



Seasonal effects on fodder yield and quality in *Cenchrus* species under semi-arid climate

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ABSTRACT

Cenchrus species are predominant pasture grasses of India and fodder and seed production is traditionally taken during monsoon as rainfed crop. In present investigation besides monsoon, observations were also recorded during autumn and spring season for fodder and seed production for three years (2014-17). Experimental material consisted of seven genotypes of *C. ciliaris* and *C. setigerus* each. Combined analysis of variance revealed significant differences for genotype, season and their interactions for fodder and seed yield and its attributing traits. High fodder yield and tiller height were observed during monsoon while, high seed yield and more tillers/m row length were observed during spring in both the species. In *C. ciliaris* fodder yield ranging from 11.5 (autumn) to 51.0 q/ha (monsoon) and highest annual yield was given by IG 67-365 followed by CAZRI-75. Seed yield was higher during spring (117.0 kg/ha) and lowest during autumn (47.8 kg/ha) and highest annual seed yield was produced by IG 67-3833 followed by IG 96-414. In *C. setigerus* fodder yield ranging from 9.8 (autumn) to 46.3 q/ha (monsoon) and highest annual yield was given by IG 96-706 followed by IG 96-593. Seed yield was higher during spring (102.3 kg/ha) and lowest during autumn (65.3 kg/ha) and highest annual seed yield was produced by IG 97-432 followed by IG 96-401. Crude protein and neutral detergent fiber content also significantly differed among the season ranging from 5.6 (monsoon) to 8.0% (spring) and 74.0 (autumn) to 79.9% (monsoon), respectively in both the species.

Key words: *Cenchrus ciliaris*, *Cenchrus setigerus*, Crude protein, Fodder yield, Seed yield

The livestock population has increased continuously whereas the land under permanent pastures has shrunk. The pasture land covers about 4.0% of geographical area (12 m ha) of the country with high grazing intensity (12.6 ACU/ha). Out of total area of Rajasthan and Gujarat 40% and 30% area are available as grazing lands and only 5.4 and 3.5% under permanent pasture, respectively. *Cenchrus ciliaris* L. (Anjan grass) and *C. setigerus* Vahl. (Dhaman grass) are predominant pasturegrass component of the *Dichanthium-Cenchrus-Lasiurus* pasture cover of India (Dabadghao and Shankarnarayan 1973). The *Cenchrus* species can grow on wide range of soils and environments due to its drought and high temperature tolerance. It is highly palatable with high nutrition value (protein 8-10% with 60-70% digestibility) for all kinds of grazing animals (Sawal *et al.* 2009). After well establishment it give 8-10 t/ha dry fodder and 80-150 kg/ha seed during monsoon under rainfed condition. Most of the grasslands are underused due to lack of availability of location specific genotypes and quality seed. These

grasses are naturally propagated through seed and for improved grassland development the easy and cheap way to propagation is also through seed. There is a wide gap between demand and supply of seed of *Cenchrus* grass resulted about 85% area of grazing lands and wastelands of the country remains underutilized (Singh and Hazra 1995). Low fertility of soils and high risks of diseases are reported to affect pasture grass seed yield and viability in wet season (Kizima *et al.* 2014). Therefore, rejuvenation/establishment of improved grasslands and systematic utilization of pasture lands with suitable species and genotypes would facilitate sustainability of livestock production in semi-arid regions. Being perennial in nature *Cenchrus* grasses faces different kinds of environmental adversities during its different growth and developmental stages which make sustainability studies more pertinent in range species. Further, information on fodder yield sustainability of different genotypes of *C. ciliaris* and *C. setigerus* over the seasons are meager, therefore, an attempt was made to assess the production potential and sustainability of some genotypes of these species during three seasons in a year.

MATERIALS AND METHODS

The experiment was conducted at Research Station of ICAR-IGFRI, Avikanagar (Raj) situated between latitude

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26°18'37" N and longitude 75°25'50" E during 2014-2017. The climate of the experimental site is semi-arid with an average rainfall of 560 mm and mean maximum temperature varied from 40-45°C and minimum of 5-6°C. The experimental material consisted of five promising genotypes and two check varieties (IGFRI-3108 and CAZRI-75) of *C. ciliaris* and six promising genotypes and one check variety (CAZRI-76) of *C. setigerus*. Two separate experiments for both the species were established during *kharif*, 2014 in randomized complete block design. Each genotype was grown in 6 rows of 4 m length, keeping row-to-row and tussock-to-tussock spacing of 50 cm.

