



Research Article

Association studies in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) for early maturity and yield contributing traits at high altitude region

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Abstract

Barnyard millet is an under-utilized minor millet which is being popularized nowadays bestowing with high nutrient content in grains. Forty genotypes were evaluated in high altitude region to determine the correlation and path coefficient among the yield and yield attributing traits. Correlation analysis evinced that grain yield per plant had positive significant correlation with agro-morphological traits viz., plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, number of racemes and thousand grain weight. The trait length of peduncle alone expressed negative significance with grain yield. The path coefficient estimation indicated that stem diameter had exposed high magnitude of direct effect on grain yield. Henceforth, the direct selection based on the flawless relationship between grain yield and these traits would benefit in selecting high yielding genotypes.

Key words

Correlation coefficient, Path analysis, Barnyard millet

INTRODUCTION

Millet is the oldest cultivated food known to humans and has traditionally been the main component of the food basket of the poor people in India. Barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) is one among them which is categorized as under-exploited crop for long years ago due to institutional neglect after the green revolution era. This crop can be grown in temperate, sub tropical and tropical regions of Asia and Africa as it performs well even under adverse climatic conditions Saleh *et al.* (2013). In India, its cultivation expanded to Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Maharashtra, Orissa, Madhya Pradesh, Gujarat, Bihar and Uttar Pradesh (Channappagoundar *et al.*, 2008). It is also cultivated on the hills under double cut production system with better yield Bandyopadhyay (2009). It has also been utilized for the reclamation of sodicity, arsenic and cadmium problem soils (Sherief, 2007; Abe *et al.*, 2011). Barnyard millet has a fair source of nutritional composition like carbohydrate (65.5g), protein (6.2g), fat (2.2g), crude fibre (9.8g),

mineral matter (4.4g), calcium (20mg) and phosphorus (280mg) Gopalan *et al.*, (2007). It is an excellent source of Fe content which ranged from 2.29 to 18.00 mg/100g (Renganathan *et al.*, 2017).

Studies on correlation provide cognition of association among different traits and yield which results in selecting genotypes possessing desired traits for genetic improvement of yield. The Path coefficient analysis is nothing but a standardised partial regression of coefficient which splits the correlation coefficient into the measures of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent traits on a dependent character. The present research was undertaken to investigate the correlation and path analysis in different diverged genotypes of barnyard millet to develop a criterion for selection that could be effectively used for selecting the favourable genotypes for early maturity with high yield potential in future.

MATERIALS AND METHODS

Fourty germplasm accessions including 17 ICRISAT germplasm along with two check varieties MDU 1 and CO (Kv) 2 were used for the study. These genotypes were resourced from International, National Research Institutions and State Agricultural University and Colleges (Table 1). The local check varieties have good grain yield, widely cultivated by rainfed millet farmers in the state of Tamil Nadu, India.. The experiment was conducted in the hilly region during *summer 2019* at Idukki, Kerala which has latitude of 10.02 North and longitude of 77.35 East and the average rainfall of 1082 mm with average temperature of 21.9° C. The study utilized the experimental design of RBD (Randomized Block Design) with two replications. A single row of plants with 3 m length along with the spacing on 30 x 15 cm was maintained for each

genotype as intra row and inter row spacing. Thinning and gap filling was carried out at the 20th day of sowing to maintain optimum population. Adequate irrigation and recommended fertilizer application was provided in time with proper crop management. The data were recorded for seventeen traits which contain days to flowering, days to maturity, plant height, number of nodes, length of internodes, number of basal tillers, stem diameter, flag leaf length, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, length of peduncle, number of racemes, Single ear head weight, Thousand grain weight and grain yield per plant. The data on the quantitative characters were recorded based on the descriptors of IPGRI (1983). All the statistical analysis was done by utilizing TNAU STAT software.

