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Seed Yield and its Components in Winter Regenerated Flush of Buffel Grass (*Cenchrus ciliaris* Linn.) under Rainfed Conditions of Rajasthan

M.P. RAJORA AND MANJIT SINGH
Central Arid Zone Research Institute, Jodhpur-342 003

ABSTRACT Thirteen accessions of *Cenchrus ciliaris* were evaluated for seed yield and its components in a completely randomized block design under rainfed conditions. The extent of variability was high for all the traits studied. Estimates of heritability and genetic advance were also high. Highest seed yield (381.8 kg/ha) was recorded in accession CAZRI 2162 from winter-regenerated flush after taking herbage yield during November 2001. It was closely followed by CAZRI 1106 (346.5 kg/ha). The yield of these accessions was significantly higher than var. CAZRI 75 (172.2 kg/ha). The high mean seed germination (45.7%) indicated the good quality of seed. The number of spikes per plant had positive and significant association with seed yield (r= 0.76). Number of spikes per plant and seed yield had more variability among accessions and showed high heritability and genetic advance implying that winter seed yield can be improved by simple selection. The study demonstrates the potential for quality seed production of buffel grass during winter in dry areas of western Rajasthan. The study was undertaken from June 2001 to September 2002.

Keywords: Buffel grass, seed yield, variability, heritability, correlation

Buffel grass (*Cenchrus ciliaris* L.), a native of North tropical and South Africa, India and Indonesia has been considered as a highly drought resistant and one of the prominent species of *Dichanthium-Cenchrus-Lasiurus* grass cover, the most dominant grass cover in the arid Rajasthan [1]. It is an obligate apomictic species; therefore, the seed development is comparatively less influenced by the climatic conditions. In northern India *kharif* (summer) is the main season for forage and seed production of this species but it also produces seed in winter under protected conditions with less vegetative growth. Sharma [2] noticed that seed-shedding problem was more during summers whereas, it was comparatively less during winters. Therefore, if seed production is taken during winter, shedding problem can be minimised up to a considerable extent. Sharma [2] further observed that the seed production during *kharif* was not of better quality because due to high wind velocity and rains lodging occur resulting in discoloured spikelets and poor germination. The winter climate, except soil moisture is conducive for seed production. Therefore, selection of better seed yielding genotypes during winter may be a good proposition for pasture workers/ranchers, as it may help in bridging the gap in the demand and supply of pasture grasses seed. Information on the nature of variation, heritability, *per se* performance and inter-relationship for seed yield and its related traits may provide information about the selection of suitable genotypes for seed production.

MATERIALS AND METHODS

Experimental site and environment

The site was located in the Central Research Farm of the Central Arid Zone Research Institute, Jodhpur, India (26°18′N, 73°01′E m altitude). The soil was loamy sand with pH 8.1, organic carbon 0.27%, total N 0.03%, available N 140 kg per ha, P 12.6 kg per ha and K 248 kg per ha. Rainfall from the start of experiment till the harvest of seed (June 2001 to March 2002) was 396.7 mm. Last effective rainfall, i.e. 14.6 mm was received in the month of October 2001 during the study period. Peak maximum and minimum temperatures were 38.5°C in June 2001 and 9.9°C in January 2002, respectively. During seed collection period, i.e. Feb. and March of 2002, the

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rainfall was only 0.7 mm in February, and the temperature ranged from 11.7 to 27.9°C during the month, and the range of temperature was narrow (18.4 to 35.0°C) during March. Due to severe drought during *kharif* 2002 buffel grass accessions could not regenerate.

Experimental procedure

Field experiment was conducted from June 2001 to March 2002 and seed germination test was conducted in September 2002. Thirteen accessions, viz. CAZRI 2162, CAZRI 2185, CAZRI 2217, CAZRI 2224, IGFRI 742, IGFRI 747, IGFRI 521, IGFRI 727, CCR 9, CCR 12, CAZRI 75, IGFRI 3108 and CAZRI 1106 of buffel grass (*Cenchrus ciliaris* L.) were sown in nursery beds during June 2001 and seedlings were transplanted in the field during July 2001 in a randomized complete block design with 3 replications. Line to line distance was 75 cm and plant-to-plant 50 cm. Each plot had 40 plants. Just after transplanting water was provided through hand sprinkler. After that 2 light irrigations were provided through hand sprinkler on alternate days for better establishment, thereafter no artificial watering was provided.

