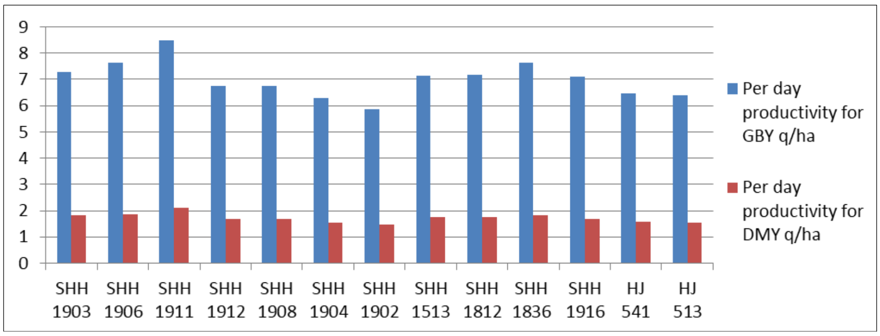
Table 1: Showing range and mean for all the traits under study among forage sorghum hybrids

Traits	Range	Mean
Days to 50% flowering	70 - 88	82.15
GBY (q/ha)	516.0 - 673.5	600.4
DMY (q/ha)	128.7 - 161.2	147.04
Per day productivity for GBY q/ha	5.86 - 8.48	6.97
Per day productivity for DMY q/ha	1.46 - 2.09	1.72
Plant Height(cm)	256.3 - 339.5	304.6
Number of Leaves/plant	19.8 - 29.9	25.72
Leaf Length(cm)	77.5 - 86.5	82.15
Leaf Breadth(cm)	7.0 - 8.8	7.96
Leaf Stem Ratio	0.24 - 0.29	0.26
Stem girth(mm)	12.4 - 16.7	15.06
TSS%	7.0 - 11.3	8.39
CP%	8.6 - 11.4	9.83
IVDMD%	50.8 - 61.2	54.69
Grey leaf spot	1.0 -1.8	1.26
Zonate leaf spot	1.0 -1.8	1.34
Sooty stripe	1.0 - 1.8	1.31
Shoot fly(% dead hearts)	11.0 - 16.4	14.05
Stem borer (% dead hearts)	14.6 - 28.2	19.28.
Stem tunneling %	10.4 - 19.2	12.75

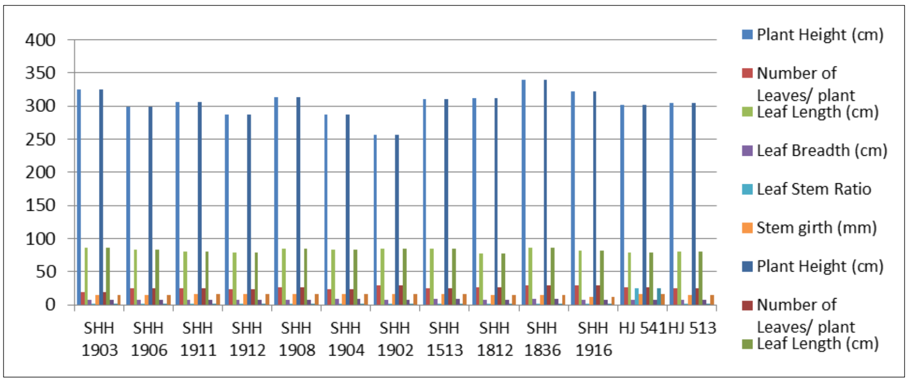
*GBY: Green biomass yield; DMY: dry matter yield; TSS: Total soluble sugar; CP: Crude Protein; IVDMD: *invitro* dry matter digestibility



