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Assessment of genetic variability and heritability of grain yield components in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) germplasm

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Abstract
Present investigation of genetic variability, heritability and genetic advance for yield and yield contributing characters in thirty-five diverse genotypes including three checks viz., VL-172, VL-207 and PRJ-1 of barnyard millet was conducted during *kharif*, 2014 in Ranichauri Campus. Observations were recorded for different type of growth, yield and quality morpological characters. From the observation analysis of variance was recorded highly significant variation among all the thirty-five genotypes with a wide range of mean values for all the traits studied. The plant height was recorded highest genotypic and phenotypic variances while the magnitudes of genotypic and phenotypic variances low for number of productive tillers per plant. High heritability attached with high genetic advance in per cent of mean was recorded by finger length while moderate estimates of heritability coupled with high genetic advance in per cent of mean were observed for flag leaf area and biological yield per plant. Direct selection for different characters would be effective as heritability and genetic advance might be due to additive gene interaction.

Keywords: Barnyard millet, variability, coefficient of variance, heritability, genetic advance

Introduction
Millets refers to a group of annual grasses mainly found in the arid and semi-arid regions of the world. Barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) (2n=4x=36) also called as *Jhangora*, *Sawan* or *Madira* is largely a self-pollinated crop, tall erect upto 60 to 120 cm in height and belongs to a family poaceae. Barnyard millet is mostly grown in India, China, Japan, and Korea for human being consumption and fodder (Upadhyaya *et al*., 2014) [20]. The crop is valued for its drought tolerance (Dwivedi *et al*., 2012) [6], short growth period and superior nutrition value (Saleh *et al*., 2013) [15]. In India, the crop is grown in Madhya Pradesh, Uttarakhand, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Bihar. Barnyard millet has emerged as very imperative dual purpose nourishes and feed crop. It is also an suitable food for patients bigoted to gluten causing celiac sickness or other forms of allergies/intolerance of wheat (Annonymus, 2010) [2]. Nutritionally, barnyard millet is an important crop having fair source of protein (12%) which is highly digestible (81%) and is an excellent source of dietary fiber (13%), with good amounts of soluble (4%) and insoluble (8%) fractions. The carbohydrate content is low (58%) and also slowly digestible (25%). Hence, the millet has an important role to play in the human dietary. However, like other cereals, barnyard millet is also deficient in lysine (21.3 mg/g N). Methionine and cystine are second restrictive amino acids (33.1 mg/g N) in contrast with FAO/WHO reference pattern (Veena, 2003) [22]. Barnyard millet contains fair amounts of calcium (25mg/100g) and iron (1.40mg/100g).

The apposite information of interrelationships between seed yield and its contributing components can considerably improve the proficiently of breeding programme through the use of suitable selection indices (Mohammadia *et al*., 2003 and Rafiq *et al*., 2010) [12, 13]. Genetic variability together with the heritability estimates would give a better idea on the amount of genetic gain expected out of selection (Burton, 1952 and Swarup and Chaugle, 1962) [5, 19]. Heritability estimates alongside with genetic advance are other helpful in calculate the gain underneath selection than heritability estimates unaided. However, it is not necessary that a

character showing high heritability will always exhibit high genetic advance (Johnson *et al*., 1955) [8]. Hence, the present investigation is conducted to estimation the extent of difference for yield contributing traits in 35 barnyard millet germplasm accessions by studying the genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance, which may contribute to formulation of suitable selection indices for improvement in this crop.

2. Materials and Methods

The present investigations were carried out during *kharif* 2014 at the Research Block of Department of Crop Improvement and Seed Testing Laboratory of Department of Seed Science and Technology, College of Forestry, Ranichauri, Tehri Garhwal, Uttarakhand. The experimental materials comprised to 35 diverse germplasm of barnyard millet (*Echinochloa spp.*) including three checks *viz.*, VL-172, VL-207 and PRJ-1 (a variety released from the Department of Crop Improvement, College of Forestry, Ranichauri). The seed material used in study was obtained from Department of Crop Improvement, College of Forestry, Ranichauri Project Coordinator Unit of All India Small Millet Improvement Project, Banglore and National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The experiment was conducted in the Randomized Block Design (RBD) during first week of June under rainfed condition. Each of the entry was sown in three replications with spacing of 22.5 cm within rows and 10 cm between the plants. Observations were recorded on the basis of five randomly selected plants in each entry in each replication for fourteen morphological characters *viz*., days to 50 per cent flowering, days to maturity, plant height, number of productive tillers per plant, number of leaves on main tiller, flag leaf area, peduncle length, ear length, finger length, number of fingers per ear, biological yield per plant, harvest index, 1000 seed weight and grain yield per plant.

