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Research Article

Morphological Characterization and Evaluation of Little millet (*Panicum sumatrense* Roth. ex. Roem. and Schultz.) Germplasm

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Abstract

Evaluation of hundred and nine little millet germplasm accessions was done during *rabi*, 2008-2009 at Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore to study descriptive statistics, genetic variability, correlation and path analysis of yield and its components. High estimates of variability together with high heritability and high genetic advance were observed for grain yield, number of productive tillers per plant, total number of tillers per plant, flag leaf width and flag leaf sheath length indicated additive gene effects for these characters. Phenotypic selection based on these characters may be effective for yield improvement. Highly significant positive correlations of most of the component characters with grain yield and strong inter correlation among themselves indicated possibility of simultaneous improvement of these characters by selection. High positive direct effect and indirect effects of other characters through days to 50 per cent flowering indicated this character should be given importance in selection.

Key words:
Little millet, germplasm, variability, correlation, path analysis.

Introduction

Little millet (*Panicum sumatrense* Roth. ex. Roem. and Schultz.) is one of the important small millets indigenous to Indian subcontinent. It is widely cultivated as minor cereal across India, Nepal and western Burma and presently grown throughout India in more than half a million hectares. It is cultivated both in the tropics and sub-tropics and even at an altitude of 7000 ft above MSL. Little millet is well known for its drought tolerance and is considered as one of the least water demanding crops. Being the first crop to be harvested in the season, it produces the much needed food grain among the tribal and is staple food for millions in many parts of the world. It is a good source of protein (7.7g/ 100 g), very rich in carbohydrate (67.0 g/ 100 g), fat (4.79 g/100 g), minerals and vitamins and should be considered as essential food for nutritional security.

Progress in any crop improvement programme depends mainly on the degree of variability for the desired characters existing in the germplasm collection. In order to utilize the variability available in the gene pool, it is imperative to critically evaluate and characterize the available germplasm collections. An estimate of the extent of variability available in the germplasm would be of immense value to the breeder to efficiently design the breeding procedure for further improvement of the crop and to identify superior genotypes in the population. Studies on descriptive statistics are helpful in the estimation of simple measures of variability like mean, range, standard deviation, variance, standard error and

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coefficient of variability which can be used for preliminary evaluation. Fisher *et al*. (1932) emphasized the usefulness of third order statistics (skewness and kurtosis) in the study of quantitative traits in addition to first and second order statistics. It is essential to partition the overall variability into heritable and non heritable components with the help of genetic parameters like genotypic and phenotypic coefficients of variation. Heritability estimates along with genetic advance are fairy helpful in predicting the gain under selection and in formulating suitable selection procedures. Knowledge on correlation between yield and its component characters may be helpful in selection of suitable plant type. In order to get the information on actual contribution of each character to yield, it is necessary to partition the correlation into direct and indirect effects through path analysis. Therefore, correlation in conjunction with path analysis would help in identifying suitable selection criteria for improving the yield. Hence the present investigation was undertaken to characterize the germplasm accessions, to assess the variability and to determine the interrelationship among yield and its contributing characters in little millet.

Material and methods

Experimental material consisted of 109 little millet germplasm accessions maintained at small millets section of Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore which is situated at about 11^{o}N latitude and 77^{o}E longitude at an altitude of 427 m above MSL and the average annual rainfall is around 700mm. For characterization and evaluation these germplasm accessions were grown in Randomized Block Design with three replications during *rabi*, 2008-2009**.** Each accession was grown in a single row of 3 m length with a spacing of 30 x10cm. Observations were recorded on five randomly selected competitive plants in each accession in every replication for nine quantitative traits such as days to 50 per cent flowering, plant height (cm), total number of tillers per plant, number of productive tillers per plant, flag leaf length (cm), flag leaf width (cm), flag leaf sheath length (cm), panicle length (cm) and grain yield per plant (g) as per descriptors for *Panicum miliaceum* and *Panicum sumatrense* (IBPGR, 1985). The estimation of mean, standard deviation, standard error, skewness and kurtosis were worked out by adopting the standard methods (Panse and Sukhatme, 1964). Phenotypic variance and genotypic variance were estimated according to the formula given by Lush (1940). Phenotypic and genotypic coefficients of variation were computed according to the method suggested by Burton (1952). Heritability in broad sense was calculated as per the formula given by Allard (1960). Genetic advance was expressed as per cent of mean by using the formula suggested by Johnson *et al.* (1955). Correlation coefficients were worked out using the formula as suggested by Falconer (1960). The correlation coefficient was partitioned into direct and indirect causes according to Dewey and Lu (1959).

