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Correlation analysis of some growth, yield and quality parameters of barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) Germplasm

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Abstract
The present investigation was conducted during *Kharif*, 2014 at Research Block, Department of Crop Improvement and Seed Testing at Department of Seed Science and Technology, V. C. S. G. Uttarakhand University of Horticulture and Forestry, College of Forestry, Ranichauri Campus with 35 diverse genotypes of barnyard millet including three checks *viz*., VL-172, VL-207 and PRJ-1. Observations were recorded for growth, yield and seed quality parameters accordingly, phenotypic and genotypic correlations among the traits were estimated biological yield per plant, number of fingers per ear, number of leaves on main tiller and 1000 seed weight, grain yield per plant. The data was utilized for estimation of correlation coefficients. Biological yield per plant, number of fingers per ear, number of leaves on main tiller and 1000 seed weight exerted a very strong positive association towards grain yield per plant at phenotypic and genotypic level. Maximum positive direct effect on grain yield per plant was imposed by biological yield per plant and harvest index at genotypic and phenotypic level. However, high negative direct effect at genotypic level was noted for flag leaf area and number of fingers per ear.

Keywords: Barnyard millet, correlation, growth, yield and quality related traits.

Introduction
Millets are some of the oldest one cultivated crops and important component in dry land agriculture. Small millet crops have a long history of cultivation of more than 5000 years and grown in many states (Gowda *et al.* 2006) [11] due to their unique adaptation properties for poor degraded lands and ability to tolerate abiotic stress. Millets refers to a group of annual grasses mainly found in the arid and semi arid regions of the world. The term millets is used for a number of grasses, belonging to the grass family Poaceae with small edible seeds which do not shatter readily at maturity (Thurston, 1989) and include seven genera; *Pennisetum, Panicum, Setaria, Paspalum* and *Echinochloa*, all in the tribe Paniceae, genus *Eleusine* in the tribe Chlorideae and genus *Eragrostis* in the tribe Festuceae. These grasses produce small seed and are often cultivated as cereals.

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, the stem as well as leaves being green in colour. Its leaves are flat, glabrous or slightly hairs without ligules. The inflorescence is usually narrow thickened with densely crowded unawned spikelets in 3-5 rows. The second lemma bears hermaphrodite flowers with three stamens. The grain is caryopsis and white or yellow in colour (Prasad, 2005) [4].

Information on the correlation co-efficient between grain yields with yield contributing traits is prerequisite for improving yield. In formulating selection program for the improvement of yield in any crop, study on the relationship of yield with other traits would be of great value. The path coefficient analysis allows partitioning of correlation coefficient into direct and indirect contributions (effects) of various traits towards dependent variable and thus helps in assessing the cause-effect relationship as well as effective selection.

Materials and Methods
Experimental site and Design
The experimental materials for the present investigation comprised to 35 diverse germplasm of barnyard millet (*Echinochloa spp.*) including 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 experimental site is located at

10 km away from chamba (Rishikesh - Gangotri road) at an altitude of about 2100 m above mean sea level, lying between 30°15' N latitude and 78°30' E longitude under mid hill zones of Uttarakhand, India. The field evaluations of the genotypes are carried out in the experimental block of Department of Crop Improvement. The laboratory tests and evaluation of seeds were conducted in the Seed Technology Laboratory of the Department of Seed Science and Technology. The experiment was conducted in the Randomized Block Design (RBD) during *kharif* season under rainfed condition with three replications'. The seeds were sown on 04 June, 2014, at about 3-4 cm depth by opening furrow with *kutla.* Each furrow was manually dribbled with seed and covered with soil immediately. The recommended row to row distance 22.5 cm and plant to plant distance 10 cm was maintained after germination by thinning of extra plant population after 20 days of germination. The crop was fertilized with 40kg nitrogen, 20kg of phosphorous and 20kg of potash. All fertilizers were applied at the time of sowing under rainfed condition. Data collection was done on as; plant height (cm), days to 50 per cent flowering, Ear length, Finger length, ear length, flag leaf area, number of leaves on main tiller, number of productive tillers per plant, number of leaves on main tiller, number of fingers per ear, grain yield per plant, 1000 seed weight, harvest index, biological yield per plant were recorded. The correlations between all characters under study, at genotypic and phenotypic level were estimated as per the method described by Searle (1961) [1]:

Phenotypic correlation between characters X and Y

$$r_{xy\,(p)} = \frac{Cov_{xy\,(p)}}{\sqrt{Var_{x(p)}\ X\ Var_{y(p)}}}$$

1. **Genotypic correlation between characters X and Y:**

$$r_{xy\,(g)} = \frac{Cov_{xy\,(g)}}{\sqrt{Var_{x(g)}\ X\ Var_{y(g)}}}$$

2. **Environmental correlation between characters X and Y:**

$$r_{xy\,(e)} = \frac{Cov_{xy\,(e)}}{\sqrt{Var_{x(e)}\ X\ Var_{y(e)}}}$$

Where: $Cov_{xy(p)}$, $Cov_{xy(g)}$, $Cov_{xy(e)}$ denote phenotypic, genotypic and environmental covariance between characters X and Y, respectively.

