Deciphering Trait Association and their Effect on Yield, Yield Attributing and Quality Traits in Barnyard Millet [*Echinochloa frumentacea* (Roxb.) Link]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Barnyard millet is viewed as a climate-resilient crop comprising high nutrient content and antioxidant properties therefore, it considered as a functional food crop. Results revealed that grain yield exhibited high positive correlation with panicle weight implying attention that this trait will help in improving yield in barnyard millet. Panicle weight showed highly significant positive correlation with flag leaf width, flag leaf area, panicle length and test weight revealing that selection for any one of these traits will contribute in improvement of all the other major component trait and overall yield. Peduncle length alone expressed negative significant correlation with grain yield. The cause and effect results revealed that test weight, days to 50% flowering, number of productive tillers,

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panicle weight, panicle length and flag leaf area had positive direct effect on grain yield per plant. It can be concluded that panicle weight is the most important component character in barnyard millet because of its high significant positive association with grain yield, its high direct effect on grain yield and being the most used path by the other component traits contributing positively towards grain yield.

Keywords: Barnyard millet; correlation; panicle; path; association.

1. INTRODUCTION

 "Millets are the oldest cultivated food known to humans and have traditionally been the prime component of the food basket of the poor people in India. Barnyard millet is an important short duration nutri-cereal. It is generally grown in warm and temperate climates around the world, particularly in India, Japan, China and Korea. It is mainly grown in India; in Himalayan region of Uttarakhand in the north and other in the Deccan plateau region of Tamil Nadu in the south" [1]. Because of its resistance to drought and fast growth and exceptional nutritional properties, barnyard millet is an important crop for marginal farmers of Asian countries. It is a short duration crop that can be grown in poor environmental conditions with little input having tolerance against variety of biotic and abiotic stresses [2]. Further these characteristic enabled barnyard millet as a good supplementary crop for subsistence farming as well as an alternative crop during monsoon crop failure.

"Knowledge on trait association studies for yield and its component traits is essential while aiming yield improvement through selection. Vegetative characters which are positively associated with reproductive traits assist in selection at the early growth stage of crop. Unfavourable associations with desirable component traits may also be identified so as to avoid genetic slippage" [3]. "Besides, path coefficient analysis is helpful to recognize direct and indirect association of traits and also enables comparison of causal factors for their relative contributions". Wang et al., [3] Keeping the above facts in mind the present investigation was carried out to study the association between yield and its contributing traits in barnyard millet.

2. MATERIALS AND METHODS

The present experiment was carried out at Experimental Farm of Division of Plant Breeding and Genetics, Faculty of Agriculture, SKUAST-J, Main Campus, Chatha, Jammu during *kharif*

2021. The experimental material comprised of 30 genotypes of Barnyard millet procured from IIMR Hyderabad as well as collected from different locations of Jammu region of J&K (Table 1). These genotypes were evaluated in Randomized Complete Block Design (RCBD) in three replications having a plot size of $1m^2$ with row to row spacing of 25cm. All agronomic and plant protection measures were followed to raise a good crop as per package and practices. Data was recorded for 14 different quantitative characters as per DUS guidelines for barnyard millet provided by Protection of Plant Varieties and Farmer's Rights (PPV & FR) Authority, India (https://www. plantauthority.gov.in/). "Genotypic correlation coefficients and phenotypic correlation coefficients were estimated following [4] while path coefficient analysis was carried out according to Wright, [5]. Simultaneously the heat map was constructed using R-Software" [6].

3. RESULTS AND DISCUSSION

Genotypic and phenotypic correlation coefficients estimated for grain yield per plant along with all yield attributing and quality traits are illustrated in Table 2 and Fig. 1. Genotypic correlation coefficients were found to be higher than the phenotypic correlation coefficient for all the traits indicating that polygenes governing the traits were similar and influence of environment for the trait expression was minimal.