Results and discussion

An insight into the magnitude of variability present in the gene pool of a crop species is of utmost importance to plant breeder for starting a judicious plant breeding programme. Phenotypic expression of a character is the result of interaction between genotype and environment. Hence it is essential to partition the overall variability into heritable and non heritable components. Burton (1952) suggested that heritability estimates coupled with genotypic coefficient of variation would provide an accurate picture about the extent of genetic advance to be expected through selection.

Descriptive statistics

Mean values were subjected to statistical analysis to study the descriptive statistics like mean, range, standard deviation, standard error, coefficient of variation, variance, skewness and kurtosis (Table 1). Large phenotypic diversity has been observed for almost all the characters studied. Variation in panicle compactness and shape is depicted in Figure 1. Grain yield per plant, plant height and days to 50 per cent flowering recorded wide range indicating the extent of variability for these characters. There are accessions in the collection, which can flower as early as 49 days and as late as 83 days after sowing with a mean of 60 days. Plant height ranged from 88 to 142 cm with a mean of 111 cm. Number of productive tillers per plant varied from 3 to 26 with a mean of 6.9. Flag leaf length showed variation from 18 to 41 with a mean of 28.9 cm. Flag leaf width varied from 0.5 to 1.9 cm with a mean of 0.99 cm. Grain yield per plant showed a wide range of 2.9 to 50.1g with a mean of 13.8g. Among the traits studied grain yield per plant, number of productive tillers and total number of tillers showed higher variance. All the characters showed positive skewness indicating non- additive gene action.

Accessions were categorized into three different classes based on the range observed for each character. Relative frequencies and corresponding percentage values of different classes are given in Table 2. Most of the genotypes studied were low yielding (63.3%), earlier in flowering (55.05%), low tillering (88.99%), medium in plant height (55.96%), medium in flag leaf length (63.3%), medium in flag leaf width (56.88%), short in panicle length (59.63%) and flag leaf sheath length (87.15%). Histogram has been provided for plant height to illustrate the genetic diversity available in the material (Figure 2).

Studies on variability

The estimates on genotypic and phenotypic co-efficients of variation, heritability and genetic advance as per cent of mean are furnished in Table 2. The magnitude of PCV was higher than that of GCV for all characters under study (Figure 3). It means that apparent variation is not only due to genotypes but also due to the influence of environment. However the narrow differences between PCV and GCV indicated little influence of environment on the expression of these characters and variability was due to genetic components only. This implied phenotypic variability to be a reliable measure of genotypic variability. High genotypic coefficients of variation were recorded by number of productive tillers per plant (46.08%) followed by number of total tillers (38.71%) and grain yield per plant (33.94%).

High estimates of PCV and GCV were recorded for number of productive tillers, total number of tillers, grain yield per plant, flag leaf width and flag leaf sheath length indicating that these characters are more variable in the germplasm. There is a great scope for improvement of these characters by direct selection among the genotypes. Similar results had been recorded by Yadav and Srivastava (1976a), Rao (1991) and Chidambaram and Palanisamy (1996) for grain yield per plant. Padmaja (1998) had also reported high GCV and PCV for total number of tillers and number of productive tillers. Days to 50 per cent flowering, flag leaf length and panicle length showed medium GCV and PCV which indicated variation for these characters were moderate among these genotypes. These observations are in agreement with the earlier reports of Yadav and Srivastava (1976a) for panicle length. Low GCV and PCV estimates were observed for plant height indicating that this character was less variable among these genotypes. These results are in accordance with Yadav and Srivastava (1976a) and Padmaja (1998) for plant height. Moderate to low variability of these characters indicated the need for improvement of base population.

