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COMPARATIVE ANALYSIS OF FODDER AND SWEET SORGHUM CULTIVARS FOR SILAGE PURPOSE

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SUMMARY

Sorghum is an important fodder crop in India that produces high biomass yield in diverse agro-climatic conditions. A study was conducted during Kharif 2021 for comparative analysis of nineteen sorghum cultivars belonging to single-cut fodder, multi-cut fodder and sweet sorghum type for silage making potential. Significant differences were observed amongst sorghum cultivars for dry matter (%) in fodder before and after ensiling, °brix content, pH, silage yield, dry matter yield, plant height, number of leaves/plant, length of leaves, width of leaves, L:S and fresh biomass weight/plant. On the basis of group mean values, many parameters viz. plant height, fresh biomass weight/plant and dry matter accumulation/plant were observed to be higher in single-cut type fodder cultivars as compared to sweet sorghum and multi-cut fodder type cultivars. Non-significant differences were observed amongst sorghum cultivars for leaf area index, dry matter accumulation/plant (g) and plant population (lakh/ha), however, the differences ranged between 0.59-1.23, 62.00-170.00 and 0.23-0.37, respectively. All the sorghum cultivars showed potential to produce good quality of silage as pH in silage and °brix content in stem juices were observed to be in highly desirable range viz. 3.50-4.23 and 9.40-16.47%, respectively. Silage and dry matter yields were recorded to be significantly higher in cultivars HJ 541 (40.23 t/ha) and CSV 44F (13.97 t/ha), respectively. Single-cut sorghum cultivars, HJ 541 and CSV 44F out yielded check cultivar CSV 21F by 34.48% and 30.83% for silage yield and; 27.36% and 34.43% for dry matter yield, respectively. Significantly lowest silage yield (21.68 t/ha) and dry matter yield (6.82 t/ha) were recorded in cultivar CSV 40F. During this study, green fodder of nineteen cultivars belonging to single-cut fodder, multi-cut fodder and sweet sorghum types harvested at ninety days stage was found suitable for silage making, however, few cultivars like HJ 541, CSV 44F, CSV 35F and Madhura 2 were found to be most suitable cultivars for obtaining high silage yields (>35 t/ha) during *kharif* season under Central Gujarat conditions.

Key words: Fodder sorghum, sweet sorghum, single-cut, multi-cut, silage, pH, °brix and dry matter yield

Sorghum [*Sorghum bicolor* (L.) Moench] also known as jowar, chari, cholam and durra in India, is widely grown for human food, animal feed, fodder and other industrial uses. Sorghum is a fifth most important cereal globally and plays a crucial role in ensuring food security and economic stability for numerous communities. In India, once it was the major cereal staples during 1950s and occupied 18 million hectares (m ha) land. However, over the years area under sorghum cultivation declined and during 2020-21, estimated area recorded under grain sorghum and fodder sorghum cultivation was 4.38 m ha and 3.00 m ha, respectively (Aruna *et al*., 2023). Anonymous (2023) reported that the *kharif* sorghum crop (36.60%) was grown predominantly in Rajasthan (43.30%), Uttar Pradesh (15.60%), Haryana (10.10%) and Madhya Pradesh (9.80%). While *rabi* sorghum crop (63.40%) was grown in Maharashtra (63.50%), Karnataka (22.00%), Tamil Nadu (7.90%) and Andhra Pradesh (3.20%).

For fodder purpose, single and multi-cut type cultivars are primarily cultivated by farmers. Single-cut fodder cultivars are mostly grown during *kharif* or rainy season under rainfed conditions and multi-cut type fodder sorghum cultivars are cultivated during *zaid* or summer season under assured irrigated conditions. In many countries, sweet sorghums have also been widely used for the production of forage and silage for animal feed, whereas, the grain sorghum stover are utilised as fodder. Sorghum crop occupies

8.00 m ha area in India with 0.002 per cent share of sweet sorghum (Dubey and Kewalanand, 2013). Sweet sorghum crop owing to its high fodder yielding ability coupled with sweet and juicy stalks is more often used as a fodder crop than for its intended use as a sugar or bio-energy crop (Nimbkar *et al.*, 2010). Due to its multi-purpose uses and blending of ethanol in petrol, cultivation of sweet-stalked sorghum is gaining popularity in few states in India.