After taking the fodder yield in last week of November 2001, the experiment was left for seed production. All spikes within each plot were harvested manually from February to March of 2002 as per the maturity of the spikes. Seed yield was recorded on plot basis and converted into kg per hectare. Plant height and spikes per plant (tussock) were recorded on 5 randomly selected tussocks (referred as plants hereafter) in each plot at harvest. Spike length and number of seeds per spike were recorded from 5 spikes in each plot. Harvested seed was air dried for 3-4 days and thousand seed (fascicles) weight was recorded from each plot. Seeds were stored in cloth bags under ambient conditions. Germination tests were performed at 20-30°C (16-h for 20°C and 30°C for 8-h); four replicates of 100 seeds from each genotype and seeds were placed in the dark, in 15-cm diameter petri dishes in sand substratum (top of sand). The approximate amount of water to be added to the sand was calculated as follows [3]-

$$\text{ml of water to be added to every 100 g of sand} = \frac{118.3 \text{ ml sand}}{\text{wt. of 118.3 ml of sand (in g)}} \times (20.2-8.0)$$

Initial germination counts were made after one week of planting the experiment and the experiment lasted for 4 weeks. Data were subjected to statistical analyses by the analysis of variance procedures for a complete randomised block design, using standard statistical procedures. The mean differences between treatments were tested for significance by least significant difference procedures. Percent germination data were statistically analysed after arcsine transformation.

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance revealed that genotypes had significant differences for plant height, spikes per plant, spike length, seed per spike, 1000-seed weight, seed germination and seed yield ($P<0.01$) showing variability for all the characters. The replication effect was significant for spikes per plant and seed yield at $P<0.05$ and spike length at $P<0.01$.

Variability and heritability

The range was widest for seed yield followed by number of spikes per plant while it was narrowest for 1000-seed weight followed by spike length (Table 1). Genotypic and phenotypic variances were also high for seed yield and spikes per plant. The phenotypic coefficient of variation was maximum for spikes per plant (92.9) followed by seed yield (80.4). The genotypic coefficient of variation followed the same pattern suggesting that genetic factor contributed for the recorded variability. This suggests hope for improvement in seed yield of this species through simple selection.

Phenotype reflects genotype truly when the character is highly heritable hence heritability is important from the breeder's point of view for adopting suitable breeding methodology for improvement. Burton [4] suggested that genotypic coefficient of variation, along with heritability estimates, would give better idea about the efficiency of selection. The broad sense heritability was maximum for seed germination (91.5%). Rest of the characteristics had fairly high heritability, which indicated the least influence of environment on these characteristics. Expected genetic advance as percentage of mean was high for spikes per plant (164.5) followed by seed yield (139.1), and moderately high for seeds per spike (60.0), seed germination (51.6), 1000-seed weight (40.7), and low for spike length (33.2) and plant height (27.1). Very high genetic advance for spikes per plant and seed yield was mainly due to the wide range resulting in reduced overall mean.

Genetic advance depends on selection intensity, heritability and phenotypic standard deviation.

Table 1. Parameters of variability for seed yield and its related components in buffel grass

Characters	Range	Mean	Variance		Coefficient of variation		Heritability (%)	Genetic advance as %age of mean
			Genotypic	Phenotypic	Genotypic	Phenotypic		
Plant height (cm)	32.13-52.53	44.54±1.81	42.36	52.20	14.61	16.22	81.14	27.12
No. of spikes/plant	5.40-302.00	140.37±28.23	14624.61	17014.83	86.15	92.93	85.95	164.54
Spike length (cm)	4.27-8.93	6.52±0.26	1.27	1.47	17.29	18.58	86.65	33.16
Seeds/spike	36.20-123.67	62.13±7.15	441.02	594.46	33.80	39.24	74.19	59.98
1000-seed weight (g)	1.26-3.96	2.96±0.26	0.48	0.68	23.44	27.82	70.99	40.69
Seed germination (%)	24.32-68.92 (17.00-86.75)	42.47±1.70 (45.67)	123.85	135.40	26.20	27.40	91.47	51.62
Seed yield (kg/ha)	7.50-381.79	163.74±30.44	14550.62	17329.94	73.67	80.40	83.96	139.06

Figures in parentheses indicate the original values for seed germination.

