

COMPARATIVE EVALUATION OF *CENCHRUS CILIARIS* GENOTYPES FOR FODDER YIELD AND ITS ATTRIBUTES WITH QUALITY PARAMETERS UNDER DIFFERENT AGRO-ECOLOGICAL ZONES OF INDIA

Y. JINDAL* AND SATPAL

Department of Genetics & Plant Breeding
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India

*(e-mail : yjindalhau@gmail.com)

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SUMMARY

A varietal evaluation trial on perennial *Cenchrus ciliaris* (Buffel grass) was conducted at 13 locations under three different agro-ecological zones viz. North-western (NW), Central (CZ) and South (SZ) zones of India from 2016-17 to 2018-19. Six genotypes of *Cenchrus ciliaris* were evaluated along with three national checks viz. CAZRI 75, IGFRI 3108 and IGFRI 727 for assessing their fodder yield potential and quality parameters at CCS HAU, Hisar. The same set of entries was also tested at thirteen different locations distributed in the three zones for fodder trial. The highest green fodder yield pooled over three years (1317.2 q/ha) was recorded at Coimbatore in south zone followed by Urulikanchan (437.3 q/ha) in the central zone and in Hisar, Haryana (388.2 q/ha) whereas, the highest pooled dry matter yield (233.8 q/ha) was recorded at Coimbatore in south zone followed by Urulikanchan (195.8 q/ha) and Hisar (91.1 q/ha) in the central zone. Highest per day productivity of green fodder pooled over three years was recorded at Hisar, Ludhiana and Jhansi (GFY (q/ha/day – 4.03, 3.27 and 3.0, respectively) in different zones. The national check CAZRI 75 gave highest green fodder yield (543.5 q/ha) and the genotype IG-67-365 gave highest dry fodder yield (400.8 q/ha) pooled over three years. The highest crude protein yield pooled over three years was obtained at Urulikanchan (12.1 q/ha) followed by Anand (7.2 q/ha) and Hisar (5.3 q/ha). Top two genotypes that gave the best crude protein yield are IG-67-365 (6.0 q/ha) and the best check CAZRI 75 (5.5 q/ha) pooled over three years. *Cenchrus ciliaris* genotype RCCB-03-23 gave In vitro dry matter digestibility (IVDMD%) pooled over three years (53.9%) which is almost at a par with the best check IGFRI 3108 (53.7%). At Hisar, the *Cenchrus ciliaris* genotype RCCB-04-3 gave Neutral Detergent Fiber (66.8%) as compared to the best check IGFRI 3108 (69.1%). The genotype RCCB-03-23 gave Acid Detergent Fiber (ADF%) (42.5%) as compared to the best check IGFRI 3108 (43.5%). A close look at the data reveals that Southern zone gave higher green fodder and dry matter yields, plant height and production efficiency thereby indicating that climatic and edaphic conditions are very suitable for *Cenchrus ciliaris* as compared to Central Zone and North West Zone.

Key words : *Cenchrus ciliaris*, buffel grass, green fodder, dry matter, quality parameters

India feeds nearly 20% of the world's livestock being the leader in cattle (16%) and buffalo (5.5%) population. The livestock contributes 32% of the agricultural output, which is 22% of the total GDP in India. Deficiency in feed and fodder has been identified as one of the major components in achieving the desired level of livestock production in India. The shortage in dry fodder is around 21.8% compared with requirement of 560 million tons for the current livestock population (Kumar *et al.*, 2012a; Kumar *et al.*, 2013). India is a thickly populated country of world; therefore, to satisfy their appetite, cultivation of food fodder crops is must. But, in our country

livestock population is also very huge and we are unable to produce sufficient green fodder for them, due to lack of resources (Kumar *et al.*, 2012b; Preeti *et al.*, 2016). Therefore, it is an instant need to utilize the marginal lands and forest areas to cultivate the perennial grasses.

