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Performance Evaluation of Released Genotypes of Pearl Millet (Pennisetum glaucum) in Agro-Climatic Zone 1C of Rajasthan

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Abstract

The present study was conducted at the Agricultural Research Station, Bikaner, during the Kharif season of 2023 to evaluate the performance of 21 released genotypes of pearl millet. The research aimed to identify genotypes with superior agronomic traits suitable for the agro-climatic conditions of zone 1C in Rajasthan. The experiment was laid out in a randomized block design with three replications. Key traits such as plant height, number of productive tillers per plant, panicle length, panicle diameter, test weight, dry fodder yield, and grain yield were recorded. The cultivar KBH 108 takes the longest to reach 50% flowering, while PB 1756 is the quickest. Again, KBH 108 takes the longest to mature, while PB 1756 matures the fastest. Pusa Composite 701 is the tallest cultivar, and AHB 1200 is the shortest. GHB 905 has the most productive tillers, while several cultivars have the least. Pusa Composite 383 has the longest panicle length, and MPMH 21 has the shortest. 86M86 has the largest panicle diameter, and HHB 67 Imp. has the smallest. PB 1756 has the highest test weight, and Pusa Composite 383 has the lowest. Pusa Composite 701 produces the highest dry fodder yield, and PB 1852 produces the lowest. MPMH 17 yields the most grain, while Pusa Composite 383 yields the least. All the characters listed in the table 2 show significant differences among the treatments (different cultivars), as indicated by the mean sum of squares for treatments being significantly greater than the mean sum of squares for error at the 1% level of significance. This implies that the variation in these traits is not due to random chance but due to the genetic differences among the cultivars.

Significant variability was observed among the genotypes for all measured traits, indicating potential for selecting high-yielding and well-adapted genotypes for this region. In conclusion, most characters in pearl millet exhibit high heritability and considerable genetic advance, making them suitable for improvement through selective breeding programs. The high genetic advance in some traits like dry fodder yield and grain yield indicates substantial potential for achieving significant gains in these traits through selection. Strong Direct Effects: Productive tillers: 0.854, Panicle diameter: 0.5236. Moderate Direct Effects: Panicle length: 0.3464, Days to maturity: -0.3777, Days to 50% flowering: 0.2122. Indirect Effects: Significant indirect contributions through days to maturity, panicle diameter, and productive tillers for several traits. Negative indirect effects observed in days to maturity and productive tillers.

Keywords: Pearl Millet, Agro-Climatic, Genotypes.

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Introduction

Pearl millet commonly known as bulrush millet (Pennisetum glaucum L.). R. Br. also classified as P. typhoides, P. americanum, or P. spicatum, is a cultivated small-grain tropical cereal grass. Vernacular names include: “bajra” (India), “gero” (Nigeria, Hausa language), “hegni” (Niger, Djerma language), “sanyo” (Mali), “dukhon” (Sudan, Arabic), and “mahangu” (Namibia). Pearl millet is quantitatively the most important millet, with world annual production $\sim$14 million tons (Mt). It is cultivated mainly in the semi-arid tropics, almost exclusively by subsistence and Grain yield is an unpredictable character and relies upon number of component characters which are quantitatively inherited. Thus, before starting any breeding programmes, intensive information on the nature and greatness of genetic variability is extremely essential. The presence of genetic variability is of utmost importance for any breeding programme and due to this reason the plant breeders have emphasized the evaluation of germplasm for the improvement of crop yield as well as for utilization in further breeding programmes. Evaluation of plant genetic resources is a pre- requisite for which the future breeding work is based. Crop improvement depends on the magnitude of genetic variability present in the base population. Genetic diversity is one of the criteria for parent’s determination in the hybridization programmes. The accessibility of transgressive segregant in any breeding project depends upon the diversity between the parents associated. Identification of high grain yield traits of pearl millet genotypes is important to further breeding programmes to develop a hybrids or cultivar. This is done through variability and genetic divergence analysis.

