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PRINCIPAL COMPONENT ANALYSIS IN MULTICUT FORAGE SORGHUM GENOTYPES FOR FODDER YIELD AND QUALITY TRAITS

Pummy Kumari*, Neeraj Kharor, Satpal, Dibyendu Seth and S.K. Pahuja

Forage Section, Department of Genetics and Plant Breeding, C.C.S. Haryana Agricultural University, Hisar-125 004, Haryana, India.

*Corresponding author E-mail : pummy.hau@gmail.com

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ABSTRACT

An experimental was conducted to identify the forage sorghum genotypes having high green and dry fodder yield potential along with high nutritive value. The results revealed that the hybrid SPH 1970 (863.7 q/ha) has recorded significantly high green fodder yield followed by CSH 43MF (833.5 q/ha) and SPH 1935 (819.5 q/ha). Principal component analysis indicated that four components with eigen values more than one accounted for about 81.8% of the total variation among eleven quantitative characters responsible for fodder yield and quality in forage sorghum genotypes. The principal components PC1, PC2, PC3 and PC4 contributed about 42.48%, 16.77%, 13.26 and 9.29%, respectively to the total variation. High positive loading for green fodder yield, dry fodder yield, number of tillers per plant, number of leaves per plant, leaf length and leaf breadth were exhibited by first principal component. The second principal component showed high loading for *in-vitro* dry matter digestibility and leaf breadth. Therefore, the present study revealed that the hybrids SPH 1935, SPH 1970 and CSH 43MF are good for both fodder yield and quality but CSV33MF is comparable to hybrids for green fodder production and gives 5-6 cuts in one season if proper management practices are followed.

Key words : Fodder, Multicut, Quality and Sorghum.

Introduction

Forage sorghum is a high green and dry biomass yielding crop with high tillering ability, high protein content (6-11%), *in-vitro* dry matter digestibility (40-65%) and ratooning ability, that makes it a popular fodder crop as compared to maize and pearl millet. It can grow in arid and semi-arid tropics of Asia and Africa. Sorghum belongs to family *Poaceae* having diploid chromosome number (2n=20). Forage sorghum is leafy, palatable and very nutritious feed stock for cattle to ensure good milk yield (Pankaj and Dhankar, 2023). Being any time forage, forage sorghum can be grazed or cut and fed at any growth stage after 35-40 days of sowing. To avoid hydrocyanic acid toxicity do not cut crop before 35 days after sowing and if necessary first irrigate the field or leave the crop after harvesting for 3-4 hours to lower down the toxic concentration. It is an excellent crop for making silage (Gupta *et al*., 2000; Kumari *et al*., 2020) and used as hay also during lean period. Scarcity of green fodder is the most common problem in the months of May and June. Most of recommended forage sorghum varieties were released for single cut, but few very popular multicut varieties/hybrids of forage sorghum released at national level are SSG 59-3, CSV 33MF, CSH 20MF, CSH 24MF, CSH 43MF etc., which are available in market and have green fodder potential of 75 -104 t/ha and farmers use them for 3-4 cuts according to their needs (Kumari *et al*., 2022). Among all these CSV33MF is having perennial nature also and having high tillering ability (5-7) and good regeneration score (4.17).

Milk productivity of milch cattle will be enhanced by continuous supply of well-balanced nutritive forage during summers (Meena *et al*., 2012). In North India multicut forage sorghum is grown during summers especially to supply green fodder. At present, India is having scarcity of green fodder, dry fodder and concentrates in terms of both quantity and quality, which consequently adversely affects the livestock health and their productivity (IGFRI Vision, 2050). To overcome such situation, genetically stable varieties/hybrids of multicut nature with high biomass potential are urgently needed to meet out the fodder requirement (Singh *et al*., 2013).