Table 2. Coefficient of correlation for seed yield and its related components in buffel grass

Characters	Plant height (cm)	Spikes/ plant	Spike length (cm)	Seeds/ spike	1000-seed weight (g)	Germination (%)	Seed yield (kg/ha)
Plant height (cm)	1.000	-0.174	0.812**	0.451	0.536	-0.186	0.231
Spikes/plant		1.000	-0.246	-0.639*	-0.190	0.619*	0.764**
Spike length (cm)			1.000	0.658*	0.427	-0.089	0.097
Seeds/spike				1.000	0.049	-0.567*	-0.261
1000-seed weight (g)					1.000	0.091	0.081
Seed germination (%)						1.000	0.180
Seed yield (kg/ha)							1.000

*,** Significant at $P<0.05$ and $P<0.01$, respectively.

Hence high heritability need not necessarily mean that the character will show high genetic advance but whenever this association occurs additive gene effects are probably important. In the present study, such association was found for spikes per plant, seed yield, seed germination, seeds per spike and seed weight. Simple selection can be used to improve these characteristics. On the other hand, high heritability coupled with low genetic advance was observed for plant height and spike length indicating the effect of non-additive gene effects such as epistatis, dominance type of interaction [5]. Hybrid development programme, provided sexual types are isolated may be helpful in exploitation of the variability for the improvement of these characteristics.

Simple correlation

Seed yield showed a significant positive correlation (r= 0.76) with spikes per plant only (Table 2). Spikes per plant also had a significant and positive correlation with seed germination (r=0.62) and it was negatively correlated with seeds per spike (r=-0.64). Significant positive correlation of spike number with seed germination indicated that there is no adverse effect of increased spikes on the seed quality. The association analysis showed that more seed production is expected by selecting spikes per plant without compromising with the seed quality. Spike length had significant positive correlation with seeds per spike (r= 0.66) and plant height (r= 0.81). The association analysis revealed that number of

Table 3. Seed yield and its components in winter regenerated flush of buffel grass during 2001-2002

Accessions	Plant height (cm)	Number of spikes/plant	Spike length (cm)	Seeds/spike	1000-seed weight (g)	Germination (%)	Seed yield (kg/ha)
CAZRI 2162	37.20	302.00	5.93	36.20	3.16	56.25 (48.60)	381.79
CAZRI 2185	48.53	254.13	7.47	58.67	1.81	57.75 (49.47)	251.84
CAZRI 2217	41.87	293.87	5.93	46.80	2.70	49.00 (44.43)	227.69
CAZRI 2224	42.00	235.87	5.93	63.40	2.76	47.25 (43.27)	285.17
IGFRI 742	45.60	9.33	6.60	74.80	3.36	25.50 (30.17)	68.03
IGFRI 747	51.93	27.13	7.93	72.67	3.96	35.25 (36.35)	142.72
IGFRI 521	52.07	17.53	7.13	68.07	3.83	35.00 (36.13)	95.80
IGFRI 727	45.27	12.20	6.60	61.60	3.22	41.75 (40.22)	63.31
CCR 9	39.20	179.80	6.27	46.80	3.28	60.75 (51.22)	54.15
CCR 12	38.13	166.13	5.87	46.73	3.23	86.75 (68.92)	31.93
CAZRI 75	52.53	37.13	8.93	123.67	2.81	30.50 (33.49)	172.16
IGFRI 3108	32.13	5.40	4.27	66.20	1.26	17.00 (24.32)	7.50
CAZRI 1106	52.53	284.27	5.93	42.07	3.13	51.00 (45.58)	346.53
Mean	44.54	140.37	6.52	62.13	2.96	45.67(42.47)	163.74
LSD (P<0.05)	5.29	82.39	0.75	20.87	0.75	4.87	88.84
LSD (P<0.01)	7.17	111.65	1.01	28.29	1.01	6.54	120.40
CV (%)	7.04	34.83	6.79	19.94	14.99	8.00	32.20

Figures in parentheses indicate the transformed values.

spikes per plant and spike length are probably important in determining the seed yield in this pasture species.

Seed yield and its components

The *per se* performance of seed yield and its components presented in this paper may be of use for buffel grass breeders while selecting plant types and for those planning commercial seed production as there is huge demand of pasture grass seed for pasture establishment in general and for development of wastelands of India in particular.