Cenchrus ciliaris (Buffel grass) is a perennial grass and grown widely in tropical and sub-tropical arid rangelands around the globe because of its high tolerance to drought and capacity to withstand heavy grazing. It can rapidly invade native vegetation, roadsides and urban landscapes, altering the wildfire regime and displacing the native flora and fauna

(Marshall *et al.*, 2012). It is a pasture grass used in Africa, India, USA and Australia. In India, it is mainly grown in traditional pastureland farming system (Adlin *et al.*, 2018). It encompasses a wide range of variation, and is generally apomictic. Buffel grass is an African native species that is drought-tolerant, resistant to heavy grazing and has fast growth, features that make this species valuable as a forage plant (Tinoco-Ojanguren *et al.*, 2016). Because of its importance as a forage plant, ecophysiological studies on buffel grass germination have been more agronomically oriented, trying to improve its germination and establishment in specific areas (Bhattarai *et al.*, 2008).

MATERIALS AND METHODS

Six entries of perennial *Cenchrus ciliaris* (RCCB-03-23, IGFRI-67-75, RCCB-04-3, IGFRI-96-79, CAZRI-231 and IG-67-365) contributed by various Coordinating Centers under AICRP (FCU) were evaluated along with three national checks *viz.* CAZRI 75, IGFRI 3108 and IGFRI 727 for assessing their fodder yield potential in trials during 2016 to 2018 at CCS HAU, Hisar. The same set of entries was also tested at thirteen different locations distributed in the three different agro-ecological zones *viz.* North western (NWZ), Central (CZ) and South (SZ) zones of India during this period for fodder trial (Anonymous, 2016, 2017, 2018).

The experiment was sown at the research farm area of Forage Section, CCS HAU, Hisar in *Kharif* season with three replications. The plot size was 4.0 m × 3.0 m, with row to row distance of 50 cm. The data of green fodder yield, plant height, leaf: stem ratio was recorded at 50 % flowering. Dry matter yield was

recorded after drying the green fodder samples; production efficiency was calculated by dividing the green fodder or dry matter yield by number of days to harvesting. The samples of dry fodder were analyzed for quality parameters using standard protocols. Total nitrogen in the samples was estimated by conventional Micro-kjeldahl's method and nitrogen content was converted to crude protein percent by multiplication of a factor 6.25. *In vitro* dry matter digestibility was determined by the method of Tilley and Terry (1963) as modified by Barnes *et al.* (1971). Structural carbohydrates *viz.* neutral detergent fibers (NDF), acid detergent fiber (ADF), were determined by the method of Goering and Van Soest (1970). The data so obtained was statistically analyzed by using OPSTAT software available at CCSHAU website (Sheorn *et al.*, 1998).

RESULTS AND DISCUSSION

The results of the present experiment on six entries of perennial *Cenchrus ciliaris* are presented in Tables 1-7 and discussed under following sub-heads.

Green Fodder Yield (GFY) : In Haryana at Hisar, *Cenchrus ciliaris* best check CAZRI 75 (543.5 q/ha) gave highest pooled green fodder yield (Table 1). At All-India level, IG-67-365 gave highest pooled green fodder yield (GFY- 400.8 q/ha) as compared to the best national check CAZRI 75 (388.4 q/ha). The mean GFY at Hisar (388.2 q/ha) was higher than the mean GFY at All-India level (319.4 q/ha).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 6) revealed that the highest green fodder yield pooled over three years (1317.2 q/ha) was recorded at Coimbatore in south zone followed

TABLE 1
Performance of *Cenchrusciliaris* genotypes for fodder yield over three years

