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Assessment of inter-characters associations in the genotypes of finget millet (*Eleusine coracana* L. Gaertn)

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Abstract
The present investigation was conducted during *Kharif*, 2017-18 at the Instructional Farm, College of Agriculture, Junagadh Agricultural University with 30 different genotypes of finger millet. Observations were recorded for growth, yield and seed quality parameters accordingly, phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958). 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. Grain yield per plant had significant and positive correlations both at genotypic and phenotypic levels with number of productive tillers per plant (rg=0.818, rp=0.744), grain weight per main ear (rg=0.814, rp=0.824), biological yield per plant (rg=0.821, rp=0.817), harvest index (rg=0.731, rp=0.468) and chlorophyll content (rg=0.344, rp=0.294). These traits could be considered for grain yield selection. Path coefficient analysis revealed that grain weight per main ear (0.487) had the highest direct positive effect towards the grain yield followed by number of productive tillers per plant (0.383), biological yield per plant (0.226), panicle length (0.196), harvest index (0.193), plant height (0.063), SLW (0.062). The characters identified above merit due consideration in formulating effective selection strategy in finger millet for developing high yielding varieties.

Keywords: correlation, path analysis, finger millet, yield and quality related traits

Introduction
Finger millet (*Eleusine coracana* L. Gaertn) (2n=4x=36) also known as *Ragi*, *Nagli*, *Nachani*, *Mandua*, *Kapai* and *Madua* in different parts of the India (Karnataka, Tamil nadu and Andhra Pradesh). Being rich in protein, iron and calcium finger mill*et al*so referred as 'Nutritional Millet' and serves as an important staple food for rural populations in developing tropical countries where calcium deficiency and anemia are widespread (Babu *et al*. 2007) [5]. Finger millet covers an area of 1194 thousand hectares in India, with a production of 1983 thousand tonnes and productivity of 1661 kg per hectare during 2013-14 (Anon., 2017) [2]. In Gujarat it is cultivated in an area of 20 thousand hectares with a production of 13.9 thousand tonnes and productivity of 695 kg per hectare during 2010-11 (Anon., 2017) [2]. It is mainly cultivated as rainfed crop in *Kharif* in the less fertile hilly soils of Dangs, Valsad, Navsari, Panchamahal and Dahod districts of Gujarat state. It is an important staple food for the traditional consumers and the people belonging to the lower economic strata. It is small seeded minor cereal having light brown to red and also white coloured seed coat with minutely undulated surface.

The crop is performing well under diverse conditions of soil and climate. Finger millet is an erect, tufted annual growing to 60-120 cm height with profuse tillers. The tillers have ear consisting of whorl of finger like spike. The spikelets in spike are arranged closely on both sides of a slender rachis. Flowers are hermaphrodite, alternately arranged on the zigzag rachilla. The terminal ones may be male or sterile. Being cleistogamy flowering nature it leads to self fertilization.

The ultimate expression of yield in crop plants is usually dependent upon the action and interaction of a number of important characters (Elias, 1992) [7]. This is due to the fact that in the integrated plant structure, most of the characters are interrelated with one another and often a change in one is likely to influence the other, so that the net gain obtained by selection of one may be counterbalanced or even negated by a simultaneous change in the other. Correlation, therefore, is helpful in determining the component characters of a complex trait, like yield. 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 present investigation was carried out to assess the correlation and path analysis in finger millet. The study was conducted during *kharif* 2017-18 under three different dates of sowing as early, timely and late at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. This research paper is about timely (16-7-2017) date of sowing. Geographically Junagadh is situated at 21.5^0 N latitude and 70^0 E longitudes with an altitude of 60 meters above the mean sea level. The soil of experimental site was medium black, alluvial in origin and poor in organic matter. The climate of the area represents tropical and semi arid.