Among *kharif* forages sorghum is playing important role due to its wide ecological adaptability and xerophytic characteristics. Therefore, it helps to enhance fodder production during the lean period under unfavorable weather conditions. Development of intra-specific forage hybrids that combine the ability for multicut, earliness, short harvesting intervals, quick regeneration, high tillering potential, high green fodder yield, high crude protein content, high *in-vitro* dry matter digestibility and low anti-nutritional factors like hydrocyanic acid and nitrates. Their multi-location testing will also help to identify stable genotypes for fodder. For any crop improvement program understanding of the existing usable variability from population panel (Nachimuthu *et al.* 2014). Principal component analysis is the most powerful and acceptable approach to study large number of data and to extract most significant data points. Total number of components extracted is equal to the number of variables being analyzed and PC1 accounts for a large amount of the total variance (Kavithamani *et al*., 2019). Each succeeding component accounts for progressively smaller amounts of variance. Therefore to quantify the fodder yield and quality potential of forage sorghum cultivars for multicut and to identify major components for variability, an experimental study was conducted under AICRP on Sorghum project at CCS Haryana Agricultural University to identify the suitable genotypes of the multicut type suitable for lean period to overcome fodder scarcity.

Materials and Methods

The experimental material comprising of twelve hybrids, one genotype and four checks (CSV24MF, CSH43MF, CSV33MF and local check (SSG 59-3) (Table 1) was sown in Randomized Complete Block Design (RCBD) with 3 replications during *kharif* season of 2021 on 1st May at Research Area of Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. It is situated in semi-arid sub-tropical region at 29^0=10^0N latitude and 75^0-46^0E longitude with elevation of 215.52 m above mean sea level and Graph 1 (depicts details of all weather parameters during crop season). Each genotype was grown in 5 meter length of 18 rows with spacing of 25-25cm between rows and 15 cm between plants. All the recommended cultural and plant protection practices were adopted for raising the forage sorghum crop.

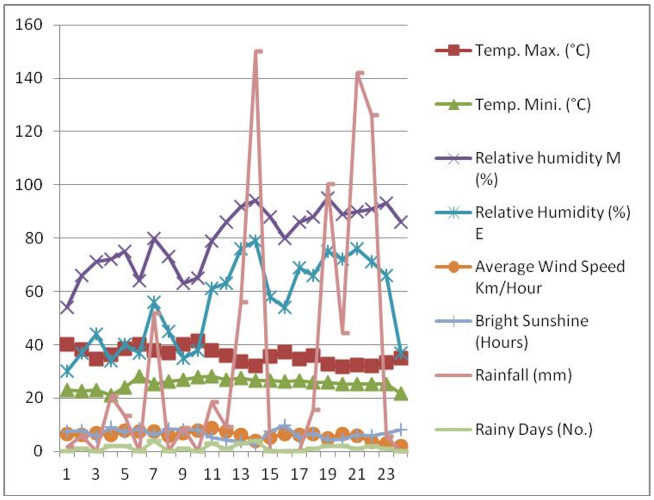
Observations were taken on five randomly selected competitive plants of each genotype from each plot for twenty nine different phenological and biochemical traits. The data for all the phenological traits were recorded at the time of 50% flowering. The first cut was taken at 68 days after sowing (DAS), second was at 116 DAS and third cut 165 DAS. Hydrocyanic acid content (HCN) µg/g on fresh weight basis was estimated from the young shoots 30 days after sowing by method suggested by Gilchrist *et al.* (1967). Refractometer was used to measure total soluble solids (TSS%) in °brix present in main stalk. 500g green fodder samples was taken from each genotype at the time of 50% flowering and dried in field and then in the oven to estimate dry fodder yield. After drying the samples were ground and used to

Table 1 : List of genotypes with pedigree or centre code details.

