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Correlation and Path Analysis for Grain Yield and its component Traits in Finger Millet (*Eleusine coracana* L.)

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ABSTRACT: Finger millet is famine reserve crop and lacks high yielding varieties. The current investigation for correlation and path analysis in finger millet was done using 101 genotypes and sixteen parameters. Grain yield per plant was found to be highly significant and positively correlated with days to 50 % flowering, plant height, main ear head length, finger width, finger length, 1000 seed weight, fodder yield per plant, harvest index, calcium content and iron content. Direct positive selection for such characters would be effective for improving grain yield per plant. Path coefficient analysis revealed that for improving yield in finger millet, weightage in selection should be given to harvest index, fodder yield per plant, fingers per earhead, finger length, iron content and calcium content. Selecting for above traits in segregating generations can result in high yielding varieties.

Keywords: Correlation, Path analysis, Grain yield, Direct and indirect effect.

INTRODUCTION

Finger millet is annual crop which belongs to grass family Poaceae. It is largely consumed as food, fodder and feed. Special ability of millets like adaptation to poor, degraded grounds and their ability to withstand abiotic stress have led to millet crop cultivation for more than 5000 years and are grown in many states (Gowda *et al.*, 2006). Finger millet is highly self-pollinated crop with chromosome number of 2n = 4X = 36. The most economically significant of these at present is finger millet, but the other small millets like little millet, barnyard millet, proso millet, foxtail millet, and kodo millet are also have their own importance to the tribal farmers who grow them (Patil *et al*., 2018). It is cultivated mostly as a rainfed crop in India for its valued food grains. Finger millet is widely recognised as "poor people's crop" in many countries and is grown by a huge number of small farmers with little water resources. It is grown in semi-arid regions of South Asia, Eastern Africa, and Southern Africa, where it provides a staple meal for millions of underprivileged people (Vasisth *et al*., 2022). It was presumably brought to India more than three thousand years ago at a very early age. Finger millet grain is the ideal food grain for locations that are prone to famine because it can be stored for years without being infested by storage pests. Grains provide 8-10 times more calcium than that of rice and wheat (Sharma *et al*., 2022). Although grains are consumed by humans, crop wastes are a great supply of dry matter for animals, particularly during the dry season but when used as fodder, finger millet straw can contain up to 61% of the entire amount of nutrients that are digestible.

Estimates of the degree of relationship between the yield and its various components as well as between the components would be provided through studies of correlation. Given that yield was dependent on inheritance owing to its polygenic character, understanding the degree of genetic linkage between them would be helpful in isolating the genotypes that would provide the greatest yield. The path coefficient analysis provides a more realistic picture of the association by taking into consideration both the direct as well as indirect effects of the variables by splitting the correlation coefficients from dependent components into independent variables. A polygenic trait like grain yield is affected by its numerous components both directly and indirectly through other characteristics, which presents a breeder with a challenging decision-making scenario. As a result, path coefficient analysis, which partitions the correlation coefficient into both the direct and indirect effects of the variables, may present a more accurate picture of the interaction. Thus, looking to importance offered by correlation studies and path analysis, goal of the current experiment was to examine the correlation and path coefficient analysis in 101 genotypes of finger millet.

MATERIALS AND METHODS

The current investigation was carried out at two location *viz*., Hill Millet Research Station, NAU, Waghai, The Dangs and College Farm, N. M. College of Agriculture, NAU, Navsari during *Kharif* - 2021 for two different dates of sowing within a gap of one month essentially creating four environments utilizing 101 genotypes of finger millet sown in RBD design in three replication. Five competing plants chosen at random from each single row plot in each replication, ignoring the border, various observations were made, with the exception of the days to 50% flowering and the days to maturity, which were recorded on a population basis.

The following estimates of covariances were worked out as reviewed by Panse and Sukhatme (1978).

$$\sigma_{p_i p_j} = \sigma_{g_i g_j} + \sigma_{e_i e_j}$$

Where,

$\sigma_{p_i p_j}$ = Phenotypic covariance between i^{th} and j^{th} character

$\sigma_{g_i g_j}$ = Genotypic covariance between i^{th} and j^{th} character

$\sigma_{e_i e_j}$ = Environmental covariance between i^{th} and j^{th} character

The genotypic correlation is chiefly caused by pleiotropy and linkage action of genes and correlation coefficient was estimated as well as genetic and environmental causes of correlation combined together gives phenotypic correlation coefficient and were estimated with help of following formula which was suggested by Hazel *et al*. (1943). The significance of the correlation coefficient values for n – 2 degrees of freedom was done by calculating the 't' value using following formula described by Panse and Sukhatme (1985). The path coefficient analysis was carried-out according to the method suggested by Wright (1921) and used by Dewey and Lu (1959). Genotypic correlation coefficients of 15 variables with grain yield were used to estimate the path coefficients for the direct effects of various independent characters on grain yield per plant.

