International Journal of Research in Agronomy 2024; 7(10): 92-99

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(10): 92-99
Received: 15-09-2024
Accepted: 07-10-2024

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Evaluation of pearl millet (*Pennisetum glaucum* L.) genotypes for growth, yield and yield attributing traits in Vindhyan region of Uttar Pradesh

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i10b.1703

Abstract
The present investigation consists of 12 genotypes of Pearl Millet (*Pennisetum glaucum* L.). The experiment was conducted during Rabi 2023 in RBD having 3 replications. The data were recorded on 20 characters to study the variability, heritability, genetic advance, correlation. Analysis of variance revealed that there was considerable genetic variability in the available germplasm for most of the characters studied and DUS characteristics. Performance of seed yield and seed yield attributing traits showed that Bajra M4 was found best followed by MPMH 24 M. Performance of Seedling Vigour showed that BJ 527. A close examination of variability coefficients revealed that the difference between PCV and GCV was minor indicating little influence of environment on the expression of characters studied. A detailed investigation of the genetic parameters of various field and laboratory traits. For field parameters, GCV and PCV were observed in plant height at 30, 60, and 90 (cm), Number of Panicles per Plant, and Biological Yield, indicating substantial genetic variability. Estimation of heritability were high, with traits showed values 0.9, indicated strong genetic control. Genetic advance as a percentage of the mean were also significant, especially for traits Plant Height (cm), Number of Tillers per Plant, and Seed Yield per Hectare (Qtl), showed potential for effective selection. In contrast, laboratory parameters exhibited moderate to high GCV and PCV values, with traits Root Length (cm) and Dry Weight (g) showed high heritability and genetic advance, indicated strong genetic influence.
Genotypic and Phenotypic correlations among traits in a plant population. Significantly positive correlation was found for traits Plant Height at 30, 60 and 90 DAS, Number of Leaves per Plant, Number of Nodes per Plant, and Seed Yield per Plant and Grain Weight per Plant. Genotypic correlations showed significant with Plant Height at 30, 60, and 90 DAS, Number of Leaves per Plant, and Yield, indicating that these traits are genetically linked. Phenotypic correlations, while also showed significant among similar traits, were generally slightly lower than genotypic correlations. These characters are recognized as the efficient and potential traits for indirect selection for the improvement of Pearl Millet productivity in the present experimental materials.

Keywords: Pearl millet 12 genotypes, genotype evaluation, yield, growth traits, Vindhyan region

Introduction
Pearl millet (*Pennisetum glaucum* L.), a significant coarse grain millet from the Poaceae family, is a diploid plant with a chromosome number of 2n=14 (Sattler FT *et al.*, 2019) [14]. Known for its hardiness and drought resistance, this crop has been cultivated for thousands of years and originates from Africa. It is usually stated to as bajra, bulrush millet, or cat tail millet, Pearl millet is a vital cereal crop due to its nutritious grains and its ability to flourish in low-water, low-energy environments, as well as some of the most challenging and marginal conditions globally. It is a warm-season crop that grows in areas with rainfall ranging from 150-700mm and is cultivated on approximately 27 million hectares, primarily in Asia (>10 million ha) and Africa (about 18 million ha), producing around 36 million tons annually (Yadav OP and Rai KN, 2013) [18].
Considerate variability is crucial for breeders to identify genotypes with high variability and strong performance in yield and its components. Selecting genetically stable parents early in the breeding program is vital for its success. Hence, comprehending the nature of genotypes is important for breeders to test and choose the most efficient ones.

Breeding genotypes with broad adaptability is a longstanding goal for plant breeders. Genotypes significantly effect multi environmental trials, and genotype-environment interactions can restrict selection in both high and low yielding environments. Thus, evaluating the environmental sensitivity of genotypes is necessary to achieve higher yields.

Environments where crops cultivate consist of numerous factors each season, including weather conditions, which are crucial in determining the yield potential of a genotype. Yield capacity often varies among cultivars based on environmental conditions (Mungra KD *et al.*, 2011) [9]. Plant breeders have observed that different genotypes respond differently to environmental changes, prompting them to evaluate their genotypes for stability under various conditions. Breeders aim to develop varieties or hybrids with broad adaptability. Information on the adaptability and performance of genotypes across multiple years and locations is critical for national crop production policies. Characterizing breeding materials at various stages of genotypes development typically involves assessing their response to environmental changes and the stability of that response. For these measures to be valuable in a breeding program, they must be genetic, repeatable, and provide insights beyond yield alone (Casler MD and Hovin AW. 1984) [2].

Various methods have been proposed to describe and interpret the response of genotypes to environmental variation. These include approaches based on analysis of variance. The analysis of variance approach, developed and modified [Carlos TSD and Koranowski WJ (2003)] [1], evaluations of genotype x environment interaction. Pearl millet is a crucial staple cereal for subsistence farmers in the semiarid tropics of Africa, as noted [Comstock RE, Moll RH (1963) [3], and Ramanatha Rao and Toby Hodgkin (2002)] [11]. It serves as a primary source of energy and protein for millions in Africa and is recognized for its numerous nutritional and medicinal benefits (Yang X *et al*., 2012) [20].