S. No.	Genotypes	Green Fodder Yield (q/ha)								Dry Matter Yield (q/ha)							
		Hisar				All-India				Hisar				All-India			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	RCCB-03-23	51.7	225.3	607.4	294.8	281.6	311.3	281.4	291.4	15.3	55.1	66.3	45.6	66.2	87.0	73.2	75.5
2	IGFRI-67-75	253.3	261.0	625.3	379.9	316.5	307.6	268.6	297.6	85.0	80.5	70.5	78.7	80.5	91.1	70.3	80.6
3	RCCB-04-3	153.6	294.0	370.3	272.6	279.9	306.2	254.7	280.3	51.9	84.1	92.0	76.0	73.3	91.7	79.5	81.5
4	IGFRI-96-79	438.1	423.2	556.3	472.5	410.5	427.9	309.1	382.5	144.1	126.4	97.0	122.5	116.8	125.3	89.8	110.6
5	CAZRI-231	284.2	309.5	445.3	346.3	305.0	342.8	264.7	304.2	96.0	91.7	78.9	88.9	78.3	103.4	76.3	86.0
6	IG-67-365	441.9	479.9	496.4	472.7	410.4	470.7	321.2	400.8	155.0	141.6	108.9	135.2	119.6	137.4	91.5	116.2
7	CAZRI 75 (C)	500.6	415.7	714.2	543.5	429.3	415.2	320.7	388.4	176.3	136.1	100.8	137.7	121.4	125.0	89.0	111.8
8	IGFRI 3108 (C)	363.6	354.2	500.3	406.0	354.3	321.6	281.4	319.1	135.8	104.0	106.0	115.3	94.1	95.1	80.1	89.8
9	IGFRI 727 (C)	165.0	322.9	428.7	305.5	190.8	205.2	234.2	210.1	60.7	95.7	99.8	85.4	68.7	70.2	72.7	70.5
	Mean	294.7	342.9	527.1	388.2	330.9	345.4	281.8	319.4	102.2	101.7	91.1	98.3	91.0	102.9	80.3	91.4
	C. D. (P=0.05)	56.2	58.2	45.3						20.5	19.6	16.5					
	CV %	11.2	10.0	12.2						11.8	11.3	12.9					

TABLE 2
Performance of *Cenchrus ciliaris* genotypes for production efficiency over three years

S. No.	Genotypes	Green Fodder Yield (q/ha/day)							Dry Matter Yield (q/ha/day)						
		Hisar			All-India				Hisar			All-India			
		2016	2017	Pooled	2016	2017	2018	Pooled	2016	2017	Pooled	2016	2017	2018	Pooled
1.	RCCB-03-23	0.97	1.67	1.32	0.98	1.59	1.60	1.39	0.30	0.36	0.33	0.26	0.45	0.45	0.39
2.	IGFRI-67-75	5.01	1.43	3.22	1.83	1.66	1.56	1.68	1.77	0.40	1.09	0.61	0.50	0.47	0.53
3.	RCCB-04-3	3.27	1.91	2.59	1.63	1.70	1.52	1.62	1.17	0.49	0.83	0.59	0.58	0.48	0.55
4.	IGFRI-96-79	8.84	2.40	5.62	2.66	2.16	1.85	2.22	3.01	0.64	1.83	1.02	0.71	0.61	0.78
5.	CAZRI-231	5.64	1.94	3.79	1.99	1.80	1.61	1.80	1.98	0.52	1.25	0.67	0.54	0.48	0.56
6.	IG-67-365	8.88	2.83	5.86	2.71	2.24	1.91	2.29	3.26	0.73	2.00	1.11	0.71	0.62	0.81
7.	CAZRI 75 (c)	10.07	2.39	6.23	2.82	2.12	1.69	2.21	3.77	0.71	2.24	1.09	0.69	0.57	0.78
8.	IGFRI 3108(c)	7.59	2.24	4.92	2.31	1.79	1.70	1.93	3.00	0.59	1.80	0.86	0.54	0.49	0.63
9.	IGFRI 727(c)	3.40	2.10	2.75	2.34	1.66	1.57	1.86	1.33	0.54	0.94	0.91	0.60	0.64	0.72
	Mean	5.96	2.10	4.03	2.14	1.86	1.67	1.89	2.18	0.55	1.37	0.79	0.59	0.53	0.64

TABLE 3
Performance of *Cenchrus ciliaris* genotypes for morphological traits over three years

