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Genetic variability studies for yield and yield contributing characters in pearl millet [*Pennisetum glaucum* (L.) R. Br] germplasm

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Abstract
An experiment entitled "Genetic variability studies for yield and yield contributing characters in pearl millet [*Pennisetum glaucum* (L.) R. Br.] germplasm." was carried out during *Kharif* 2022-23 at the research farm of National Agricultural Research Project, Chhatrapati Sambhajinagar, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (M.S). The experiment was laid out in Randomized Block Design (RBD) with 32 genotypes and two replications to estimate the extent of genetic variability, heritability, genetic advance among all the genotypes. Analysis of variance showed highly significant differences among the genotypes for all the characters under study, indicated availability of wide spectrum of variability among the genotypes. The phenotypic coefficient of variation (PCV) was slightly higher than the respective genotypic coefficient of variation (GCV) for all the characters under study which indicated less influence of environment on the genotypes in expression of traits. Moderate GCV and PCV were observed for Fe content, no. of productive tillers per plant, 1000 grain weight, whereas, the lowest GCV and PCV were observed for days to maturity. High estimate of heritability along with high genetic advance as percentage of means were observed for Fe content, no. of productive tillers, 1000 grain weight indicated the role of additive gene action for expression of these characters and are prove their importance for improving seed yield. High heritability values with moderate genetic advance as percentage of means were observed for Zn content, grain yield per plot, grain yield per plant, plant height, panicle girth, green fodder yield per plot.

Keywords: Variability, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an annual, diploid, highly allogamous cereal crop having chromosome no 2n = 14 belongs to family *Poaceae* sub family *Panicoideae* with genus *Pennisetum*. It is commonly called as *Bajra, Bajri, Sajje, Kambu, Kamban, Sajjalu* etc in various Indian local languages. It is a tropical C4 smallgrained cereal crop having avery high photosynthetic efficiency and dry matter production capacity with a short life cycle and large genome size i.e. 2352 Mbp (Bennett, 2000) [6]. It is believed to have originated in West Africa (Vavilov, 1950) and subsequentlydispersed into India and other countries.It includes about 140 species in the world. One African species [*Pennisetum glaucum* (L.) R. Br.] is being cultivated as the cereal, commonly known as pearl millet.

In India production of Pearl millet during *kharif* 21-22 as per second advance estimates found 9.22 million tonnes over target of 10.50 million tones (Anonymous 2022) [2]. However, Rajasthan is the highest producing stage in the country. The primary states for pearl millet cultivation in India include Rajasthan, Maharashtra, Uttar Pradesh, Gujarat, and Haryana. These states collectively account for 90% of the total production in the country. In addition to enhancing yield, there has been a dedicated focus on improving the nutritional aspects of pearl millet. Notably, pearl millet has become the pioneer crop globally in introducing benchmark levels for iron (Fe - 42 ppm) and zinc (Zn - 32 ppm) in cultivar promotion and release since 2018.

Genetic variability defined as the formation of individuals differing in genotype, or the presence of genotypically different individuals, in contrast to environmentally induced differences which, as a rule, cause only temporary, nonheritable changes of the phenotype. The possibility of achieving improvement in any crop plants depends on the magnitude of genetic variability.

Heritability specifies the ratio of the genotypic variance to the total phenotypic variance. It is a good index for the transmission of characters from parents to the offspring's. Genetic advance is the difference between the mean genotypic value of progeny of selected lines and mean genotypic value of parental population (original population before selection). The study of genetic advance is equally important as it measures the genetic gain based on the selection in a particular character. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection (Johnson *et al*., 1955) [9]. Therefore, for any crop improvement programme through selection, the study of genetic variability and heritability together with genetic advance will be more useful.