The fodder and seed production of these grasses is traditionally taken during monsoon season (July to September) as rainfed crop. In present investigation besides monsoon season observations were also recorded during autumn (September to November) and spring season (February to April) with application of need based irrigation to evaluate the possibility and potential of fodder and seed production during different seasons. Individual seasons were considered to be separate environment for analysis of variance. The observations on dry fodder yield, tiller height, numbers of tillers/running meter and seed yield were recorded during three seasons within a year for three years. Fodder yield was recorded on plot basis after last seed picking and dry fodder yield was calculated on the dry matter basis of oven dried samples. The observations for growth parameters were recorded on ten randomly selected tussocks. Seed picking of whole plot was done 3 times in each season and seed of all pickings were bulked for recording of seed yield in each season. Fodder samples were collected after seed picking in every season for analysis

of crude protein (CP) and neutral detergent fiber (NDF) during 2015 and 2016. Samples were analyzed for CP and NDF as per the method of (AOAC 2000) and Van Soest *et al.* (1991), respectively. Three years average of each season separately was calculated and used for comparing seasonal effects. Pooled analysis of the data obtained from study for nine seasons of three years 2014-17 were undertaken and analyzed statistically by ANOVA using randomized block design (RBD) and the means were compared between the genotypes, seasons and their interactions by critical difference (CD) at P<0.05 level of significance. Coefficient of variation (CV) was calculated for monsoon, autumn and spring over the genotypes of three years for both the species separately. Sustainability index (SI) for each genotype and season over three years was calculated by following the formula used by earlier workers (Singh and Agarwal 2003, Gangwar *et al.* 2004). The values of SI were divided arbitrarily into five groups, viz. very low (up to 20%), low (21-40%), moderate (41-60%), high (61-80%) and very high (above 80%).

$$\text{Sustainability index (SI)} = \frac{\text{Average performance of a genotype-standard deviation}}{\text{Best performance of a genotype}} \times 100$$

Meteorological data: Owing to perennial nature of *Cenchrus* species the experiment was continued for three years and weather data has been acquired from the weather observatory of ICAR-Central Sheep and Wool Research Institute, Avikanagar (Table 1). At the experiment site about 90% of total annual rainfall was received during monsoon with average rainfall of 395 mm and range of 352-459

Table 1 Average (range) of weather data of different seasons of experimental site

Season	Cropping period	Crop Duration	Total rainfall (mm)	No. of rainy days	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean maximum humidity (%)	Mean Minimum humidity (%)	Mean soil moisture (%)
Autumn 2014	29 Sept to 28 Dec, 2014	86	8.5	2	29.9 (19.8-36.5)	14.5 (5.9-22.6)	76.6 (70.4-83.7)	61.1 (49.1-68.3)	2.6 (1.6-4.6)
Autumn 2015	10 Sept to 30 Nov, 2015	81	13.1	2	34.1 (28.1-38.1)	19.2 (11.9-25.5)	76.6 (69.1-82.6)	58.7 (52.1-63.6)	2.4 (1.1-2.1)
Autumn 2016	8 Sept to 2 Dec, 2016	85	16.1	3	33.2 (29.9-37.3)	17.9 (10.4-24.5)	73.9 (63.6-85.3)	56.0 (47.4-72.3)	3.3 (1.6-5.2)
Spring 2015	22 Jan to 19 Apr, 2015	82	77.6	4	29.8 (19.7-42.1)	15.1 (6.9-25.4)	74.9 (56.6-85.6)	55.5 (39.3-67.6)	3.0 (1.8-4.6)
Spring 2016	5 Feb to 16 Apr, 2016	71	12.0	1	33.3 (24.9-39.2)	17.8 (11.1-22.8)	68.7 (49.6-84.0)	48.0 (33.6-54.4)	2.0 (1.3-2.5)
Spring 2017	25 Jan to 12 Apr, 2017	78	15.1	2	32.7 (24.2-41.6)	15.8 (11.1-20.9)	67.7 (50.3-84.1)	52.2 (37.3-69.6)	3.1 (1.6-5.2)
Monsoon 2015	5 Jul to 3 Sept, 2015	61	351.9	21	32.8 (28.0-37.1)	25.2 (22.8-27.2)	86.3 (76.4-90.9)	75.8 (55.0-84.7)	4.6 (1.3-6.1)
Monsoon 2016	26 Jun to 3 Sept, 2016	69	458.6	31	32.2 (29.1-37.2)	25.2 (23.4-27.6)	88.5 (81.1-93.7)	77.6 (64.3-85.7)	6.0 (1.6-8.0)
Monsoon 2017	24 Jun to 29 Aug, 2017	66	379.2	27	32.7 (29.4-35.8)	25.6 (24.2-29.0)	81.6 (71.6-86.4)	68.5 (58.3-77.6)	5.2 (3.0-6.3)