S. No.	Genotypes	Plant Height (cm)							Leaf : Stem Ratio								
		Hisar			All-India				Hisar			All-India					
		2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
1.	RCCB-03-23	67.1	84.1	88.3	79.8	77.4	88.1	84.1	83.2	1.31	2.30	0.67	1.43	0.92	1.44	1.05	1.14
2.	IGFRI-67-75	82.8	89.8	93.5	88.7	88.1	93.4	89.2	90.2	1.01	1.76	0.64	1.14	0.88	1.44	1.17	1.16
3.	RCCB-04-3	73.4	76.6	80.3	76.8	78.0	76.3	75.4	76.6	2.17	2.20	0.60	1.66	1.07	1.49	1.24	1.27
4.	IGFRI-96-79	90.6	102.5	109.8	101.0	92.2	100.4	93.1	95.2	1.29	1.66	0.65	1.20	1.14	1.29	1.34	1.26
5.	CAZRI-231	97.6	95.7	92.5	95.3	87.9	92.9	88.8	89.9	1.04	2.18	0.52	1.25	0.91	1.33	1.10	1.11
6.	IG-67-365	88.4	114.0	109.0	103.8	93.3	99.4	94.1	95.6	1.41	1.43	0.57	1.14	1.10	1.29	1.24	1.21
7.	CAZRI 75 (c)	96.7	99.9	114.9	103.8	93.5	98.8	93.4	95.2	1.21	1.57	0.56	1.11	0.97	1.36	1.18	1.17
8.	IGFRI 3108(c)	99.8	87.1	96.0	94.3	86.2	87.3	84.5	86.0	1.08	2.08	0.70	1.29	0.87	1.30	1.28	1.15
9.	IGFRI 727(c)	81.0	94.0	96.7	90.6	78.0	86.1	77.1	80.4	1.09	1.60	0.57	1.09	0.79	0.86	0.63	0.76
	Mean	86.4	93.7	97.9	92.7	86.1	91.4	86.6	88.0	1.29	1.86	0.61	1.25	0.96	1.31	1.14	1.14

TABLE 4
Performance of *Cenchrus ciliaris* genotypes for quality parameters over three years

S. No.	Genotypes	Crude Protein Yield (q/ha)						Crude Protein (%)					
		Hisar		All-India				Hisar			All-India		
		2017	2016	2017	2018	Pooled	2016	2017	Pooled	2016	2017	2018	Pooled
1	RCCB-03-23	3.1	3.1	5.0	4.3	4.1	9.5	5.6	7.6	7.8	6.6	6.5	7.0
2	IGFRI-67-75	4.3	4.6	5.0	3.9	4.5	9.5	5.3	7.4	7.5	6.4	6.3	6.7
3	RCCB-04-3	4.4	3.6	5.0	4.7	4.4	10.0	5.2	7.6	7.8	6.9	6.5	7.1
4	IGFRI-96-79	6.1	5.6	7.3	4.5	5.8	9.8	4.8	7.3	7.4	6.5	6.5	6.8
5	CAZRI-231	4.6	3.5	6.2	3.9	4.5	10.1	5.0	7.6	7.0	6.4	6.2	6.5
6	IG-67-365	7.0	5.0	8.4	4.5	6.0	9.4	5.0	7.2	7.6	6.7	7.2	7.2
7	CAZRI 75 (c)	7.4	5.1	6.9	4.4	5.5	10.1	5.5	7.8	7.2	6.3	6.3	6.6
8	IGFRI 3108(c)	5.8	4.7	4.8	4.3	4.6	10.2	5.6	7.9	7.5	6.3	6.2	6.7
9	IGFRI 727(c)	4.9	0.8	2.6	2.3	1.9	10.1	5.1	7.6	8.4	5.6	5.5	6.5
	Mean	5.3	4.0	5.7	4.0	4.6	9.8	5.2	7.5	7.6	6.4	6.3	6.8

by Urulikanchan (437.3 q/ha) in the central zone and Hisar (388.2 q/ha) in the north west zone. The genotype IG-67-365 gave a slight increase of 3.19% for green fodder yield as compared to best check CAZRI 75 over three years. The highest green fodder yield is due to characters like plant height, regeneration capacity and leaf stem ratio. Similar results are also reported by Shashikanth *et al.* (2013) and Sheoran *et al.* (2017).