The present study aims to evaluate the agronomic performance of 21 released genotypes of pearl millet under the agro-climatic conditions of Bikaner, Rajasthan. This region is characterized by extreme temperatures and limited rainfall, making it crucial to identify genotypes that can thrive under these conditions and contribute to food and fodder security.

Materials and Methods

The experiment was carried out at the Agricultural Research Station, Bikaner, located at 27°1’ N latitude and 71°54’ E longitude, at an altitude of 228.50 meters above mean sea level. The research farm falls under the agro-climatic zone 1C of Rajasthan. The experimental material comprised 21 released genotypes of pearl millet. The field was divided into three blocks of equal size, with each plot consisting of six rows, each 4

meters long. Row spacing was maintained at 60 cm, and plant-to-plant spacing was 15 cm. Recommended agronomic practices were followed to ensure a healthy crop. Observations were recorded for ten randomly selected plants per genotype per replication for plant height, number of productive tillers per plant, panicle length, panicle diameter, test weight, dry fodder yield, and grain yield. Days to 50% flowering and days to maturity were recorded on a plot basis.

Results

The evaluation of 21 released genotypes of pearl millet revealed significant variation across various genetics and agronomic traits. The key results for each measured trait are summarized from table 1. The genotypes exhibited a range of 41 to 50 days to reach 50% flowering. Genotype PB 1756 was the earliest to flower (41 days), while KBH 108 took the longest (60 days). Over all mean of days 50% flowering were 50 days. The days to maturity varied from 71 to 90 days among the genotypes. The earliest maturing genotype was PB 1756 (71 days), and the latest was KBH 108 (90 days). Over all mean of days to maturity were 80 days. Plant height ranged from 160 cm to 211 cm. The tallest genotype was Pusa Composite 701 (211 cm), while the shortest was GHB 905 (160 cm). Over all mean of Plant height was 173 cm. The number of productive tillers per plant ranged from 1.0 to 1.5. The genotypes GHB 905 and GHB 719 had the highest number of productive tillers (1.5), while PB several cultivars had the lowest (1.0). Over all mean of productive tillers per plant was 1.1. Panicle length varied between 20 cm to 30 cm. The longest panicles were observed in Pusa Composite 383 (30.7 cm), whereas the shortest were in MPMH 21 (22 cm). Over all mean of panicle length was observed 26.2 cm. Panicle diameter ranged from 2.0 mm to 2.4 mm. The genotype 86M86 had the largest panicle diameter (2.7 mm), and HHB 67 Imp. had the smallest (2.0 mm). Over all mean of Panicle diameter was 2.4 mm. Test weight ranged from 8.6 g to 11.9 g. PB 1756 had the highest test weight (11.9 g), while Pusa Composite 383 had the lowest (8 g). Over all mean of test weight was 9.4 g. Dry fodder yield varied between 1.419 kg to 8.852 kg per plot. Pusa Composite 701 recorded the highest dry fodder yield (8.852 kg), and PB 1852the lowest (1.419 kg). Over all mean of dry fodder yield was 5.195 kg. Grain yield ranged from 0.95 kg to 3.193 kg per plot. The highest grain yield was produced by MPMH 17 (3.193 kg), and the lowest by Pusa Composite 383 (0.95 kg). Over all mean of grain yield was 1.83 kg/plot.