The experimental materials consisted of 30 genotypes of finger millet derived from different origins. The genotypes were obtained from the Main Hill Millet Research Station, Waghai, Dangs under Navsari Agricultural University. 30 genotypes of finger millet were sown in Randomized Block Design (RBD) with three replications and three dates of sowing during *kharif* 2017-18. Each genotype was accommodated in a single row of 3m length with a spacing of 30.0 cm. The experiment was surrounded by two meter free distance to avoid damage and border effects. The fertilizers in the experimental area was applied at the rate of 120 kg/ha N, 60 kg/ha P_2O_5 and 40 kg/ha K_2O, as it is a recommended dose for cultivation of finger millet in the region. In each replication and in each plot, five plants were randomly selected and tagged excluding border plants to minimize border effects and average value are used for statistical analysis. Except, days to 50% flowering and days to maturity all the characters studied were recorded on five randomly selected plants per plot. For days to 50% flowering and days to maturity, the observations were recorded for plot basis. All the weights were recorded with the help of a physical balance. Observations were recorded on the following characters. The phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958). The data were subjected to covariance analysis:

a. Genotypic correlation coefficient ($r_{g_{1.2}}$)

$$r_{g1.2} = \frac{Cov_{g1.2}}{\sqrt{\sigma^2_{g_1}\,\sigma^2_{g_2}}}$$

b. Phenotypic correlation coefficient ($r_{p_{1.2}}$)

$$r_{p_{1.2}} = \frac{Cov_{p_{1.2}}}{\sqrt{\sigma^2_{p_1}\,\sigma^2_{p_2}}}$$

The significance of the correlation values at n-2 degrees of freedom was tested by adopting the formula of calculate't' suggested by Panse and Sukhatme (1995) [13].

$$t = \frac{r}{\sqrt{(1-r^2)}} \times \sqrt{(n-2)}$$

Results and Discussion

Correlation coefficient

The correlation coefficients were worked-out among 14 characters to find out association of grain yield per plant with its components as well as association among yield components at genotypic (r_g) and phenotypic (r_p) levels. The data given in Table 1 revealed that, in general, the genotypic correlation coefficients were relatively higher than their corresponding phenotypic correlations. In present study, a very strong positive association of grain yield per plant were observed at both genotypic and phenotypic levels with number of productive tillers per plant (rg=0.818, rp=0.744), grain weight per main ear (rg=0.814, rp=0.824), biological yield per plant (rg=0.821, rp=0.817), harvest index (rg=0.731, rp=0.468) and chlorophyll content (rg=0.344, rp=0.294). The characters SLW (rg=0.087, rp=0.052), flag leaf blade length (rg=0.075, rp=0.124) and flag leaf blade width (rg=0.157, rp=0.151) were found to be non-significant but positively correlated with the grain yield at both the levels. This result is in agreement with results obtained by Arya *et al*. (2017) [4], Bhasker *et al*. (2017) [6], Negi *et al*. (2017) [12] and Singh *et al*. (2018) [14]. Days to 50% flowering had showed significant and positive correlation at both the level with days to maturity (rg= 0.735, rp= 0.668), panicle length (rg= 0.508, rp= 0.399), chlorophyll content (rg= 0.704, rp= 0.571), number of fingers on main ear (rg= 0.439, rp= 0.317) and flag leaf blade width (rg= 0.626, rp= 0.460). This result is in agreement with results obtained by Muduli *et al*. (2012) [11], Eric *et al.* (2016) [8], Arya *et al*. (2017) [4] and Singh *et al*. (2018) [14]. Days to maturity had significant and positive correlations both at genotypic and phenotypic levels with panicle length (rg=0.742, rp=0.645), chlorophyll content (rg=0.393, rp=0.358) and number of fingers on main ear (rg=0.667, rp=0.510).

