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Gohel DS
College of Agriculture, JAU, Junagadh, Gujarat, India

Chaudhari SB
Assistant Research Scientist, Genetics & Plant Breeding, JAU, Junagadh, Gujarat, India

Correspondence
Gohel DS
College of Agriculture, JAU, Junagadh, Gujarat, India

Study of correlation and path analysis of finger millet genotypes (*Eleusine coracana* L. *Gaertn*)

Gohel DS and Chaudhari SB

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 weight per main ear (rg=0.847, rp=0.831), harvest index (rg=0.883, rp=0.697), number of productive tillers per plant (rg=0.795, rp=0.685), biological yield per plant (rg=0.463, rp=0.434) and panicle length (rg=0.318, rp=0.294) positive association towards grain yield per plant at phenotypic and genotypic level. These traits could be considered for grain yield selection. Path coefficient analysis revealed that grain weight per main ear (0.534) had the highest direct positive effect towards the grain yield followed by number of productive tillers per plant (0.353), panicle length (0.166), days to flowering (0.133), harvest index (0.124), biological yield per plant (0.081), leaf blade length (0.011). 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) [2]. 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) [3]. 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) [3]. 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, climate and moisture. 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. Flowering takes place simultaneously in all fingers. 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.
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 present investigation was carried out to assess the correlation and path analysis in finger millet. The study was conducted during *kharif* 2017-18 at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. 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 3 m 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 ($r_{g_{1.2}}$)

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

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

$$\mathbf{r_{p1.2}} = \frac{\mathbf{Cov_{p1.2}}}{\sqrt{\boldsymbol{\sigma}^2_{\mathbf{p_1}}\,\boldsymbol{\sigma}^2_{\mathbf{p_2}}}}$$

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).

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

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. The results on correlation coefficients between different pairs of characters are presented**:** The grain yield per plant had significant and positive correlations at both genotypic and phenotypic levels with grain weight per main ear (rg=0.847, rp=0.831), harvest index (rg=0.883, rp=0.697), number of productive tillers per plant (rg=0.795, rp=0.685), biological yield per plant (rg=0.463, rp=0.434) and panicle length (rg=0.318, rp=0.294). This character showed non-significant and positive correlation at both the levels with days to 50% flowering (rg=0.196, rp=0.206), 1000 seed weight (rg=0.167, rp=0.079), number of fingers on main ear (rg=0.034, rp=0.138) and flag leaf blade length (rg=0.010, rp=0.097) This result is in agreement with results obtained by Arya *et al*. (2017) [4], Bhasker *et al*. (2017) [5], Negi *et al*. (2017) [6] and Singh *et al*. (2018) [7]. Days to 50% flowering had significant and positive correlation at both the levels with days to maturity (rg= 0.874, rp= 0.695), panicle length (rg= 0.694, rp= 0.604), harvest index (rg= 0.531, rp= 0.272), SLW (rg= 0.394, rp= 0.285), chlorophyll content (rg= 0.614, rp= 0.429) and number of fingers on main ear (rg= 0.855, rp= 0.682), while it had non-significant but positive correlations both at genotypic and phenotypic levels with number of productive tillers per plant (rg=0.035, rp=0.052) and grain weight per main ear (rg=0.250, rp=0.211) This result is in agreement with results obtained by Muduli *et al*. (2012) [8], Eric *et al.* (2016) [9], Arya *et al*. (2017) [4] and Singh *et al*. (2018) [7]. Days to maturity had significant and positive correlation with panicle length (rg=0.628, rp=0.543), SLW (rg=0.544, rp=0.354), harvest index (rg=0.497, rp=0.304), chlorophyll content (rg=0.497, rp=0.288) and number of fingers on main ear (rg=0.678, rp=0.550) at both the levels. This character showed significant and positive correlation with flag leaf blade width (rp=0.600) at phenotypic level. Plant height had significant and positive correlation at both the levels with biological yield per plant (rg=0.881, rp=0.438), 1000 seed weight (rg=0.578, rp=0.367) and flag leaf blade length (rg=0.683, rp=0.274). Number of productive tillers per plant had significant and positive correlation both at genotypic and phenotypic levels with harvest index (rg=0.869, rp=0.598) This result is in agreement with results obtained by Wolie and Dessalegn (2011) [11], Anuradha *et al*. (2013) [10], Bhasker *et al*. (2017) [5] and Singh *et al*. (2018) [7]. 1000 seed weight (rg=0.042) and flag leaf blade width (rg=0.075) showed non-significant and positive correlation at genotypic level, while grain weight per main ear (rg=0.351) had significant and positive correlation with grain yield at genotypic level. Panicle length had significant and positive correlation both at genotypic and phenotypic levels with harvest index (rg=0.631, rp=0.460), SLW (rg=0.503, rp=0.402), chlorophyll content (rg=0.456, rp=0.313) and number of fingers on main ear (rg=0.698, rp=0.576), while this character showed significant and positive correlation with grain yield at genotypic level with flag leaf blade length (rg=0.350) and showed significant and positive correlation at phenotypic level with flag leaf blade width (rp=0.503) This result is in agreement with results obtained by Wolie and Dessalegn (2011) [11], Muduli *et al*. (2012) [8], Eric *et al.* (2016) [9], Arya *et al*. (2017) [4] and Bhasker *et al*. (2017)) [4]. Grain weight per main ear had significant and positive correlation at both genotypic and phenotypic levels with biological yield per plant (rg=0.523, rp=0.506) and harvest index (rg=0.623, rp=0.482). Biological yield per plant had significant and positive correlation at both genotypic and phenotypic level with 1000 seed weight (rg=1.020, rp=0.419), whereas flag leaf blade length (rg=0.605) had significant and positive correlation at genotypic level, while harvest index (rp=0.303) had significant and positive correlation at phenotypic level. Harvest index had significant and positive correlation at both genotypic and phenotypic levels with number of fingers on main ear (rg=0.485, rp=0.284). 1000 seed weight had