Material and Methods

The present investigation was conducted during Kharif season of 2022 at experimental farm of National Agricultural Research Project, Paithan Road, Chhatrapati Sambhajinagar. The experimental material consisted of thirty two diverse genotypes of pearl mill*et al*ong with two checks ABPC 4-3 and AIMP-92901. The evaluation of different genotypes was performed in two replications using Randomized Block Design (RBD). Each genotype was sown in a two rows of 4 m length with spacing of 45 cm between rows and 15 cm between plants. The recommended agronomical and plant protection practices were implemented to ensure successful crop cultivation. Observations were recorded for five randomly selected plants from each replication for 14 characters including days to 50% flowering, days to maturity, plant height (cm), no. of productive tillers per plant, panicle length (cm), panicle girth (cm), 1000 - grain weight (g), grain yield per plant (g), grain yield per plot (kg/plot), green fodder yield per plant (g), green fodder yield per plot (kg/plot), harvest index (%), Fe content (ppm), Zn content (ppm).The genotypic and phenotypic coefficient of variation were calculated by using formulae given by Burton, (1952). Heritability in broad sense was estimated for various characters as suggested by Hanson *et al*. (1956) [8]. Genetic advance (at 5% selection intensity) was calculated using the formula given by Allard (1960) [1] and Johnson *et al*. (1955) [9].

Results and Discussions

The data on the values of different characters and the analysis of variance showed significant differences among genotypes for all fourteen characters indicating that the material has adequate variability to support the present investigation for improving the grain yield of pearl millet shown in Table 1. The wide range of mean values were recorded for the characters, days to 50% flowering from 45 days to 51 days, days to maturity from 79 days to 91 days, plant height from 115cm to 174 cm, no. of productive tillers per plant from 1.15 to 2.25, panicle length from 18.25 cm to 24.50 cm, panicle girth from 2.15 cm to 2.90 cm, 1000 grain weight from 6.50 g to 13.55 g, grain yield per plant from 22.95 g to 33.00 g, grain yield per plot from 1.19 kg/plot to 1.71 kg/plot, green fodder yield per plant from 127.50 g to 207.50 g, green fodder yield per plot from 6.63 kg/plot to 10.79 kg/plot, harvest index from 28.81% to 37.17%, iron content 48.60 ppm to 103.50 ppm and zinc content 34.12 ppm to 52.15 ppm.

Less differences between the GCV and PCV values for all the characters, indicating that high degree of genetic variability present in these characters and consequently, greater scope for selection based on these characters. (Table 2) It also indicated that the characters were less influenced by environment. PCV was observed higher than GCV for all the characters under investigation suggested that the role of environment was considerable in the expression of these characters. Similar findings have been reported by Bhaskar *et al*. (2017) [5], Nehra *et al*. (2017) [14] and Singh *et al*. (2018) [19], Anuradha *et al*. (2018) [3].

The present investigation reported moderate GCV and PCV for iron content (18.81% and 19.55%), no. of productive tillers (17.75% and 19.31%), 1000 grain weight (16.41% and 18.69%), and zinc content (10.11% and 11.22%) shown in table. 2 and fig.1. Similar results were observed by Kahate *et al*. (2023) [10] for iron and zinc content. Kahate *et al*. (2023) [10] for 1000 grain weight.

On the contrary, low GCV and PCV were reported for grain yield per plot (9.45% and 10.84%), grain yield per plant (9.41% and 10.48%), green fodder yield per plant (8.05% and 12.91%), green fodder yield per plot (8.05% and 12.48%), plant height (7.97% and 10.41%), panicle girth (7.59% and 10.33%), panicle length (6.55% and 9.24%), days to 50% flowering (5.35% and 7.66%), days to maturity (3.17% and 4.55%). Similar results were reported earlier for days to 50% flowering by Nehra *et al*. (2017) [14], Narasimhulu *et al*. (2021) [13] and Yadav *et al*. (2022) [22]. Similar result were observed by Anuradha *et al*. (2020) [4], Narasimhulu*et al* (2021) [13] and Rani *et al*. (2022) [18] for days to maturity. Similar works were reported for plant height by Nehra *et al*. (2017) [14], Anuradha *et al*. (2020) [4]. Anuradha *et al*. (2020) [4] and Narasimhulu *et al* (2021) [13] for panicle length. Anuradha *et al*. (2020) [4] and Yadav *et al*. (2021) [22] for panicle diamater. Similar works were reported by Anuradha *et al*. (2020) [4] for grain yield per plot and green fodder yield per plant. Similar works were reported by Bind *et al*. (2015) [23] for green fodder yield per plant.