Plant height had significant and positive correlation at both the levels with flag leaf blade length (rg=0.413, rp=0.320). Number of productive tillers per plant had significant and positive correlation at both the levels with biological yield per plant (rg=0.481, rp=0.471) and harvest index (rg=0.801, rp=0.530), while it showed significant and positive correlation at genotypic level with grain weight per main ear (rg=0.333) and SLW (rg=0.324). This result is in agreement with results obtained by Wolie and Dessalegn (2011) [15], Anuradha *et al*. (2013), Bhasker *et al*. (2017) [6] and Singh *et al*. (2018) [14]. Panicle length had significant and positive correlation at both the levels with chlorophyll content (rg=0.525, rp=0.418) and number of fingers on main ear (rg=0.797, rp=0.675), while showed non-significant and positive correlation at both the levels with harvest index (rg=0.034, rp=0.030) and flag leaf blade width (rg=0.111, rp=0.125). This result is in agreement with results obtained by Wolie and Dessalegn (2011) [15], Muduli *et al*. (2012) [11], Eric *et al.* (2016) [8], Arya *et al*. (2017) [4] and Bhasker *et al*. (2017)) [6]. Grain weight per main ear had significant and positive correlation genotypic as well as phenotypic levels with biological yield per plant (rg=0.871, rp=0.798), harvest index (rg=0.815, rp=0.360) and flag leaf blade width (rg=0.372, rp=0.262). Biological yield per plant had significant and positive correlation at both genotypic and phenotypic levels with chlorophyll content (rg=0.317, rp=0.291) and flag leaf blade length (rg=0.566, rp=0.404). Harvest index had significant and positive correlation at both genotypic and phenotypic levels with SLW (rg=0.314,

rp=0.256). SLW had significant and positive correlation at both the levels with chlorophyll content (rg=0.439, rp=0.268), while flag leaf blade width (rp=0.362) showed significant and positive correlation at phenotypic level. Chlorophyll content had significant and positive correlation at both genotypic and phenotypic levels with number of fingers on main ear (rg=0.404, rp=0.346). The flag leaf blade length had significant and positive correlation at phenotypic level with flag leaf blade width (rp=0.310). This result is in agreement with results obtained by Bhasker *et al*. (2017) [6], Negi *et al*. (2017) [12] and Singh *et al*. (2018) [14].

Path coefficient analysis

Path coefficient analysis is a tool to partition the observed correlation coefficient in direct and indirect effects of yield components on grain yield to provide clear picture of character associations for formulating efficient selection strategy. Total fourteen characters were considered for path coefficient analysis.

Direct effect

It is evident from the data presented in Table-2 that positive direct genetic effect were observed with grain weight per main ear (0.487) had the highest direct positive effect towards the grain yield followed by number of productive tillers per plant (0.383), biological yield per plant (0.226), panicle length (0.196), harvest index (0.193), plant height (0.063), SLW (0.062). Ganapathy *et al*. (2011) [9], Kumar *et al*. (2014) [10], Eric *et al.* (2016) [8], Negi *et al.* (2017) [12] and Singh *et al.* (2018) [14].

Indirect effect

Days to 50% flowering showed positive indirect effect via panicle length (0.100), harvest index (0.069), 1000 seed weight (0.066), number of productive tillers per plant (0.020), SLW (0.015), flag leaf blade length (0.002). Days to maturity showed positive indirect effect via panicle length (0.145), 1000 seed weight (0.030), harvest index (0.027), SLW (0.015), number of productive tillers per plant (0.015), plant height (0.014) and flag leaf blade length (0.002). Plant height showed positive indirect effect via flag leaf blade length (0.004), days to 50% flowering (0.001) and chlorophyll content (0.001). Number of productive tillers per plant showed positive indirect effect via grain weight per main ear (0.162), harvest index (0.155), biological yield per plant (0.109), SLW (0.020) flag leaf blade width (0.007), chlorophyll content (0.004), number of fingers on main ear |(0.002) and flag leaf blade length (0.002). Panicle length showed positive indirect effect via harvest index (0.007), 1000 seed weight (0.006) and flag leaf blade length (0.004). Grain weight per main ear showed positive indirect effect via biological yield per plant (0.197), number of productive tillers per plant (0.128), harvest index (0.075), days to maturity (0.036), 1000 seed weight (0.027), number of fingers on main ear (0.003) and days to 50% flowering (0.001). Biological yield per plant showed positive indirect effect via grain weight per main ear (0.424), number of productive tillers per plant (0.185), harvest index (0.040), days to maturity (0.032), days to 50% flowering (0.009) number of fingers on main ear (0.003) and 1000 seed weight (0.001). Harvest index showed positive indirect effect via number of productive tillers per plant (0.307), grain weight per main ear (0.189), biological yield per plant (0.047), 1000 seed weight (0.033), SLW (0.019), panicle length (0.007), flag leaf blade length (0.008) and number of fingers on main ear (0.002). 1000 seed weight showed positive indirect effect via days to maturity (0.049), chlorophyll content (0.036), flag leaf blade width (0.028), days to 50% flowering (0.027), plant height (0.017) and SLW (0.012). SLW SLW showed positive indirect effect via number of productive tillers per plant (0.124), harvest index (0.061) and chlorophyll content (0.030). Chlorophyll content showed positive indirect effect via grain weight per main ear (0.301), panicle length (0.103), biological yield per plant (0.072), harvest index (0.040) and 1000 seed weight (0.038). The number of fingers on main ear showed positive indirect effect via panicle length (0.156) and plant height (0.011). Flag leaf blade length showed positive indirect effect via biological yield per plant (0.128), grain weight per main ear (0.102), plant height (0.026), 1000 seed weight (0.037), days to maturity (0.020), days to 50% flowering (0.006) and chlorophyll content (0.003). Flag leaf blade width showed positive indirect effect via grain weight per main ear (0.181), 1000 seed weight (0.055), biological yield per plant (0.042) SLW (0.027), panicle length (0.022), harvest index (0.018).