Traditional crop genotypes that have been developed by farmers over many years through natural and human selection, adapting to local conditions. These distinct plant populations are named and maintained by farmers to fulfill their social, economic, cultural, and ecological needs (Worede M *et al*., 2000) [17]. The accomplishment of a breeding program aimed at yield improvement through phenotypic selection relies significantly on the nature and extent of variation in the available material, as well as the environmental influence on the expression of plant characters.

Principal component analysis (PCA) is a critical method for reducing the complexity of observed variables into a smaller set of independent dimensions (Johnson RA and Wichern DW, 2007). General combining ability (GCA) provides an evaluation of a genotype's average performance, indicating its breeding value. Studies on combining ability are thus instrumental in identifying and excluding inferior genotypes from breeding programs.

The objective of this study was to assess the productivity of 6 pearl millet genotypes, examine genetic parameters, and analyze the variation in yield and its component traits. This analysis aims to provide insights that could inform crop improvement strategies.

Materials and Methods

The experiment material for studied is 6 Genotypes of pearl millet (84A, 86M14, BJ 527, Dhana Shakthi, Bajra M4, MPMH 24M, ABV-04, 86M84, BAJRA 48 F/S, MOTI BAJRA, PB106M, TSFB-15-8). Selected genotypes of pearl millet and evaluated in this study (Table 1). This experiment was carried out at Field Experimental Centre at Department of Genetic and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences Naini Prayagraj, Vindhyan Region Uttar Pradesh. During *Kharif* seasons 2023. The field trial was arranged in a Randomized Block Design with 3 replications.

Studied Traits were as follow: Germination percentage (%), Plant Height at 30, 60 and 90 DAS (cm), Days to 50% Flowering, Leaf Blade Length, Width, Number of Leaves, Nodes, Productive tillers Panicle length, Width (cm), Seed Shape, Colour, 1000 Seed Weight (g), Seed Yield per Plant (g), Plot (g), Hectare (quintal) Biological Yield (g), Harvest Index (%) and Green Weight per Plant (g). Statistical investigation was imperiled to proper statistical analysis of Randomized Block Design with three replications. Means were associated at 0.05 level of significance by least significant different (L.S.D) test using (Mstat C. 1986) [8]. Genetic parameters were estimated rendering the formula given by (Robbinson HV. *et al*., 1951; Johanson HW. *et al*., 1951) [13, 4].

Results and Discussion

Analysis considered factors, as well as germination percentage, Plant Height at different growth stages, Days To 50% Flowering, Number of Leaves and Nodes per Plant, Leaf Blade Dimensions, Number of Productive Tillers, Panicle Dimensions, Test Weight, Seed Yield, Biological Yield, Harvest Index, and Green and Dry Matter Yield per Plant.

ANOVA revealed the high significance of the differences between genotypes concerning the following traits: germination percent, plant height at different stages of growth (30, 60, and 90 cm), days to 50% flowering, number of leaves and nodes per plant, leaf blade length-width, number of productive tillers per plant, panicle length-width, test weight, and seed yield calculated by different methods (per plant, per plot, and per hectare). The magnitude of genotype variance for plant height at 90 cm was exceptionally high, with a mean square value of 18918.87 in comparison to the error with a mean square value of 6.45, indicating that this character is under strong genetic control (Kumar *et al.*, 2023) [5]. Similarly, the productive tillers per plant also manifested highly significant genotypic variation, with a mean square value of 13.602, which postulates that this character is effectively selectable in breeding programs for yield improvement (Sharma and Singh. 2022) [15].

ANOVA table for seedling growth Parameters showed ANOVA showed that there was a significant effect of the genotype on all the parameters studied, among them the germination percentage and index, the length of seedlings, shoot and root length, dry weight, and seed vigor indices. The mean square of the genotype for seedling length is 18.09 versus an error mean square of 1.57, while genotypic differences have a profound impact on the initial growth stages, which are so important in establishing a healthy crop. The high variability for seed vigor indices, especially Seed Vigour Index II, was genotype mean square = 128704.4, which, together with the potential for early selection of genotypes for the trait early vigour-an important one in improving crop establishment under varied environmental conditions of the Vindhya region (Patel *et al*., 2022) [10].

These results indicate genotypes for growth and yield-attributing traits and for seedling traits. High variability in plant height, panicle characteristic, and seeds of yield metrics follows the high possibility of selection of these traits in order to gain adequate improvement in Pearl Millet breeding programs. Besides this, the marked genetic variability in seedling growth attributes indicates that early vigor is one of the most important characteristics which can provide a good establishment of proper crop under the prevailing climatic and soil conditions of the Vindhya region, thereby bringing about a better yield. The results are in tune with findings from other workers which have indicated the role of genetic variability in the improvement of crop attributes through the selection program (Singh *et al*., 2021) [16].

Genetic Parameters

The Genetic parameters for field traits, including Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), Environmental Coefficient of Variation (ECV), Heritability, Genetic Advance, and Genetic Advance as a Percentage of Mean (GA as % of Mean).