In the present study the estimates of heritability were found to be high for all the characters under study and it ranged from 65.57 (flag leaf width) to 88.56 per cent (days to 50 per cent flowering). Heritability was more than 80 per cent for days to 50 per cent flowering, flag leaf sheath length, panicle length and plant height (Figure 3) which indicated that these characters were less influenced by environmental conditions and selection would be effective on the basis of phenotype alone with equal probability of success. Yadav and Srivastava (1976a) and Padmaja (1998) also reported high heritability for all the characters studied. Genetic advance as per cent of mean ranged from 13.03 (days to 50 per cent flowering) to 83.19 (number of productive tillers per plant). High genetic advance as per cent of mean was observed for all characters except days to 50% flowering and plant height. High genetic advance indicated that these characters are governed by additive genes and selection will be rewarding for improvement of these traits. Similar findings had been reported in the past by Yadav and Srivastava (1976a) and Padmaja (1998) for grain yield per plant, number of tillers and panicle length. Medium genetic advance for plant height and days to 50 per cent flowering indicated that these characters are governed by non additive genes.

High heritability coupled with high genetic advance was observed for flag leaf sheath length, number of productive tillers, total number of tillers, grain yield, flag leaf length, flag leaf width and panicle length. This indicated that the heritability is due to additive gene effects and can be improved by simple selection. Yadav and Srivastava (1976a) and Padmaja (1998) reported similar results for number of tillers, grain yield and panicle length. High heritability coupled with medium genetic advance for days to 50 per cent flowering and plant height indicated non additive gene action and high genotype x environment interaction.

Correlation studies

Grain yield is a complex character and its expression depends on the interplay of a number of component characters. An insight into the association between grain yield and other traits helps to improve the efficiency of selection. Correlation coefficient measures the mutual relationship between various plant characters and determines the component characters on which selection can be relied upon for genetic improvement of yield. At genetic level, a positive correlation occurs due to coupling phase of linkage and negative correlation occurs due to repulsion phase of linkage of genes controlling two different traits.

Among the possible 36 correlation combinations, 26 character pairs showed significant correlation either in positive or negative direction. Grain yield per plant had significant positive correlation with all the component characters studied except flag leaf sheath length and panicle length (Table 3). This is in agreement with the earlier reports of Yadav and Srivastava (1976b), Subramanian (1979), Reddy *et al*. (1984), Singh *et al.* (1995) and Chidambaram and Palanisamy (1996). Significant positive association suggested high association and increase in one character will increase the other also. Maximum positive correlation was observed for days to 50 per cent flowering (0.766), followed by flag leaf width (0.515) and number of productive tillers (0.476). Significant positive correlation of most of the characters on grain yield indicated that all these characters can be simultaneously improved and it also suggested that increase in any one of them would lead to improvement of other character. Significant negative correlation observed for flag leaf sheath length and panicle length with grain yield indicated increase in one character will lead to decrease in another character.

Most of the characters showed significant positive inter correlation among them. Days to 50 per cent flowering recorded positive and significant inter correlation with total number of tillers, number of productive tillers and flag leaf width. Plant height showed positive significant correlation with flag leaf length, flag leaf width and panicle length. Total number of tillers had significant correlation with number of productive tillers and flag leaf width. Number of productive tillers had significant positive correlation with flag leaf width. Flag leaf length showed significant positive correlation with flag leaf width and panicle length. Flag leaf sheath length had significant positive correlation with panicle length. Positive correlations indicated that the selection in any one of these yield attributing traits will lead to increase in the other trait, thereby finally boosting the grain yield. Hence, primary selection for traits like days to flowering, number of tillers and plant height may be given importance in selection to obtain genotypes with increased grain yield per plant. In addition, the significant associations between these component traits suggest the possibility of simultaneous improvement of these traits by single selection. Thus selection for these component characters either singly or in combination would be more efficient in improving yield.

Some of the correlations among the component traits such as days to 50 per cent flowering with panicle length and flag leaf sheath length were found to be negative. It is difficult to exercise simultaneous selection of these characters for improving grain yield and negative association between important characters is undesirable. Such negative correlation could arise primarily from developmentally induced relationships such as two developing components competing for limited resources such as nutrients and water supply.

Path analysis

Path coefficient analysis permits the partition of correlation coefficients into direct and indirect effects and helps in identifying the effective components and to get information on actual contribution of each component character to yield. The path analysis takes into account the cause and effect relationship between the variables by partitioning the association into direct and indirect effects through other independent variables.