Dry Matter Yield (DMY) : At Hisar in Haryana, *Cenchrus ciliaris* genotype IG-67-365 (Table 1) gave high dry matter yield pooled over three years (DMY- 135.2 q/ha) as compared to the best check CAZRI 75 (137.7 q/ha). At All-India level also, IG-67-365 gave highest pooled dry matter yield (DMY- 116.2 q/ha) as compared to the best check CAZRI 75 (111.8 q/ha). The mean DMY at Hisar (98.3 q/ha) was also higher than the mean DMY at All-India level (91.4 q/ha).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 6) revealed that the highest dry matter yield pooled over three years (233.8 q/ha) was recorded at Coimbatore in south zone followed by Urulikanchan (195.8 q/ha) in the central zone and Hisar (91.1 q/ha) in the north west zone. The highest dry matter yield is due to characters like plant height and leaf stem ratio. Similar results are also reported by Vanlauwe (2004).

Production Efficiency : At Hisar, *Cenchrus ciliaris* national check CAZRI 75 (Table 2) gave highest per day production of green fodder pooled over two years (6.23q/ha/day) as compared to genotypes IG-67-365 and IGFRI-96-79 (5.86 and 5.62 q/ha/day,

respectively). However, at All-India level, the genotypes IG-67-365 and IGFRI-96-79 (2.29 and 2.22 q/ha/day, respectively) were just at par with the national check CAZRI 75 (2.21 q/ha/day). The mean GFY (q/ha/day) at Hisar (4.03) was higher than the mean GFY (q/ha/day) at All-India level (1.89 q/ha/day).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 6) revealed that the highest per day productivity of green fodder pooled over three years was recorded at Hisar, Ludhiana and Jhansi (GFY (q/ha/day – 4.03, 3.27 and 3.0, respectively) in different zones. Almost same trend was observed for per day production of dry matter (q/ha/day).

Plant Height : At Hisar, national check CAZRI 75 and IG-67-365 of *Cenchrus ciliaris* (Table 3) were tallest (103.8 cm) pooled over three years followed by IGFRI-96-79 (101.0 cm). However, at All-India level, the genotypes national check CAZRI 75, IG-67-365 and IGFRI-96-79 were found to be tall (95.2, 95.6 and 95.2 cm, respectively). The mean plant height at Hisar (92.7 cm) was slightly taller than the mean plant height at All-India level (88.0 cm).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 7) revealed that the tallest plants pooled over three years (121.1 cm) was recorded at Anand followed by Ludhiana (114.2 cm) and Avikanagar (106.4 cm). More height of the plants is mainly due to the high input intake by the buffel grass plants. Similar reports are also reported by Tessema *et al.* (2003).

Leaf Stem Ratio : At Hisar, all the *Cenchrus ciliaris* genotypes (Table 3) gave a high value for leaf:

TABLE 5
Performance of *Cenchrus ciliaris* genotypes for quality parameters over three years at Hisar

S. No.	Genotypes	IVDMD%				NDF%				ADF%			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	RCCB-03-23	53.0	54.3	54.3	53.9	60.1	74.9	69.5	68.2	41.4	43.4	42.6	42.5
2	IGFRI-67-75	50.7	49.8	56.3	52.3	64.2	74.1	69.0	69.1	47.8	44.1	42.2	44.7
3	RCCB-04-3	52.0	51.5	55.5	53.0	60.7	69.6	70.1	66.8	42.1	45.0	43.3	43.5
4	IGFRI-96-79	52.3	49.4	55.4	52.4	63.4	72.8	70.7	69.0	43.0	45.1	43.5	43.9
5	CAZRI-231	51.9	49.7	54.1	51.9	63.4	73.8	70.6	69.3	44.8	45.4	42.4	44.2
6	IG-67-365	52.7	49.5	-	51.1	63.5	75.5	71.4	70.1	44.0	44.8	43.2	44.0
7	CAZRI 75 (c)	51.2	51.9	51.8	51.6	66.8	77.0	73.4	72.4	49.0	44.7	44.9	46.2
8	IGFRI 3108(c)	54.4	51.0	55.8	53.7	62.8	74.8	69.8	69.1	44.1	44.2	42.2	43.5
9	IGFRI 727(c)	51.9	45.1	55.7	50.9	-	-	-	-	-	-	-	-
Mean		52.2	50.2	54.8	52.4	63.1	74.1	70.6	69.3	44.5	44.6	43.0	44.0