Field Traits

Germination %

The percent germination manifested moderate genetic variability, with GCV of 6.719%, somewhat lower than the PCV value of 7.014%. High heritability, 0.918, suggests that the variability manifested in the germplasm would be due to genetic causes. Genetic advance of 13.26% of the mean depicts a moderate possibility of improvement through selection. Breeding for higher germination percentage should hence be successful through selection based on phenotypic performance.

Plant Height at Different Growth Stages [PH@30, PH@60, PH@90 cm] Plant height at different growth stages showed very high magnitude of GCV and PCV at 30, 60, and 90 cm. PH@60 and PH@90 cm had almost similar GCV estimate of 44.591% and PCV of 44.61%, respectively, and hence heritability was almost complete, 0.999. The percentage of the mean through GA was very high, 91.81%-91.82%, thus suggesting a great genetic potential through selective breeding to increase the plant height. This indicated that plant height is a highly heritable trait and a significant amount of genetic gain can be realized through selection on this trait.

Number of Leaves per Plant

The number of leaves per plant showed high genetic variability, as GCV accounted for 23.778%, while PCV was slightly higher, 24.49%. Heritability was high, 0.943, with a high GA percentage of the mean, 47.57%, indicating that selection can bring a considerable potential improvement in this character. This indicates that the number of leaves per plant can effectively be improved through selection.

Number of Nodes per Plant

Like the number of leaves, a high variability represented by GCV of 41.215% and a PCV of 42.27% was found in the number of nodes per plant. The heritability was 0.951 and the GA in terms of percentage of mean was 82.81%. This high heritability coupled with a high GA suggests that the number of nodes per plant is under strong genetic control, hence significant improvement could be achieved through selection.

Yield and Associated Components Biological Yield (g), Harvest Index, Seed Yield /Plant, Seed Yield / Hectare, Green Weight /Plant Yield-associated attributes such as biomass yield, green weight per plant, and seed yield per hectare recorded a high range of heritability 0.94-0.999 with moderate to high GA as % of mean 74.48%-91.81%. These attributes have a comparatively major part of genetic control in them so far as selection for these traits is highly effective and would eventually pay off in terms of the overall crop yield.

Harvest Index

A low heritability value of 0.239 and a low GA as a percentage of the mean of 1.21% are recorded in the harvest index. This observation further suggests that this trait is more influenced by environmental parameters rather than genetic parameters, hence a less reliable criterion for selection.

Laboratory Traits

Seedling Length (cm), Shoot Length (cm), and Root Length (cm): These characters showed high genetic variability as revealed by GCV with a magnitude of 24.85%, 24.07%, and 44.73%, respectively. Heritability estimates for these characters fell within the range of 0.65 to 0.78, categorizing them from moderate to high heritability. The GA as percentage of mean varied from 39.81 to 79.97%. This implied that selection could be effectively applied for the improvement of these characters, and root length showed the maximum possibility for genetic improvement.

Dry Matter (gm) and Vigour Index (VI-I, VI-II)

Dry weight and vigour indices showed high heritability ranging from 0.76 to 0.86 with high genetic advance under selection, as would be evidenced from the parameter of 'GA as % of mean' which varies between 53.93% and 79.30%. These growth parameters are often regarded as very important indicators of seedling vigor and overall plant health, and this may clearly indicate a high heritability and thus good scope for improvement through selective breeding.

Evaluation of Genotypic and Phenotypic Correlations Analysis: Pearl Millet (*Pennisetum glaucum* L.) Growth and Yield and Yield attributing Traits reveals significant relationships that are essential for breeding and selection programs. Present investigation was undertaken to find out the genotypic and phenotypic associations between different agronomic characters in pearl millet [*Pennisetum glaucum* L.]. Analysis was done to establish the association among seed yield with other growth attributes to understand the important traits that most contribute to yield performance under prevailing environmental conditions of the Vindhyan Region in Uttar Pradesh.

Some key traits studied for their associations included germination percentage, plant height at different stages of growth, the number of leaves per plant, and nodes per plant including the length and width of its leaf blade in relation to seed yield per hectare. Highly significant positive associations were observed among various traits including plant height at different stages of growth, number of leaves per plant, and seed yield per hectare. There is, for example, a very strong positive correlation between PH@ 60 and SY/Ha that was reported at r = 0.652, genotypic, which should indicate that at this stage of growth, taller plants tend to produce higher yields. Another one is NL/P, which also correlated well with seed yield, r = 0.7541 (genotypic level), hence the higher the leaves per plant, the better the tendency for yielding more seeds. Interestingly, Number of Productive Tillers per Plant also presented a high positive correlation with seed yield, followed by Panicle Length, and thus these traits could be used as potential selection criteria in breeding programs for yield improvement. Other important traits like Harvest Index and Panicle Width did not show significant association with yield, and thus they contributed little to seed yield directly under the studied conditions.

Genotypic and phenotypic correlation analysis of Pearl Millet traits came up with important topographies, informing future breeding objectives toward the improvement in yield performance. The strong positive correlation between plant height at different growth stages and seed yield points to the fact that plant height may be an important key trait for indirect selection in breeding programs. The high magnitude of genotypic correlation estimated between plant height at 60 cm and seed yield (r = 0.652) suggests that selection of taller plants at an early stage of growth may result in increased overall yields, probably because of an association with enhanced biomass accumulation and effective distribution of assimilates.

