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Genotype x Environment Interactions in Buffel Grass

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Abstract : Green fodder and dry matter yields of ten buffel grass (*Cenchrus ciliaris* Linn.) varieties were recorded in nine environments (location - year combinations). Joint regression analysis revealed significant variation due to environments, genotypes and genotype x environment interaction for each yield. Growth response index and stability indices were used to compare the varieties for specific adaptation and stability of forage production. None of the varieties combined high mean yield with average response and stability as desired in an ideal population. CAZRI 358, CAZRI 531, Bundel Anjan and CAZRI 1263 were stable in performance. Adaptation to low environment was found in CAZRI 358 and Bundel Anjan, whereas, CAZRI 1263 appeared to suits high environment. Considering the difficulties for recombination breeding in an apomictic species like buffel grass, population improvement through varietal mixtures is suggested.

Key word : Buffel grass, genotype x environment interaction, fodder yield, apomictic, varietal mixture.

Buffel grass (*Cenchrus ciliaris* Linn.), an apomict with variable chromosome number (2n = 34, 36, 40, 54), is a much valued perennial forage grass, suited to pastures and rangelands of arid and semi-arid zones. Its fodder is highly nutritious and palatable to grazing animals even at maturity. Once established, it can survive extreme and prolonged drought and grow vigorously when favorable conditions set in.

Varietal improvement in this apomictic grass has been mainly based on clonal selection. Diverse collections of indigenous and exotic origin are evaluated and compared in multilocation trails, each extending for more than a year. Genotype x environment interactions provide additional information for more effective varietal comparisons for yield and adaptation. The present study was, therefore, undertaken to analyse the genotype x environment interactions in buffel grass under the variable arid and semi-arid conditions.

Materials and Methods

Asexual (apomictic) seeds of 10 varieties/strains of buffel grass were sown in nursery in 1988 and the resultant seedlings of each variety were transplanted in 3 x 3.5 m plots at a spacing of 50 cm, in rows 70 cm apart. Randomized complete block design with 3 replications was followed. The experiment was conducted over a period of 3 years (1988 to 1990) at Jodhpur and Pali in western Rajasthan and Bhuj in Kutch region of Gujarat.

Forage was harvested by cutting 5 random plants at half-bloom stage, and later at convenient intervals, depending on regrowth. The harvests from all cuttings of the same year were combined to give the green fodder and dry matter yield estimates. Since repeated harvests were taken from same plots over the years in the experiment, years were considered as split-blocks (Steel and Torrie, 1980). In the statistical analysis, all effects, except replications, were considered fixed.

Analysis for genotype x environment interactions was done using the method of joint regression (Perkins and Jinks, 1968). Growth response of the varieties was studied using the linear regression (b-value) of varietal mean yield on the averge yield of all varieties in each environment (environmental index), and deviation from regression mean squares (S^2d) was used as stability index (Eberhart and Russell, 1966). The ecovalence or w-values of each variety (Wricke, 1962), and

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coefficients of determination (R^2) calculated between average yield of each variety and the environmental index further helped in interpreting stability.

Results and Discussion

Variations due to locations and varieties were significant, whereas, differences due to years were not significant for either green fodder or dry matter yield. Effect of location on the yields is possible due to location differences in rainfall, aridity and the soil characteristics. All interactions were significant for both the yields except for year x location effect, which was detected only for dry matter. Similar results were reported for orchard grass by Gray (1982). When interactions are present, it is difficult to identify superior varieties based on mean performance over different environments. Additional statistics, derivable from genotype x environment analysis, facilitate comparison of varieties in such situation.

Genotype x environment analysis (Perkins and Jinks, 1968) revealed that variation due to genotypes, environments and genotype x environment interactions, all were significant (Table 1)..

Table 1. Joint regression analysis for genotype x environment interactions in buffel grass

Source	d.f.	Mean squares	
		Green fodder	Dry matter
Genotype	9	1618.13* +	220.35* +
Environment	8	10802.74* +	1607.06* +
Genotype x environment	72	426.16* +	63.64* +
Heterogeneity of regression	9	669.41 +	158.15* +
Remainder	63	891.41* +	50.14* +
Pooled error	162	73.14	12.95

* Significant at P = 0.01 when tested against pooled error.
\+ Significant at P = 0.01 when tested against remainder mean squares..

Linear regression of genotype x environment interaction of individual varieties on the environmental index allowed partitioning of genotype x environment sum of squares into two useful parts, linear and non-linear. Mean squares due to heterogeneity between regressions, representing the linear or predictable component was significant for both the yields. Significant remainder mean squares indicated the simultaneous presence of non-linear or unpredictable component. Green fodder yield, however, appeared less predictable as compared to dry matter yield, as its contribution to total genotypes x environment interaction through regressions was relatively smaller (Table 1). Roy *et al.* (1993) opined the opposite for marvel grass.

The significant linear and non-linear genotype x environment interactions indicated that there are differences among the regression coefficients and among the deviations from regressions (remainder mean squares) of the buffel grass varieties. Tan *et al.* (1979) found differences among regression coefficients in smooth bromegrass and tall fescue, respectively, and significant deviations from regression in smooth bromegrass.