RESULTS AND DISCUSSION

In plant breeding, the correlation coefficients between the attributes are very important. It is a tool that may be used for indirect selection. The breeder can get an overview of the components of the yield *via* correlation studies, which are helpful during selection. The computed correlation coefficients between the attributes revealed that genotypic correlation coefficients were marginally greater than phenotypic correlation coefficients. The correlation coefficients between yield and its components and among the components were estimated at genotypic and phenotypic levels. The genotypic (r_g) and phenotypic (r_p) correlation coefficients of sixteen characters were presented in Table 1.

Productive tillers per plant was found to be in positive and significant genotypic correlation with days to 50 % flowering (r_g = 0.23), fingers per earhead (r_g = 0.32) and iron content (r_g = 0.22). Productive tillers were negatively correlated with plant height (r_g = -0.23) and zinc content (r_g = -0.56 and r_p = -0.24). Sapkal *et al.* (2019); Priyadharshini *et al.* (2011) confirmed same results for fingers per earhead. Significant positive genotypic correlation of fingers per earhead was found with days to 50 % flowering (r_g = 0.28), days to maturity (r_g = 0.27), plant height (r_g = 0.27), productive tillers per plant (r_g = 0.32), grain yield per plant (r_g = 0.32) and harvest index (r_g = 0.26). Chunilal *et al.* (1996) reported significant phenotypic correlation of days to 50 % flowering, maturity and plant height with fingers per earhead. Priyadharshini *et al.* (2011) confirmed same results for harvest index and productive tillers per plant. Priyadharshini *et al.* (2011); Devaliya *et al.* (2017); Patel *et al*. (2020) posted same results with grain yield per plant.

Table 1: Genotypic and phenotypic correlations of grain yield per plant with other characters in finger millet.

	DF	DM	PH	PTP	FPE	MEHL	FW	FL	SW	GYP	FYP	HI	Protein	Ca	Fe	Zn
DF	**1****	0.88**	0.03	0.23*	0.28**	0.33**	0.08	0.33**	0.16	0.31**	0.40**	0.14	-0.05	0.25*	0.18	-0.08
DM	0.59**	**1****	-0.1	0.06	0.27**	0.25*	-0.01	0.23*	0.08	0.17	0.27**	0.07	-0.01	-0.07	0.1	-0.05
PH	-0.03	-0.02	**1****	-0.23*	0.27**	0.18	0.26**	0.20*	0.50**	0.67**	0.39**	0.45**	-0.24	0.28**	0.06	0.02
PTP	0.06	0.04	-0.05	**1****	0.32**	-0.03	0.05	-0.02	-0.05	-0.09	-0.02	-0.09	-0.06	-0.03	0.22*	-0.56**
FPE	0.03	-0.02	0.02	-0.06	**1****	0.17	-0.29**	0.08	0.13	0.32**	0.11	0.26**	0.14	0.25**	-0.04	0.05
MEHL	0.26**	0.13**	0.11*	0.02	0.10*	**1****	0.21*	0.98**	0.07	0.31**	0.16	0.19	-0.08	0.06	0.06	-0.18
FW	0.06	0.004	0.13**	0.03	-0.16**	0.19**	**1****	0.21*	0.31**	0.34**	0.55**	0.03	-0.14	0.10	-0.22*	-0.1
FL	0.26**	0.13**	0.10*	-0.005	0.09	0.89**	0.18**	**1****	0.11	0.35**	0.21*	0.20*	-0.1	0.11	0.09	-0.18
SW	0.14**	0.04	0.32**	-0.01	0.04	0.07	0.27**	0.11*	**1****	0.87**	0.58**	0.59**	-0.19	0.28**	0.13	0.09
GYP	0.20**	0.02	0.31**	0.01	0.06	0.22**	0.23**	0.23**	0.72**	**1****	0.56**	0.73**	-0.28**	0.33**	0.20*	-0.1
FYP	0.14**	0.05	0.06	-0.04	0.0005	0.06	0.21**	0.09	0.27**	0.33**	**1****	-0.15	-0.11	0.33**	0.17	0.14
HI	0.09	0.003	0.26**	-0.03	0.09	0.15**	0.01	0.13**	0.50**	0.68**	-0.19**	**1****	-0.21*	0.08	0.06	-0.15
Protein	-0.04	-0.007	-0.15**	-0.02	0.05	-0.08	-0.13**	-0.09	-0.19**	-0.21 **	-0.04	-0.16**	**1****	-0.25*	-0.09	0.19
Ca	0.21**	-0.04	0.18**	-0.01	0.10*	0.05	0.09	0.10*	0.27**	0.26**	0.15**	0.06	-0.25**	**1****	0.31**	0.05
Fe	0.15**	0.06	0.04	0.09	-0.02	0.06	-0.20**	0.08	0.13**	0.15**	0.08	0.07	-0.08	0.31**	**1****	0.08
Zn	-0.07	-0.03	0.01	-0.24**	0.02	-0.17**	-0.09	-0.16**	0.09	-0.08	0.06	-0.12*	0.19**	0.05	0.08	**1****