Dairy farms and farmers cultivate, sorghum cultivars mostly for green fodder production purpose, however, due to surplus availability of green fodder during *kharif* season, small quantities of green fodder are also conserved in form of silage. Singh and Chauhan (2017) and Tahuk *et al.* (2020) have reported suitability of sorghum cultivars for silage making purpose. However, few workers have reported that the quick conversion of water-soluble carbohydrates present in the sorghum by lactic bacteria into lactic acid causes abrupt decrease in the pH of the ensiled wet biomass, favouring the growth of the yeast population, which is the main microorganism responsible for the alcoholic fermentation and aerobic deterioration of the silage when it is exposed to air (Tabacco *et al.*, 2009; Schmidt and Kung Jr., 2010 and Ferrero *et al.*, 2019).

In recent years, the emerging areas of sorghum research are development of cultivars for high yields, sweet stalks, fodder quality and to increase the density of grain micronutrient traits. With the increasing demand of sorghum for fodder and sweet sorghum for alternate source of bioethanol; a number of hybrids and open pollinated varieties have been released for cultivation in India. Although during last few decades in India, in order to tackle fodder deficit issues during lean periods, maize has remained a primary choice of farmers for silage production due to ease in ensiling and low buffering capacity of fodder. However, under the adverse agro-climatic and limited water availability, sorghum has the feature of being an alternative to maize in many ways.

Gokkus and Degismanci (2023) found no significant difference between maize and sorghum silage in terms of their protein contents (8.47% and 8.25%, respectively), acid detergent fibre (ADF), or neutral detergent fibre (NDF) values and concluded that sorghum can be an alternative to maize in terms of nutritional quality particularly in arid and semi-arid condition. In India, large area exits under the arid zone (15.8%) and semi-arid zone (37.0%) of the total geographical area as reported by (Kalsi, 2013) that are highly suitable for sorghum cultivation. However, for arid and semi-arid zones big gap exists in identification of highly suitable sorghum cultivars for silage making purpose. Considering this, the present study was conducted for comparative analysis of different types of sorghum cultivars released for cultivation as single-cut fodder, multi-cut fodder and sweet sorghum types for silage making (ensiling) potential under central Gujarat conditions.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2021 at fodder demonstration unit (FDU) of National Dairy Development Board, Anand (Gujarat). During the growing seasons, average monthly weather parameters data are mentioned in Fig. 1.

Anand is located at 22.57°N latitude and 72.93°E longitude. It has an average elevation of 39 metres. The soil of the experimental site was sandy loam type with EC-0.18, pH-7.7, total nitrogen (880 kg/ha), available P_2O_5 (15 kg/ha) and available K_2O (295 kg/ha). The soil contained DTPA-extractable Fe (5.5 ppm), Mn (4.6 ppm), Zn (1.7 ppm) and Cu (1.6 ppm). The experiment was laid out in a randomized block design (RBD) with three replications consisting