Table1. Details of germplasm used for the study

Sl.No	Genotypes	Origin/Parentage	Source	
1	ACM 110	India		
2	ACM 161	India		
3	ACM 295	India		
4	ACM 331	India	Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai	
5	ACM 333	India		
6	ACM-15-343	A cross derivative from ACM cultures		
7	ACM-15-353	A cross derivative from ACM cultures		
8	GECH 10	India		
9	GECH 15	India	All India Co-ordinated Small Millets Improvement Project, Bengalore.	
10	IEc – 52	India		
11	IEc - 167	India		
12	IEc – 568	India		
13	IEc – 166	India		
14	IEc – 672	India		
15	IEc – 82	India		
16	IEc – 109	India		
17	IEc – 107	India		ICRISAT, Hyderabad
18	IEc – 108	India		
19	IEc – 386	India		
20	IEc – 385	India		
21	IEc – 356	India		
22	IEc – 350	India		
23	IEc – 391	India		
24	IEc – 71	India		
25	IEc – 296	India		
26	IEc – 396	India		
27	T 5	India		Department of Millets, Tamil Nadu Agricultural University, Coimbatore
28	M1			
29	M2			
30	M3			
31	M5			Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai
32	M12			
33	M18			
34	M27	Mutant lines of Co (KV)-2 Variety, India		
35	M28			
36	M36			
37	M37			
38	M38			
39	MDU – 1	India	Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai	
40	Co (KV)- 2	India	Department of Millets, Tamil Nadu Agricultural University, Coimbatore	

RESULTS AND DISCUSSION

The genotypic and phenotypic correlation coefficients estimated between grain yield per plant with all quantitative traits are illustrated in **Table 2**. In the present investigation, the genotypic correlation coefficients were higher than the phenotypic correlation coefficient for the characters studied as observed by Johnson *et al.* (1955). This is because of polygene governing the traits were similar and influence of environment for the trait expression might be minimal..

Grain yield performed highly positive significant correlation with plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, number of racemes and single ear head weight (**Table 2**). The highest yield was with width of flag leaf (0.8926) followed by number of racemes (0.8805), stem diameter (0.8715), days to maturity (0.8027),

days to flowering (0.7934), single ear head weight (0.785), number of nodes (0.7653), length of flag leaf (0.704), width of inflorescence (0.7039), plant height (0.7002) and length of lower racemes (0.3263) implying the attention to these traits in yield enhancement of barnyard millet. Similar results were also reported by Arunachalam *et al.* (2012); Gupta *et al.* (2009); Upadhaya *et al.* (2014); Sood *et al.* (2015); Joshi *et al.* (2015) and Arya *et al.* (2017) in barnyard millet.

Days to flowering and days to maturity demonstrated highly significant positive genetic association with grain yield, which hinted that selecting late maturity genotypes could fruit in better yield improvement. It has similarity with the findings of Arunachalam *et al.*, (2012) who concluded that the early maturing germplasm in barnyard millet were poor yielders and *vice versa*. This was supported by the investigation of Sood *et al.*, (2016) too.

Table 2. Phenotypic (above diagonal) and genotypic (below diagonal) Correlation coefficient matrix between 17 biometric traits in 40 germplasm of high altitude region.

NN	LON	NBT	SD	LFL	WFL	LOI	WOI	LLR	LOP	NOR	TGW	SEW	GY/P
0.8574**	0.3704*	0.0742	0.7546**	0.7079**	0.7547**	0.8885**	0.7705**	0.3109*	-0.184	0.8085**	0.2145	0.6864**	0.6721**
0.88**	0.2767*	-0.141	0.8836**	0.7289**	0.8261**	0.7397**	0.6857**	0.3231*	-0.475	0.887**	0.3673*	0.8586**	0.784**
0.8844**	0.2201	-0.132	0.8955**	0.7403**	0.808**	0.7475**	0.6861**	0.3646*	-0.515	0.8806**	0.376*	0.8476**	0.7884**
1	0.1287	-0.099	0.8427**	0.639**	0.7592**	0.708**	0.64**	0.2365	-0.448	0.7969**	0.2472	0.8087**	0.7385**
0.1644	1	-0.149	0.216	0.3818**	0.2877*	0.4392**	0.3719*	0.2039	0.1109	0.2208	0.0837	0.2002	0.2254
-0.108	-0.2698	1	-0.252	-0.078	-0.198	-0.006	0.0076	-0.01	0.3501*	-0.141	-0.235	-0.191	-0.182
0.8885**	0.2645	-0.2487	1	0.7009**	0.8593**	0.6597**	0.6824**	0.3729*	-0.616	0.8835**	0.3911**	0.8524**	0.8373**
0.7015**	0.3843**	-0.1611	0.7969**	1	0.7704**	0.7542**	0.7236**	0.3879**	-0.291	0.765**	0.1844	0.6127**	0.6513**
0.8129**	0.3441*	-0.2643	0.9357**	0.8405**	1	0.6819**	0.6847**	0.2955	-0.402	0.8791**	0.2409	0.7263**	0.8259**
0.7481**	0.4393**	-0.0187	0.694**	0.8041**	0.7404**	1	0.7561**	0.3665*	-0.069	0.7153**	0.2581	0.5748**	0.5342**
0.7707**	0.4537**	-0.0228	0.7974**	0.8545**	0.83**	0.865**	1	0.5439**	-0.156	0.7252**	0.2301	0.5417**	0.6046**
0.3434*	0.3685*	-0.0868	0.4864**	0.5472**	0.3502*	0.5152**	0.6049**	1	-0.102	0.3218*	0.2876*	0.2136	0.2522
-0.4709**	0.1122	0.3722*	-0.644**	-0.3165*	-0.4577**	-0.0806	-0.2145	-0.2087	1	-0.432**	-0.397**	-0.584**	-0.549**
0.8435**	0.2597	-0.138	0.9313**	0.8112**	0.9613**	0.741**	0.8536**	0.4371**	-0.439**	1	0.2968*	0.7682**	0.8502**
0.2656	0.1005	-0.2765	0.4404**	0.199	0.2784*	0.2581	0.2375	0.3247*	-0.4433**	0.3169*	1	0.2543	0.2019
0.8374**	0.2193	-0.219	0.8951**	0.6497**	0.7911**	0.5938**	0.6417**	0.3011*	-0.599**	0.7821**	0.2687	1	0.7732**