IVDMD - In vitro dry matter digestibility; NDF - Neutral Detergent Fiber; ADF - Acid Detergent Fiber.

stem ratio (range 1.66 – 1.14) against the best check CAZRI 75 (1.11) pooled over three years. At All-India level RCCB-04-3, IGFRI-96-79 and IG-67-365 gave high leaf: stem ratio (1.27, 1.26 and 1.21, respectively) which is comparable with the best check CAZRI 75 (1.17). The mean leaf: stem ratio at Hisar (1.25) was a bit higher than the mean leaf: stem ratio at All-India level (1.14).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 7) revealed that the leaf: stem ratio (pooled over three years) of 2.57 recorded at Jodhpur followed by Anand, Rahuri and Hisar (1.37, 1.36 and 1.25, respectively). Leaf: stem ratio increase is mainly due to increase in the foliage that has utilized

the solar energy in the production of photosynthates ending in higher biomass production. Similar results have been reported by Shashikanth *et al.* (2013).

Forage Quality parameters

The nutritive value or quality of forage (*i.e.* content of CP, NDF and extent of digestibility) is important for animal consumption and productivity (Abdalla *et al.*, 2007). Plant cell wall is an important source of energy for the ruminant. Its main components are structural carbohydrates *i.e.* Neutral Detergent fibre and acid detergent fibre. Digestibility of structural carbohydrates and amount of energy released depends

TABLE 6
Location wise performance of *Cenchrus ciliaris* varietal trial for fodder yield over three years

S. No.	Locations across the country	GFY (q/ha)				DMY (q/ha)				GFY (q/ha/day)				DMY (q/ha/day)			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	Ludhiana	380.9	469.4	206.8	352.4	110.3	129.1	41.9	93.8	-	4.39	2.14	3.27	-	1.16	0.44	0.80
2	Hisar	294.7	342.9	527.1	388.2	102.2	101.7	91.1	98.3	5.96	2.10	-	4.03	2.18	0.55	-	1.37
3	Jodhpur	181.5	130.3	112.1	141.3	-	34.0	26.7	30.4	1.86	1.42	2.20	1.83	-	0.37	0.51	0.44
4	Avikanagar	70.4	-	131.6	101.0	14.5	20.4	31.3	22.1	1.17	1.71	2.17	1.68	0.24	0.34	0.52	0.37
5	Bikaner	-	137.3	126.3	131.8	-	66.3	57.6	62.0	-	1.67	1.50	1.59	-	0.81	0.69	0.75
	NWZ Average	228.0	234.2	227.9	222.9	75.5	72.7	52.1	61.3	3.00	2.26	2.00	2.48	1.21	0.65	0.54	0.74
6	Anand	550.8	293.5	226.9	357.1	187.9	84.0	60.6	110.8	1.44	0.88	0.65	0.99	0.49	0.25	0.18	0.31
7	Rahuri	236.4	302.2	138.6	225.7	74.8	76.7	45.5	65.7	-	-	-	-	-	-	-	-
8	Urulikanchan	109.7	746.9	455.3	437.3	24.7	290.8	195.8	170.4	-	-	-	-	-	-	-	-
9	Jabalpur	88.1	114.3	111.1	104.5	13.8	20.2	19.8	17.9	0.24	0.31	0.30	0.28	0.04	0.05	0.05	0.05
10	Jhansi	301.2	302.3	304.6	302.7	141.3	142.4	144.7	142.8	2.98	2.99	3.02	3.00	1.40	1.41	1.43	1.41
	CZ Average	250.9	336.2	243.2	285.5	87.0	117.8	91.6	101.5	1.55	1.39	1.32	1.42	0.64	0.57	0.55	0.59
11	Coimbatore	1609.0	1344.8	997.7	1317.2	265.3	309.8	233.8	269.6	-	-	-	-	-	-	-	-
12	Mandya	233.4	249.3	211.9	231.5	66.9	70.1	64.3	67.1	-	-	-	-	-	-	-	-
13	Hyderabad	111.3	171.5	174.0	152.3	23.6	39.4	40.0	34.3	0.89	1.43	1.45	1.26	0.19	0.33	0.33	0.28
	SZ Average	651.2	588.5	461.2	567.0	118.6	139.8	112.7	123.7	0.89	1.43	1.45	1.26	0.19	0.33	0.33	0.28
	All India Average	330.9	345.4	281.8	319.4	91.0	102.9	80.3	91.4	2.14	1.86	1.67	1.89	0.79	0.59	0.53	0.64