mm. The rainfall during autumn and spring seasons was very meager ranging from 8.5-16.1 and 12.0-77.6 mm, respectively. Soil moisture was recorded at 15 days interval during the experimental period and average of each season was calculated. The average soil moisture during monsoon, autumn and spring was 5.2, 2.8 and 2.6%, respectively.

RESULTS AND DISCUSSION

Pooled analysis of variance of nine seasons over three years revealed significant differences for genotype, season (environment) and their interactions for all the characters under study which reveals the variability exists among the genotypes as well as seasons in both the species. Significant interaction effects showed that genotypes behaved differently in different seasons. Differences in seasons (between seasons and within season over years) were caused due to weather variations such as temperature, rainfall, humidity, solar radiation etc. Fodder yield potential is higher in *C. ciliaris* as compare to *C. setigerus* while the seed yield is higher in *C. setigerus* irrespective of seasons and genotypes. Similar results were also reported by Visser *et al.* (2015) for yield and yield stability of remnant populations of *C. ciliaris*, Arshadullah *et al.* (2011) for seasonal and genotypic variations influence for biomass and nutritional ingredients of *C. ciliaris*. Rajora *et al.* (2008), Amina *et al.* (2012) and Meena and Nagar (2017) also observed significant variability

for genotypes, environments and genotype \times environment interactions for fodder and seed yield, and attributing traits in *C. ciliaris*.

Seasonal variations: The highest fodder yield was recorded during monsoon as the species are adapted to tropical and sub-tropical climatic conditions. *C. ciliaris* produced more fodder yield as compared to *C. setigerus* due to less water requirement and adopted in sandy soils while, high seed yield obtained in *C. setigerus* due to high test weight irrespective of genotypes and seasons. High fodder yield in monsoon was contributed through more tiller height and tiller numbers. Low fodder yield in autumn might be due to low temperature. Njarui and Wandera (2004) reported significant differences for dry matter yield between seasons while evaluating effect of harvest intervals on dry matter yield of 5 range grasses including *C. ciliaris* under different seasons, viz. long rains season (March-May), short rains season (October-December) with two dry seasons (June-September; January-February) in Kenya. High fodder yield during spring as compared to autumn contributed through more tillers but low fodder yield as compared to monsoon due to low tiller height. During the spring season low humidity (<50%) and low soil moisture (<5%) might be reason for reduction in growth parameters.

Crude protein significantly varied among the genotypes and seasons as well as their interactions in both the species

Table 2 Fodder and seed yield in *Cenchrus* species across the seasons (three years mean)