Conclusions

The study has provided crucial information on character association and path analysis in finger millet. 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 number of productive tillers per plant, grain weight per main ear, biological yield per plant, harvest index. The genotypic path coefficient analysis revealed that the number of productive tillers per plant and grain weight per main ear exhibited high and positive direct effects on grain yield per plant, while biological yield per plant exhibited moderate and positive direct effects on grain yield per plant.

Table 1: Genotypic (rg) and phenotypic (rp) correlation coefficients among 14 characters in 30 genotypes of finger millet

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Grain weight per main ear (g)	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	SLW	Chlorophyll content	Number of fingers on main ear	Flag leaf blade length (cm)	Flag leaf blade width (cm)
Grain yield per plant	r_g	-0.021	-0.142	-0.322*	0.818**	-0.140	0.814**	0.821**	0.731**	-0.161	0.087	0.344*	-0.606**	0.075	0.157
	r_p	-0.017	-0.107	-0.116	0.744**	-0.123	0.824**	0.817**	0.468**	-0.156	0.052	0.294*	-0.302*	0.124	0.151
Days to 50% flowering	r_g		0.735**	-0.041	0.051	0.509**	-0.035	-0.269*	0.355**	-0.815**	0.240	0.704**	0.439**	-0.173	0.626**
	r_p		0.668**	-0.113	0.061	0.399**	-0.051	-0.118	0.179	-0.450**	0.173	0.571**	0.317*	-0.121	0.460**
Days to maturity	r_g			0.214	0.038	0.742**	-0.277*	-0.245	0.139	-0.376**	0.241	0.393**	0.677**	-0.149	0.235
	r_p			0.090	0.084	0.645**	-0.227	-0.166	0.105	-0.244	0.188	0.358**	0.510**	-0.094	0.198
Plant height (cm)	r_g				-0.280*	-0.003	-0.234	-0.123	-0.385**	0.265*	-0.183	-0.009	0.177	0.413**	-0.105
	r_p				-0.223	0.035	0.020	0.047	-0.257*	0.099	-0.126	0.025	0.184	0.320*	-0.030
Number of productive tillers per plant	r_g					-0.009	0.333*	0.481**	0.801**	0.002	0.324*	-0.058	-0.405**	-0.117	-0.177
	r_p					-0.039	0.247	0.471**	0.530**	-0.029	0.214	-0.008	-0.304*	-0.034	-0.078
Panicle length (cm)	r_g						-0.259*	-0.233	0.034	-0.070	-0.107	0.525**	0.797**	-0.282*	0.111
	r_p						-0.170	-0.163	0.030	-0.045	-0.108	0.418**	0.675**	-0.203	0.125
Grain weight per main ear (g)	r_g							0.871**	0.389**	-0.335*	-0.148	0.619**	-0.566**	0.210	0.372**
	r_p							0.798**	0.232	-0.215	-0.087	0.443**	-0.184	0.196	0.262*
Biological yield per plant (g)	r_g								0.206	-0.011	-0.080	0.317*	-0.496**	0.566**	0.186
	r_p								-0.114	-0.106	-0.088	0.291*	-0.137	0.404**	0.148
Harvest index (%)	r_g									-0.404**	0.314*	0.206	-0.370**	-0.573**	0.094
	r_p									-0.194	0.256*	0.075	-0.292*	-0.377**	0.088
1000 seed weight (g)	r_g										0.189	-0.474**	-0.075	-0.457**	-0.677**
	r_p										0.190	-0.286*	-0.120	-0.250	-0.338*
SLW	r_g											-0.401**	-0.443**	-0.231	0.443**
	r_p											-0.301*	-0.355**	-0.202	0.266*
Chlorophyll content	r_g												0.404**	-0.035	0.240
	r_p												0.346*	0.006	0.244
Number of fingers on main ear	r_g													-0.084	-0.026
	r_p													-0.051	0.027
Flag leaf blade length(cm)	r_g														0.177
	r_p														0.310*