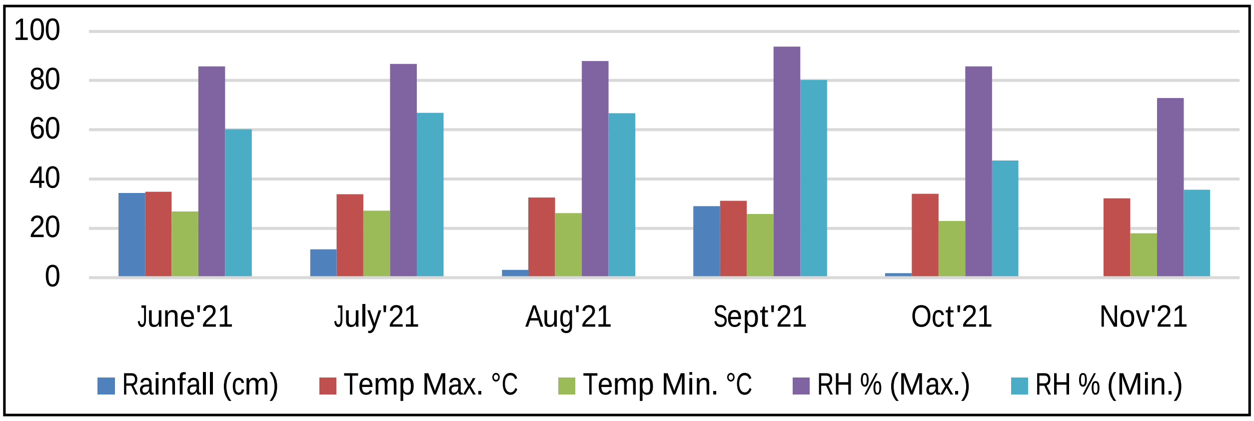

Fig. 1. Monthly weather parameters during *Kharif* 2021 at Anand, Gujarat.

of 19 sorghum cultivars (Table 1). For comparison sorghum cultivars were grouped into three categories; (a) single-cut fodder sorghum type: Gujarat Fodder Sorghum-6 (GFS 6), Gujarat Anand Forage Sorghum 11 (GAFS 11), Gujarat Anand Forage Sorghum 12 (GAFS 12), Pant Chari 5 (PC 5), Pant Chari 6 (PC 6), CSV 35F, CSV 38F, CSV 40F, CSV 44F, CSV 46F, Haryana Jowar 541 (HJ 541) & CSV 21F (check) (b) sweet sorghum type: one hybrid (Madhura 1) and two varieties (Madhura 2 and Madhura 3) and (c) multi-cut fodder sorghum hybrids type: SSG 898, CSH 40F, CSH 24MF and CSH 43MF. Details related to year of release/notification of sorghum cultivars and source of seed used in the trial are given in Table 1.

The crop was sown manually on 15th July, 2021 with seed rate of 40 kg/ha at row distance of 45 cm. The total plot size was 4.5m x 4.0m (18.0 metre square) with net plot area of 3.1 m x 2.5 m (7.75 metre square) at harvest. The crop was fertilized with 120:60:30 kg NPK/ha. Entire quantity of P & K was given as basal dose. Nitrogen fertiliser was divided in two equal doses and was applied as basal and 30 days after sowing. After sowing two herbicides, pendimethalin @ 1.25 litre/ha and atrazine @ 1 kg/ha were tank mixed and applied as pre-emergence to control weeds. One hand hoeing operation was done between 25-30 days after sowing to control emerging weeds. No irrigations were applied during the crop growing period due to well distributed rainfall. Major insect's pests of sorghum were kept in check by two sprays of insecticides Chlorantraniliprole 18.5 SC (80 ml/acre) @ 0.4 ml/litre of water and Emamectin benzoate 5% SG (80g/acre) @ 0.4g/litre of water by hand sprayer. The crop was harvested on 14th October, 2021 for silage making (ensiling) at around 92 days stage. At the time of harvest, growth parameters (plant height, number of leaves/plant, length of leaves, width of leaves, leaf area index, leaf:stem (L:S), fresh biomass weight/plant, dry matter accumulation and plant population), yield (silage and dry matter) and quality parameters (dry matter content, total soluble solids (TSS) or Úbrix and pH) were measured.

From each net plot area, total number of plants at two randomly selected spots of 3.0 metre row length

TABLE 1

Year of notification and source of seed of sorghum cultivars cultivated during trial