Days to 50 per cent flowering, plant height, total number of tillers per plant, flag leaf length and flag leaf width showed positive direct effect. High magnitude of positive direct effect was exhibited only by days to 50 per cent flowering. Reddy (1985) also reported positive direct effect of days to 50 per cent flowering. The high direct effect of days to 50 per cent flowering revealed the true relationship of this trait with grain yield and hence direct selection for this trait could be rewarding for the improvement of grain yield and to reduce the undesirable effect of other component traits studied. Plant height had low direct effect with grain yield. Negligible positive direct effect was observed for total number of tillers, flag leaf length and flag leaf width. Total number of tillers, number of productive tillers and flag leaf width had high positive indirect effects through days to 50 per cent flowering. Significant correlations in spite of low direct effect observed for these characters was due to their indirect effect through days to 50 per cent flowering and indirect selection through this trait will be effective in yield improvement.

Negative direct effect was observed for number of productive tillers per plant, flag leaf sheath length and panicle length. Maximum negative direct effect was observed for number of productive tillers. Significant correlation observed for this character was due to high indirect. Flag leaf sheath length and panicle length which showed negligible direct effect had significant negative correlation because of high negative indirect effect through days to 50 per cent flowering.

Conclusion

All the accessions studied showed wide range of variation for all the characters including grain yield per plant and this genetic diversity can be effectively utilized for crop improvement. Number of productive tillers was the highly variable and heritable character and it showed highest genetic advance also. In the present study, all nine characters studied except panicle length and flag leaf sheath length showed significant positive correlation with grain yield per plant. It would be inferred that selection in positive direction for all these traits will increase the grain yield. Highest correlation coefficient, high positive direct effect and indirect effect of other characters through days to 50 per cent flowering suggested that this character may be successfully used as selection criteria in improving grain yield.

References

Allard, R. W. 1960. *Principles of Plant Breeding*, John Wiley and Sons Inc., New York. p. 219 –233.

Burton, G. W. 1952. Quantitative inheritance in grasses. *Proceedings of 6th International Grassland Congress* **1:** 277-283.

Lush, J. L. 1940. Intra – sire correlation and regression of offspring on dams as a method of estimating heritability of characters. *Proceedings of American Society of Animal Production* **33:** 293 – 301.

Chidambaram, S. and Palanisamy, S. 1996. Dry matter production and harvest index in Samai (Little millet). *Madras Agric. J.,* **83**(11): 15-17.

Dewey, D.R. and Lu, K.M. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.,* **51:** 515 – 516.

Falconer, D. S. 1960. *Introduction to Quantitative Genetics 2nd ed.*, Longman, New York.

Fisher, R.A., Immer, F.R. and Tedin,O. 1932. The genetical interpretation of the statistics of the third degree in the study of quantitative inheritance. *Genetics* **17:** 107-124.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.,* **47:** 314-318.

IBPGR. 1985. Descriptors for *Panicum miliaceum* and *P. sumatrense*, 1985. Rome, Italy: International Board for Plant Genetic Resources. 14 p.

Padmaja, 1998. Studies on variability, correlation, path analysis and D^2 analysis for yield and yield attributes in littlemillet (*Panicum sumatrense* Roth.). *M.Sc. (Ag.) Thesis* submitted to Tamil Nadu Agricultural University, Coimbatore.

Panse, V.G. and Sukhatme, P.V. 1964. *Statistical methods for agricultural workers*, 2nd Ed. ICAR, New Delhi.

Rao, S.S.1991. Genetic variability in minor millet. *Indian J. Agric. Sci.,* **61:** 322-323.

Reddy, H.D. 1985. Genetic variability and association of morphological characters to seed yield in little millet. *Mysore J. Agric.Sci,.* **19:** 287.

Singh, A.K., H.S. Yadava and M.L. Sarathe.1995. factors influencing grain yield in litllemillet (*Panicum sumatrense*). *Ann. Agric. Res.,* **16**(4): 417-419.

Subramanian, E. 1979. Biometrical studies on variability, correlation, path analysis and genetic divergence in littlemillet (*Panicum miliare* Lam.). M.Sc (Ag.) Thesis submitted to Tamil Nadu Agricultural University, Coimbatore.