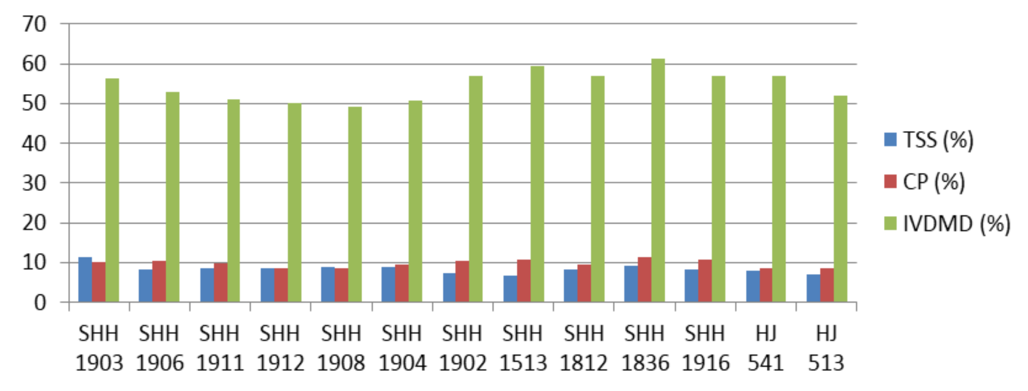
Graph 1: Green biomass yield and dry matter yield among hybrids



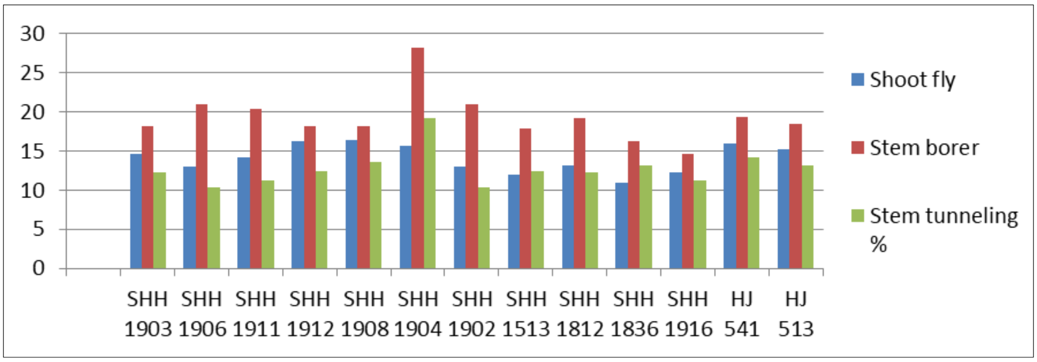
Graph 2: Green biomass productivity and dry matter productivity among hybrids



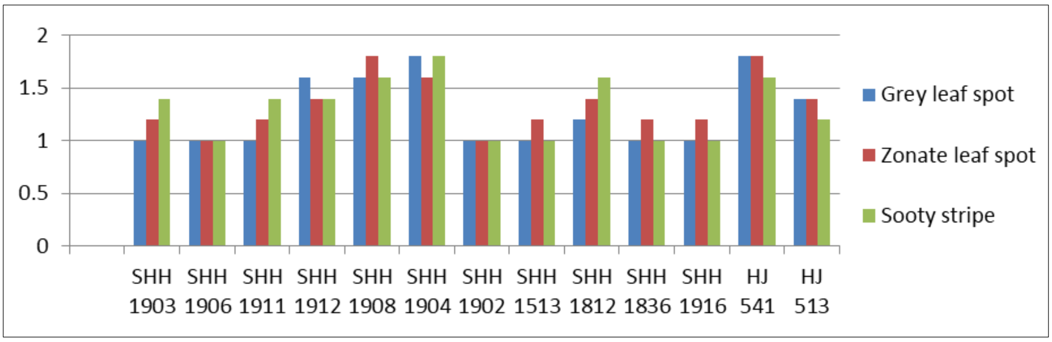
Graph 3: Comparative performance of hybrids for various morphological traits



Graph 4: Comparative performance of hybrids for various quality traits



Graph 5: Comparative performance of hybrids for insect pest attack



Graph 6: Comparative performance of hybrids for foliar disease incidence

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