Similarly, Number of Leaves /Plant and Number of Nodes /Plant showed a positive association with seed yield, indicating their importance as life-history determinants of reproductive success. This result is consistent with previous studies that highlight a strong vegetative growth as essential to maximize the yield potential in cereals (Yadav *et al.,* 2017) [19]. Positive correlations between PL and seed yield further support the role of panicle architecture in yield determination, with longer panicles offering more space for seed development, hence resulting in higher grain production (Kumar and Sharma, 2021) [6].

By contrast, the non-significant association between harvest index and seed yield indicates that partitioning dry matter between vegetative and reproductive organs might not be a reliable index of selection. It thus provides an implication that HI, though normally considered a critical yield component, plays its role in an environmentally specific way, or even its role is masked by other more influential traits under certain conditions.

Table 1: ANOVA Table Evaluation of Pearl Millet (*Pennisetum glaucum* L.) Genotypes for Growth, Yield and Yield Attributing traits in Vindhya Region of Uttar Pradesh

Traits	Mean sum of Squares		
	Replication (df = 2)	Genotypes (df = 11)	Error (df = 22)
Germination percentage (%)	1.1	93.5*	2.72
Plant Height at 30(cm)	11.33	1937.29*	0.66
Plant Height at 60(cm)	70.85	12108.08*	4.13
Plant Height at 90 (cm)	110.71	18918.87*	6.45
Days to 50% Flowering	2.8	24.61*	0.49
Number of Leaves per Plant	0.1	8.31*	0.16
Number of Nodes per Plant	2.43	15.49*	0.26
Leaf Blade Length (cm)	100.79	2600.64*	24.98
Leaf Blade Width (cm)	0.11	2.55*	0.07
Number Productive Tillers per Plant	1.92	13.602*	0.27
Panicle Length (cm)	85.66	98.22*	0.62
Panicle Width (cm)	0.74	0.43*	0.05
Test Weight (gm)	0.098	1.56*	0.049
Seed Yield per Plant (gm)	56.05	546.03*	10.05
Seed Yield per Plot (gm)	1401.45	13650.84*	251.32
Seed Yield per Hectare (qtl)	181.629	1769.14*	32.57
Biological Yield (gm)	9487.92	102878.85*	2317.76
Harvest Index (%)	1.27	0.41	0.97
Green Weight per Plant (gm)	237198.1	251971.27*	53444.21
Dry Matter Yield per Plant (gm)	7942.02	88265.62*	1898.22

Table 2: ANOVA Table Evaluation of Pearl Millet (*Pennisetum glaucum* L.) Genotypes on Seedling Growth

Traits	Mean Sum of Square		
	Replication (df = 2)	Genotypes (df = 11)	Error (df = 22)
Germination percentage (%)	3.11	113.89*	25.89
Germination Index (%)	0.003	0.14*	0.03
Seedling Length (cm)	0.86	18.09*	1.57
Shoot length (cm)	0.1	4.89*	0.75
Root Length (cm)	0.44	13.87*	1.37
Dry Weight (gm)	0.004	0.28*	0.014
Seed Vigour Index II	2046.08	128704.4*	12441.01
Seed Vigour Index II	59.24	1758.86*	120.29

Table 3: Mean performance table of Evaluation of Pearl Millet (*Pennisetum glaucum*) Genotypes for Growth, Yield and Yield Attributing traits in Vindhya Region of Uttar Pradesh