* and ** significant at 5 and 1 per cent levels, respectively; Values above the diagonal bold values are genotypic correlation and below are phenotypic correlation

DF: Days to 50 % flowering, **DM:** Days to maturity, **PH:** Plant Height, **PTP:** Productive Tillers per Plant, **FPE:** Fingers per Ear Head, **MEHL:** Main ear head length, **FW:** Finger Width, **FL:** Finger Length, **SW:** 1000 Seed Weight, **GYP:** Grain Yield per Plant, **FYP:** Fodder Yield per Plant, **HI:** Harvest Index, **Protein:** Protein content, **Ca:** Calcium content, **Fe:** Iron content, **Zn:** Zinc content

Test weight or 1000 seed weight (g) showed positive significant genotypic and phenotypic correlation with traits plant height (r_g = 0.5 and r_p = 0.32), finger width (r_g = 0.31 and r_p = 0.27), grain yield per plant (r_g = 0.87 and r_p = 0.72), fodder yield per plant (r_g = 0.58 and r_p = 0.27), harvest index (r_g = 0.59 and r_p = 0.5) and calcium content (r_g = 0.28 and r_p = 0.27).

Negi *et al.* (2017); Suman *et al.* (2018); Lad *et al.* (2020) reported similar results for grain yield per plant (g). Fodder yield per plant (g) was in positive significant association with 1000 seed weight (g) as reported by Lad *et al.,* (2020). Devaliya *et al.* (2017); Lad *et al.* (2020) found positive significant correlation with harvest index (%).

Grain yield per plant was in positive and significant genotypic and phenotypic correlation with other characters like days to 50 % flowering (r_g = 0.31 and r_p = 0.20), plant height (r_g = 0.67 and r_p = 0.31), main ear head length (r_g = 0.31 and r_p = 0.22), finger width (r_g = 0.34 and r_p = 0.23), finger length (r_g = 0.35 and r_p = 0.23), 1000 seed weight (r_g = 0.87 and r_p = 0.72), fodder yield per plant (r_g = 0.56 and r_p = 0.33), harvest index (r_g = 0.73 and r_p = 0.68), calcium content (r_g = 0.33 and r_p = 0.26) and iron content (r_g = 0.20 and r_p = 0.15). Trait fingers per earhead (r_g = 0.32) had positive genotypic correlation with productive tillers per plant while protein content (r_g = -0.28 and r_p = -0.21) had significant negative correlation with grain yield.

Positive correlation of grain yield with days to 50 % flowering was reported by Anuradha *et al.* (2020); Sapkal *et al.* (2019); Patel *et al*. (2019). Positive significant association of grain yield with plant height (cm) was reported Negi *et al.* (2017); Mahanthesha *et al.*, (2018). Devaliya *et al.* (2017); Sapkal *et al.* (2019); Gayathri *et al.* (2022) observed similar results for main ear head length (cm) while Mahanthesha *et al.* (2018) obtained same results for finger width (cm). Lad *et al.* (2020) showed positive correlation of grain yield per plant (g) with finger length (cm). Negi *et al.* (2017); Suman *et al.* (2018); Lad *et al.* (2020) reported similar results for 1000 seed weight. Suman *et al.*, (2018); Gayathri *et al.* (2022) reported positive correlation of grain yield with fodder yield per plant. Devaliya *et al.* (2017); Negi *et al.* (2017); Suman *et al.* (2018); Gayathri *et al.* (2022) observed likewise results for harvest index (%). Devaliya *et al.,* (2017) posted positive correlation with traits calcium and iron content (mg/100g). Priyadharshini *et al.* (2011); Devaliya *et al.* (2017) posted same results for significant correlation between productive tillers and fingers per ear head.