All the characters listed in the table 2 show significant differences among the treatments (different cultivars), as indicated by the mean sum of squares for treatments being significantly greater than the mean sum of squares for error at the 1% level of significance. This implies that the variation in these traits is not due to random chance but due to the genetic differences among the cultivars. The table indicates that the treatments (different cultivars) have a significant effect on each character, as denoted by the ** (significant at 1% level of significance). Let's analyze each character: for Days to 50% Flowering Treatment mean sum of squares (88.89) is significantly greater than the error mean sum of squares (5.76). for days to maturity Treatment mean sum of squares (87.71) is significantly greater than the error mean sum of squares (5.37). for Plant Height (cm) Treatment mean sum of squares (744.62) is significantly greater than the error mean sum of squares (74.63). for Productive Tillers Treatment mean sum of squares (0.07) is significantly greater than the error mean sum of squares (0.02). for panicle length (cm) treatment mean sum of squares (18.17) is significantly greater than the error mean sum of squares (1.68). For panicle diameter (mm) treatment mean sum of squares (0.11) is significantly greater than the error mean sum of squares (0.01). For test weight (g) treatment mean sum of squares (4.09) is significantly greater than the error mean sum of squares (0.16). For dry fodder yield per Plot (kg) Treatment mean sum of squares (9.87) is significantly greater than the error mean sum of squares (0.75). For grain yield per Plot (kg) treatment mean sum of squares (1.02) is significantly greater than the error mean sum of squares (0.09)

Analysis of Variability Parameters for Different Characters

The table 3 provides variability parameters for various characters in pearl millet, including phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H2), genetic advance (GA), and genetic advance as a percentage of the mean (GA as % of mean). PCV (Phenotypic Coefficient of Variation): Indicates the overall variation in a trait, including both genetic and environmental factors. GCV (Genotypic Coefficient of Variation): Indicates the genetic variation in a trait. H2 (Heritability): The proportion of the total variation in a trait that is due to genetic factors. GA (Genetic Advance): The expected improvement in a trait from selection. GA as % of mean: The genetic advance expressed as a percentage of the trait mean, indicating the potential for improvement through selection.

Table 3 show that all traits exhibit high heritability (above 70%), suggesting that genetic factors play a significant role in their variation. Traits like dry

Table 1. Mean performance of 21 cultivars of pearl millet

		Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers	Panicle length (cm)	Panicle diameter (mm)	Test weight (g)	Dry fodder yield per plot (kg)	Grain yield per plot (kg)
1	RHB 223	43	74	167	1.3	26.6	2.2	9.2	4.248	2.39
2	PB 1756	41	71	165	1.1	30.0	2.4	11.9	3.890	1.967
3	MPMH 21	43	73	163	1.3	22.0	2.3	8.6	4.405	2.22
4	GHB 719	47	77	173	1.4	22.6	2.2	9.4	4.832	2.21
5	HHB 67 Imp.	45	75	164	1.2	24.4	2.0	8.7	4.733	1.399
6	PB 1852	56	86	185	1.1	25.8	2.6	10.6	1.419	2.21
7	PB 1705	55	86	169	1.1	25.7	2.5	10.8	3.190	1.883
8	MPMH 17	47	77	164	1.3	27.0	2.4	8.3	4.243	3.193
9	GHB 905	46	76	160	1.5	26.1	2.3	8.3	4.447	2.691
10	GHB 732	51	82	161	1.2	25.0	2.4	9.4	3.100	2.72
11	KBH 108	60	90	162	1.0	25.5	2.6	8.7	5.733	1.313
12	Kaveri Super Boss	58	88	185	1.0	28.4	2.6	8.9	8.063	1.705
13	86M86	55	85	168	1.0	25.3	2.7	10.0	3.677	1.533
14	AHB 1269	54	84	168	1.0	23.2	2.6	11.3	4.747	1.210
15	AHB 1200	50	80	149	1.0	25.8	2.4	9.7	5.880	1.730
16	Dhanshakti	43	73	169	1.0	23.6	2.3	10.6	5.727	1.433
17	ICMV 221	49	79	172	1.0	25.7	2.5	10.6	7.050	1.260
18	Pusa Composite 701	53	83	211	1.1	30.3	2.3	8.4	8.852	1.500
19	Pusa Composite 383	53	83	209	1.0	30.7	2.2	8.0	6.567	0.950
20	JBV 2	50	80	195	1.0	29.5	2.2	8.2	7.040	1.440
21	Raj 171	46	77	175	1.2	26.1	2.1	8.1	7.243	1.400
	Mean	50	80	173	1.1	26.2	2.4	9.4	5.195	1.83
	C.V.	4.81	2.9	4.99	12.18	4.96	3.24	4.22	16.64	16.36
	S.E.	1.39		4.99	0.08	0.75	0.04	0.23	0.499	0.172
	C.D. (5%)	3.96		14.26	0.23	2.14	0.13	0.66	1.426	0.493
	C.D. (1%)	5.30		19.08	0.31	2.87	0.17	0.88	1.908	0.659