Species/ Genotype	Fodder yield (q/ha)				Seed yield (kg/ha)			
	Autumn	Spring	Monsoon	Total	Autumn	Spring	Monsoon	Total
<i>C. ciliaris</i>								
IG 67-365	14.1	17.2	59.9	91.2	18.9	73.3	18.7	110.9
IG 96-531	10.4	13.4	55.1	78.9	33.3	89.9	-	123.2
IG 96-414	11.9	13.4	56.8	82.1	69.0	132.6	130.6	332.2
IG 67-3833	9.7	14.9	44.1	68.7	73.1	204.1	68.2	345.4
IGFRI-727	10.8	14.6	46.1	71.5	30.2	49.1	26.9	106.2
IGFRI-3108	8.6	11.8	40.3	60.7	59.2	149.0	119.1	327.3
CAZRI-75	15.1	15.3	54.7	85.1	50.7	121.1	56.9	228.7
Mean	11.5	14.4	51.0	76.9	47.8	117.0	70.1	234.9
CV (%)	22.0	13.6	24.0		45.5	35.4	82.4	
CD (5%)	Season- 1.2; Genotype-1.9; Season \times Genotype- 3.3				Season-3.2; Genotype-4.9; Season \times Genotype -8.5			
<i>C. setigerus</i>								
IG 96-593	9.5	13.0	50.7	73.5	48.9	72.1	40.0	161.0
IG 96-706	9.7	13.9	55.8	79.4	52.3	76.0	48.5	176.8
IG 96-401	10.0	10.2	48.3	68.5	83.3	154.4	109.9	347.6
IG 97-109	11.9	14.0	47.6	73.2	61.1	76.7	39.5	177.3
IG 97-432	8.0	7.7	40.2	55.9	87.6	124.3	153.5	365.4
CAZRI-392	8.0	7.7	39.6	55.3	66.3	104.0	157.1	327.4
CAZRI-76	11.3	12.3	42.2	65.8	57.5	108.6	54.9	221.0
Mean	9.8	11.3	46.3	67.4	65.3	102.3	86.2	253.8
CV (%)	26.1	15.9	25.6		41.8	37.5	64.9	
CD (5%)	Season-1.0; Genotype-1.5; Season \times Genotype- 2.7				Season-3.1; Genotype-4.8; Season \times Genotype -8.3			

Table 3 Fodder quality attributes of *Cenchrus* species across the seasons (three years mean)

Species/ Genotype	Crude protein (% dry matter basis)				Neutral detergent fiber (% dry matter basis)			
	Autumn	Spring	Monsoon	Mean	Autumn	Spring	Mean	Mean
<i>C. ciliaris</i>								
IG 67-365	6.3	8.2	6.4	6.9	73.6	73.4	79.5	75.5
IG 96-531	7.0	7.4	5.3	6.6	76.4	77.8	80.5	78.2
IG 96-414	5.4	7.2	5.4	6.0	77.6	78.8	81.6	79.3
IG 67-3833	6.3	6.8	5.9	6.3	77.1	77.4	79.9	78.2
IGFRI-727	6.1	7.1	5.6	6.3	74.0	75.3	79.5	76.3
IGFRI-3108	6.8	7.7	5.8	6.8	73.4	74.2	79.1	75.6
CAZRI-75	5.8	8.1	5.0	6.3	73.1	73.2	79.1	75.1
Mean	6.3	7.5	5.6	6.5	75.0	75.7	79.9	76.9
CV (%)	14.3	9.27	13.1		12.5	7.4	9.5	
CD (5%)	Season- 0.31; Genotype- NS; Season × Genotype- 0.83				Season- 0.59; Genotype- 0.91; Season × Genotype- 1.56			
<i>C. setigerus</i>								
IG 96-593	7.6	7.8	5.2	6.9	74.0	75.3	80.4	76.6
IG 96-706	5.9	7.5	5.9	6.4	73.6	75.0	79.6	76.1
IG 96-401	6.1	8.3	6.4	6.9	74.7	73.9	78.7	75.8
IG 97-109	6.7	7.7	5.8	6.7	75.3	73.1	79.9	76.1
IG 97-432	7.2	8.2	6.0	7.1	72.4	74.6	77.3	74.8
CAZRI-392	6.4	8.4	5.8	6.9	72.2	73.6	78.2	74.7
CAZRI-76	7.0	7.8	6.0	6.9	76.1	77.6	79.7	77.8
Mean	6.7	8.0	5.9	6.8	74.0	74.7	79.1	76.0
CV (%)	15.10	8.18	13.8		13.2	7.8	11.7	
CD (5%)	Season- 0.29; Genotype- NS; Season × Genotype- 0.76				Season- 0.55; Genotype- 0.84; Season × Genotype- 1.46			