S. no.	Genotypes	Centre Code/Pedigree	S.No.	Genotypes	Centre Code/Pedigree
1	**SPH1933**	Foragen-FS2019MC	**10**	**SPH1996**	NSSG1933
2	**SPH1934**	UTMCH 1320 (ICSA 469 x Pant Chari 6)	**11**	**SPH1997**	ICS444A x SGL87
3	**SPH1935**	DFSH188	**12**	**SPH1998**	NFSH3048
4	**SPH1966**	ADV6606	**13**	**SPV2861**	CSV21F×HJ541 P2-3-6-1
5	**SPH1967**	ADV6690	**14**	**CSH 24MF**	ICSA467 x UPMC 503
6	**SPH1970**	CFSH50	**15**	**CSV 33MF**	Selection from COFS 29
7	**SPH1993**	ADV6630	**16**	**CSH 43MF**	11A2 x Pant Chari 6
8	**SPH1994**	ADV6644	**17**	**SSG 59-3 (LC)***	Selection from a cross between (Non-sweet sudan grass x JS 263)
9	**SPH1995**	MR750A2 × Pant chari 6			

*Local Check (LC) is national multicut forage sorghum variety.

estimate crude protein (%) by Micro-Kjeldhal's method and *in-vitro* dry matter digestibility (IVDMD) by Tilley and Terry (1971). Graphs were prepared using MS-EXCEL. For PCA analysis the statistical software (GRAPES) General R-shiny based Analysis Platform Empowered by Statistics was used.



Weather parameters during crop season (*Kharif* 2021).

Results and Discussion

Data were collected from five randomly selected plants and their mean and range was estimated (Table 2). Mean values of some important biomass and quality related traits were plotted as scatter graph shown in Fig. 1a, 1b and 1c. Seventeen genotypes were evaluated for various morphological and quality traits. Early vigor of genotypes varied from 3 to 4, days to 50% flowering varied from 55-66 days in SPH 1967 and SPH 1997, respectively and SPH 1935, SPH 1994 and CSV33MF did not flower up to 68 days. Days to 50% flowering are very important parameter in forage crops as at this stage nutritional quality of fodder is maximum (Nelson and Moser, 1994). It was also observed that, there is large difference in the green fodder yield potential between hybrids and varieties. In 1st cut all hybrids produced significantly high green fodder yield but in 2nd cut performance of CSV 33MF and SPV 2671 was better than hybrids Morphological parameters and some quality parameters (HCN and IVDMD%) were recorded only for the Ist cut. Maximum plant height was observed in SPH 1998 (217.4 cm), tillering was observed in CSV33MF

Table 2 : Performance of multicut genotypes for various phenological and quality traits.

S. no.	Traits	Mean	Range
1	GFY 1st cut (q/ha)	559.1	366.3-662.2
2	GFY 2nd cut (q/ha)	148.4	96.0-217.0
3	GFY 3rd cut (q/ha)	50.7	36.8-62.8
4	GFY (q/ha) pooled	758.0	505.0-864.0
5	DFY 1st cut (q/ha)	132.6	86.16- 156.2
6	DFY 2nd cut (q/ha)	35.24	22.59-51.54
7	DFY 3rd cut (q/ha)	12.1	8.77-14.8
8	DFY (q/ha) pooled	179.9	119.0-203.6
9	Days to 50% flowering	63.0	55-66
10	Days of 1st Harvest	68	-
11	Days of 2nd Harvest	116	-
12	Days of 3rd Harvest	165	-
13	Early Vigor	3.75	3-4
14	Plant height (cm)	74.3	120.9-217.4
15	Leaf length (cm)	85.83	74.33-93.89
16	Leaf breadth (cm)	6.19	4.5-7.71
17	Number of tillers	2.6	1.89-3.44
18	Number of leaves/plant	23.89	19.25-28.89
19	Stem girth (cm)	1.54	1.32-1.55
20	TSS%	5.62	5.02-6.92
21	Leaf:Stem ratio	0.3	0.26-0.33
22	Regeneration score (1-5)	4.02	3.33-5.0
23	CP% 1st cut	8.53	8.03-9.94
24	CP% 2nd cut	7.34	7.1-7.5
25	CP% 3rd cut	4.07	3.5-4.8
26	CP% pooled	6.6	6.1-7.2
27	IVDMD% 1st cut	51.4	42.4-58.0
28	IVDMD% 2nd cut	58.7	54.2-64.4
29	IVDMD% 3rd cut	53.2	50.6-57.2
30	CPY (q/ha)	15.0	11.5-19.0
31	HCN (µg/g fresh wt. basis)	84.7	67.9-106.9