*, ** significant at 5%and 1% levels, respectively.

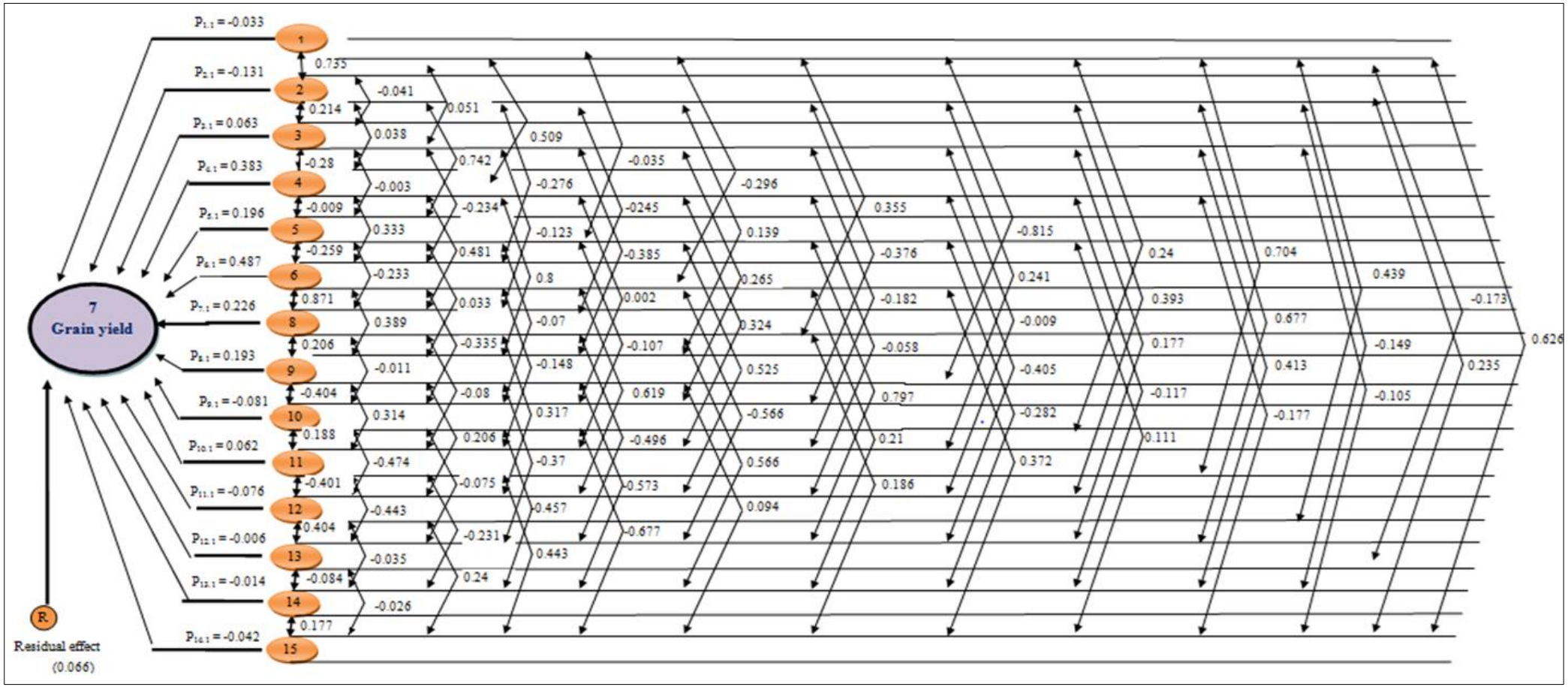
Note: Here, rg > 1.0, may be due to subtraction effect arises from sampling error (Sharma, 2008).