ranging from 5.6 (monsoon) to 7.5% (spring) in *C. ciliaris* and 5.9 (monsoon) to 8.0% (spring) in *C. setigerus*. NDF also significantly differed due to seasonal effects ranging from 75.0 (autumn) to 79.9% (monsoon) in *C. ciliaris* and 74.0 (autumn) to 79.1% (monsoon) in *C. setigerus* (Table 3). Similar results were also reported by Aster *et al.* (2012) while undertaken nutritional analysis and *in vitro* dry matter digestibility for three grass species. While findings of Keba *et al.* (2013) were contrary to present investigation, they recorded high CP during rainy season (8.5%) as compared to cold dry season (5.1%), while, fiber constituents were relatively low in the rainy season compared to the cold dry season. In contrast to fodder yield, high seed yield was recorded in spring followed by monsoon due to frequently rains during flowering/seed developmental stage caused pollen wash resulted low proportion of filled spikelet with true seed. Abel and Boelt (2018) also reported that increases in the total precipitation during anthesis reduced the anthesis synchrony and the seed set. Kizima *et al.* (2014) studied effect of seasons and agronomic practices on seed yield of *C. ciliaris* in two seasons in a year for long rains and dry season, respectively in Tanzania. Conde-Lozano *et al.* (2011) evaluated four varieties of *C. ciliaris* to compare the effect of agro-ecological environment on seed production. Bhatt *et al.* (2016) revealed that seed collected in summer (April-May) was heavier as compared to seed collected in

winter (September-October) in *C. ciliaris* while evaluating effect of seasons on seed production of three grass species.

Varietal performance: Season wise average performance of genotypes over three years for fodder yield, seed yield and fodder quality traits calculated separately for both the species (Table 2 and 3). *Cenchrus* grass being perennial species, season × genotypes effects is quite important. It was assumed that, for a given set of genotypes, differences between years were primarily due to direct and indirect effects of weather conditions. When genotype × seasonal interaction arise from variation in unpredictable environmental factors, such as year-to-year weather effects, as in this study, the breeder or agronomist must select genotypes that can perform reasonably well over a range of weather conditions. This emphasizes the need for evaluation of genotypes across the seasons and years to adequately characterize genotypes for fodder and seed yield. Age of crop also affects the productivity of fodder as well as seed which may be estimated by sustainability index. Increasing the number of harvest per year may offer a more cost-effective means to characterize a genotype than taking only one harvest during monsoon.

Cenchrus ciliaris: Irrespective of genotypes during monsoon fodder yield was higher and highest fodder yield was given by IG 67-365 (59.9 q/ha) followed by IG 96-414 and IG 96-531. On the basis of annual total IG 67-365 also

raked first (91.2 q/ha) followed by CAZRI-75 and IG 96-414. Chander *et al.* (2009) reported from a study of cutting schedules (half yearly and annually) of *C. ciliaris* (var. CAZRI-75) and *Lasiurus indicus* that dry fodder yield was higher in both the species under half yearly cutting schedule than annual cutting during initial two years but reverse trend was observed in later years. CP was lowest during monsoon (5.6%) while during spring it was significantly high (7.5%). Over the genotype mean NDF value was 76.9% with narrow range. Genotype IG 67-365 contain average 6.9% CP followed by IGFRI-3108 (6.8%) with similar value (75.5%) of NDF. Similar results was also reported by Aster *et al.* (2012) while undertaken nutritional analysis and *in vitro* dry matter digestibility for three grass species including *C. ciliaris*. Al-Soqeer and Nasser (2012) also reported that high value of crude protein was observed during hot dry season as compared to main rainy season. In contrast to the present findings, Keba *et al.* (2013) reported that crude protein in *C. ciliaris* ranged from 5.7 (in cold dry season with high fiber constituents) to 9.8% (in the main rain season with low fiber constituents) over seven locations of the Borana rangelands in southern Ethiopia.

On the other hand seed yield was higher during spring ranging from 49.1-204.1 kg/ha and highest seed yield produced by IG 67-3833 followed by IGFRI-3108 and IG 96-414. Monsoon season ranked second in seed yield but in seed quality parameters it ranked last. Genotype IG 96-531 did not produced seed during monsoon season across the years, may be due to photo/thermo sensitivity. Sustainability index for fodder yield was high as compared to seed yield while among the seasons it was comparable. Genotypes

varied for sustainability index ranging from 52.8 to 83.9 and 31.8 to 81.5% for fodder and seed yield, respectively. For fodder yield genotypes IG 67-365, IG 96-414 and CAZRI-75 and IG 96-531 while, for seed yield genotypes IG 96-414, IGFRI-3108 and IG 67-3833 found stable (Table 4). Rajora *et al.* (2017) studied stability parameters for dry matter yield and revealed that CAZRI-231 and CAZRI-327 produced more dry matter yield than the general mean and were considered stable over varied environments over the years.