Significant at 5 % (0.275)

Significant at 1 % (0.381)

Degrees of freedom - 38

DF – Days to Flowering, **DM** – Days to Maturity, **GY_P** – Grain Yield per Plant, **LFL** – Length of Flag Leaf, **LLR** – Length of Inflorescence; **LON** – Length of Node; **LOP** – Length of Peduncle; **NBT** – Number of Basal Tillers; **NN** – Number of Nodes; **NOR** – Number of Racemes; **PH** – Plant Height; **SD** – Stem Diameter; **SEW** – Single Ear head Weight; **TGW** – Thousand Grain Weight; **WFL** – Width of Flag Leaf; **WOI** – Width of Inflorescence

The characters such as length of nodes (0.2557) and thousand grain weight (0.2148) explicit non-significant positive correlation with grain yield. Whereas, the trait number of basal tillers showed non-significant negative association. Moreover, a significant negative companion with grain yield recorded by length of peduncle (-0.5672). These results are in accordance with the findings of Mahto *et al.* (2000) and Gowda *et al.* (2008) in finger millet.

Path coefficient analysis as outlined by Dewey and Lu (1959) was carried out to split the correlation coefficients in to measure the direct and indirect effects. The estimated coefficients were then categorized as negligible, low, moderate, high and very high based on the scales suggested by Lenka and Mishra (1973). Among the traits

studied (**Table 3**), stem diameter was observed to have maximum direct effect on yield (1.4738) followed by number of racemes (0.7177) indicating that selection based on these traits could result in better yield (Prakash and Vanniarajan, 2015). The characters length of inflorescence (0.1284), days to maturity (0.1262), and length of nodes (0.1166) exhibited low direct effects towards grain yield. The remaining traits showed negligible scale of direct effects on yield announcing that indirect effects of associated characters played major role on grain yield as the genotypic correlation exhibited high positive significance for majority of the traits. The residue value 0.3943 explains that 61 percent of total variability of grain yield has been accounted through this study.

Table 3. Path coefficient matrix expressing direct and indirect effects for 17 traits in 40 germplasm of high altitude region