Fodder yield per plant had significant positive genotypic and phenotypic correlation with days to 50 % flowering (r_g = 0.40 and r_p = 0.14), finger width (r_g = 0.55 and r_p = 0.21), 1000 seed weight (r_g = 0.58 and r_p = 0.27), grain yield per plant (r_g = 0.56 and r_p = 0.33) and calcium content (r_g = 0.33 and r_p = 0.15). Positive and significant correlation between days to 50% flowering and fodder yield per plant (g) was reported by Anuradha *et al.* (2020). Fodder yield per plant was in positive significant association with 1000 seed weight as reported by Lad *et al.* (2020). Negi *et al.* (2017); Suman *et al.* (2018); Gayathri *et al.* (2022).

In the present investigation, grain yield per plant (g) was found to be highly significant and positively correlated with days to 50 % flowering, plant height (cm), main ear head length (cm), finger width (cm), finger length (cm), 1000 seed weight (g), fodder yield per plant (g), harvest index (%), calcium content (mg/100g) and iron content (mg/100g) at both genotypic and phenotypic levels indicating that these attributes were mainly influencing the grain yield in finger millet. Thus, selection practiced for the improvement in these characters would automatically be resulted in the improvement of yield even though direct selection for improvement had not been made for the yield character.

Path coefficient analysis could provide a more realistic picture of the interrelationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficient. In this investigation, grain yield per plant was considered as the dependent variable and the remaining fifteen yield contributing characters were taken as independent (causal) variables. Direct and indirect genotypic effects of fifteen causal variables on grain yield per plant (g) are presented in Table 2.

Path coefficient analysis revealed the highest positive direct effect on grain yield per plant was recorded by days harvest index (0.87) followed by fodder yield per plant (0.86), fingers per earhead (0.14), finger length (0.08), iron content (0.04) and calcium content (0.01). It revealed that there was true relationship between these characters and grain yield per plant. Hence, direct selection of these characters could be carried out for the future breeding programs.

These results are close agreement with reports of Priyadharshini *et al.* (2011); Negi *et al.* (2017) for harvest index. Devaliya *et al.* (2017); Negi *et al*. (2017) reported positive direct effects for fodder yield. Positive direct effect of fingers per earhead on grain yield was also reported by Sapkal *et al.* (2019); Abhilash *et al*. (2020); Lad *et al*. (2020). These results are in close agreement with Priyadharshini *et al.* (2011); Mahanthesha *et al*. (2018); Vidhate *et al.* (2020) for finger length. Vidhate *et al.* (2020) also reported similar results for iron and calcium content.

Traits like fingers per earhead (0.03), zinc content (0.03), finger length (0.02), productive tillers per plant (0.01), protein content (0.01), iron content (0.004) and calcium content (0.001) also had positive indirect effect on grain yield through harvest index (%). Indirect effect of fodder yield per plant (g) through finger length (0.02), fingers per earhead (0.01), iron content (0.01), protein content (0.005), productive tillers per plant (0.003) and calcium content (0.003) were found to be positive. Indirect effect of fingers per earhead *via* harvest index (0.22), fodder yield per plant (0.09), finger width (0.02), finger length (0.01) and calcium content (0.002) was positive. Similar results were observed by Vidhate *et al.* (2020).

Negative direct effect was observed on grain yield per plant (g) by main ear head length (-0.04) followed by protein content (-0.05), days to maturity (-0.06), 1000 seed weight (-0.06), finger width (-0.08), plant height (-

0.1), days to 50 % flowering (-0.13), productive tillers per plant (-0.15) and zinc content (-0.19). Negative direct effects of above characters might be due to their negative indirect effects *via* another trait on them. Adopting a multi-trait selection approach, it becomes possible to balance the positive indirect effects and mitigate the negative direct effects. It can be done by evaluating and selecting plants based on a combination of traits, including those with positive indirect effects on yield. Das *et al.* (2013) had reported similar results for main ear head length and productive tillers per plant while Lad *et al*. (2020) reported negative direct effect of protein content (%) and 1000 seed weight on grain yield.

Table 2: Direct and indirect genotypic effects of fifteen causal variables on grain yield per plant (g).