Genotypes	G (%)	Ph at 30(cm)	PH at 60(cm)	PH at 90(cm)	D 50% F	NL/ P	No. N/P	LBL (cm)	LBW (cm)	No. PT/ P	PL (cm)	PW (cm)	TW (gm)	BY (gm)	HI (%)	GW/P (gm)	DMY/P (gm)	SY/P (gm)	SY/Pl (gm)	SY/H a (qtl)
84A	75.31	30.87	77.17	96.46	42.00	4.88	1.87	17.53	2.24	1.80	18.10	3.01	6.39	162.73	35.35	813.65	105.09	11.47	57.36	20.65
86M14	71.25	28.13	70.32	87.90	42.93	4.72	2.47	20.21	2.77	2.53	19.09	2.85	6.71	236.54	35.83	1182.68	172.95	16.94	84.68	30.48
BJ-527	74.99	30.49	76.21	95.27	42.73	4.70	3.13	19.77	3.10	3.33	16.03	2.29	6.39	293.47	36.41	1467.36	224.95	21.30	106.48	38.33
Dhana Shakthi	85.35	60.62	151.55	189.43	44.00	7.64	4.27	22.49	3.89	4.73	19.57	2.33	6.69	435.79	36.33	2178.93	356.94	31.69	158.47	57.05
BAJRAM4	79.65	44.58	111.44	139.30	43.93	6.22	4.60	23.36	4.89	5.67	19.35	2.39	7.35	570.16	36.52	2850.79	481.16	41.66	208.30	74.99
MPMH-24M	85.22	68.41	171.01	213.77	45.73	7.72	5.40	21.93	5.41	6.20	18.31	2.85	6.18	534.90	35.82	2674.50	449.94	38.32	191.60	68.98
ABV-04	86.68	60.06	150.15	187.69	47.87	7.58	7.27	78.82	3.77	5.87	24.97	3.09	7.35	598.34	35.97	2991.69	508.52	43.03	215.15	77.46
86M84	84.54	57.44	143.59	179.49	51.49	7.13	7.47	58.59	3.81	6.67	25.14	2.97	8.43	737.99	36.18	3689.95	637.58	53.41	267.03	96.13
Bajra 48 F/S	81.25	54.26	135.65	169.56	47.17	6.80	5.60	91.67	3.93	4.13	21.71	2.17	6.85	390.12	36.35	1950.61	314.62	28.32	141.62	50.98
Moti Bajra	90.20	122.50	306.25	382.82	48.31	10.5 3	8.27	83.50	4.75	8.60	32.97	3.17	7.98	656.38	36.02	3281.91	562.29	47.25	236.26	85.05
PB-106M	83.09	53.15	132.88	166.10	47.31	7.22	6.47	65.83	4.11	6.20	32.79	3.13	8.00	647.25	36.28	3236.27	553.17	46.98	234.88	84.56
TSFB-15-8	85.01	73.25	183.12	228.90	47.95	8.03	8.80	71.54	3.03	8.40	23.13	2.36	7.25	632.37	36.71	3161.83	538.41	46.43	232.13	83.57
Grand Mean	982.5 4	683.74	1709.35	2136.68	551.4 3	83.1 8	65.60	575.25	45.71	64.13	271.17	32.63	85.58	5896.0 4	433.7 8	29480.18	4905.62	426.79	2133.95	768.2 2
Mean	81.88	56.98	142.45	178.06	45.95	6.93	5.47	47.94	3.81	5.34	22.60	2.72	7.13	491.34	36.15	2456.68	408.80	35.57	177.83	64.02

Std. D	5.58	25.41	63.53	79.41	2.86	1.66	2.27	29.44	0.92	2.13	5.54	0.38	0.72	185.18	0.37	925.92	171.53	13.49	13.49	24.28
CV (%)	6.82	44.60	44.60	44.60	6.23	24.0 2	41.57	61.42	24.24	39.84	24.54	13.93	10.12	37.69	1.02	37.69	41.96	37.93	7.59	37.93
CD at 5%	0.004	0.018	0.045	0.056	0.002	0.00 1	0.002	0.021	0.001	0.002	0.004	0.000	0.001	0.131	0.003	0.655	0.121	0.010	0.048	0.017
Std. E	1.61	7.34	18.34	22.92	0.83	0.48	0.66	8.50	0.27	0.61	1.60	0.11	0.21	53.46	0.11	267.29	49.52	3.89	19.47	7.01
Min	71.25	28.13	70.32	87.90	42.00	4.70	1.87	17.53	2.24	1.80	16.03	2.17	6.18	162.73	35.35	813.65	105.09	11.47	57.36	20.65
Max	90.20	122.50	306.25	382.82	51.49	10.5 3	8.80	91.67	5.41	8.60	32.97	3.17	8.43	737.99	36.71	3689.95	637.58	53.41	267.03	96.13
Confidence Level (95.0%)	3.55	16.15	40.36	50.46	1.82	1.06	1.44	18.71	0.59	1.35	3.52	0.24	0.46	117.66	0.24	588.30	108.98	8.57	42.86	15.43

Table 4: Mean Performance Benefit Cost Ratio

Cost Benefit Ratio				
Genotypes	**CC (Rs/ha)**	**GR (Rs/ha)**	**NR (Rs/ha)**	**B:C Ratio**
84A	22616	187803.2	165187	08.3 : 1
86M14	22616	266494.4	243878	11.8 : 1
BJ-527	22616	329264	306648	14.6 : 1
DHANA SHAKTHI	22616	479002.4	456386	21.2 : 1
BAJRA-M4	22616	622520	599904	27.5 : 1
MPMH-24M	22616	574424	551808	25.4 : 1
ABV-04	22616	642257.6	619642	28.4 : 1
86M84	22616	791652.8	769037	35.0 : 1
BAJRA 48 F/S	22616	430481.6	407866	19.0 : 1
MOTI BAJRA	22616	703044.8	680429	31.1 : 1
PB-106M	22616	699070.4	676454	30.9 : 1
TSFB-15-8	22616	691160	668544	30.6 : 1
Grand Mean	271392.00	6417175.20	6145783.20	23.6 : 1
Mean	22616.00	534764.60	512148.60	23.6 : 1

***CC= Cost of Cultivation, GR= Gross Return, NR=Net Return*

Table 5: Mean performance table of Evaluation of Pearl Millet *(Pennisetum glaucum)* Genotypes on Seedling Growth