High heritability estimates were recorded for traits *viz*. Fe content (92.59%), no. of productive tillers per plant (84.48%), Zn content (81.17%), 1000 grain weight (77.07%), grain yield per plant (76.22%), grain yield per plot (75.98), plant height (58.60%), panicle girth (54.09%), days to maturity (48.65%), days to 50% flowering (48.24), panicle length (46.87%), green fodder yield per plot (41.61%), green fodder yield per plant (41.55%), harvest index (40.09%). The high, medium and low heritability estimates were classified on the basis of values given by Robinson (1951) Low heritability = <10%, Moderate heritability =10-30%, High heritability = >30. Similar results were also observed by Yadav *et al*. (2022) [22] for 50% flowering and micronutrients. Yadav *et al*. (2022) [22] and Rajpoot *et al*. (2023) [17] for days to maturity. Pallavi *et al*. (2020) [15] for plant height, Rajpoot *et al*. (2023) [17] for no. of productive tillers per plant and 1000- grain weight. Anuradha *et al*, (2020) [4] for panicle length. Also Anuradha *et al*, (2020) [4], Kumar *et al*. (2014) [12], Pallavi *et al*. (2020) [15] and Talwar *et al*. (2017) [20] for grain yield per plot. Yadav *et al*. (2022) [22] for harvest index. Priyanka *et al*. (2019) [16] for days to maturity, plant height, panicle length, panicle girth, 1000 grain weight, grain yield plant, grain yield plot, iron content and zinc content. The high heritability observed for these traits in the present investigation indicated that the influence of environment on expression of these traits is relatively low. Therefore, for improving these traits, the selection would be more effective in early generation on the basis of performance of these traits.

The maximum genetic advance was registered for green fodder yield per plot, Fe content (28.58%), plant height(18.50%), green fodder yield per plant (17.97%), Zn

content (8.01%), grain yield per plant (4.76%), days to 50% flowering (3.93%), days to (3.90%). These results were also conformity with findings of Nehra *et al*. (2017) [14] and Yadav *et al*. (2022) [22] for days to 50% flowering. Anuradha *et al*. (2020) [4] and Yadav *et al*. (2022) [22] for days to maturity. Kumar *et al*. (2020) [11] for plant height. Anuradha *et al*. (2020) [4] observed similar results for no. of productive tillers per plant, panicle girth, grain yield per plot and 1000 grain weight.

Table 1: Analysis of variance for yield and yield contributing characters in pearl millet

Source of Variation	df	MSS						
		Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of productive tiller	Panicle Length (cm)	Panicle Girth (cm)	1000 Grain weight (g)
Replication	1	40	6.250	194.2540	0.030	2.2350	0.0210	0.5440
Genotypes	31	23.282**	22.579**	372.462**	0.197**	5.672**	0.103**	6.561**
Error	31	8.129	7.798	97.22	0.017	2.052	0.031	0.849

Table 2: Greater scope for selection based on these characters

Source of Variation	df	MSS						
		Grain Yield Per Plant (g)	Green Fodder Yield Per Plant (g)	Harvest Index (%)	Grain Yield per Plot (kg/plot)	Green Fodder Yield Per Plot (kg/plot)	Fe Content (ppm)	Zn Content (ppm)
Replication	1	1.9950	103.7340	1.9250	0.0070	0.190	3.7060	8.880
Genotypes	31	16.229**	624.336**	8.003*	0.044**	1.685**	432.371**	41.598**
Error	31	2.189	257.808	3.423	0.006	0.695	16.617	4.322

Table 3: Parameters of genetic variability for yield and yield contributing traits in pearl millet