significant and positive correlation at genotypic level with flag leaf blade length (rg= 0.280) and flag leaf blade width (rg= 0.384). SLW had significant and positive correlation at genotypic level with number of fingers on main ear (rg=0.284) and negative for flag leaf blade width (rg= -0.905). This character showed 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=0.373, rp=0.357), while it had significant and positive correlation at phenotypic level with flag leaf blade width (rp=0.355). Number of fingers on main ear had significant and positive correlation at phenotypic level with flag leaf blade width (rp=0.436) had significant and positive correlation at phenotypic level. The flag leaf blade length had positive and significant correlation at both genotypic and phenotypic levels with flag leaf blade width (rg=0.458, rp=0.420) respectively This result is in agreement with results obtained by Bhasker *et al*. (2017) [4], Negi *et al*. (2017) [6] and Singh *et al*. (2018) [7].

Path coefficient analysis

The genotypic correlation coefficients calculated for different pairs of character were subjected to path coefficient analysis for partitioning these values into the direct and indirect effects. Total fourteen characters were considered for path coefficient analysis.

Direct effect

The data revealed that grain weight per main ear (0.534) had the highest direct positive effect towards the grain yield followed by number of productive tillers per plant (0.353), panicle length (0.166), days to flowering (0.133), harvest index (0.124), biological yield per plant (0.081), leaf blade length (0.011). Ganapathy *et al.* (2011) [12], Kumar *et al.* (2014) [13], Eric *et al.* (2016) [9], Negi *et al.* (2017) [6] and Singh *et al.* (2018) [7].

