Indian J. Genet., **63**(2): 115-118 (2003)

Variation and character association in fodder yield and related traits in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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(Received: January 2002; Revised: May 2003; Accepted: May 2003)

Abstract

An evaluation of 115 accessions of pearl millet [*Pennisetum glaucum* (L.) R. Br.] germplasm for green fodder yield as well as quality traits in an augmented design over two seasons revealed highly significant differences among the accessions for days to heading. Plant height, tillers per plant, stem thickness, protein content, calcium content, oxalic acid content and green fodder yield per plot in both the seasons. The genotypic and phenotypic coefficients of variation were more or less similar for all the characters. Broad sense habitability was moderate (61% for stem thickness) to high (97% for calcium and oxalic acid contents) confirming that genotypic variance has contributed substantially to the total variance. The association and path coefficient analysis revealed that tillers per plant, plant height and leaf to stem ratio were the important characters and may be selected to increase the fodder yield ability. Based on the results of the means of the two seasons considering together the various traits, the accession IP 5735 was found to be superior for earliness, plant height, tiller per plant, leaves per plant, leaf : stem ratio, oxalic acid content and green fodder yield; IP-5741 for green fodder yield, earliness, plant height and leaf : stem ratio; IP-15213 for green fodder yield, earliness, plant height and tillers per plant; IP-17998 for green fodder yield, tillers per plant, leaves per plant and leaf : stem ratio; IP-14185 for green fodder yield, stem thickness and low oxalic content; IP 14446 for green fodder yield, plant height and low oxalic content. Therefore, this accession should be utilized in further breeding program for developing superior varieties.

Key Words : Pearl millet, coefficient of variation, heritability, correlation and path coefficient

Introduction

The state of Rajasthan is well known for its cattle wealth with 4229.7 thousand cattle and 3283.8 thousand buffaloes besides sheep and goats (Anonymous, 1998). To sustain this cattle wealth and to maintain its productivity a large quantity of green fodder is required. Pearl millet [*Pennisetum glaucum* (L.) R. Br.] because of its high tolerance to high temperature and better ability to withstand drought and to grow even under low soil fertility is best suited for arid and semi arid conditions of Rajasthan. The production potential of green fodder of pearl millet at present is however, low. Obviously if productivity of the cattle population has to be improved, high fodder yielding varieties of pearl millet with better quality will have to be developed. It is a well- established fact that the progress in improvement of a crop depends on the degree of variability in the desired characters in the base material *vis-a-vis* germplasm collection. In the present study therefore, variability for the fodder yield and related attributes along with quality were estimated in a collection of 115 accessions, over two seasons.

Materials and methods

The study was conducted using 115 (33 indigenous and 82 exotic) accessions of pearl millet germplasm for green fodder yield traits in augmented complete block design [2] during two seasons namely *kharif*, 1992 and summer 1993 at the Research farm of S.K.N. College of Agriculture, Jobner. In both the seasons these accessions were divided into five blocks, each block consisted of 23 accessions and four check varieties namely UUJ-1, UUJ-2, UUJ-IVM and 15 P synthetic. Each plot of 3.0 × 0.8 m size accommodated two 3.0 m long rows spaced 40 cm apart. Plant-to-plant distance was adjusted at 10 cm by thinning at 3 leaf stages. Plots were harvested when ear heads appeared in 50% plants within a plot. At the time of harvest the data were recorded on five randomly selected plants in each plot for seven morphological and three quality traits. Statistical analyses were done according tot he standard statistical procedures [2 and 3].

Result and discussion

In an augmented design, the evaluation of checks in first done to get an estimate of error, which is used for deriving adjusted values of entries. The data obtained for each of the traits of significant for all the traits indicating the effects of season × genotype interactions. Hence the ANOVA [2] was done season-wise. Evaluation of 115 accessions in both the seasons showed significant difference for days to heading, plant height, tillers per plant, stem thickness, protein content, calcium content, oxalic acid content and green fodder yield per plot suggesting the existence of significant variation among the entries. These results support the selection programme for better quality of fodder. Similar pattern of variability in germplasm evaluation of different sizes have been earlier reported for green fodder yield by Suthamathi [6] for days to heading and plant height by Thakur [7].