Grain yield showed highly positive correlation with panicle weight for both genotypic and phenotypic correlation (r_g=0.541 & r_p=0.512) implying that attention to this trait will help in improvement of yield in barnyard millet. Traits such as flag leaf area, panicle length, number of productive tillers, days to maturity, iron content explicit positive correlation with grain yield. Some of the traits flag leaf width and test weight showed significant positive phenotypic correlation with grain yield. Our results are in consonance with Arunachalam et al. [7] Gupta et al. [8] Upadhaya et al. [9] Sood et al, [1] Joshi et

al. [10] and Arya et al. [11]. "Positive association among various characters suggested that increase in one component character will result in increased grain yield per plant in barnyard millet" [12]. The trait peduncle length recorded a significant negative association with grain yield means long the peduncle length less the size of panicle. These results are in accordance with the findings of Mahto et al, [13] and Gowda et al. [14] in finger millet and Prabu et al., [15] in barnyard millet. Whereas, the traits days to flowering, plant height, zinc content showed negative association with grain yield. "Negative association of grain yield with component traits suggested improvement in that character will decrease the grain yield per plant in barnyard millet". Sood et al., [1]. The major yield contributing trait revealed by correlation studies i.e., panicle weight showed highly significant positive correlation with flag leaf width, flag leaf area, panicle length and test weight. "Therefore, selection for any one trait will contribute in improvement of all the other major component trait and overall yield. Besides, it also has been observed that the trait plant height is

positively associated with flag leaf width, flag leaf area and peduncle length. Association of days to 50% flowering and days to maturity with number of tillers revealed negative association as more vegetative growth delays onset of reproductive phase hence grain yield" [12]. For the biochemical traits *i.e.*, iron and zinc content, highly significant positive correlation was observed for both genotypic and phenotypic correlation ($r_g=0.473$ & $r_p=0.470$) implying that increase in one trait will increase in other trait.

"Correlation among different desirable traits is further precisely divided into direct and indirect effects through path analysis which helps in strategizing breeding procedure for simultaneous selection aiming to improvement in every crop". Sood et al., [1]. Path coefficient analysis as outlined by Dewey and Lu [16] was carried out to split the correlation coefficients 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 [17].

Table 1. List of 30 barnyard genotypes with sources

S. no.	Genotype	Source	S. no.	Genotype	Source
1	VL-207	IIMR, Hyderabad	16	DHBM 93-3	IIMR, Hyderabad
2	VL-172	IIMR, Hyderabad	17	DHBM 93-2	IIMR, Hyderabad
3	VL-181	IIMR, Hyderabad	18	DHBM 23-3	IIMR, Hyderabad
4	C0-2	IIMR, Hyderabad	19	BM-2-17	IIMR, Hyderabad
5	PRJ-1	IIMR, Hyderabad	20	BM -29-17	IIMR, Hyderabad
6	IEC-217	IIMR, Hyderabad	21	JBM-1	Local Germplasm Collection
7	BM-3-1920	IIMR, Hyderabad	22	JBM-2	Local Germplasm Collection
8	BM-8-1920	IIMR, Hyderabad	23	JBM-3	Local Germplasm Collection
9	BAR-1452	IIMR, Hyderabad	24	JBM-4	Local Germplasm Collection
10	189-1(46)	IIMR, Hyderabad	25	JBM-5	Local Germplasm Collection
11	189-2(47)	IIMR, Hyderabad	26	JBM-6	Local Germplasm Collection
12	BAR 1456	IIMR, Hyderabad	27	JBM-7	Local Germplasm Collection
13	BAR 1446	IIMR, Hyderabad	28	JBM-8	Local Germplasm Collection
14	BAR1012	IIMR, Hyderabad	29	JBM-9	Local Germplasm Collection
15	BAR1396	IIMR, Hyderabad	30	JBM-10	Local Germplasm Collection

Table 2. Genotypic and phenotypic correlation coefficients among yield, yield attributing and quality traits in barnyard millet