Buffel grass grows at a slower rate during cooler weather. Average plant height was 44.5 cm, less than the half of the summer growth. The range for plant height was narrower than other attributes (Table 3). Sharma [2] in an experiment with CAZRI 358 of *C. ciliaris* reported that in summer season, grass attained an average height of 130 cm, whereas during winter season, the average height was 80 cm. Spike number per plant is one of the important seed-yielding components. Minimum spikes were recorded in IGFRI 3108 (5.4), while CAZRI 2162 produced maximum spikes per plant (302.0) followed by CAZRI 2217 (293.9) and CAZRI 1106 (284.3). The accessions from Rajasthan produced more spikes than others indicated that these are well adapted to the arid climate. The range for spike length was narrow and the longest spike (8.9 cm) was recorded in CAZRI 75 followed by IGFRI 747 (7.9 cm). In general the spike length was shorter than the *kharif* season crop. Sharma *et al.* [6] recorded 11.2 cm long spikes in *C. ciliaris* var. CAZRI 75 during *kharif* season. Seeds per spike is an important seed yield component, but contrary to the assumption we recorded least number of seeds (36.2) with the highest seed yielding genotype CAZRI 2162 indicated that spikes per plant might have contributed more towards seed yield for this accession.

In the experiment highest seed yield was recorded from CAZRI 2162 (381.8 kg/ha) followed by CAZRI 1106 (346.5 kg/ha). CAZRI 2224 (285.2 kg/ha), CAZRI 2185 (251.8 kg/ha) and CAZRI 2217 (227.7 kg/ha) were other high seed yielding accessions (Table 3). Thus there is considerable potential in buffel grass genotypes for seed production in winter season. Sharma *et al.* [6] recorded up to 104.2-kg per ha seed yield in *C. ciliaris* var. CAZRI 75 in *kharif* crop. Rai *et al.* [7] recorded maximum mean seed yield (133.7-kg/ha) and 1000-seed weight (1.977 g) from the establishment year crop in var. IGFRI 3108 during *kharif* season at Indian Grassland and Fodder Research Institute, Jhansi, India. Seed yield of CAZRI 358 was 415 kg per ha during winter season, at par with the summer crop (416 kg/ha) [2]. In this study differences in seed yield and number of spikes per plant may be due to the differential adaptation of the accessions in hot arid environment. The CAZRI accessions were collected from the hot climate of western Rajasthan hence had better adaptation in arid climate than other accessions. The results of the study clearly indicated that even after taking forage yield in *kharif* season, CAZRI accessions, viz. CAZRI 2162, CAZRI 1106, CAZRI 2224, CAZRI 2185 and CAZRI 2217 produced high seed yield in winter season. Hacker *et. al.* [8] reported that variety Molopo produced highest dry matter and several other accessions ranked consistently high in late winter and spring and the top-ranking accessions came from widely different geographical areas, the top three accessions derived from Rajasthan, Transvaal and Ghana.

Biological seed production potential in grasses is site specific and determined by the climate of the geographic region. It appears that prevailing climatic conditions were favourable for grass 'seed' yield. The high seed yielding accessions identified in the present study may further be evaluated in multi-location trials, and used for seed production programme in winter season to fulfill the growing demand of the seed.

Seed germination

In pasture grasses the seed dormancy along with after ripening requirement is pronounced. Perusal of data in Table 3 revealed wide genotypic differences for seed germination and ranged from 17.0% (IGFRI 3108) to 86.8% (CCR 12). *Cenchrus ciliaris* accessions differed in dormancy attributes, which may be adaptive to their climate of origin [9]. In the present study the germination test was conducted with six months old 'seeds', therefore, the dormancy might have got released to some extent. Mean germination was 45.7%, which is considerably higher than minimum seed certification standards limit (30%). This indicated that winter season had no adverse influence on seed germination. High germination (74.5%) in husked seeds of *C. ciliaris* genotype CAZRI 358 was recorded by Rajora *et al.* [10]. Parihar *et al.* [11] recorded up to 51.3% germination in husked (intact) seeds of vetiver grass.

Findings of the study revealed that simple selection can improve the seed yield components in general and spikes per plant and seed yield in particular. Accessions CAZRI 2162, CAZRI 1106, CAZRI 2224, CAZRI 2185 and CAZRI 2217 were superior for winter season quality seed production. The results revealed that there is great potential for buffel grass quality seed production during winters in dry areas, especially during good rainfall years or where facilities for irrigation are available.

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