The heritability in broad sense was observed to be high 74%-98% for all traits which had significant differences among the accessions in both the seasons except for stem thickness in season-I and leaves per plant in season II. High heritability coupled with high genetic advance was also observed for these traits (Table 1)

including green fodder yield per plot revealed that in general the phenotypic correlations coefficients were similar tot he genotypic correlations (Table 2). In some cases the phenotypic correlations were slightly higher than the genotypic correlation coefficients, which may be a result of modifying effect of environments on the association of characters. The green fodder yield per plot showed positive and significant correlations with plant height, tillers per plant, leaves per plant, leaf:stem ratio and stem thickness in both the seasons while with days to heading although a positive association was observed in both the seasons the value was significant only in season II. Green fodder yield exhibited negative correlation with protein content, however the

Table 1. Range, mean, coefficient of variation, heritability and expected genetic advance for green fodder yield and other characters in pearl millet

Character	Session	Range	Mean	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability (broad sense) (%)	Expected genetic advance % of mean
Days to heading	I	47.2-90.2	61.70	25.49	26.26	94.24	50.98
	II	52.3-93.3	72.30	23.50	23.80	97.49	47.80
Plant height	I	89.2-219.2	161.50	22.33	25.27	78.07	40.64
	II	77.6-246.2	149.40	28.84	29.47	95.80	58.16
Tillers per plant	I	0.6-6.9	2.60	39.74	46.27	73.77	70.71
	II	1.4-11.5	4.40	45.89	51.16	80.85	84.80
Leaves per plant	I	8.7-48.7	19.90	35.42	39.62	79.90	65.22
	II	10.4-89.6	31.90	31.24	47.01	44.18	42.78
Leaf stem ratio	I	0.17-0.94	0.57	27.13	31.60	73.70	47.98
	II	0.31-0.89	0.50	25.97	28.29	84.90	49.29
Stem thickness	I	1.9-7.6	4.20	25.77	33.00	60.96	41.45
	II	2.3-5.9	4.10	27.00	29.64	82.96	50.66
protein content (%)	I	3.29-18.44	9.34	35.05	36.94	95.10	70.41
	II	4.96-14.02	8.86	27.01	27.81	94.34	54.05
Calcium content (%)	I	0.17-0.60	0.36	26.29	28.72	97.23	52.24
	II	0.24-0.55	0.37	26.72	29.19	83.81	50.39
Oxalic acid content (%)	I	1.03-2.28	1.64	25.87	26.23	97.23	52.24
	II	1.08-2.25	1.63	24.51	24.77	97.99	49.99
Green fodder yield per plot (kg)	I	2.21-17.90	8.36	35.5	40.35	77.40	64.33
	II	5.31-32.88	18.89	40.34	41.24	95.96	81.27

From the study of heritability and genetic advance it is inferred that simple selection among germplasm accessions can bring about significant improvement in the fodder yield and its component characters as the heritability and estimated genetic advance were high. The expected genetic advance might have been biased upward as it is based on the estimates of heritability in broad sense, secondly in the augmented design the estimation of mean squares due to error is based on the performance of the check varieties only, and hence it might have given the high estimates of genetic variance due to confounding of error variance in it. This estimate of genetic variance is used in the calculation of heritability and genetic advance and hence over estimation of genetic advance was observed.

The genotypic and phenotypic correlation coefficients worked out among different characters

value was significant in season I only. Changes in direction and magnitude of correlation coefficient was observed between the seasons which may be ascribed to significant genotype × environment interaction. For example the correlation coefficient of green fodder yield with oxalic acid content was highly negative in season I but the association turned out to be very low though significant in season II indicating the effect of environment and character association. Similar to the present findings negative association of green fodder yield with oxalic acid content was reported by Singh[4].

It is also noted that character plant height, tillers per plant, leaves per plant, leaf:stem ratio and stem thickness exhibiting positive association with green fodder yield per plot have also shown positive association among themselves in both the seasons except plant height and stem thickness which did not show

Table 2. Phenotypic Correlation coefficient on the basis of unadjusted values between different characters in pearl millet

Character	Season	Character								
		Plant height	Tillers per plant	Leaves per plant	Leaf stem ratio	Stem thickness	Protein content	Calcium content	Calcium content	Oxalic acid content
Days to heading	I	−0.4524*	0.3495**	0.3496**	0.3532**	−0.3535*	−0.2067*	−0.118	0.3244**	0.0081
	II	0.3733*	0.4117**	0.4592**	0.3515**	0.3515*	−0.2421*	0.0478	0.5103**	0.4264**
Plant height	I		−0.0680	−0.0549	−0.0560	0.3416**	0.1387	0.0381	−0.2530*	0.2177*
	II		0.1398	0.1798*	0.0525	0.0310	−0.2225*	0.1611	0.2477*	0.2265**
Tillers per plant	I			0.8021**	0.5280**	−0.1660	−0.2911*	−0.0995	0.1525	0.4568**
	II			0.7796**	0.3340**	0.4025*	−0.1844*	−0.0796	0.2633**	0.6323**
Leaves per plant	I				0.5149**	−0.0697	−0.2309*	−0.0968	0.1008	0.3981**
	II				0.3966**	0.4348**	−0.2418*	−0.0087	0.2834**	0.6974**
Leaf stem ratio	I					−0.2317*	−0.1324	−0.1579	0.3564**	0.3995**
	II					0.3662**	−0.1297	−0.0263	0.1357**	0.2067*
Stem thickness	I						−0.0443	0.0151	−0.3312*	0.2046*
	II						−0.2946*	−0.0348	0.2299*	0.5280**
Protein content (%)	I							−0.0504	−0.1027	−0.2512*
	II							−0.0560	−0.1577	−0.0892
Calcium content (%)	I								0.2485**	−0.1192
	II								0.1748*	0.0285
Oxalic acid content (%)	I									−1.0071*
	II									0.2493**