		DF	FL	FW	FLA	PEDL	PANL	NPT	DTM	PH	PW	TW	IRON	ZINC	GYP
DF	r_g	1	0.789**	-0.903**	-0.839**	0.522**	-0.565**	0.819**	0.809**	-0.811**	-0.568**	-0.858**	-0.469**	-0.661**	-0.115
	r_p	1	0.775**	-0.892**	-0.828**	0.516**	-0.548**	0.774**	0.800**	-0.779**	-0.564**	-0.852**	-0.468**	-0.658**	-0.105
FL	r_g		1	-0.720*	-0.509**	0.539**	-0.302	0.653**	0.525**	-0.604**	-0.530**	-0.769**	-0.368*	-0.488**	-0.384*
	r_p		1	-0.706**	-0.492*	0.528**	-0.279**	0.619**	0.508**	-0.578**	-0.523**	-0.754**	-0.361**	-0.480**	-0.332**
FW	r_g			1	0.950**	-0.466**	0.700**	-0.783**	-0.661**	0.646**	0.796**	0.936**	0.360	0.618**	0.295
	r_p			1	0.940**	-0.456**	0.674**	-0.735**	-0.644**	0.618**	0.785**	0.921**	0.3566**	0.612**	0.263*
FLA	r_g				1	-0.374*	0.768**	-0.743**	-0.651**	0.575**	0.710**	0.846**	0.3946*	0.655**	0.152
	r_p				1	-0.368**	0.741**	-0.698**	-0.631**	0.553**	0.699**	0.829**	0.388**	0.645**	0.128
PEDL	r_g					1	-0.167	0.443*	0.225	-0.416*	-0.440*	-0.394*	-0.199	-0.263	-0.473**
	r_p					1	-0.164	0.424**	0.215*	-0.400**	-0.436**	-0.388**	-0.195	-0.260*	-0.424**
PANL	r_g						1	-0.549**	-0.404*	0.522**	0.545**	0.579**	0.142	0.445*	0.031
	r_p						1	-0.498**	-0.388**	0.485**	0.529**	0.548**	0.138	0.429**	0.023
NPT	r_g							1	0.595**	-0.618**	-0.526**	-0.752**	-0.338	-0.737**	0.081
	r_p							1	0.553**	-0.567**	-0.492**	-0.710**	-0.317**	-0.693**	0.119
DTM	r_g								1	-0.630**	-0.356	-0.583**	-0.484**	-0.575**	0.023
	r_p								1	-0.588**	-0.353**	-0.575**	-0.480**	-0.566**	0.005
PH	r_g									1	0.331	0.618**	0.4327*	0.511**	-0.062
	r_p									1	0.3196**	0.586**	0.413**	0.493**	-0.060
PW	r_g										1	0.686**	0.184	0.305	0.541**
	r_p										1	0.677**	0.183	0.303**	0.512**
TW	r_g											1	0.373*	0.587**	0.328
	r_p											1	0.370*	0.583**	0.2946**
IRON	r_g												1	0.473**	0.073
	r_p												1	0.470**	0.072
ZINC	r_g													1	-0.058
	r_p													1	-0.056

*, ** Significant at 5% and 1% level of significance, respectively, NS=non-significant r_g = Genotypic correlation coefficient; r_p = Phenotypic correlation coefficient

DF= Days to 50% flowering, FL= Flag leaf length (cm), FW= Flag leaf width (cm), FLA= Flag leaf area (cm), PEDL= Peduncle length (cm), PANL= Panicle length (cm), NPT = Number of productive tillers, DTM= Days to maturity, PH= Plant height (cm), PW= Panicle weight (g), TW= Test weight (g), IRON= Iron content (mg/100g), ZINC= Zinc content (mg/100g), GYP= Grain yield per plant

Table 3. Direct and indirect effect of different quantitative characters on grain yield in barnyard millet