Yadav, A. and Srivastava, D.P. 1976. Genotypic and Phenotypic variability in *Panicum miliare* Lam., *Mysore J. Agric. Sci.,* **10**: 185-189.

Table 1. Summary of statistics on different yield and yield contributing traits in little millet

Particulars	Days to 50 percent flowering	Plant height (cm)	Total number of tillers per plant	No. of productive tillers per plant	Flag leaf length (cm)	Flag leaf width (cm)	Flag leaf sheath length (cm)	Panicle length (cm)	Grain yield per plant (g)
Mean	60.67	111.05	8.25	6.91	28.92	0.99	10.32	26.63	13.78
Minimum	49	88.00	3.00	3.00	18.00	0.5	3.00	18.00	2.88
Maximum	83	142.00	26.00	26.00	41.00	1.9	31.00	39.00	50.09
Standard deviation	8.57	9.33	3.63	3.63	4.18	0.25	3.02	4.26	9.56
Coefficient of variation	13.37	87.04	13.19	13.18	17.48	0.06	9.14	18.12	9.44
Standard error of mean	0.82	0.89	0.35	0.35	0.41	0.02	0.29	0.41	0.92
Variance	14.12	8.40	44.03	52.55	14.46	24.78	29.30	15.99	69.37
Skewness	1.18	0.36	1.66	2.31	0.26	0.92	2.46	0.22	1.77
Kurtosis	0.36	0.32	4.53	7.14	0.81	1.57	18.91	-0.05	3.07

Table 2. Characterization and preliminary evaluation of little millet germplasm

Characters	Variation	Frequency	Percentage	Coefficient of variation (%)		Heritability in broad sense (%)	Genetic advance as % of mean
				GCV	PCV		
Days to 50 percent flowering	Early (49-59)	60	55.05	13.59	14.43	88.56	13.03
	Medium(5969)	40	36.69				
	Late(69-79)	9	8.26				
Plant height (cm)	Dwarf (88-108)	44	40.37	8.12	8.82	84.69	15.39
	Medium(108-128)	61	55.96				
	Tall (128-148)	4	3.67				
Total number of tillers per plant	Low (3-13)	97	88.99	38.71	44.21	76.67	69.83
	Medium (13-23)	11	10.09				
	High (23-33)	1	0.92				
Number of productive tillers per plant	Low (3-13)	102	93.58	46.08	52.58	76.81	83.19
	Medium (13-23)	6	5.50				
	High (23-33)	1	0.92				
Flag leaf length (cm)	Short (18-28)	35	32.11	13.03	14.75	77.96	23.71
	Medium (28-38)	69	63.30				
	Long (38-48)	5	4.59				
Flag leaf width (cm)	Narrow (0.5-1)	37	33.95	20.16	24.99	65.57	33.63
	Medium (1-1.5)	62	56.88				
	Wide (1.5-2)	10	9.17				
Flag leaf sheath length (cm)	Short (3-13)	95	87.15	27.50	29.41	87.59	53.07
	Medium(13-23)	13	11.93				
	Long (23-33)	1	0.92				
Panicle length (cm)	Short (18-28)	65	59.63	14.94	16.23	84.70	28.33
	Intermediate (28-38)	43	39.45				
	Long (38-48)	1	0.92				
Grain yield per plant (g)	Low (2.88- 12.88)	69	63.30	33.94	40.84	67.25	56.57

Table 3. Genotypic correlation coefficients between grain yield per plant and component characters in little millet

Character	Plant height (cm)	Total number of tillers per plant	No.of productive tillers per plant	Flag leaf length (cm)	Flag leaf width (cm)	Flag leaf sheath length (cm)	Panicle length (cm)	Grain yield per plant (g)
Days to 50 percent flowering	0.117	0.580**	0.648**	0.117	0.580**	-0.459**	-0.502**	0.766**
Plant height (cm)	1	0.165	0.113	0.286**	0.263**	-0.011	0.233*	0.286**
Total number of tillers		1	0.805**	0.043	0.394**	-0.247*	-0.220*	0.461**
Number of productive tillers			1	-0.008	0.352**	-0.366**	-0.271**	0.476**
Flag leaf length (cm)				1	0.327**	0.079	0.269**	0.207*
Flag leaf width (cm)					1	-0.016	-0.157	0.515**
Flag leaf sheath length (cm)						1	0.289**	-0.346**
Panicle length (cm)							1	-0.326**