(3.44), leaf length was in SPH 1933 (93.9cm), leaf breadth was in SPH 1970 (7.71cm) and maximum regeneration was observed in CSV 33MF and SSG 59-3. Highest total soluble solids (TSS%) per cent was reported in SSG 59-3 (6.92) followed by SPH 1998 (6.8). It was also observed that if irrigation facility is available than forage sorghum cultivars grow vigorously during summers and put up more biomass.

From the pooled data of 3 cuts, significant green fodder yield was recorded by the hybrid SPH 1970 (GFY: 863.7 q/ha and DFY: 203.6 q/ha) which had shown 3.62% and 3.75% increase over best hybrid check CSH43MF (GFY: 833.5 q/ha and DFY: 196.3 q/ha). Among varietal genotypes none was superior to varietal check CSV33MF (GFY: 817.7 q/ha and DFY: 193.1 q/ha). In first cut

Field view of a) SPH 1970 b) SPH 1998 c) CSV 33MF

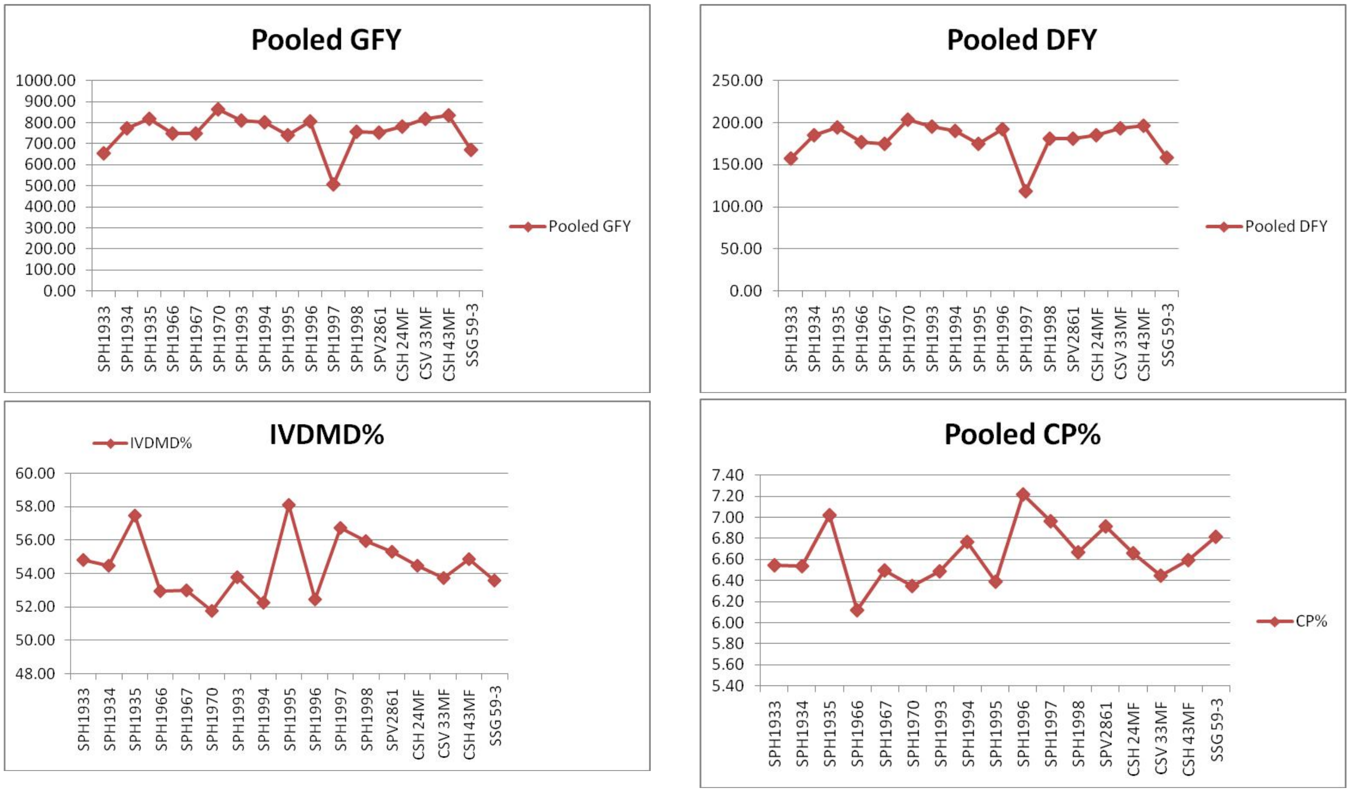


Fig. 1a : Pooled GFY (Green Fodder Yield q/ha), **1b:** Pooled DFY (Dry Fodder Yield q/ha), **1c: P**ooled IVDMD% (*In-vitro* dry matter digestibility) **1d: P**ooled CP% (Crude Protein).

maximum green fodder yield was reported in varietal check CSV 33MF (662.2 q/ha). SPV 2861 is suitable for two cuts and it has given highest green fodder yield in second cut (178 q/ha). It was also reported that during 1st cut green and dry fodder yield ranged from 366.3-662.2 q/ha and 86.16- 156.2 q/ha, respectively. However with successive cuts green and dry fodder yield decreases in sorghum *i.e.*, 96.0-217.0 q/ha and 36.8-62.8 q/ha in 2nd and 3rd cuts, respectively. Similar results for were reported by Suhartanto *et al.* (2020).