Table 2: Genotypic Path coefficient analysis showing direct (Diagonal and Bold) and indirect effect of different characters on grain yield in finger millet

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Grain weight per main ear (g)	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	SLW	Chlorophyll content	Number of fingers on main ear	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Genotypic correlation with seed yield/plant
Days to 50% flowering	-0.034	-0.096	-0.003	0.020	0.100	-0.017	-0.061	0.069	0.066	0.015	-0.053	-0.003	0.002	-0.026	-0.021
Days to maturity	-0.025	-0.131	0.014	0.015	0.145	-0.135	-0.055	0.027	0.030	0.015	-0.030	-0.004	0.002	-0.010	-0.142
Plant height (cm)	0.001	-0.028	0.063	-0.107	-0.001	-0.114	-0.028	-0.074	-0.021	-0.011	0.001	-0.001	-0.006	0.004	-0.322*
Number of productive tillers per plant	-0.002	-0.005	-0.018	0.383	-0.002	0.162	0.109	0.155	0.000	0.020	0.004	0.002	0.002	0.007	0.818**
Panicle length(cm)	-0.017	-0.097	0.000	-0.004	0.196	-0.126	-0.053	0.007	0.006	-0.007	-0.040	-0.005	0.004	-0.005	-0.140
Grain weight per main ear (g)	0.001	0.036	-0.015	0.128	-0.051	0.487	0.197	0.075	0.027	-0.009	-0.047	0.003	-0.003	-0.016	0.814**
Biological yield per plant (g)	0.009	0.032	-0.008	0.185	-0.046	0.424	0.226	0.040	0.001	-0.005	-0.024	0.003	-0.008	-0.008	0.821**
Harvest index (%)	-0.012	-0.018	-0.024	0.307	0.007	0.189	0.047	0.193	0.033	0.019	-0.016	0.002	0.008	-0.004	0.731**
1000 seed weight (g)	0.027	0.049	0.017	0.001	-0.014	-0.163	-0.002	-0.078	-0.081	0.012	0.036	0.000	0.006	0.028	-0.161

SLW	-0.008	-0.032	-0.012	0.124	-0.021	-0.072	-0.018	0.061	-0.015	0.062	0.030	0.003	0.003	-0.018	0.087
Chlorophyll content	-0.024	-0.051	-0.001	-0.022	0.103	0.301	0.072	0.040	0.038	-0.025	-0.076	-0.002	0.001	-0.010	0.344*
Number of fingers on main ear	-0.015	-0.089	0.011	-0.155	0.156	-0.276	-0.112	-0.072	0.006	-0.027	-0.031	-0.006	0.001	0.001	-0.606
Flag leaf blade length (cm)	0.006	0.020	0.026	-0.045	-0.055	0.102	0.128	-0.111	0.037	-0.014	0.003	0.001	-0.014	-0.007	0.075
Flag leaf blade width (cm)	-0.021	-0.031	-0.007	-0.068	0.022	0.181	0.042	0.018	0.055	0.027	-0.018	0.000	-0.003	-0.042	0.157

Residual effect = 0.066



1. Days to 50% flowering, 2. Days to maturity, 3. Plant height, 4. Number of productive tillers per plant, 5. Panicle length, 6. Grain weight per main ear, 7. Grain yield per plant, 8. Biological yield per plant, 9. Harvest index, 10. 1000 seed weight, 11. SLW, 12. Chlorophyll content, 13. Number of fingers on main ear, 14. Flag leaf blade length, 15. Flag leaf blade width)

Fig 1: Diagrammatic representation of genotypic path analysis in finger millet

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