Table 2. Mean sum of squares for different characters in pearl millet

S. No.	Characters	Replications (df = 2)	Treatments (df = 20)	Error (df = 40)
1	Days to 50% flowering	11.16	88.89**	5.76
2	Days to maturity	9.54	87.71**	5.37
3	Plant height (cm)	249.63	744.62**	74.63
4	Productive tillers	0.06	0.07**	0.02
5	Panicle length (cm)	0.54	18.17**	1.68
6	Panicle diameter (mm)	0.01	0.11**	0.01
7	Test wt. (g)	0.70	4.09**	0.16
8	Dry fodder yield per plot (kg)	0.51	9.87**	0.75
9	Grain yield per plot (kg)	0.17	1.02**	0.09

Note: ** indicates significant at 1% level of significance.

fodder yield per plot and grain yield per plot show exceptionally high genetic advance as a percentage of the mean, indicating a high potential for improvement through selection. Traits such as days to maturity, plant height, panicle length, and panicle diameter show moderate genetic advance, suggesting they can also be improved through selection but to a lesser extent.

Analysis of Phenotypic Correlation Among Various Characters in Pearl Millet

The table 4 presents the phenotypic correlation coefficients among different characters in pearl millet. The significance of correlations is indicated by ** (significant at 1% level) and * (significant at 5% level). A correlation coefficient close to +1 or -1 indicates a strong positive or negative relationship, respectively, while a coefficient close to 0 indicates no relationship. Positive correlation: As one trait increases, the other trait tends to increase. Negative correlation: As one trait increases, the other trait tends to decrease. Strong Positive Correlations: Days to 50% flowering with days to maturity (0.9985**), Productive tillers with grain yield per plot (0.7534**), Panicle length with plant height (0.6342**). Strong Negative Correlations: Productive tillers with days to 50% flowering (-0.5142**), Productive tillers with days to maturity (-0.5059**), Grain yield per plot with dry fodder yield per plot (-0.5459**), Moderate Positive Correlations: Plant height with days to 50% flowering (0.3018**), Panicle diameter with days to 50% flow-

Table 3. Variability parameters for different characters

S. No.	Characters	PCV (%)	GCV (%)	Heritability (H^2) (%)	Genetic advance (GA) (5%)	GA as % of mean (5%)
1	Days to 50% flowering	10.921	10.561	93.5	10.487	21.04
2	Days to maturity	6.768	6.558	93.9	10.456	13.089
3	Plant height (cm)	9.1	8.632	90.0	29.201	16.867
4	Productive tillers	13.526	11.555	73.0	0.231	20.334
5	Panicle length (cm)	9.41	8.963	90.7	4.6	17.587
6	Panicle diameter (mm)	8.129	7.912	94.7	0.374	15.862
7	Test wt. (g)	12.398	12.157	96.1	2.312	24.556
8	Dry fodder yield per plot (kg)	34.911	33.564	92.4	3.453	66.471
9	Grain yield per plot (kg)	31.972	30.546	91.3	1.098	60.118

ering (0.5975**), Dry fodder yield per plot with plant height (0.501**), Panicle diameter with days to maturity (0.6014**), Panicle length with dry fodder yield per plot (0.4191**). Moderate Negative Correlations: Plant height with grain yield per plot (-0.4061**), Productive tillers with panicle diameter (-0.4447**), Productive tillers with test weight (-0.4011**), Test weight with dry fodder yield per plot (-0.4412**). Understanding these correlations helps in making informed decisions in breeding programs to improve desired traits while considering their impact on other traits.