Data presented in Table 2 showed that anti-nutritional factor HCN ranged from 67.87-132.4 µg/g on fresh wt. basis just 30 days after sowing. Minimum HCN content was observed in SSG 59-3 (67.9 µg/g) followed by SPH 1934 (68.4 µg/g). IVDMD% ranged from (42.4-64.4%), it was maximum in SPH 1995 (58.1%) followed by SPH 1935 (57.5%) pooled over three cuts. Similar results were reported by Bharti *et al.* (2023), Dehinwal *et al.* (2017).

Crude protein content varied from (6.1-7.2%), it was highest in SPH 1996 (7.2%) pooled over three cuts. Maximum crude protein content in first cut was reported in SPH 1996 (9.94%) and maximum crude protein yield was observed in CSH 24MF (19.0 q/ha pooled over three cuts) in the multicut hybrid released in 2010 for cultivation in all forage sorghum growing areas of country. However, as the number of cuts increase quality of fodder crops deteriorates resulting in decrease in crude protein content as reported by Patil and Merwade (2016). Quality parameters of forage sorghum also play crucial role for supporting the nutritional security and overall development of cattle thus the improvement of forage crop varieties helps to provide all essential nutrients (Singh *et al.*, 2014; Bhat *et al.*, 2020). So it is essential to develop high yielding multicut varieties/hybrids with better quality fodder, wider adaptation and environmentally sustainable to deal with growing fodder demand for livestock production.

PC analysis

Principal component analysis revealed that the first four components in the PCA analysis with eigen values more than one had contributed 81.8 per cent of the variability among seventeen forage sorghum genotypes evaluated for eleven different quantitative traits. These four major principal components were retained based on the screen plot and threshold eigen value more than 1 (Fig. 2 and Table 3). The black line present in the scree plot represents the cumulative variability percentage with respect to PC1 to PC11 (Fig. 2).