$Var_{x(p)}$, $Var_{x(g)}$, $Var_{x(e)}$ denote phenotypic, genotypic and environmental variances between characters X, whereas $Var_{y(p)}$, $Var_{y(g)}$, $Var_{y(e)}$ denote phenotypic, genotypic and environmental variances between characters Y.

Results and Disucssion

The estimates among different pairs of characters at phenotypic and genotypic correlation coefficients are presented in Table 1 and 2. Biological yield per plant showed highly significant and positive phenotypic correlation with number of fingers per ear (0.7242). Grain yield per plant possessed highly significant and positive phenotypic correlation with biological yield per plant (0.5287), number of fingers per ear (0.4539), 1000 seed weight (0.4200) and number of leaves on main tiller while significant and positive correlation with harvest index (0.2108). Finger length exhibited highly significant and positive phenotypic correlation with ear length (0.4901), flag leaf area (0.3913) and number of leaves on main tiller (0.2887) along with significant positive phenotypic correlation with number of productive tillers per plant (0.2309), plant height (0.2207) and days to 50 per cent flowering (0.1986). Flag leaf area recorded highly significant and positive phenotypic correlation with plant height (0.4677). Ear length showed highly significant and positive phenotypic correlation with flag leaf area (0.4106) and number of leaves on main tiller (0.2865) while significant and positive phenotypic correlation with plant height (0.2087). 1000 seed weight exhibited highly significant and positive phenotypic correlation with biological yield per plant (0.4057), number of fingers per ear (0.3469), peduncle length (0.2819) and number of leaves on main tiller but it had highly significant and negative correlation with flag leaf area (-0.3488) while significant and negative phenotypic correlation with plant height (-0.2421). Number of leaves on main tiller showed significant and positive phenotypic correlation with plant height (0.2474). Harvest index showed highly significant and negative correlation with biological yield per plant (-0.4674) and number of fingers per ear (-0.3003). The estimates of phenotypic correlation coefficients for rest of the character pairs were non-significant. The estimates of genotypic correlation coefficient between different characters showed close parallelism in direction with their corresponding phenotypic correlation (Table 2). The genotypic correlations were slightly higher in magnitude than corresponding correlation at phenotypic level. The grain yield in almost all the crops is referred to as super character which results from multiplicative interactions of several other characters that are termed as yield components. Thus, genetic architecture of grain yield in barnyard millet as well as other crops is based on balance or overall net affected produced by various yield components directly or indirectly with one another. Therefore, identification of important yield components and information about their association with yield and also with each other is very useful for developing efficient breeding strategy for evolving high yielding variety. In this respect, the correlation coefficient which provides symmetrical measurement of degree of association between two variables or characters, help us in understanding the nature and magnitude of association among yield and yield components. The magnitude of genotypic correlation coefficients for most of the characters was higher than the corresponding phenotypic correlation coefficients, except few cases, which indicate the presence of inherent association among various characters. A similar finding was also reported by Hussain *et al.* (2003) [2] on pearl millet. Suryanarayana *et al.* (2014) [3-10] also reported higher estimates of genotypic correlation than the corresponding phenotypic correlation coefficients between yield and yield components in finger millet. In present study, a very strong positive association of grain yield per plant was observed at phenotypic and genotypic level with biological yield per plant, number of fingers per ear, number of leaves on main tiller and 1000 seed weight. Singh *et al.* (1990) [5] and Tazeen *et al.* (2009) [6] also found that grain yield positively correlated with biomass and harvest index. Positive association of grain yield per plant with 1000 grain weight was also reported by Dhagate *et al.* (1972) [7]. Thus, present results are also in consonance with Kebere *et al.* (2006) [8], Wolie and Dessalegn (2011) [9] and Suryanarayana *et al.* (2014) [3-10] in finger millet. Flag leaf area was the only character which showed strong negative association with grain yield per plant at genotypic level.