The data were subjected to analysis of variance according to the method recommended by Cochran and Cox (1992). Estimates of GCV and PCV were estimated as per formula given by Burton and Devane (1953) [14]. Heritability in broad sense was calculated as per the formula given by Allard (1960) [1]. Genetic advance was expressed by using the formula suggested by Johnson *et al*. (1955) [8].

3. Results and Discussion

3.1. Analysis of Variance

Analysis of variance revealed that mean squares due to genotypes were highly significant for all the characters except number of productive tillers per plant was found significant (Table 1). It showed that the germplasm examined were highly variable. Substantial variations in barnyard millet (Kebere *et al.* 2006) [10] and finger millet (Kumari *et al*., 2015) [11] have been also reported in previous study.

Table 1: Analysis of Variance (ANOVA) for different characters in 35 barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) genotypes

Character	Mean Sum of Square (MSS)		
	Replication	Treatment	Error
Degree of freedom	2	34	68
Days to 50% flowering	1.23	16.47**	2.41
Days to maturity	0.77	4.57**	1.50
Plant height (cm)	8.80	143.46**	13.89
No. of productive tillers/plant	0.07	0.23*	0.14
No. of leaves on main tiller	0.08	0.40**	0.17
Flag leaf area (cm²)	24.94	87.31**	23.79
Peduncle length (cm)	1.36	7.95**	1.14
Ear length (cm)	0.75	1.42**	0.64
Finger length (cm)	0.04	1.09**	0.07
No. of Fingers per ear	1.54	12.81**	3.80
Biological yield (g)	7.73	98.52**	15.29
Harvest index (%)	1.89	2.46**	0.79
1000 seed weight (g)	0.15	0.51**	0.11
Grain yield per plant (g)	0.32	0.58**	0.15

* Significant at 0.5 % level; ** Significant at 0.0 1 % level

The estimates of genotypic, phenotypic and environmental variances, genotypic coefficient of variance (GCV), phenotypic coefficient of variation (PCV) and environmental coefficient of variation (ECV), heritability (in broad sense) and genetic advance for different field parameters were presented in Table 2.

Table 2: Estimates of variance and genetic parameters of different characters in 35 barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) genotypes

S.No.	Characters	General mean	Variance			Coefficient of variation (%)			Heritability h^2 (broad sense) (%)	Genetic advance (GA) in per cent of mean
			Genotypic σ^2g	Phenotypic σ^2p	Environment σ^2e	Genotypic (GCV)	Phenotypic (PCV)	Environment (ECV)		
1	Days to 50% flowering	53.31	4.69	7.10	2.42	4.06	5.00	2.92	66.00	6.79
2	Days to maturity	131.45	1.02	2.52	1.50	0.77	1.21	0.93	40.50	1.01
3	Plant height (cm)	96.82	43.19	57.08	13.89	6.79	7.80	3.85	75.70	12.16
4	No. of productive tillers per plant	2.95	0.03	0.17	0.14	5.88	14.07	12.78	17.40	5.06
5	No. of leaves on main tiller	6.21	0.08	0.25	0.17	4.47	8.02	6.66	31.10	5.14
6	Flag leaf area (cm²)	35.63	21.18	44.96	23.79	12.92	18.82	13.69	47.10	18.26
7	Peduncle length (cm)	12.00	2.27	3.41	1.15	12.55	15.40	8.92	66.40	21.08

8	Ear length (cm)	15.98	0.26	0.90	0.64	3.19	5.93	5.01	28.90	3.53
9	Finger length (cm)	4.97	0.34	0.41	0.07	11.73	12.82	5.18	83.70	22.10
10	No. of fingers per ear	15.58	3.00	6.80	3.80	11.12	16.74	12.52	44.10	15.22
11	Biological yield per plant (g)	42.50	27.74	43.03	15.29	12.39	15.43	9.20	64.50	20.50
12	Harvest index (%)	9.87	0.56	1.35	0.79	7.55	11.75	9.00	41.30	10.00
13	1000 seed weight (g)	3.15	0.13	0.25	0.11	11.51	15.74	10.74	53.40	17.33
14	Grain yield per plant (g)	4.71	0.15	0.29	0.15	9.16	12.97	9.18	49.90	13.34