S. No.	Cultivars	Year of Notification	Source of seed
1.	SSG 898	Not-Notified	Kota Milk Union, Kota, Rajasthan
2.	GFS 6	2018	Main Sorghum Research Centre, NAU, Surat, Gujarat
3.	GAFS 11	2017	Anand Agricultural University, Anand, Gujarat
4.	GAFS 12	2018	Anand Agricultural University, Anand, Gujarat
5.	CSH 24MF	2009	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
6.	CSH 43MF	2020	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
7.	CSH 40F	2018	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
8.	CSV 35F	2018	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
9.	CSV 38F	2019	ICAR-IIMR, Hyderabad, Telangana
10.	CSV 40F	2019	Sorghum Research Station, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra
11.	CSV 44F	2020	CCSHAU, Hisar, Haryana
12.	CSV 46F	2021	Main Sorghum Research Centre, NAU, Surat, Gujarat
13.	HJ 541	2013	CCSHAU, Hisar, Haryana
14.	Pant Chari 5	1999	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
15.	Pant Chari 6	2004	Govind Ballabh Pant University of Agri. & Tech., Pantnagar, Uttarakhand
16.	CSV 21F	2006	Main Sorghum Research Centre, NAU, Surat, Gujarat
17.	Madhura 1 (Sweet Sorghum Hybrid)	1992	Nimbkar Agricultural Research Institute (NARI), Phaltan, Maharashtra
18.	Madhura 2 (Sweet Sorghum Variety)	2015	Nimbkar Agricultural Research Institute (NARI), Phaltan, Maharashtra
19.	Madhura 3 (Sweet Sorghum Variety)	2019	Nimbkar Agricultural Research Institute (NARI), Phaltan, Maharashtra

were counted for calculating number of plants per hectare. Data on growth parameters were recorded from six randomly selected plants from same area. The °brix reading was recorded by placing a drop of stem juice from middle portion on the surface of the hand refractometer. For estimation of dry matter content in green fodder of sorghum cultivars at harvest, 300 gram chopped fodder samples were dried in oven separately at 75°C to achieve constant weight. Plot wise fresh fodder yield was multiplied by respective dry matter content (%) to get dry matter weight (kg)/plot and was expressed as dry matter yield (t/ha).

For ensiling purpose, randomly selected green fodder samples from each treatment plot were chaffed to 1.0-2.0 cm size by using 2 horse power (HP) power chaff cutter. Well mixed chaffed green fodder was tightly filled, compacted and sealed manually in air tight plastic containers of 8 kg capacity for ensiling without the use of any culture or additives. After 45 days, sealed containers were opened and chemical analysis of silage samples were done for quality parameters *viz*. pH and dry matter content. pH of silage was recorded on the basis of fresh wet sample basis by using a hand-held digital pH meter. Plot wise 50 gram of silage samples were mixed in 150 ml of distilled water in a glass beaker. After 10 minutes, sensor of hand-held pH meter was dipped in silage solution to record pH reading. The 300 grams wet silage samples were oven dried at 75°C for 48 hours to achieve constant weight and thereafter, fine grinded (1 mm) for lab analysis. Experimental data were analysed statistically by 'F' test of significance using OPSTAT software as method given by Sheron *et al*. (1998). The results are presented at 5% level of significance (p=0.05) for making comparison between treatments.

RESULTS AND DISCUSSION

Growth parameters

Data (Table 2) revealed significant differences amongst the sorghum cultivars for different growth