Cenchrus setigerus: In general fodder yield of *C. setigerus* was lower as compared to *C. ciliaris* but for seed yield it was reverse due to high test weight irrespective of season and genotypes. During monsoon fodder yield was higher and highest fodder yield given by IG 96-706 (55.8 q/ha) followed by IG 96-593 and IG 96-401. Similar to *C. ciliaris* CP content was lowest during monsoon (5.9%) while during spring it was significantly high (8.0%) with low CV. Genotypes showed 76.0% mean NDF with very narrow range. *C. ciliaris* seed yield was higher in *C. setigerus* during spring ranging from 72.1-154.4 kg/ha and highest seed yield produced by IG 97-432 (365 kg/ha) followed by IG 96-401 (348 kg/ha). Genotype IG 97-432 gave highest seed yield due to its high test weight (5.7 mg). CP content ranged from 5.2% (IG 96-593 in monsoon) to 8.4% (CAZRI-392 in spring). NDF ranged from 72.2% (CAZRI-392 during autumn) to 80.4% (IG 96-593 during monsoon). Sustainability index for fodder yield was high as compared to seed yield while among the seasons it was comparable. Genotypes varied for sustainability index ranging from 42.5 to 84.3 and 31.4 to 78.6% for fodder and seed yield, respectively. For fodder yield genotypes IG 96-593, IG 96-706 and IG 97-109 found

Table 4. Sustainability index (%) for fodder and seed yield in *Cenchrus species* during different seasons

Season/ Genotype	Fodder yield (q/ha)				Seed yield (kg/ha)			
	Autumn	Spring	Monsoon	Mean	Autumn	Spring	Monsoon	Mean
<i>C. ciliaris</i>								
IG 67-365	68.2	67.2	72.4	69.3	51.2	18.5	69.2	46.3
IG 96-531	77.5	76.5	70.1	74.7				
IG 96-414	80.6	74.6	83.9	79.7	57.3	70.3	64.1	63.9
IG 67-3833	70.0	74.1	75.5	73.2	58.2	67.9	57.2	61.1
IGFRI-727	52.8	68.5	82.4	67.9	57.1	31.8	48.1	45.7
IGFRI-3108	58.4	72.9	74.0	68.4	54.6	50.7	54.5	53.3
CAZRI-75	82.1	74.6	68.5	75.1	81.5	19.2	53.9	51.5
Mean	69.9	72.6	75.3		60.0	43.1	57.8	
<i>C. setigerus</i>								
IG 96-593	73.8	71.4	80.4	75.2	48.5	33.1	60.4	47.3
IG 96-706	68.4	76.2	77.1	73.9	47.2	35.6	56.2	46.3
IG 96-401	41.6	82.0	78.9	67.5	31.6	66.4	59.6	52.5
IG 97-109	76.3	77.6	64.7	72.9	49.3	37.5	48.1	45.0
IG 97-432	42.5	68.3	82.6	64.5	31.4	52.2	63.3	49.0
CAZRI-392	68.4	67.4	84.3	73.4	57.1	78.6	44.0	59.9
CAZRI-76	67.0	61.5	71.1	66.5	43.2	54.3	42.1	46.5
Mean	61.8	73.8	78.0		44.0	51.1	53.4	

most stable coupled high fodder yields while for seed yield no genotype showed stable performance (Table 4).

It may be concluded that fodder and seed production of *Cenchrus* species can be taken during three seasons in a year with need based irrigation facility during autumn and spring seasons. Higher seed yield with better quality can be obtained in autumn and spring seasons while higher fodder yield in monsoon season. High fodder yielding genotypes are low seed yielding in both the species. For fodder and seed yield in *C. ciliaris*, genotype IG 67-365 and IG 96-414 and in *C. setigerus*, IG 96-706 and IG 96-401, respectively would be better option.

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