*** Significant at P= 0.05** **** Significant at P= 0.01**

Table 4. Direct (diagonal) and indirect effects of six characters on grain yield in little millet

Characters	Days to 50 percent flowering	Plant height (cm)	Total number of tillers	No. of producti ve tillers	Flag leaf length (cm)	Flag leaf width (cm)	Flag leaf sheath length (cm)	Panicle length (cm)	Correlation with grain yield per plant (g)
Days to 50 percent flowering	**0.680**	0.023	0.033	-0.042	0.009	0.034	0.019	0.009	0.766**
Plant height (cm)	0.122	**0.129**	0.009	-0.007	0.022	0.015	0.000	-0.004	0.286**
Total number of tillers	0.395	0.022	**0.056**	-0.052	0.003	0.023	0.010	0.004	0.461**
Number of productive tillers	0.440	0.015	0.045	**-0.065**	-0.001	0.020	0.015	0.005	0.476**
Flag leaf length (cm)	0.079	0.037	0.002	0.001	**0.077**	0.019	-0.003	-0.005	0.207*
Flag leaf width (cm)	0.395	0.034	0.022	-0.028	0.025	**0.057**	0.001	0.003	0.515**
Flag leaf sheath length (cm)	-0.312	-0.001	-0.014	0.024	0.006	-0.001	**-0.042**	-0.006	-0.346**
Panicle length (cm)	-0.342	0.029	-0.012	0.018	0.021	-0.009	-0.012	**-0.019**	-0.326**

Figure 1. Diversity for inflorescence compactness and shape of little millet germplasm

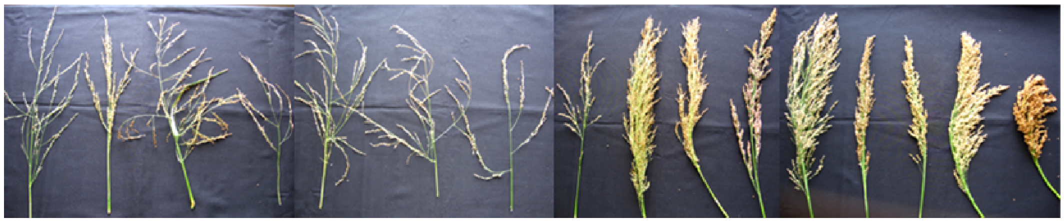

Figure 2 Frequency distribution of plant height in little millet germplasm

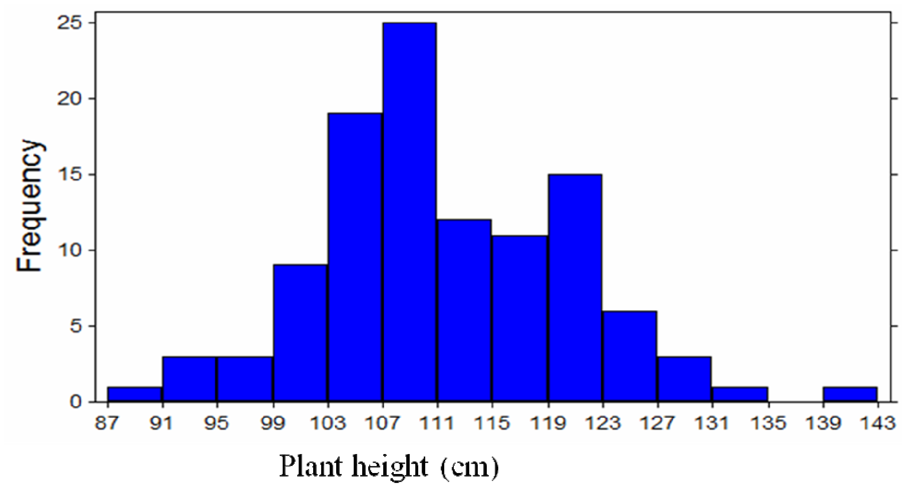

Figure 3. Comparison of GCV, PCV, heritability and genetic advance in little millet germplasm