Genotypes	G(%)	GI (%)	SL (cm)	ShL (cm)	RL (cm)	DW (gm)	VI - I	VI - II
84A	66.7	2.38	9.83	6.43	3.40	0.68	658	45.23
86M14	62.7	2.24	6.30	3.80	2.50	0.40	393	25.05
BJ-527	62.7	2.24	11.53	4.97	6.57	1.17	726	73.40
DHANA SHAKTHI	64.0	2.29	7.67	3.50	4.17	0.57	491	36.59
BAJRA-M4	60.0	2.14	8.13	4.43	3.70	0.61	489	36.53
MPMH-24M	70.7	2.52	8.90	6.30	2.60	0.57	629	40.61
ABV-04	72.0	2.57	9.00	6.77	2.23	0.63	648	45.72
86M84	76.0	2.71	7.17	4.03	3.13	0.60	546	45.47
BAJRA 48 F/S	70.7	2.52	13.37	4.57	8.80	1.25	944	88.39
MOTI BAJRA	80.0	2.86	13.10	5.90	7.20	1.26	1052	100.99
PB-106M	64.0	2.29	6.67	2.70	3.97	0.65	427	41.55
TSFB-15-8	73.3	2.62	11.67	5.17	6.50	1.10	850	80.37
Grand Mean	822.7	29.4	113.3	58.6	54.8	9.5	7853.5	659.9
Mean	68.56	2.45	9.44	4.88	4.56	0.79	654.46	54.99
Std.D	6.16	0.22	2.46	1.28	2.15	0.31	207.13	24.21
CV (%)	8.99	8.99	26.01	26.18	47.12	39.00	31.65	44.03
CD at 5%	0.35	0.01	0.14	0.07	0.12	0.02	11.86	1.39
Std.E	1.78	0.06	0.71	0.37	0.62	0.09	59.79	6.99
Min	60.00	2.14	6.30	2.70	2.23	0.40	392.80	25.05
Max	80.00	2.86	13.37	6.77	8.80	1.26	1051.87	100.99
Confidence Level (95.0%)	3.91	0.14	1.56	0.81	1.37	0.20	131.60	15.38

*G=Germination Percentage (%), GI=Germination Index, SL= Seedling Length (cm), ShL= Shoot Length (cm), RL=Root Length (cm), DW=Dry Weight (g), VI=I Vigour Index-I, VI-II= Vigour Index-II.

Table 6: Genetic Parameters of field Parameters

Trait	GCV	PCV	ECV	Heritability	Genetic Advance	GA as % of Mean
Germination percentage (%)	6.719	7.014	2.014	0.918	10.86	13.26
Plant Height at 30 (cm)	44.593	44.62	1.427	0.999	52.32	91.82
Plant Height at 60(cm)	6.170	6.36	1.525	0.942	5.67	12.34
Plant Height at 90 (cm)	44.591	44.61	1.427	0.999	130.79	91.81
Days to 50% Flowering	23.778	24.49	5.862	0.943	3.30	47.57
Number of Leaves per Plant	41.215	42.27	9.348	0.951	4.53	82.81
Number of Nodes per Plant	44.591	44.61	1.426	0.999	163.48	91.81
Leaf Blade Length (cm)	61.122	62.01	10.427	0.972	59.52	124.15
Leaf Blade Width (cm)	23.898	24.89	6.944	0.923	1.80	47.32
Number Productive Tillers per Plant	39.439	40.64	9.811	0.942	4.22	78.87
Panicle Length (cm)	24.453	24.70	3.487	0.98	11.27	49.87
Panicle Width (cm)	13.859	14.10	2.601	0.965	0.76	28.03
Test Weight (gm)	9.956	10.44	3.12	0.91	1.40	19.56
Seed Yield per Plant (gm)	37.296	38.47	9.41	0.94	365.97	74.48
Seed Yield per Plot (gm)	1.882	2.46	2.733	0.239	0.44	1.21
Seed Yield per Hectare (qtl)	37.296	38.47	9.41	0.94	1829.83	74.48
Biological Yield (gm)	41.505	42.85	10.657	0.938	338.49	82.80
Harvest Index (%)	37.585	38.62	8.94	0.94	26.80	75.35
Green Weight per Plant (gm)	37.582	38.25	8.91	0.847	134.00	75.35
Dry Matter Yield per Plant (gm)	37.588	38.65	8.15	0.94	48.24	75.35

Table 7: Genetic Parameters of Lab Parameters

Trait	GCV	PCV	ECV	Heritability	Genetic Advance	GA as % of Mean
Germination percentage (%)	7.90	10.84	7.42	0.53	8.13	11.86
Germination Index (%)	7.85	10.80	7.42	0.53	0.29	11.80
Seedling Length (cm)	24.85	28.19	13.31	0.78	4.26	45.12
Shoot length (cm)	24.07	29.96	17.84	0.65	1.94	39.81
Root Length (cm)	44.73	51.56	25.65	0.75	3.65	79.97
Dry Weight (gm)	37.97	41.02	15.30	0.86	0.57	72.53
Seed Vigour Index II	30.09	34.58	17.05	0.76	352.89	53.93
Seed Vigour Index II	42.50	46.95	19.95	0.82	43.61	79.30

Table 8: Genotypic Correlation Coefficient of Evaluation of Pearl Millet (*Pennisetum glaucum* L.) Genotypes for Growth, Yield and Yield Attributing traits.