Path Coefficient Analysis for Grain Yield in Pearl Millet

The table presents the path coefficients of various traits on grain yield in pearl millet. The diagonal values represent the direct effects, while the off-diagonal values represent the indirect effects mediated through other traits. The residual effect indicates the proportion of variation in grain yield not explained by the traits considered. Direct Effects: These values are on the diagonal of the matrix and show the direct influence of each trait on grain yield. Indirect Effects: These values are off-diagonal and show the influence of one trait on grain yield through another trait.

Direct Effects on Grain Yield

Days to 50% flowering: 0.2122, Days to maturity: -0.3777, Plant height: -0.1213, Productive tillers: 0.854 (Strongest positive direct effect), Panicle length: 0.3464, Panicle diameter: 0.5236 (Strong positive direct effect), Test weight: -0.1063, Dry fodder yield per plot: -0.2739. Strong Direct Effects: Productive tillers: 0.854, Panicle diameter: 0.5236. Moderate Direct Effects: Panicle length: 0.3464, Days to maturity: -0.3777, Days to 50% flowering: 0.2122. Indirect Effects: Significant indirect contributions through days to maturity, panicle diameter, and productive tillers for several traits. Negative indirect effects observed in days to maturity and productive tillers.

Correlation with Grain Yield

Days to 50% flowering: -0.2931* (Moderate negative correlation, significant at 5%), Days to maturity: -0.2813* (Moderate negative correlation, significant at 5%), Plant height: -0.4061** (Moderate negative correlation, significant at 1%), Productive tillers: 0.7534** (Strong positive correlation, significant at 1%), Panicle length: -0.1654 (Weak negative correlation, not significant), Panicle diameter: 0.0527 (Weak positive correlation, not significant), Test weight: -0.0935 (Weak negative correlation, not significant), Dry fodder yield per plot: -0.5459** (Strong negative correlation, significant at 1%). Residual Effect: 0.3654, This indicates that 36.54% of the variability in grain yield is not explained by the traits considered in this analysis.

Discussion

In general genotypic correlation coefficients were greater than their corresponding phenotypic correlation coefficients, indicating the preponderance of genetic variance in expression of characters as well as masking effect of environment in modifying the total expression of the genotypes. The correlation of seed yield per plant was positive and significant at phenotypic level with characters viz., harvest index, number of effective tillers per plant, biological yield per plant and test weight. These characters need due consideration during any selection programmes. Similar findings of positive and significant correlation had been reported by number of workers for seed yield per plant with number of effective tillers per plant by Izge et al. 2006 and Bikash et al. (2013) [6, 3]. Similar finding for seed yield per plant with test weight were reported by Abuali and Idris (2012). Bikash

Table 4. Phenotypic correlation among various characters in pearl millet

	Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers	Panicle length (cm)	Panicle diameter (mm)	Test wt. (g)	Dry fodder yield per plot (kg)	Grain yield per plot (kg)
Days to 50% flowering	1	0.9985**	0.3018**	-0.5142**	0.1523	0.5975*	-0.0351	0.0797	-0.2931*
Days to maturity		1	0.289*	-0.5059**	0.1488	0.6014*	-0.031	0.0663	-0.2813*
Plant height (cm)			1	-0.3049**	0.6342**	-0.1815	-0.3132**	0.501**	-0.4061**
Productive tillers				1	-0.3069**	-0.4447**	-0.4011**	-0.2814*	0.7534**
Panicle length (cm)					1	-0.1117	-0.23	0.4191*	-0.1654
Panicle diameter (mm)						1	0.5193**	-0.2959**	0.0527
Test wt. (g)							1	-0.4412**	-0.0935
Dry fodder yield per plot (kg)								1	-0.5459**
Grain yield per plot (kg)									1