Indirect effect

Days to 50% flowering showed positive indirect effect via grain weight per main ear (0.134), panicle length (0.115), harvest index (0.066), flag leaf blade width (0.053), 1000 seed weight (0.029), plant height (0.015), number of productive tillers per plant (0.012). Days to maturity showed positive indirect effect via days to 50 % flowering (0.116), panicle length (0.104), harvest index (0.062), flag leaf blade width (0.060), 1000 seed weight (0.038) and plant height (0.022). Plant height showed positive indirect effect via number of fingers on main ear (0.084), biological yield per plant (0.071), days to maturity (0.050), SLW (0.033), chlorophyll content (0.018) and flag leaf blade length (0.007). Number of productive tillers per plant showed positive indirect effect via grain weight per main ear (0.187), harvest index (0.108), number of fingers on main ear (0.030), chlorophyll content (0.035), SLW (0.024), days to maturity (0.014), plant height (0.006), biological yield per plant (0.006) and days to 50 % flowering (0.005). Panicle length showed positive indirect effect via grain weight per main ear (0.104), days to 50% flowering (0.092), harvest index (0.078), number of productive tillers per plant (0.075), flag leaf blade width (0.062), 1000 seed weight (0.021) plant height (0.015) and Flag leaf blade length (0.004). Grain weight per main ear showed positive indirect effect via number of productive tillers per plant (0.124), harvest index (0.077), biological yield Per plant (0.050), days to 50% flowering (0.033), panicle length (0.032), days to maturity (0.019), flag leaf blade width (0.013) and SLW (0.011). Biological yield per plant showed positive indirect effect via grain weight per main ear (0.332), number of fingers on main ear (0.111), days to maturity (0.079), number of productive tillers per plant (0.028) SLW (0.011), flag leaf blade length (0.007) and harvest index (0.003) Harvest index showed positive indirect effect via grain weight per main ear (0.332), panicle length (0.104), number of productive tillers per plant (0.306), days to 50% flowering (0.071), plant height (0.022), flag leaf blade width (0.015), SLW (0.010) chlorophyll content (0.003) and biological yield per plant (0.002). 1000 seed weight showed positive indirect effect via number of fingers on main ear (0.154*)*, grain weight per main ear (0.112), biological yield per plant (0.082), days to maturity (0.062), chlorophyll content (0.032), SLW (0.019) number of productive tillers per plant (0.015) and flag leaf blade length (0.003). SLW showed positive indirect effect via panicle length (0.083), days to 50% flowering (0.052), flag leaf blade width (0.047) and plant height (0.016), 1000 seed weight (0.013) and flag leaf blade length (0.001). Chlorophyll content showed positive indirect effect via days to 50% flowering (0.082), panicle length (0.075), flag leaf blade width (0.050), grain weight per main ear (0.042), biological yield per plant (0.014), 1000 seed weight (0.008), plant height (0.003) and flag leaf blade length (0.002). The number of fingers on main ear showed positive indirect effect via panicle length (0.116), days to 50% flowering (0.114), grain weight per main ear (0.076), harvest index (0.060), 1000 seed weight (0.035), flag leaf blade width (0.035) and plant height (0.013). Flag leaf blade length showed positive indirect effect via panicle length (0.058), biological yield per plant (0.049), number of fingers on main ear (0.049), days to maturity (0.025), grain weight per main ear (0.006). Flag leaf blade width showed positive indirect effect via chlorophyll content (0.157), number of fingers on main ear (0.122), days to maturity (0.078), SLW (0.054), number of productive tillers per plant (0.026), biological yield per plant (0.008) and flag leaf blade length (0.005).

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 number of productive tillers per plant, grain weight per main ear, biological yield per plant and harvest index with grain yield. 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.

Table 1: Genotypic (r_g) and phenotypic (r_p) correlation coefficients among different characters in 30 genotypes of finger millet