Table 1: Estimates of phenotypic correlation coefficients between different parameters in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) genotypes

Characters	Days to maturity	Plant height (cm)	No. of productive tillers/plant	No. of leaves on main tiller	Flag leaf area (cm^2)	Peduncle length (cm)	Ear length (cm)	Finger length (cm)	No. of fingers/ear	Biological yield/plant (g)	Harvest Index (%)	1000 seed weight (g)	Grain yield/plant (g)
Days to 50% flowering	0.1591	-0.0479	-0.0471	0.0408	0.1891	-0.0120	0.1884	0.1986 *	-0.1714	-0.1883	0.1270	-0.0530	-0.0682
Days to maturity		-0.0087	0.0340	0.0329	0.0000	0.0552	-0.0843	-0.1652	0.1245	0.1255	-0.0843	0.1434	0.1436
Plant height (cm)			0.0529	0.2474 *	0.4677 **	-0.0746	0.2087 *	0.2207 *	-0.0569	0.0961	-0.0292	-0.2421 *	0.0718
No. of productive tillers/plant				-0.0146	0.0713	0.0791	0.1792	0.2309 *	0.1298	0.1073	-0.1754	-0.0326	0.0580
No. of leaves on main tiller					0.1038	0.0922	0.2865 *	0.2887 **	0.0759	0.1473	0.1204	0.2643 **	0.2877 **
Flag leaf area (cm^2)						-0.1524	.4106 **	0.3913 **	-0.1759	-0.0419	-0.0608	-0.3488 *	0.0221
Peduncle length (cm)							0.0566	0.0951	0.1732	0.1696	-0.0450	0.2819 **	0.1536
Ear length (cm)								0.4901 **	-0.0274	0.0129	0.0111	0.0085	0.1345
Finger length (cm)									-0.1289	-0.0514	0.0367	-0.1807	0.0176
No. of fingers/ear										0.7242 **	-0.3003 **	0.3469 **	0.4539 **
Biological yield/plant (g)											-0.4674 **	0.4057 **	0.5287 **
Harvest Index (%)												0.1278	0.2108 *
1000 seed weight (g)													0.4200 **

*Significant at 5% level ** Significant at 1% level

Table 2: Estimates of genotypic correlation coefficients between different parameters in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) genotypes

Characters	Days to maturity	Plant height (cm)	No. of productive tillers/plant	No. of leaves on main tiller	Flag leaf area (cm^2)	Peduncle length (cm)	Ear length (cm)	Finger length (cm)	No. of fingers/ear	Biological yield/plant (g)	Harvest Index (%)	1000 seed weight (g)	Grain yield/plant (g)
Days to 50% flowering	0.3629	-0.1280	0.0526	-0.2663	0.2679	0.0477	0.3718	0.2249	-0.2208	-0.1590	0.1671	-0.0964	-0.0812
Days to maturity		0.0930	-0.0720	0.2026	0.0615	0.0785	-0.0625	-0.2084	0.2295	0.2072	0.1689	0.2860	0.3508
Plant height (cm)			0.1411	0.1846	0.7184	-0.0040	0.4574	0.2739	-0.0789	0.2338	-0.2922	-0.4637	0.0890
No. of productive tillers/plant				-0.0558	0.2149	0.3026	1.0483	0.6728	0.4740	0.4333	-0.2950	0.1894	0.3232
No. of leaves on main tiller					0.1377	0.3725	0.3239	0.4965	0.3492	0.6106	-0.0786	0.4557	0.7159
Flag leaf area (cm^2)						-0.2150	0.6922	0.4941	-.3434	0.0698	-0.2499	-0.5880	-0.2369
Peduncle length (cm)							0.2650	0.1277	0.0743	0.1327	0.1473	0.5714	0.3083
Ear length (cm)								0.7754	0.3607	0.3735	-0.4203	-0.0997	0.1207
Finger length (cm)									-0.1894	-0.0402	-0.0411	-0.2383	-0.0841
No. of fingers/ear										0.8722	-0.6551	0.5483	0.8092
Biological yield/plant (g)											-0.7377	0.6484	0.9178
Harvest Index (%)												-0.3913	-0.0355
1000 seed weight (g)													0.7029

*Significant at 5% level ** Significant at 1% level

Conclusions

The genotypic correlation was generally similar in nature and higher in magnitude than corresponding phenotypic correlation coefficients. A very strong positive association of grain yield per plant at phenotypic and genotypic level was observed with biological yield per plant, number of fingers per ear, number of leaves on main tiller and 1000 seed weight. Thus, there is an opportunity to bring about improvement of the crop yield through direct and indirect selection as well as improving of these characters through hybridization using the germplasm collections in Ranichauri, Tehri Garhwal. This finding, being the result of one year and one location, it is recommended that the experiment be repeated at more locations and over more years to confirm the obtained results.

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