TABLE 2
Growth parameters of sorghum as affected by cultivars

S. No.	Treatments	Growth Parameters								
		Plant height (cm)	Leaves/ plant	Length of leaves (cm)	Width of leaves (cm)	Leaf area index (LAI)	L:S	Fresh biomass weight/ plant (g)	Dry matter accumulation/ plant (g)	Plant Population (Lakh)
Single-cut fodder type										
1.	GAFS 11	295.33	9.80	78.00	6.43	0.93	0.26	239.00	116.67	0.25
2.	GAFS 12	310.33	7.60	81.10	6.17	1.10	0.15	180.00	94.00	0.37
3.	GFS 6	255.33	8.19	80.67	6.50	0.81	0.20	252.33	98.00	0.26
4.	CSV 21F (check)	280.00	9.17	82.07	6.83	0.91	0.21	349.33	158.33	0.24
5.	HJ 541	286.00	9.17	76.37	6.33	1.01	0.16	306.67	126.00	0.30
6.	CSV 46F	228.00	8.37	73.00	4.27	0.71	0.22	138.00	62.00	0.35
7.	Pant Chari 5	249.00	8.47	85.33	6.57	0.82	0.19	265.33	117.00	0.23
8.	CSV 35F	254.00	9.77	90.53	6.47	0.96	0.29	378.00	152.33	0.23
9.	CSV 38F	252.33	8.67	77.97	6.97	0.96	0.21	327.67	152.33	0.27
10.	CSV 40F	257.33	10.00	77.83	6.27	1.23	0.23	245.33	122.33	0.32
11.	CSV 44F	302.00	8.93	82.93	5.77	1.02	0.18	311.67	170.00	0.31
12.	CSH 40F	263.33	9.07	81.53	7.00	1.18	0.17	343.67	150.00	0.29
	Group mean	269.42	8.93	80.61	6.30	0.97	0.21	278.08	126.58	0.29
Sweet sorghum type										
13.	Madhura 1	263.00	9.10	80.27	6.27	1.15	0.20	262.33	119.00	0.33
14.	Madhura 2	252.67	10.10	88.20	6.77	1.27	0.22	324.67	117.00	0.27
15.	Madhura 3	234.33	9.73	84.10	5.73	0.91	0.22	236.67	97.33	0.30
	Group mean	250.00	9.64	84.19	6.26	1.11	0.21	274.56	111.11	0.30
Multi-cut fodder type										
16.	SSG 898	261.00	7.23	79.20	5.57	0.59	0.19	212.33	84.00	0.25
17.	Pant Chari 6	270.00	8.00	74.77	6.07	0.72	0.17	246.67	94.00	0.27
18.	CSH 24 MF	243.00	8.07	77.37	6.97	0.92	0.21	301.67	140.33	0.28
19.	CSH 43 MF	267.67	7.60	77.83	6.83	0.71	0.17	286.33	119.67	0.23
	Group mean	260.42	7.73	77.29	6.36	0.74	0.19	261.75	109.50	0.26
	S. Em±	11.26	0.58	2.86	0.46	0.21	0.02	43.8	23.27	0.04
	CD at 5%	32.42	1.67	8.22	1.32	NS	0.07	126.14	NS	NS

parameters viz. plant height (cm), number of leaves/plant, length of leaves (cm), width of leaves (cm), leaf to stem ratio (L:S) and fresh biomass weight/plant (g). GAFS 12 (310.33 cm) cultivar on a par with CSV 44F (302.00 cm), GAFS 11 (295.33 cm), CSV 21F (280.00 cm) and HJ 541 (286.00 cm) recorded significantly higher plant height in comparison to remaining cultivars. Lowest plant height was observed in sorghum cultivar Madhura 3 (234.33 cm).

Sorghum cultivar Madhura 2 (10.10 cm) on a par with eleven sorghum cultivars viz. HJ 541, CSV 21F, CSV 44F, CSV 35F, Madhura 1, CSV 40F, CSV 38F, Pant Chari 5, CSH 40F, Madhura 3 and GAFS 11 recorded significantly a greater number of leaves/plant in comparison to GAFS 12, CSH 43MF, Pant Chari 6, GFS 6, CSH 24MF, CSV 46F and SSG 898 (7.23 cm) that recorded lowest number of leaves/plant. These results are in close conformity with Shanti *et al.* (2019) that reported number of leaves/plant between 5.70-10.30 amongst seven forage sorghum cultivars in Hyderabad conditions.

Significantly higher length of leaves was recorded in cultivar CSV 35F (90.53 cm) in comparison to many sorghum cultivars but on a par with CSV 44F, Pant Chari 5, Madhura 2 and Madhura 3 cultivars. Sorghum cultivar, CSV 46F recorded lowest (73.00 cm) length of leaves. Width of leaves was recorded significantly higher in sorghum cultivar CSH 40F (7.00 cm) in comparison to two sorghum cultivars viz. SSG 898 (5.57 cm) and CSV 46F (4.27 cm) but at par with remaining sorghum cultivars.

Amongst all the sorghum cultivars, CSV 35F (0.29) at par with GAFS 11 (0.26), CSV 40F (0.23), CSV 46F (0.22), Madhura 2 (0.22) and Madhura 3 (0.22) recorded significantly higher leaf:stem (L:S) in comparison to all the other remaining cultivars. However, the lowest L:S ratio was recorded in GAFS 12 (0.15). Sorghum cultivar CSV 35F (378.00 g) recorded significantly higher fresh biomass weight/plant in comparison to many sorghum cultivars but at par with HJ 541, CSV 21F, CSH 43 MF, CSV 44F, GFS 6, Madhura 1, Madhura 2, CSH 24 MF, CSV 38MF, Pant Chari 5 and CSH 40F. Lowest fresh biomass weight/plant was recorded in cultivar CSV 46F (138.00 g).