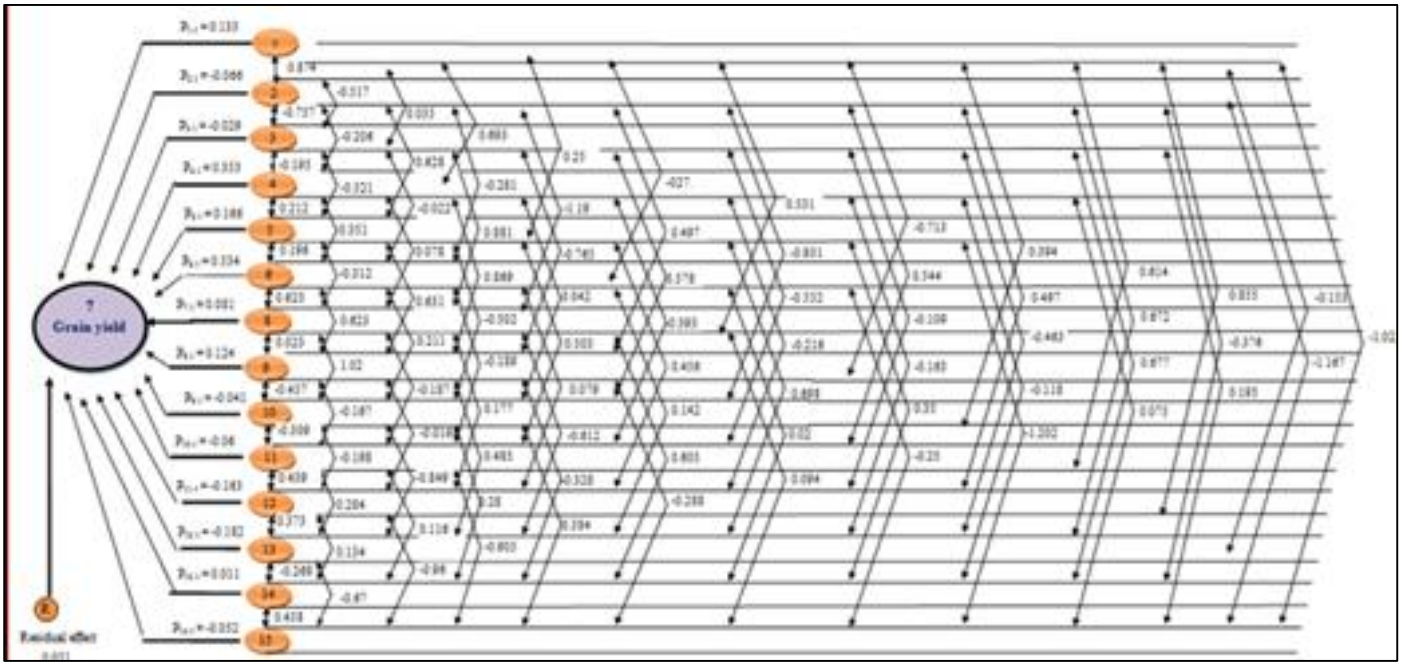
Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Grain weight per main ear (g)	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	SLW	Chlorophyll content	Number of fingers on main ear	Flag leaf blade length (cm)	Flag leaf blade width (cm)
Grain yield per plant	r_g	0.196	-0.223	-0.129	0.795**	0.318*	0.847**	0.463**	0.883**	0.167	-0.283*	-0.093	0.034	0.010	-0.128
	r_p	0.206	-0.134	-0.054	0.685**	0.294*	0.831**	0.434**	0.697**	0.079	-0.111	-0.071	0.138	0.097	0.158
Days to 50% flowering	r_g		0.874**	-0.517**	0.035	0.693**	0.250	-0.270*	0.531**	-0.713**	0.394**	0.614**	0.855**	-0.153	-1.023**
	r_p		0.695**	-0.336*	0.052	0.604**	0.211	-0.112	0.428**	-0.591**	0.285*	0.429**	0.682**	-0.055	0.539**
Days to maturity	r_g			-0.757**	-0.206	0.628**	-0.282*	-1.191**	0.497**	-0.931**	0.544**	0.497**	0.672**	-0.376**	-1.167**
	r_p			-0.519**	-0.186	0.543**	-0.089	-0.510**	0.304*	-0.648**	0.354**	0.288*	0.546**	-0.019	0.600**
Plant height (cm)	r_g				-0.195	-0.521**	-0.022	0.881**	-0.766**	0.578**	-0.552**	-0.109	-0.463**	0.677**	0.195
	r_p				-0.120	-0.377**	0.031	0.438**	-0.458**	0.367**	-0.303*	-0.033	-0.202	0.274*	-0.080
Number of productive tillers per plant	r_g					0.212	0.351**	0.078	0.869**	0.042	-0.393**	-0.216	-0.163	-0.118	0.075
	r_p					0.152	0.179	0.111	0.598**	-0.036	-0.287*	-0.122	-0.108	-0.151	-0.086
Panicle length (cm)	r_g						0.196	-0.312*	0.631**	-0.503**	0.503**	0.456**	0.698**	0.350**	-1.202**
	r_p						0.207	-0.114	0.460**	-0.372**	0.402**	0.313*	0.576**	0.196	0.503**
Grain weight per main ear (g)	r_g							0.623**	0.623**	0.211	-0.189	0.079	0.142	0.010	-0.250
	r_p							0.506**	0.482**	0.143	0.021	-0.003	0.231	0.194	0.231
Biological yield per plant (g)	r_g								0.023	1.020**	-0.187	0.177	-0.612**	0.605**	0.094
	r_p								-0.303*	0.419**	-0.035	0.108	-0.075	0.240	0.083
Harvest index (%)	r_g									-0.457**	-0.167	-0.016	0.485**	-0.328*	-0.288*
	r_p									-0.289*	-0.055	-0.028	0.284*	-0.066	0.134
1000 seed weight (g)	r_g										-0.309*	-0.198	-0.849**	0.280*	0.384**
	r_p										-0.160	-0.186	-0.641**	0.119	-0.291*
SLW	r_g											0.439**	0.284*	0.116	-0.905**
	r_p											0.268*	0.238	0.170	0.362**
Chlorophyll content	r_g												0.373**	0.134	-0.960**
	r_p												0.357**	0.056	0.335*
Number of fingers on main ear	r_g													-0.269*	-0.670**
	r_p													0.078	0.436**
Flag leaf blade length(cm)	r_g														0.458**
	r_p														0.420**