Characters	Range	Mean	Genotypic Variance	Phenotypic Variance	Genotypic Coefficient of Variance	Phenotypic Coefficient of Variation	Heritability (bs) (%)	Genetic Advance (5%)	Genetic Advance as percentage of mean (5%)
Days to Flowering	45-51	51.69	7.577	15.706	5.325	7.667	48.241	3.938	7.62
Days to Maturity	79-91	85.53	7.39	15.189	3.178	4.557	48.656	3.906	4.567
Plant Height (cm)	115-174	147.14	137.621	234.841	7.973	10.415	58.602	18.5	12.573
No. of productive tillers per plant	1.15-2.25	1.69	0.09	0.107	17.756	19.318	84.482	0.569	33.619
Panicle Length (cm)	18.25-24.50	20.85	1.81	3.862	6.454	9.427	46.878	1.898	9.103
Panicle Girth (cm)	2.15-2.90	2.50	0.036	0.067	7.599	10.332	54.092	0.288	11.513
1000 Grain Weight (g)	6.50-13.55	10.30	2.856	3.705	16.415	18.697	77.076	3.056	29.686
Grain Yield Per Plant (g)	22.95-33.00	28.13	7.02	9.209	9.418	10.787	76.226	4.765	16.938
Green Fodder Yield Per Plant (g)	127.50-207.50	168.13	183.264	441.072	8.052	12.491	41.55	17.976	10.691
Harvest Index (%)	28.81-37.17	33.05	2.29	5.713	4.579	7.233	40.09	1.974	5.973
Grain Yield Per Plot (Kg/Plot)	1.19-1.71	1.46	0.019	0.025	9.455	10.847	75.989	0.248	16.979
Green Fodder Yield Per Plot (Kg)	6.63-10.79	8.74	0.495	1.19	8.052	12.481	41.615	0.935	10.7
Fe Content (ppm)	48.60-103.50	76.64	207.877	224.494	18.812	19.55	92.598	28.581	37.292
Zn Content (ppm)	34.12-52.15	42.67	18.638	22.96	10.117	11.228	81.176	8.013	18.777

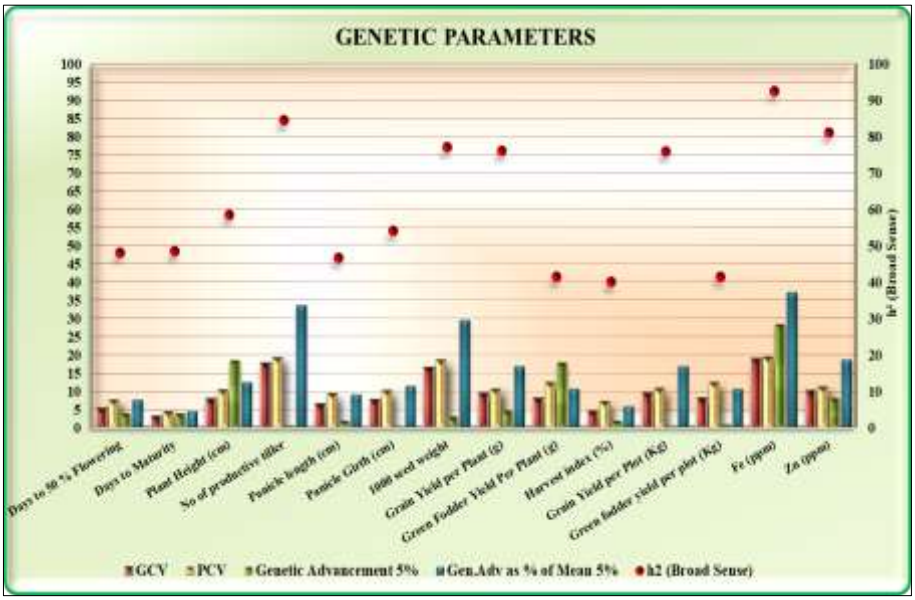

Fig 1: Parameters of genetic variability for yield and yield contributing traits in pearl millet

Conclusion

Analysis of variance in 32 genotypes of pearl millet indicated the presence of high and significant variability among genotypes. From results of variability parameters, it was concluded that moderate genotypic (GCV) and phenotypic (PCV) coefficient of variations were observed for iron content, no. of productive tillers per plant, 1000 grain weight and zinc content indicating that more emphasize would be given on these traits for improvement of grain yield. Minimum differences between GCV and PCV were noted for grain yield per plot, Fe content, days to maturity indicated the maximum reflection of genotype into phenotype and emphasize given on this traits to improve grain yield. High heritability with high genetic advance as per cent of means were observed for Fe content, no. of productive tillers per plant, Zn content, 1000 grain weight and grain yield per plant. Thus, selection of such characters will be useful for varietal improvement.

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