A critical analysis of data reveals that the major yield contributing traits like plant height, leaf length, leaf breadth had contributed maximum 42.48% variability to the first principal component (PC1). Similar trend using PC

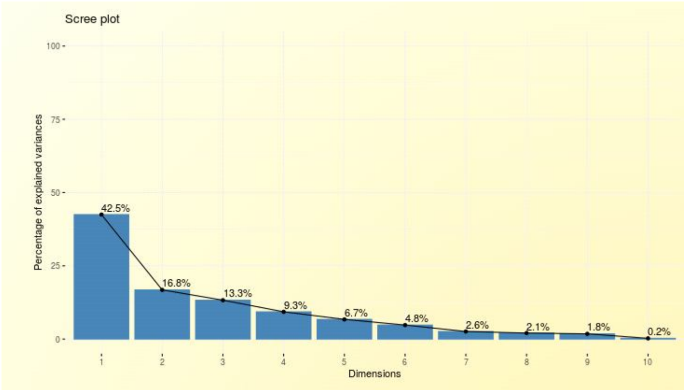


Fig. 2 : Scree Plot (pooled data).

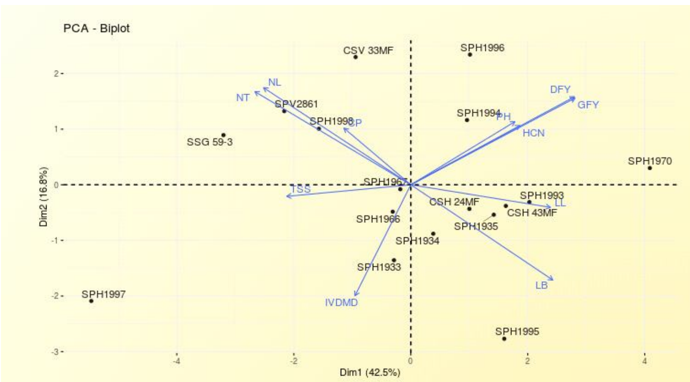


Fig. 3 : PCA biplot based on PC 1 and PC 2.

Table 3 : Principal components, eigen value, percentage of variance and cumulative percentage of variance.

Principal Component	Eigen value	Percentage of variance	Cumulative percentage of variance
PC1	4.673	42.481	42.481
PC2	1.845	16.773	59.254
PC3	1.459	13.263	72.517
PC4	1.023	9.297	81.814
PC5	0.739	6.719	88.533
PC6	0.526	4.778	93.311
PC7	0.285	2.588	95.899
PC8	0.226	2.054	97.953
PC9	0.196	1.779	99.732
PC10	0.027	0.247	99.979
PC11	0.002	0.021	100

analysis in forage sorghum for green and dry fodder yield has been reported by Ali *et al.* (2022), Subramanian *et al.* (2019). IVDMD% and leaf breadth had mainly contributed for the second principal component (PC2) accounting for 16.77 per cent of the variability explained.

In biplot graph, the PCA in general confirmed the groupings of the forage sorghum genotypes based on PC1 and PC2 (Fig. 3). Forage sorghum genotypes *viz.***,** SPH 1970, SPH 1993, CSH43MF, CSH 24MF were grouped for high green fodder yield and dry fodder yield (Jain and Patel, 2016; Vijaylaxmi *et al.*, 2019; Kavithamani *et al.*, 2019).

The above results clearly depicted that there is enormous variability in the material under study. Varieties/ hybrids *viz.*, CSV33MF, CSH43MF, CSH 24MF, SSG59-3 and advanced genotypes like SPH 1970 having high green and dry fodder yield with better nutritional quality should be used at farmer's field to fulfills the demand of forages on the regional and seasonal basis. In addition to this use of multicut varieties like CSV33MF and SSG59-3 in crossing program helps to evolve high yielding multicut forage sorghum hybrids/varieties. But engagement of govt. seed producing agencies would further strengthen our efforts to achieve the desired goal.

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