* and ** significant at 5 and 1 per cent level probability respectively

consistency in association with other traits. These characters are also having the high broad sense heritability and high expected genetic advance (expressed as % of mean) should be used in selection programme.

Furthermore, the path coefficient analysis based on both the seasons revealed that the character like plant height, tillers per plant, and stem thickness which had positive correlation with green fodder yield also exerted positive and high direct effects on green fodder yield (Table 3). This confirms the role of these characters in determining the green fodder yield and therefore, their values in constructing the selection criterion. Where as leaf : stem ratio and leaves per plant showed positive significant association with green fodder yield in both the seasons. But the direct effect of leaves per plant was negative with green fodder yield in season I, which may be a result of the indirect effects of this trait via plant height, stem thickness. Between seasons I and II the magnitude and direct effect varied only for leaves per plant and leaf to stem ratio. This can be attributed to g × e interactions.

The conclusion that can be reached from the variability, correlations and path coefficient is that tiller per plant is the most important component character for the green fodder yield per plot. The other important characters are plant height, leaves per plant and stem thickness which should be considered as selection criteria including green fodder yield *per se* in a selection programme. All these component characters had high variability, heritability, genetic advance and hence, these may be successfully improved ultimately improving the green fodder yield.

Based on the results of the means of the two seasons some of the accessions identified superior for different morphological and quality characters are IP-15189 (50.75 days), IP-15213 (51.75 days) and IP-5753 (53.0 days) for early heading and UP-17394, (89-75 days) and IP-17427 (88.75 days) for delayed heading; IP-8472, IP-17428, IP-16248 and IP-14446 for plant height, IP-17998, IP-14689 IP-13598 and IP-3613 for number of tillers; IP-17425 IP-17998 and IP 14689 for number of leaves per plant; IP-5189, IP-3613, IP-5741, and IP-14450 for higher leaf : stem ratio; IP-9777 and IP-13395 for stem thickness; IP-9141, and IP-11717 for protein content; IP-14253, IP-8554 and IP-14248 also for calcium content; IP-5735 and IP-14185 for low oxalic acid content; IP-5735, IP-17425, IP-8575 and IP-3614 had higher green fodder yield (Table 4). Considering together the various traits, the accession IP-5735 was found to be superior for earliness, plant height, tillers per plant, leaves per plant, leaf :stem ratio, oxalic acid content and green fodder yield; IP-5741 for green fodder yield, earliness, plant height and leaf: stem ratio; IP-15213 for green fodder yield, earliness, plant height and tillers per plant; IP-17998 for green fodder yield, tillers per plant, leaves per plant and leaf: stem ratio; IP-14185 for green fodder yield, stem thickness and low oxalic content; IP-14446 for green fodder yield, plant height and low oxalic content. Therefore, this accession should be utilized in further breeding program for developing superior varieties.

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Table 3. Direct (diagonal) and indirect (non diagonal) effects of different characters on green fodder yield in pearl millet at genotypic level

Character	Season	Character					
		Plant height	Tillers per plant	Leaves per plant	Leaf stem ratio	Stem thickness	Genotypic correlation with green fodder yield/plot
Plant height	I	0.1640	0.0267	0.0017	–0.0155	0.0942	0.2177**
	II	0.1165	0.0260	0.0827	–0.0082	0.0095	0.2265**
Tillers per plant	I	–0.0112	0.3920	–0.0249	0.1466	–0.0458	0.4568**
	II	0.0163	0.1862	0.3586	–0.0522	0.1235	0.6323**
Leaves per plant	I	–0.0090	0.3144	–0.0310	0.1429	–0.0192	0.3981**
	II	0.0209	0.1452	0.4599	–0.062	0.1334	0.6974**
Leaf stem ratio	I	–0.0092	0.2071	–0.0160	0.2775	–0.0639	0.3955**
	II	0.0061	0.0622	0.1824	–0.1563	0.1123	0.2067*
Stem thickness	I	0.0560	–0.0651	0.0022	–0.0643	0.2758	0.2046*
	II	0.0036	0.0750	0.2000	–0.0573	0.3067	0.5280**