Locations: 1-5: North West Zone; 6-10: Central Zone of India; 11-13: South zone.

TABLE 7
Location wise performance of *Cenchrus ciliaris* varietal trial for morphological traits over three years

S. No.	Locations across the country	Plant height (cm)				Leaf : stem ratio				Crude Protein Yield (q/ha)				Crude Protein (%)			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
1.	Ludhiana	129.6	102.0	110.9	114.2	-	-	-	-	-	-	-	-	-	-	-	-
2.	Hisar	86.4	93.7	97.9	92.7	1.29	1.86	0.61	1.25	-	5.3	-	5.3	9.8	5.2	-	7.5
3.	Jodhpur	96.9	99.7	107.7	101.4	-	2.50	2.63	2.57	-	-	-	-	-	-	-	-
4.	Avikanagar	99.5	118.6	101.0	106.4	1.49	1.89	1.66	1.68	-	1.6	2.6	2.1	-	7.7	8.1	7.9
5.	Bikaner	-	100.9	70.1	85.5	-	1.07	1.19	1.13	-	3.1	2.5	2.8	-	4.8	4.3	4.6
6.	Anand	99.9	133.0	130.4	121.1	1.16	1.55	1.39	1.37	13.2	4.1	4.2	7.2	6.6	4.9	6.9	6.1
7.	Rahuri	86.3	79.9	67.4	77.9	1.23	1.38	1.47	1.36	5.1	5.4	3.0	4.5	7.0	7.2	6.7	7.0
8.	Urulikanchan	67.2	60.5	54.1	60.6	0.72	0.70	0.67	0.70	2.0	21.8	12.6	12.1	7.9	7.5	6.5	7.3
9.	Jabalpur	57.1	59.2	59.4	58.6	0.55	0.56	0.48	0.53	1.1	1.3	1.3	1.2	6.9	6.6	6.9	6.8
10.	Jhansi	95.0	95.9	100.9	97.3	-	-	-	-	-	-	-	-	-	-	-	-
11.	Mandya	66.1	68.6	63.6	66.1	0.67	0.69	0.65	0.67	3.1	5.7	3.8	4.2	4.7	8.2	5.8	6.2
12.	Hyderabad	73.6	-	-	73.6	0.72	-	-	0.72	1.9	-	-	1.9	7.8	-	-	7.8
	Average	86.1	91.4	86.6	87.9	0.96	1.31	1.14	1.20	4.0	5.7	4.0	4.6	7.2	6.4	6.3	6.8

Locations : 1-5: North West Zone; 6-10: Central Zone of India; 11-12: South zone.

largely on the degree of lignification of the tissue and tends to decline as plant age increase (Said *et al.*, 1979). Large amount of cell wall carbohydrates remains undigestible even with a relatively small amount of lignin. A strong negative correlation exists between lignin concentration and digestibility of tropical forages (Ford *et al.*, 1979).