Table 5. Path matrix of grain yield in pearl millet

	Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers	Panicle length (cm)	Panicle diameter (mm)	Test wt. (g)	Dry fodder yield per plot (kg)
Days to 50% flowering	0.2122	0.2119	0.064	-0.1091	0.0323	0.1268	-0.0075	0.0169
Days to maturity	-0.3771	-0.3777	-0.1092	0.1911	-0.0562	-0.2271	0.0117	-0.025
Plant height (cm)	-0.0366	-0.0351	-0.1213	0.037	-0.0769	0.022	0.038	-0.0608
Productive tillers	-0.4391	-0.4324	-0.2604	0.854	-0.2621	-0.3798	-0.3425	-0.2403
Panicle length (cm)	0.0527	0.0516	0.2197	-0.1063	0.3464	-0.0387	-0.0797	0.1452
Panicle diameter (mm)	0.3129	0.3149	-0.0951	-0.2329	-0.0585	0.5236	0.2719	-0.1549
Test wt. (g)	0.0037	0.0033	0.0333	0.0427	0.0245	-0.0552	-0.1063	0.0469
Dry fodder yield per plot (kg)	-0.0218	-0.0182	-0.1372	0.0771	-0.1148	0.081	0.1208	-0.2739
Grain yield per plot (kg)	-0.2931*	-0.2813*	-0.4061**	0.7534**	-0.1654	0.0527	-0.0935	-0.5459*

et al. (2013) [1, 3] noticed positive and significant correlation between seed yield per plant and harvest index. Positive and significant correlation of seed yield per plant with biological yield per plant was reported by Kumar et al. (2016) [7]. Nehra et al. (2017) [3] reported that seed yield was positive and significantly correlated with harvest index, effective tillers per plant and biological yield per plant. Days to 50 per cent flowering and days to maturity were negatively significant associated with seed yield per plant. Similar finding had been reported by Singh et al. (1999) [12]. Ear head length showed positive association with plan height and no. of effective tillers per plant. Similar findings of positive and significant correlation had been reported by Izge et al. (2006) and Abuali and Idris (2012) [6, 1]. Biological yield per plant was positive and significantly correlated with days to maturity, no. of effective tillers per plant, test weight and seed yield per plant. These results are in accordance with the earlier finding of Kumar et al. (2016) [7]. These results indicated that early days to 50% flowering, test weight, number of effective tillers per plant, biological yield and harvest index are the important yield determiners in arid region. The association of days to 50 flowering and days to maturity with seed yield was significant and negative which is desirable for the development of hybrids with high yield and early maturity.The results indicate significant genotypic differences in the key agronomic traits of pearl millet. These differences are crucial for selecting suitable genotypes for specific growing conditions. For instance, the genotypes PB 1756 and RHB 223 showed promising results for early flowering and high grain yield, respectively, making them potential candidates for regions with shorter growing seasons or where grain yield is the primary focus. The variability observed in traits like plant height, panicle length, and productive tillers can be exploited to develop genotypes with desired characteristics for different agro-climatic zones.

Conclusion

The study demonstrated that considerable variability among the 21 pearl millet genotypes for all traits revealed significant variation across various genetics and agronomic traits. Traits like productive tillers and panicle diameter have strong positive direct effects and should be targeted in breeding programs to improve grain yield. Negative direct effects of days to maturity and dry fodder yield per plot suggest these traits might need careful management to avoid reducing grain yield. Indirect effects show the complex interplay among traits and highlight the importance of considering multiple traits simultaneously in selection programs. High heritability traits: Days to 50% flowering, days to maturity, and panicle diameter, combined with significant positive correlations, suggest these traits can be effectively improved through selection. Negative correlations with grain yield: Traits like plant height and productive tillers have negative correlations with

grain yield, indicating that selection for increased grain yield might result in shorter plants with fewer productive tillers. Positive correlations with grain yield: Productive tillers show a strong positive correlation with grain yield, suggesting that selecting for more productive tillers could directly improve grain yield

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