(Residual effect = 0.6314 and 0.4055 in session I and II respectively)

Table 4. Top ranking accessions selected on the basis of average mean of different characters over two seasons (Kharif 1992 and summer, 1993) in pearl millet accessions

S. No.	Days to heading	Plant height	Tillers per plant	Leaves per plant	Leaf stem ratio	Stem thickness	Protein content (%)	Calcium content (%)	Oxalic acid content (%)	Green fodder yield per (kg)
1	IP-15159 (50.75)	IP-8472 (206.32)	IP-13598 (7.82)	IP-17425 (56.02)	IP-5189 (0.79)	IP-9777 (6.29)	IP-9141 (15.81)	IP-14253 (0.56)	IP-9143 (1.10)	IP-5735 (22.82)
2	IP-15189 (50.75)	IP-17428 (197.28)	IP-17998 (6.99)	IP-14689 (51.36)	IP-3613 (0.75)	IP-13395 (6.24)	IP-14416 (14.73)	IP-14023 (0.54)	IP-5735 (1.12)	IP-17425 (21.97)
3	IP-15213 (51.75)	IP-16248 (196.48)	IP-14689 (6.68)	IP-17998 (50.32)	IP-5735 (0.75)	IP-14184 (6.01)	IP-11717 (14.05)	IP-14248 (0.53)	IP-14185 (1.13)	IP-8575 (21.67)
4	IP-5735 (53.00)	IP-5789 (194.42)	IP-3613 (5.89)	IP-8569 (41.81)	IP-5741 (0.5)	IP-14189 (5.74)	IP-13236 (13.27)	IP-14259 (0.53)	IP-14611 (1.16)	IP-3616 (21.14)
5	IP-8564 (54.00)	IP-14446 (191.63)	IP-3615 (5.74)	IP-3615 (36.51)	IP-14450 (0.75)	IP-14185 (5.71)	IP-14190 (13.25)	IP-8554 (0.53)	IP-14416 (1.17)	IP-5741 (20.21)
6	IP-8556 (54.50)	IP-14447 (188.00)	IP-14012 (5.64)	IP-3613 (36.51)	IP-14689 (0.74)	IP-13355 (5.54)	IP-8581 (12.60)	IP-8574 (0.51)	IP-8556 (1.18)	IP-10573 (19.83)
7	IP-3613 (5.50)	IP-8575 (186.87)	IP-14691 (5.53)	IP-5735 (35.66)	IP-14184 (0.74)	IP-8581 (5.46)	IP-14450 (12.21)	IP-14017 (0.50)	IP-12951 (1.18)	IP-14185 (19.64)
8	IP-14189 (56.25)	IP-6516 (186.67)	IP-15213 (5.19)	IP-17416 (34.73)	IP-17389 (0.73)	IP-12951 (5.44)	IP-14689 (12.14)	IP-14009 (0.49)	IP-1375 (1.19)	IP-17998 (19.43)
9	IP-15161 (56.25)	IP-5741 (186.07)	IP-14183 (5.14)	IP-17397 (34.52)	IP-16248 (0.71)	IP-14731 (5.26)	IP-8571 (12.06)	IP-12951 (0.48)	IP-14446 (1.19)	IP-15213 (19.36)
10	IP-5741 (57.00)	IP-14691 (186.00)	IP-14184 (4.74)	IP-9143 (34.35)	IP-17998 (0.71)	IP-13983 (5.26)	IP-15161 (12.04)	IP-12950 (0.48)	IP-14232 (1.20)	IP-14418 (19.16)
11	IP-6513 (57.00)	IP-5735 (183.32)	IP-14259 (4.69)	IP-14418 (33.77)	IP-3616 (0.69)	IP-14435 (5.11)	IP-5735 (11.82)	IP-13743 (0.46)	IP-5189 (1.21)	IP-14446 (18.94)
12	P-14343 (57.25)	IP-14343 (182.11)	IP-16248 (4.54)	IP-14183 (33.47)	IP-8472 (0.69)	IP-13307 (5.11)	IP-15159 (11.65)	IP-14343 (0.45)	IP-12448 (1.22)	IP-11890 (18.88
13	IP-8574 (57.50)	IP-15213 (177.48)	IP-5735 (4.44)	IP-14199 (33.37)	IP-14017 (0.69)	IP-14851 (4.96)	IP-10627 (11.63)	IP-17428 (0.45)	IP-14433 (1.24)	IP-12447 (18.48)

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