Coefficients of regression or b-values, worked out for each variety, ranged from 0.61 to 1.45 and from 0.61 to 1.50 for green fodder and dry matter yield, respectively (Table 2). Several of the b-values were significantly different from unit (b = 1). The proportion of genotype x environment sum of squares attributable to each variety is represented by the ecovalence or w-values (Wricke, 1962). Strong positive correlation between the w-values and S^2_d statistic (Table 3) indicated that stability of an entry is inversely proportional to the w-index. The variability among the w-values suggested differences in stability of varieties over the environments. The coefficients of determination (R^2) between average yield of individual varieties and average yield of all varieties, in each environment, were nega-

Table 2. Estimates of stability parameters, growth response index(b) and mean yield ($\bar{x}$) of buffel grass varieties

Variety/Strain	Green fodder (q ha^{-1})					Dry matter (q ha^{-1})				
	$\bar{x}$	b	S^2d	R^2	w	$\bar{x}$	b	S^2d	R^2	w
Marwar Anjan	106.81	1.45	456.03**	0.832	5640.12	43.79	1.50*	15.45	0.935	518.43
CAZRI 358	66.07	0.61**	34.01	0.812	2044.53	27.58	0.61*	11.73	0.734	368.35
CAZRI 531	68.31	0.98	32.45	0.920	742.99	28.21	0.86	2.43	0.899	131.86
IGFRI 660	64.30	1.28	820.44**	0.696	6944.26	28.28	0.92	119.38**	0.539	935.33
IGFRI 678	60.26	0.84	196.83**	0.762	21157.60	27.61	0.61*	17.24	0.697	403.01
CAZRI 1106	82.22	0.70	682.64*	0.448	6047.64	34.38	0.53	72.75**	0.378	880.64
Biloela	78.29	1.19	351.25**	0.806	3298.12	31.44	1.43*	18.65	0.922	454.59
CAZRI 1263	78.59	1.24*	-6.86	0.966	976.90	34.67	1.30*	2.34	0.953	223.44
Bundel Anjan	66.93	0.81*	-13.21	0.931	730.19	31.14	1.04	10.36	0.897	165.70
FS 391	71.29	0.88	239.58**	0.752	2323.15	32.70	1.19	51.80**	0.801	500.63
GM	74.31					31.98				
SEm ±	6.99					2.50				
C.D. at P = 0.05	13.98					5.01				

*, ** Significantly different from 1.0 for the regression coefficients and from 0.0 for the deviation mean squares at the 0.05 and 0.01 levels of probability, respectively.

tively correlated to $S^2{}_d$ values. Similar high correlations among $S^2{}_d$, w and R^2 were reported in oats (Langer *et al.*, 1979) suggesting that any of them may be used as stability parameter.

Correlation between mean yield ($\bar{x}$) and response index (b) was found non-significant for both yields (Table 3). Similarly, non significant relationship was found between these statistics and the stability indices except for the positive correlation with R^2 for dry matter yield. This indicated that selection for improved yields and response to environment or stability may be carried out separately. The significant association of b and R^2, however, suggested that buffel grass genotypes selected for better response to environment may also show greater stability for dry matter production across environments. Gray (1982) reported that neither the average yield nor the response index was generally correlated with the stability indices R^2, w or $S^2{}_d$ in orchard grass.

Varieties with high mean yield could be differentiated further, based on response values and stability parameters. Eberhart and Russell (1966)

Table 3. Simple correlation coefficients among mean yield ($\bar{x}$), growth response index (b) and stability parameters

		b	$S^2{}_d$	R^2	w
$\bar{x}$	r (GF)	0.555	0.266	-0.060	0.413
	r (DM)	0.619	-0.116	0.255	0.121
b	r (GF)		0.309	0.301	0.349
	r (DM)		-0.236	0.726*	-0.208
$S^2{}_d$	r (GF)			-0.773**	0.969**
	r (DM)			-0.770**	0.905**
R^2	r (GF)				-0.724*
	r (DM)				-0.807**

r (GF) and r (DM) are simple regression coefficients for green fodder and dry matter yield, respectively.

considered a stable variety to have high mean, unit regression (b = 1) and the deviations from regression as small as possible ($S^2{}_d = 0$). Present experiment exhibited predominant effect of locations, rather than of years, on the yields and there was no consistent increase or decrease of yields over years. So, the concept of ideal population given by Eberhart and Russell (1966), appeared more applicable for this study.

The high mean and average growth response (b = 1), appeared dispersed among the buffel grass varieties with no single variety having all the attributes. Highest yielding variety, Marwar Anjan, showed inconsistent stability and response values. The entries CAZRI 358, CAZRI 531, Bundel Anjan and CAZRI 1263, which recorded yields not significantly different from grand population mean, were the only stable varieties. Since b-values indicate response to increments in an improving environment, genotypes with b specifically adapted to good or high environment. CAZRI 358 and Bundel Anjan with below average response (b) appeared suited to low environment, whereas, CAZRI 1263 was evidently adapted to high environment.

Buffel grass is an obligate apomict with rare sexual plant (Bashaw, 1962). Sexual recombination, accordingly, is severely limited by the availability of sexual types. The desirable variability existing in different clones, however, may be exploited through varietal mixtures. Selected high yielding varieties, which generally complement each other for production stability and response to environment, may be excepted to result in mixed clonal populations with significant improvement in fodder yield and its stability under variable environments.

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