	Genotypic Correlation																			
Traits	G(%)	PH@30 (cm)	D50 % F	PH@60 (cm)	NL/P	NNo/P	PH@90 (cm)	LBL (cm)	LBW (cm)	No. PT/ P	PL (cm)	PW (cm)	TW (gm)	SY/P (gm)	SY/Pl (gm)	SY/Ha (qtl)	BY (gm)	HI (%)	GW/P (gm)	DMY/P (gm)
G(%)	1																			
PH@30(cm)	0.8762 **	1																		
D50%F	0.7505 **	0.6037 *	1																	
PH@60(cm)	0.8762 **	1.0 **	0.6037 *	1																
NL/P	0.9761 **	0.9821 **	0.682 *	0.9821 **	1															
NNo/P	0.8531 **	0.7746 **	0.9136 **	0.7746 **	0.8452 **	1														
PH@90(cm)	0.8762 **	1.0 **	0.6037 *	1.0 **	0.9821 **	0.7746 **	1													
LBL (cm)	0.6238 *	0.5961 *	0.7973 **	0.5962 *	0.6443 *	0.8097 **	0.5962 *	1												
LBW (cm)	0.623 *	0.5592 NS	0.3549 NS	0.5592 NS	0.6277 *	0.4119 NS	0.5592 NS	0.1641 NS	1											
No.PT/P	0.8627 **	0.8413 **	0.7783 **	0.8413 **	0.8926 **	0.9393 **	0.8413 **	0.5929 *	0.5721 NS	1										
PL (cm)	0.6376 *	0.6689 *	0.6883 *	0.6689 *	0.7131 **	0.7203 **	0.6689 *	0.739 **	0.3036 NS	0.6704 *	1									
PW (cm)	0.2346 NS	0.2767 NS	0.3093 NS	0.2767 NS	0.2723 NS	0.2007 NS	0.2767 NS	0.1612 NS	0.0763 NS	0.1846 NS	0.5889 *	1								
TW (gm)	0.5166 NS	0.4637 NS	0.8105 **	0.4637 NS	0.5223 NS	0.7154 **	0.4637 NS	0.6213 *	0.2522 NS	0.6547 *	0.8426 **	0.4309 NS	1							
SY/P (gm)	0.8271 **	0.6583 *	0.8693 **	0.6583 *	0.7587 **	0.9047 **	0.6584 *	0.5807 *	0.619 *	0.9234 **	0.6953 *	0.2646 NS	0.8019 **	1						
SY/Pl (gm)	0.2278 NS	0.117 NS	0.2471 NS	0.117 NS	0.222 NS	0.3999 NS	0.117 NS	0.2228 NS	0.1712 NS	0.3964 NS	0.0785 NS	-0.4874 NS	0.3163 NS	0.4701 NS	1					
SY/Ha (qtl)	0.8271 **	0.6583 *	0.8693 **	0.6583 *	0.7587 **	0.9047 **	0.6584 *	0.5807 *	0.619 *	0.9234 **	0.6953 *	0.2646 NS	0.8019 **	1.0 **	0.4702 NS	1				

BY (gm)	0.828 **	0.6593 *	0.8701 **	0.6594 *	0.7594 **	0.9049 **	0.6594 *	0.581 *	0.6199 *	0.9236 **	0.6965 *	0.2674 NS	0.8022 **	1.0 **	0.4752 NS	1.0 **	1			
HI (%)	0.8213 **	0.652 *	0.865 **	0.652 *	0.7541 **	0.9043 **	0.652 *	0.5786 *	0.6119 *	0.9228 **	0.6895 *	0.2489 NS	0.8012 **	1.0003 **	0.446 NS	1.0003 **	1.0004 **	1		
GW/P (gm)	0.8213 **	0.652 *	0.865 **	0.652 *	0.7541 **	0.9043 **	0.652 *	0.5786 *	0.6119 *	0.9228 **	0.6895 *	0.2489 NS	0.8012 **	1.0003 **	0.446 NS	1.0003 **	1.0004 **	1.0 **	1	
DMY/P (gm)	0.8213 **	0.652 *	0.865 **	0.652 *	0.7541 **	0.9043 **	0.652 *	0.5786 *	0.612 *	0.9228 **	0.6895 *	0.2489 NS	0.8012 **	1.0003 **	0.446 NS	1.0003 **	1.0004 **	1.0 **	1.0 **	1

Table 9: Phenotypic Correlation Coefficient of Evaluation of Pearl Millet (*Pennisetum glaucum* L.) Genotypes for Growth, Yield and Yield Attributing traits.