On the basis of group mean values, parameters viz. plant height, fresh biomass weight/plant and dry matter accumulation/plant were found to be higher in single-cut fodder type cultivars in comparison to sweet sorghum and multi-cut fodder types cultivars. Whereas, group mean values of parameters such as number of leaves/plant and length of leaves were found to be higher in sweet sorghum type cultivars in comparison to other two groups of cultivars. However, higher width of leaves was observed in multi-cut fodder type cultivars as compared to other single-cut and sweet sorghum types of sorghum cultivars (Table 2). Non-significant differences were observed amongst sorghum cultivars for growth parameters such as leaf area index (LAI), dry matter accumulation/plant and plant population, however, the difference ranged between 0.59-1.23, 62.00-170.00 g and 0.23-0.37 lakh, respectively.

Silage yield and quality

Significant differences were observed amongst the sorghum cultivars for dry matter (%) in green fodder before ensiling, dry matter (%) in silage, °brix, pH, silage yield and dry matter yield (Table 3). Dry matter (%) in green fodder before ensiling was recorded significantly higher in cultivar GAFS 12 (37.74) in comparison to most of the cultivars but statistical at par with three cultivars GAFS 11 (35.00), SSG 898 (35.12) and CSV 44F (34.83). However, after completion of ensiling period, dry matter (%) in silage of sorghum cultivars was observed to be significantly higher in cultivar GAFS 11 (35.00) as compared to most of the cultivars but at par with two cultivars CSV 40F (34.71) and GAFS 12 (32.41). Lowest dry matter (%) in green fodder and silage was observed in cultivar Madhura 2 (29.80) and Pant Chari 5 (25.34). Amongst different groups of sorghum cultivars, mean dry matter (%) between green fodder and silage differed by 7.89, 8.08 and 9.48 for single-cut, sweet sorghum and multi-cut types, respectively. Gordon (1967) reported loss of dry matter (%) during ensiling period primarily due to combinations of factors such as moisture content of crop, permeability of silo and silage to air, and length of storage period. Zimmer (1980) reported that the losses associated with fermentation in the silo are primarily from carbon dioxide production and these losses typically are in the range of 2.0 to 4.0%. Borreani *et al.* (2018) reported that the factors affecting dry matter and quality losses in silage are attributed to field and pre-ensiling conditions, respiration and temperature at ensiling, fermentation patterns, methods of covering and weighting the silage cover, and management of aerobic deterioration. Browning (1965) observed an average loss of 6.0% in four gas tight silos filled with

TABLE 3
Quality and yield of sorghum as affected by cultivars

S. No.	Treatments	Quality & Yield Parameters					
		Dry matter (%) in green fodder before ensiling	Dry matter (%) in silage	°brix%	pH	Silage yield (t/ha)	Dry matter yield (t/ha)
Single-cut fodder type							
1.	GAFS-11	35.00	35.80	16.47	3.73	27.22	10.32
2.	GAFS-12	37.74	32.41	11.73	4.23	26.77	11.05
3.	GFS 6	30.94	27.80	16.03	3.70	32.49	11.31
4.	CSV 21F (check)	32.39	31.18	12.80	3.87	26.36	9.16
5.	HJ 541	30.35	27.97	13.33	3.93	40.23	12.61
6.	CSV 46F	30.00	29.10	14.87	3.50	29.88	9.37
7.	Pant Chari 5	30.51	25.34	12.23	3.77	31.73	9.59
8.	CSV 35F	32.14	28.41	11.93	3.53	36.47	12.09
9.	CSV 38F	30.79	26.00	14.77	3.73	29.64	9.14
10.	CSV 40F	32.10	34.71	14.70	4.17	21.68	6.82
11.	CSV 44F	34.83	30.22	15.30	4.00	38.11	13.97
12.	CSH 40F	31.18	28.37	14.33	3.83	34.06	10.15
	Group mean	32.33	29.78	14.04	3.83	31.22	10.47
Sweet sorghum type							
13.	Madhura 1	31.74	31.73	13.97	4.13	27.84	9.29
14.	Madhura 2	29.80	27.20	11.20	3.87	35.63	11.27
15.	Madhura 3	31.98	27.01	15.50	4.03	31.94	10.61
	Group mean	31.17	28.65	13.56	4.01	31.80	10.39
Multi-cut fodder type							
16.	SSG 898	35.12	27.78	11.50	3.63	28.74	9.88
17.	Pant Chari 6	32.30	29.72	9.40	4.10	22.99	7.63
18.	CSH 24 MF	30.16	28.92	15.13	4.00	24.70	7.72
19.	CSH 43 MF	32.77	31.58	13.10	3.93	29.32	9.93
	Group mean	32.59	29.50	12.28	3.92	26.44	8.79
	SEM+	1.40	1.31	0.79	0.07	2.81	1.19
	CD at 5%	4.04	3.76	2.28	0.2	8.08	3.42