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

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	0.133	-0.058	0.015	0.012	0.115	0.134	-0.022	0.066	0.029	-0.024	-0.100	-0.122	-0.002	0.053	0.196
Days to maturity	0.116	-0.066	0.022	-0.073	0.104	-0.150	-0.096	0.062	0.038	-0.033	-0.081	-0.122	-0.004	0.060	-0.223
Plant height (cm)	-0.069	0.050	-0.029	-0.069	-0.086	-0.012	0.071	-0.095	-0.024	0.033	0.018	0.084	0.007	-0.010	-0.129
Number of productive tillers per plant	0.005	0.014	0.006	0.353	0.035	0.187	0.006	0.108	-0.002	0.024	0.035	0.030	-0.001	-0.004	0.795**
Panicle Length (cm)	0.092	-0.042	0.015	0.075	0.166	0.104	-0.025	0.078	0.021	-0.030	-0.074	-0.127	0.004	0.062	0.318*
Grain weight per main ear (g)	0.033	0.019	0.001	0.124	0.032	0.534	0.050	0.077	-0.009	0.011	-0.013	-0.026	0.000	0.013	0.847**
Biological yield per plant (g)	-0.036	0.079	-0.026	0.028	-0.052	0.332	0.081	0.003	-0.042	0.011	-0.029	0.111	0.007	-0.005	0.463**
Harvest index (%)	0.071	-0.033	0.022	0.306	0.104	0.332	0.002	0.124	0.019	0.010	0.003	-0.088	-0.004	0.015	0.883**
1000 seed weight (g)	-0.095	0.062	-0.017	0.015	-0.083	0.112	0.082	-0.057	-0.041	0.019	0.032	0.154	0.003	-0.020	0.167
SLW	0.052	-0.036	0.016	-0.138	0.083	-0.101	-0.015	-0.021	0.013	-0.060	-0.072	-0.052	0.001	0.047	-0.283*
Chlorophyll content	0.082	-0.033	0.003	-0.076	0.075	0.042	0.014	-0.002	0.008	-0.026	-0.163	-0.068	0.002	0.050	-0.093
Number of fingers on main ear	0.114	-0.045	0.013	-0.058	0.116	0.076	-0.049	0.060	0.035	-0.017	-0.061	-0.182	-0.003	0.035	0.034
Flag leaf blade length (cm)	-0.020	0.025	-0.020	-0.042	0.058	0.006	0.049	-0.041	-0.011	-0.007	-0.022	0.049	0.011	-0.024	0.010
Flag leaf blade width (cm)	-0.136	0.078	-0.006	0.026	-0.199	-0.134	0.008	-0.036	-0.016	0.054	0.157	0.122	0.005	-0.052	-0.128

Residual effect = 0.051



(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 widt**h)**

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

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