Characters	Direct and Indirect effects for the characters																Genotypic correlation with GY/P
	PH	DF	DM	NN	LON	NBT	SD	LFL	WFL	LOI	WOI	LLR	LOP	NOR	TGW	SEW	
PH	-0.0733	0.1081	-0.0836	-0.3077	0.0402	-0.0015	1.2059	-0.0901	-0.5052	0.1168	0.0517	-0.1252	0.0279	0.6112	-0.077	-0.198	0.7002**
DF	-0.0628	0.1262	-0.0951	-0.3151	0.035	0.0051	1.363	-0.0923	-0.5442	0.0977	0.0443	-0.1119	0.0672	0.6488	-0.1306	-0.2417	0.7934**
DM	-0.0626	0.1225	-0.098	-0.3175	0.0266	0.005	1.3951	-0.0934	-0.5391	0.0986	0.0444	-0.1261	0.0734	0.6467	-0.1333	-0.2397	0.8027**
NN	-0.0653	0.1151	-0.09	-0.3458	0.0192	0.0035	1.3095	-0.0839	-0.4929	0.096	0.0433	-0.089	0.0647	0.6054	-0.0901	-0.2344	0.7653**
LON	-0.0253	0.0379	-0.0224	-0.0568	0.1166	0.0087	0.3898	-0.046	-0.2087	0.0564	0.0255	-0.0956	-0.0154	0.1864	-0.0341	-0.0614	0.2557
NBT	-0.0034	-0.0199	0.0152	0.0373	-0.0315	-0.0323	-0.3666	0.0193	0.1602	-0.0024	-0.0013	0.0225	-0.0512	-0.0991	0.0939	0.061	-0.1978
SD	-0.06	0.1167	-0.0928	-0.3072	0.0308	0.008	1.4738	-0.0953	-0.5673	0.0891	0.0448	-0.1261	0.0886	0.6684	-0.1495	-0.2506	0.8715**
LFL	-0.0553	0.0975	-0.0766	-0.2425	0.0448	0.0052	1.1745	-0.1196	-0.5096	0.1032	0.048	-0.1419	0.0435	0.5822	-0.0675	-0.1819	0.704**
WFL	-0.0611	0.1133	-0.0871	-0.2811	0.0401	0.0085	1.379	-0.1005	-0.6063	0.095	0.0466	-0.0908	0.0629	0.6899	-0.0945	-0.2214	0.8926**
LOI	-0.0667	0.096	-0.0753	-0.2587	0.0512	0.0006	1.0229	-0.0962	-0.449	0.1284	0.0486	-0.1336	0.0111	0.5318	-0.0876	-0.1662	0.5574**
WOI	-0.0676	0.0997	-0.0775	-0.2665	0.0529	0.0007	1.1753	-0.1022	-0.5033	0.111	0.0562	-0.1569	0.0295	0.6127	-0.0806	-0.1796	0.7039**
LLR	-0.0354	0.0545	-0.0476	-0.1187	0.043	0.0028	0.7168	-0.0654	-0.2123	0.0661	0.034	-0.2593	0.0287	0.3137	-0.1102	-0.0843	0.3263*
LOP	0.0149	-0.0617	0.0523	0.1628	0.0131	-0.012	-0.9492	0.0378	0.2775	-0.0104	-0.012	0.0541	-0.1375	-0.3152	0.1505	0.1678	-0.5672**
NOR	-0.0625	0.1141	-0.0883	-0.2916	0.0303	0.0045	1.3726	-0.097	-0.5829	0.0951	0.0479	-0.1133	0.0604	0.7177	-0.1076	-0.2189	0.8805**
TGW	-0.0166	0.0486	-0.0385	-0.0918	0.0117	0.0089	0.6491	-0.0238	-0.1688	0.0331	0.0133	-0.0842	0.061	0.2275	-0.3394	-0.0752	0.2148
SEW	-0.0519	0.109	-0.0839	-0.2896	0.0256	0.0071	1.3193	-0.0777	-0.4797	0.0762	0.036	-0.0781	0.0824	0.5613	-0.0912	-0.2799	0.785**

Residual value – 0.3943

The figures indicated in dark represent the direct effects for the corresponding characters

DF – Days to Flowering, **DM** – Days to Maturity, **GY_P** – Grain Yield per Plant, **LFL** – Length of Flag Leaf, **LLR** – Length of Inflorescence; **LON** – Length of Node; **LOP** – Length of Peduncle; **NBT** – Number of Basal Tillers; **NN** – Number of Nodes; **NOR** – Number of Racemes; **PH** – Plant Height; **SD** – Stem Diameter; **SEW** – Single Ear head Weight; **TGW** – Thousand Grain Weight; **WFL** – Width of Flag Leaf; **WOI** – Width of Inflorescence

Based on the correlation and path analysis, the main yield contributing characters in barnyard millet are plant height, days to flowering, days to maturity, number of nodes, stem diameter, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of lower racemes, number of racemes and thousand grains weight. The traits stem diameter and number of racemes had high direct positive effect on grain

yield resulting selection based on these traits could be benefited for crop improvement programme.

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