	Phenotypic Correlation																			
Traits	**G(%)**	**PH@30 (cm)**	**D50% F**	**PH@60 (cm)**	**NL/P**	**NNo/P**	**PH@90 (cm)**	**LBL (cm)**	**LBW (cm)**	**No.PT/ P**	**PL (cm)**	**PW (cm)**	**TW (gm)**	**BY (gm)**	**HI (%)**	**GW/P (gm)**	**DMY/P (gm)**	**SY/P (gm)**	**SY/Pl (gm)**	**SY/Ha (qtl)**
G(%)	1																			
PH@30(cm)	0.8414 **	1																		
D50%F	0.6839 **	0.5833 **	1																	
PH@60(cm)	0.8414 **	1.0 **	0.5834 **	1																
NL/P	0.8871 **	0.9527 **	0.6479 **	0.9527 **	1															
NNo/P	0.8314 **	0.7558 **	0.8647 **	0.7558 **	0.8032 **	1														
PH@90(cm)	0.8414 **	1.0 **	0.5834 **	1.0 **	0.9527 **	0.7558 **	1													
LBL (cm)	0.5931 **	0.5873 **	0.7551 **	0.5873 **	0.6126 **	0.7892 **	0.5873 **	1												
LBW (cm)	0.6068 **	0.5381 **	0.334 *	0.5382 **	0.5653 **	0.4226 *	0.5382 **	0.1849 NS	1											
No.PT/P	0.8349 **	0.8169 **	0.7307 **	0.8169 **	0.8414 **	0.932 **	0.8169 **	0.59 **	0.5719 **	1										
PL (cm)	0.6072 **	0.6613 **	0.6805 **	0.6613 **	0.6872 **	0.7028 **	0.6613 **	0.7151 **	0.2992 NS	0.6448 **	1									
PW (cm)	0.229 NS	0.272 NS	0.285 NS	0.272 NS	0.2552 NS	0.1965 NS	0.272 NS	0.1545 NS	0.0715 NS	0.1814 NS	0.5717 **	1								
TW (gm)	0.4836 **	0.4412 **	0.7426 **	0.4412 **	0.4908 **	0.6723 **	0.4412 **	0.5847 **	0.2083 NS	0.6174 **	0.7821 **	0.4242 **	1							
BY (gm)	0.7873 **	0.6383 **	0.8213 **	0.6383 **	0.7376 **	0.8903 **	0.6383 **	0.5631 **	0.5955 **	0.9078 **	0.6666 **	0.262 NS	0.7676 **	1						
HI (%)	0.0647 NS	0.048 NS	0.0946 NS	0.048 NS	0.0377 NS	0.136 NS	0.048 NS	0.124 NS	0.084 NS	0.1596 NS	0.0463 NS	-0.2781 NS	0.0473 NS	0.0923 NS	1					
GW/P (gm)	0.7873 **	0.6383 **	0.8213 **	0.6383 **	0.7376 **	0.8903 **	0.6383 **	0.5631 **	0.5955 **	0.9077 **	0.6666 **	0.262 NS	0.7676 **	1.0 **	0.0923 NS	1				
DMY/P (gm)	0.7875 **	0.6386 **	0.8212 **	0.6386 **	0.7381 **	0.8897 **	0.6386 **	0.5624 **	0.5956 **	0.9068 **	0.6668 **	0.2652 NS	0.7676 **	1.0 **	0.0853 NS	1.0 **	1			
SY/P (gm)	0.785 **	0.6344 **	0.82 **	0.6344 **	0.733 **	0.8924 **	0.6344 **	0.5652 **	0.592 **	0.9119 **	0.6642 **	0.2439 NS	0.7683 **	0.9988 **	0.1283 NS	0.9988 **	0.9984 **	1		
SY/Pl (gm)	0.785 **	0.6344 **	0.82 **	0.6344 **	0.733 **	0.8924 **	0.6344 **	0.5652 **	0.592 **	0.9119 **	0.6642 **	0.244 NS	0.7684 **	0.9988 **	0.1284 NS	0.9988 **	0.9984 **	1.0 **	1	
SY/Ha (qtl)	0.785 **	0.6344 **	0.82 **	0.6344 **	0.733 **	0.8924 **	0.6344 **	0.5651 **	0.5921 **	0.9119 **	0.6642 **	0.2441 NS	0.7684 **	0.9988 **	0.1283 NS	0.9988 **	0.9984 **	1.0 **	1.0 **	1

Conclusion

The study concluded that field and lab traits have varying degrees of genetic control and environmental influence. Field traits like Germination Percentage (%), Plant Height @30 (cm), Plant Height @60 (cm), and Plant Height @90 (cm) show high heritability and significant genetic advances, indicating potential for selection and improvement. Lab traits like Germination percentage and Germination Index have moderate GCV but lower heritability. Root Length and Dry Weight show high GCV and heritability, suggesting strong genetic control. Seedling Length and Shoot Length show moderate to high heritability with substantial genetic advances. Seed Vigour Index II is a promising target for breeding programs. On the basis of performance, Seed Yield is highest in BAJRA M4 and lowest in 84A, with BAJRA M4 also having the highest cost benefit ratio. In terms of seedling growth, BJ 527 exhibits the maximum performance, while 86 M14 shows the minimum and correlation analysis shows significant positively among all the characters. These characters may be given due consideration during selection for crop improvement.

Acknowledgement

This is part of the author's post-graduate thesis work at Sam Higginbottom University of Agriculture Technology and Sciences, Department of Genetics and Plant Breeding, Field Experimental Centre. The author is highly grateful for the research services provided by Dr.
Prashant Kumar Rai, Assistant Director of Seed Farm, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh.

Competing Interests

Authors have declared that no competing interests exist.

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