3.2. Coefficient of Variation

Phenotypic coefficients of variation (PCV) were found greater than corresponding genotypic coefficient of variation (GCV) in respect of all quantitative traits. Highest genotypic and phenotypic coefficients of variation were not observed for any of the characters. While moderate phenotypic coefficient of variation were observed for flag leaf area (18.82%) followed by number of fingers per ear (16.74%), 1000 seed weight (15.74%), biological yield per plant (15.43%) and peduncle length (15.40%). Hence, these characters are more suitable for direct selection procedure. Some other characters showed low values of phenotypic coefficient of variations. Genotypic coefficient (GCV) of variation was recorded low for all characters. Similar results also reported by Rao and Agrawal (2000) [14] in barnyard millet; Ganapathy *et al*. (2011) [7], Karad *et al*. (2013) [9], Suryanarayana *et al*. (2014) [18] and Bisht *et al*. (2015) [3] in finger millet.

3.3. Heritability

Broad sense heritability ranged from 17.40% to 83.70%. Maximum heritability in broad sense was recorded for finger length (83.70%) and moderate heritability in broad sense was recorded for plant height (75.70%) followed by days to 50 per cent flowering (66.00%), peduncle length (66.40%), biological yield per plant (64.50%) and 1000 seed weight (53.40%) while low estimates of heritability (<50%) was noticed for rest of all the characters. High heritability for different traits indicated that large proportion of phenotypic variance was attributed to genotypic variance and therefore, reliable selection could be made for these traits on the basis of phenotypic expression. Similar results have also in agreement with the result of Selvarani and Chandirasekaran (2000) [16]; Rao and Agrawal (2000) [14] in barnyard millet, Ganapathy *et al*. (2011) [7]; Suryanarayana *et al*. (2014) [18] and Bisht *et al*. (2015) [3] in finger millet.

3.4. Genetic advance

Genetic advance as per cent of mean ranged from 1.01% to 22.10%. High estimates of genetic advance was recorded for finger length (22.10%) followed by peduncle length (21.08 %) and biological yield per plant (20.50%), whereas moderate value of genetic advance was noticed for flag leaf area (18.26%), 1000 seed weight (17.33%), number of fingers per ear (15.22%), grain yield per plant (13.34%), plant height (12.16%) and harvest index (10.00%). Lower estimates of genetic advance were recorded for rest of the characters. High genetic advance has also been reported by Varu *et al*. (2005) [21] for plant height in pearl millet and Subramanian *et al*. (2010) [17] for dry fodder yield in kodo millet.

High estimates of heritability coupled with high genetic advance in per cent of mean was observed only by finger length while moderate estimates of heritability coupled with high genetic advance in per cent of mean were observed for flag leaf area and biological yield per plant. Similar results were also reported by Subramanian *et al*. (2010) [17] in kodo millet, Ganapathy *et al*. (2011) [7] in finger millet. Plant height and 1000 seed weight showed moderate heritability coupled with moderate genetic advance in per cent of mean which indicated possibility of obtaining reasonable response to selection in these traits owing to their high transmissibility but moderate to high variability. The characters *viz.* days to 50 per cent flowering, days to maturity, number of productive tillers per plant, number of leaves on main tiller and ear length showed low genetic advance which indicated that selection may not be effective in improving these traits due to non-additive gene action which may be epitasis and dominance effect.

4. Conclusion

Wide spectrum of variation was observed for yield and its components in barnyard millet germplasm. Genotypic and phenotypic variances were highest for plant height. Moderate magnitude of phenotypic coefficient of variation were noticed for flag leaf area, number of finger per ear, 1000 seed weight, biological yield per plant and peduncle length. Hence, these characters are more suitable for selection procedure. A high estimates of heritability coupled with high genetic advance in per cent of mean was observed only by finger length. Moderate estimates of heritability coupled with high genetic advance in per cent of mean were observed for flag leaf area and biological yield per plant. Direct selection for these characters would be effective as heritability and genetic advance might be due to additive gene interaction.

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