GPath	DF	DM	PH	PTP	FPE	MEHL	FW	FL	SW	FYP	HI	Protein	Ca	Fe	Zn	GYP
DF	**-0.13**	-0.05	-0.003	-0.03	0.04	-0.01	-0.01	0.03	-0.01	0.34	0.13	0.002	0.002	0.01	0.02	0.31**
DM	-0.12	**-0.06**	0.01	-0.01	0.04	-0.01	0.001	0.02	-0.01	0.23	0.06	0.0005	-0.001	0.005	0.01	0.17
PH	-0.003	0.01	**-0.1**	0.04	0.04	-0.01	-0.02	0.02	-0.03	0.33	0.39	0.01	0.002	0.003	-0.003	0.67**
PTP	-0.03	-0.004	0.02	**-0.15**	0.04	0.001	-0.004	-0.002	0.003	-0.02	-0.08	0.003	-0.0002	0.01	0.11	-0.09
FPE	-0.04	-0.02	-0.03	-0.05	**0.14**	-0.01	0.02	0.01	-0.01	0.09	0.22	-0.01	0.002	-0.002	-0.01	0.32**
MEHL	-0.04	-0.02	-0.02	0.004	0.02	**-0.04**	-0.02	0.08	-0.004	0.14	0.16	0.004	0.0005	0.003	0.03	0.31**
FW	-0.01	0.0004	-0.03	-0.01	-0.04	-0.01	**-0.08**	0.02	-0.02	0.47	0.03	0.01	0.001	-0.01	0.02	0.34**
FL	-0.04	-0.01	-0.02	0.003	0.01	-0.04	-0.02	**0.08**	-0.01	0.18	0.18	0.005	0.001	0.004	0.03	0.35**
SW	-0.02	-0.01	-0.05	0.01	0.02	-0.003	-0.02	0.01	**-0.06**	0.49	0.51	0.01	0.002	0.01	-0.02	0.87**
FYP	-0.05	-0.02	-0.04	0.003	0.01	-0.01	-0.04	0.02	-0.04	**0.86**	-0.13	0.005	0.003	0.01	-0.03	0.56**
HI	-0.02	-0.004	-0.05	0.01	0.03	-0.01	-0.003	0.02	-0.04	-0.13	**0.87**	0.01	0.001	0.004	0.03	0.73**
Protein	0.01	0.001	0.02	0.01	0.02	0.003	0.01	-0.01	0.01	-0.09	-0.18	**-0.05**	-0.002	-0.004	-0.04	-0.28**
Ca	-0.03	0.004	-0.03	0.004	0.04	-0.002	-0.01	0.01	-0.02	0.28	0.07	0.01	**0.01**	0.01	-0.01	0.33**
Fe	-0.02	-0.01	-0.01	-0.03	-0.005	-0.003	0.02	0.01	-0.01	0.15	0.07	0.004	0.003	**0.04**	-0.01	0.20*
Zn	0.01	0.003	-0.002	0.09	0.01	0.01	0.01	-0.01	-0.01	0.12	-0.13	-0.01	0.0005	0.003	**-0.19**	-0.10

DF: Days to 50 % flowering, **DM:** Days to maturity, **PH:** Plant Height (cm), **PTP:** Productive Tillers per Plant, **FPE:** Fingers per Ear Head, **MEHL:** Main ear head length (cm) **FW:** Finger Width (cm), **FL:** Finger Length (cm), **SW:** 1000 Seed Weight (g), **GYP:** Grain Yield per Plant,**FYP:** Fodder Yield per Plant (g), **HI:** Harvest Index (%), **Protein:** Protein content (%), **Ca:** Calcium content (mg/100g), **Fe:** Iron content (mg/100g),**Zn:** Zinc content (mg/100g) * Bold values are direct effects

CONCLUSIONS

All in all, according to correlation studies, selection practiced for days to 50 % flowering, plant height (cm), main ear head length (cm), finger width (cm), finger length (cm), 1000 seed weight (g), fodder yield per plant (g), harvest index (%), calcium content (mg/100g) and iron content (mg/100g), as they are highly correlated at both genotypic and phenotypic levels, would automatically result in the improvement of grain yield even though direct selection for improvement had not been made for the yield character.

In the present study, overall picture of path coefficient analysis revealed that for improving yield in finger millet, weightage in selection should be given to harvest index (%), fodder yield per plant (g), fingers per earhead, finger length (cm), iron content (mg/100g) and calcium content (mg/100g). Selecting such traits would directly or indirectly contribute in the improvement or increase in grain yielding ability as these traits were highly correlated and had high direct effect on yield which would allow simultaneous improvement.

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Conflict of Interest. None.

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