sudan grass and grain sorghum forages at 55.0% moisture.

Sugar content is a key driver of fermentation process in silage making process. Measuring °brix in freshly cut forage gives a rapid estimate of fermentation potential before chopping and packing. In pure sugar solutions, generally, one °brix equals about 1 g of sucrose per 100 g of solution, but in plant juice, the reading represents all soluble solids, including sugars, amino acids, salts, and organic acids. A higher water-soluble carbohydrate (WSC) concentration in fodder, as indicated by a higher °brix reading, is generally desirable for good silage quality, as it promotes a more rapid growth of lactic acid bacteria. An efficient fermentation by LAB, quickly converts WSC into lactic acid, leading to a lower pH needed for preservation of wet fodder as silage. Garcia (2025) indicated that sugar levels between 12.0-18.0% in fresh fodder before ensiling generally lead to faster and more complete fermentation, whereas, low sugar levels can slow the process and increase the risk of spoilage. Crops with higher °brix levels might have an advantage in the fermentation process for silage and baleage (Lemus and White, 2022).

In this trial °brix content was found to be significantly higher in cultivar GAFS 11 (16.47%) in comparison to many cultivars but at par with GFS 6 (16.03%), Madhura 3 (15.50%), CSV 44F (15.30%), CSH 24MF (15.13%), CSV 46F (14.87%), CSV 38F (14.77%), CSV 40F (14.70%) and CSH 40F (14.33%). Higher °brix level greater than 11.00% were recorded in stem juices of all the sorghum cultivar except Pant Chari 6 (9.40%). Amongst the three groups of cultivars, mean °brix levels were recorded greater in single-cut fodder type cultivars (14.04%) as compared to sweet sorghum type (13.56%) and multi-cut fodder type (12.28%) sorghum cultivars. These results in close conformity with Kumar *et al.* (2022) that also reported °brix (13.38%) in sweet sorghum cultivar SPSSV 6. These differences in °brix content may be due to genetical diverse among sorghum cultivars. Patel (2024) reported that °brix (26.72%) was the main contributor to the total genetic divergence in sorghum.

Perusal of data in Table 3 reveal that pH in silage of all sorghum cultivars were found to be in highly desirable range (3.50-4.23) that may be attributed to the higher °brix content in stem juices. Significantly lowest pH was recorded in silage of cultivar CSV 46F (3.50) in comparison to many cultivars but at par with cultivars CSV 35F (3.53), SSG 898 (3.63) and GFS 6 (3.70). Highest pH was recorded in GAFS 12 (4.23). Bandara *et al.* (2015) reported that silage should have pH range between 3.8-4.2 to be in good quality and recorded pH value of 3.59 in silage of sorghum cultivar sugar graze. Amer *et al.* (2012) reported that high WSC content improved ensiling characteristics in forage sorghum due to higher lactic acid concentration. Despal *et al.* (2011) reported that high WSC content in feed ingredients provides optimal conditions for lactic acid bacteria to increase carbohydrate fermentation into organic acids. In the trial, among three groups of cultivars, mean pH values were recorded lower in single-cut fodder type cultivars (3.80) as compared to multi-cut fodder type (3.92) sorghum cultivars and sweet sorghum type (4.01) cultivars.