Crude Protein Yield (q/ha) : At Hisar, *Cenchrus ciliaris* genotype IGFRI-96-79 (Table 4) gave high crude protein (7.0 q/ha) as compared to the best check CAZRI 75 (7.4 q/ha). At All-India level also, two top genotypes gave the crude protein yield as 6.0 q/ha (IG-67-365) and the best check CAZRI 75 (5.5 q/ha) pooled over three years. The mean crude protein yield at Hisar (5.3 q/ha) was higher than the mean at All-India level (4.6 q/ha) for this character. Higher crude protein yields may be due to increased photosynthetic activities leading to higher cell division and elongation of the cells that resulted in accumulation of more photosynthates, leading to higher dry matter production which ultimately resulted in higher crude protein production. These results are also in line with the findings of Joshi *et al.*, (2012) and Prajapatiet *al.*, (2020).

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 7) revealed that the highest crude protein yield pooled over three years was obtained at Urulikanchan (12.1 q/ha) followed by Anand (7.2 q/ha) and Hisar (5.3 q/ha).

Crude Protein content (%) : At Hisar, the *Cenchrus ciliaris* best check IGFRI 3108 (Table 4) gave highest crude protein percent pooled over three years (range 7.9 - 7.2%) as compared to both checks (7.9%). At All-India level IG-67-365, RCCB-04-3 and RCCB-03-23 gave crude protein (7.2, 7.1 and 7.0%) which were a bit higher than the best check IGFRI 3108 (6.7%). The mean crude protein percent at Hisar (7.5%) was higher than the mean at All-India level (6.8%) for this character.

Location wise performance of the varietal trial on *Cenchrus ciliaris* (Table 4) revealed that the highest crude protein percent pooled over three years was obtained at Avikanagar (7.9%) followed by Hyderabad (7.8%) and Hisar (7.5%). Higher crude protein percent may be due to more nitrogen accumulation and its conversion to the protein in the particular genotype.

In vitro Dry Matter Digestibility (IVDMD %) : At Hisar, the *Cenchrus ciliaris* genotype RCCB-03-23 (Table 5) gave IVDMD% pooled over three

years (53.9%) which is almost at a par with the best check IGFRI 3108 (53.7%). Higher IVDMD percent is desirable and it was mainly due to less lignin content in RCCB-03-23 (42.5%) than the best check IGFRI 3108(43.5%) as observed in ADF%. Moreover, IVDMD primarily depends upon the concentration of cellulose and hemicelluloses, which in turn influenced by the degree of lignification, silicification (Van-Soest and Jones, 1968) and fiber components (Luthra *et al.*, 1988). A strong negative correlation exists between lignin concentration and digestibility of tropical forages (Ford *et al.*, 1979).

Neutral Detergent Fiber (NDF %) : At Hisar, the *Cenchrus ciliaris* genotype RCCB-04-3 (Table 5) gave NDF% (66.8%) as compared to the best check IGFRI 3108 (69.1%). Lower NDF percent is desirable and it might be due to low hemicellulose and less lignifications of the tissues. Further, high leaf to stem ratio also contribute to low NDF content as leaves are generally less lignified than stem.

Acid Detergent Fiber (ADF %) : At Hisar, the *Cenchrus ciliaris* genotype RCCB-03-23 (Table 5) gave ADF% (42.5%) as compared to the best check IGFRI 3108 (43.5%). Lower ADF percent is desirable and it might be due to low lignin content.

Multipurpose fodder trees that had NDF and ADF content below 30% and 40%, respectively, are believed to have high digestibility (Solomon, 2002). The NDF, ADF and CP contents of *Cenchrus ciliaris* were comparable to findings of Kiraz (2011). NDF digestion can be attributed to lignin which in association with cell walls limit microbial degradation. In addition, lignin, being a component of the cell wall, influences directly its digestibility and hence forage digestibility (Jung and Allen, 1995).

A close look at the data reveals that Southern zone represented by Hyderabad, Coimbatore and Mandya gave higher green fodder and dry matter yields, plant height and production efficiency thereby indicating that climatic and edaphic conditions are very suitable for *Cenchrus ciliaris* as compared to Central Zone and North West Zone.

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