Characters	Days to 50% flowering	Flag leaf length (cm),	Flag leaf width (cm)	Flag leaf area (cm)	Peduncle length (cm)	Panicle length (cm)	Number of productive tillers	Days to maturity	Plant height (cm)	Panicle weight (g)	Test weight (g)
Days to 50% flowering	0.823	-0.326	0.388	-0.030	-0.317	-0.065	0.599	-0.289	0.166	-0.261	-0.803
Flag leaf length (cm)	0.650	-0.413	0.310	-0.018	-0.327	-0.034	0.478	-0.188	0.124	-0.244	-0.720
Flag leaf width (cm)	-0.744	0.298	-0.430	0.034	0.283	0.081	-0.573	0.236	-0.132	0.366	0.876
Flag leaf area (cm)	-0.691	0.210	-0.409	0.036	0.227	0.088	-0.543	0.233	-0.118	0.326	0.791
Peduncle length (cm)	0.430	-0.223	0.200	-0.013	-0.607	-0.019	0.324	-0.080	0.085	-0.202	-0.369
Panicle length (cm)	-0.465	0.125	-0.301	0.028	0.101	0.115	-0.402	0.144	-0.107	0.250	0.542
Number of productive tillers	0.675	-0.270	0.337	-0.027	-0.269	-0.063	0.732	-0.213	0.127	-0.241	-0.704
Days to maturity	0.667	-0.217	0.284	-0.023	-0.137	-0.046	0.435	-0.358	0.129	-0.163	-0.546
Plant height (cm)	-0.668	0.250	-0.278	0.020	0.253	0.060	-0.452	0.225	-0.205	0.152	0.579
Panicle weight (g)	-0.468	0.219	-0.342	0.025	0.267	0.063	-0.385	0.127	-0.068	0.459	0.642
Test weight (g)	-0.707	0.318	-0.402	0.030	0.239	0.067	-0.550	0.209	-0.127	0.315	0.935
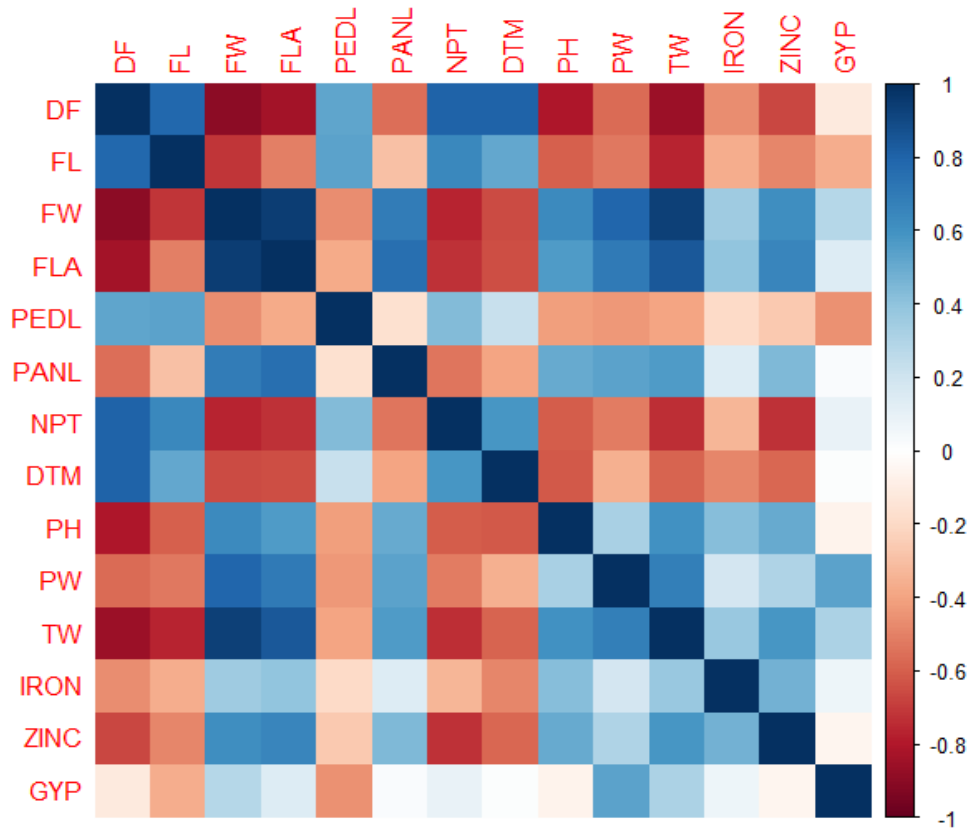
Fig. 1. Correlation between yield and quality traits depicting the amount of association RsStudio team (2016)
http://www.rstudio.com

"Thus, path analysis provides the information about yield components and their relative importance. Since the magnitude of genotypic correlation coefficients was desirable and was found higher than phenotypic correlation coefficients for most of the character pairs, only genotypic correlation coefficients were considered for path analysis". Sood et al., [1].

The direct and indirect contribution of each component character towards grain yield per plant in barnyard millet is presented in Table 3. Test weight (0.935), days to 50% flowering (0.823), number of productive tillers (0.732), panicle weight (0.459), panicle length (0.115) and flag leaf area (0.036) had positive direct effect on grain yield per plant. On the other hand, flag leaf length (-0.413), flag leaf width (-0.430), peduncle length (-0.607), days to maturity (-0.358) and plant height (-0.205) had direct negative effect on the grain yield per plant [18].

4. CONCLUSION

From the above results, it became clear that direct selection based on panicle weight may help in augmenting grain yield in the experimental material, whereas test weight, days to 50% flowering, number of productive tillers, panicle length and flag leaf area are Other most important characters for indirect selection.

It can be concluded that panicle weight is the most important component character in barnyard millet because of its high significant positive association with grain yield, its high direct effect on grain yield and being the most used path by the other component traits contributing positively towards grain yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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