In this trial, silage yield was recorded to be significantly higher in sorghum cultivar HJ 541 (40.23 t/ha) in comparison to many cultivars but on a par with five cultivars *viz.* CSV 44F (38.11 t/ha), CSV 35F (36.47 t/ha) Madhura 2 (35.63 t/ha), CSH 40F (34.06 t/ha) and GFS 6 (32.49 t/ha). Amongst the sorghum cultivars, significantly highest dry matter yield was recorded in cultivar CSV 44F (13.97 t/ha) but on a par with sorghum cultivars viz. HJ 541 (12.61 t/ha), CSV 35F (12.09 t/ha), GFS 6 (11.31 t/ha), Madhura 2 (11.27 t/ha), GAFS 12 (11.05 t/ha), and Madhura 3 (10.61 t/ha). These results are in conformity with Satpal *et al.* (2020) that also reported significant differences amongst the nine forage sorghum cultivars for dry matter yield. Kumari *et al.* (2020) reported that in three years trial, CSV 44F cultivar produced 40.70 t/ha and 11.43 t/ha of green fodder and dry matter yields, respectively; and out yielded check cultivar CSV 21F. Higher silage yield and dry matter yield in sorghum cultivar viz. HJ 541 and CSV 44MF may be attributed to the combined effects of different attributes that recorded at higher levels in these cultivars viz. plant height (>280cm), number of leaves/plant (8.9), length of leaves (75 cm), fresh biomass yield/plant (305 g/plant) and dry matter content in green fodder (30%). Pushpendra *et al.* (2025) reported that green fodder yield in sorghum is positive correlated with plant height, leaf length, leaf breadth, stem girth, leaves per plant and leaf area at genotypic and phenotypic level. Agrawal *et al.* (2003) reported that green and dry matter yield in sorghum elite genotypes are highly correlated with leaf length and plant height. Pandey *et al.* (2006) also reported that fodder yield in sorghum is significantly correlated with plant height and number of leaves/plant. Lowest yields for silage (21.68 t/ha) and dry matter (6.82 t/ha) were observed in cultivar CSV 40F.

Single-cut sorghum cultivars, HJ 541 and CSV 44F out yielded check cultivar CSV 21F by 34.48% and 30.83% for silage yields and, 27.36% and 34.43% for dry matter yields, respectively (Table 3). Amongst sweet sorghum cultivars, higher silage yield (35.63 t/ha) and dry matter yield (11.27 t/ha) were recorded in cultivar Madhura 2. Whereas, amongst multi-cut type sorghum cultivars, CSH 43MF recorded higher silage yield (29.32 t/ha) and dry matter yield (9.93 t/ha). Singh *et al.* (2015) reported that Madhura 2 gave the significantly higher green fodder yield of 40 t/ha as against 34.00 t/ha, 30.00 t/ha and 35.00 t/ha for the national checks CSV 19SS, CSV 24SS and CSH 22SS, respectively.

Overall in this trial on the basis of group mean values, lower silage and dry matter yields were observed in multi-cut fodder type group as compared to single-cut and sweet sorghum type group of cultivars. This may be due to genetic variability amongst sorghum cultivars.

CONCLUSION

This study indicated that the good quality mean silage yields between 26.44 to 31.80 t/ha having pH between 3.83-4.01 may be achieved by cultivating notified single-cut fodder type, multi-cut fodder type and sweet sorghum type sorghum cultivars in the country. In the green fodder of sorghum cultivars, presence of mean °brix content (>12%) in stem juices resulted in excellent fermentation process leading to production of good quality of silage. It was observed that silage making process affect the mean dry matter content in silage in comparison to green fodder before ensiling and resulted in decline in dry matter content between 7.89-9.48% amongst three groups of sorghum cultivars.

In this trial, three single-cut type sorghum cultivars HJ 541, CSV 44F and CSV 35F as well as one sweet sorghum type cultivar Madhura 2 produced combination of more than 35.0 t/ha of silage and 11.0 t/ha of dry matter yields, therefore, for good quality silage production, these four cultivars may be highly recommended for cultivation under central Gujarat conditions.

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