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Path analysis studies in pearl millet [*Pennisetum glaucum* (L.) R. Br] germplasm

MB Akhare, AB Bagade, MD Patil, SL Haloli and PR Ingle

Abstract
An experiment entitled "Path analysis studies in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. germplasm" was carried out during *Kharif* 2022-23 at the experimental farm of National Agricultural Research Project, Chhatrapati Sambhajinagar, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani (M.S). The experiment was laid out in Randomized Block Design (RBD) with 32 genotypes and two replications to estimate the path analysis for yield contributing character in germplasm of pearl millet. Among all the characters, highest positive direct effects were observed for grain yield per plot, days to maturity, no. of productive tillers per plant, plant height, harvest index, panicle length, iron content and green fodder yield per plant on grain yield per plant at both levels. This revealed true relationship of these characters with grain yield per plant. Hence, direct selection for these traits could be rewarding for improvement of grain yield.

Keywords: Path analysis studies, pearl millet, [*Pennisetum glaucum* (L.) R. Br], germplasm

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a highly cross pollinated crop with protogynous mechanism, which fulfils one of the essential biological requirements for hybrid development. It is the fifth most important cereal in the world. It is extensively cultivated for grain as well as fodder in dry areas of South Asia, particularly in India and Africa (Khannan *et al*., 2014) [6]. The crop can adapt to diverse and ecological conditions, hence is grown in environments of low and erratic rainfall, high temperature and low soil fertility.

In India production of Pearl millet during *kharif* 21-22 as per second advance estimates found 9.22 million tonnes over target of 10.50 million tones. (Directorate of Economics and Statistics second advance estimate 16-02-22) however Rajasthan is the highest producing stage in the country. Pearl millet effectively helps in maintaining the blood sugar level constant in diabetes patient for long period of time (D. Rao *et al*. 2017) [12]. It is good source of energy, with calorific value of 361 Kcal/100g and high in fiber content (1.2g / 100g) (Singh *et al*. 2018) [16].

Path coefficient analysis of grain yield components brings out the relative importance of their direct and indirect effects and gives a clear understanding of their association with grain yield. Selection on the basis of direct and indirect effects is much more useful than selection for grain yield.

Materials and Methods

The present investigation was conducted during *Kharif* season of 2022 at the National Agricultural Research Project, Paithan Road, Chhatrapati Sambhajinagar VNMKV Parbhani Maharashtra. The experimental material consisted of thirty two diverse genotypes of pearl mill*et al*ong with two checks ABPC 4-3 and AIMP-92901. The evaluation of different genotypes was performed in two replications using Randomized Block Design (RBD). Each genotype was sown in a two row of 4 m length with spacing of 45 cm between rows and 15 cm between plants. There commended agronomical and plant protection practices were implemented to ensure successful crop cultivation. Observations were recorded for five randomly selected plants from each replication for 14 characters including days to 50% flowering, days to maturity, plant height (cm), no. of productive tillers per plant, panicle length (cm), panicle girth (cm), 1000 grain weight (g), grain yield per plant (g), grain yield per plot (kg/plot), green fodder yield per plant (g), green fodder yield per plot (kg/plot), harvest index (%), Fe content (ppm), Zn content (ppm).

To establish a cause and effect relationship the first step used was to partition the genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) [3] and developed by Wright (1921) [18].

Results and Discussion

Path coefficient analysis provides a thorough understanding of contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects (Wright, 1921) [18], which helps the breeder in determining the yield components. The aim of this analysis in the present investigation was to demonstrate the significance of path coefficient analysis in determining the true nature of character association. According to Falconer (1960) [4], it is often assumed that association between two characters is an evidence of pleiotropy rather than linkage hence under such complex situations, path coefficient analysis is a powerful tool for studying character association.

Grain yield is a complex character, depend upon other component characters which exert their effect directly and indirectly. Direct effect of any character on grain yield gives an idea about how effective selection can be made to bring improvement in the latter. The indirect effect indicate interrelationship of component characters towards contribution to yield.

Therefore, results pertaining to direct and indirect effect at genotypic levels is presented in Table 1 and Fig 1 and at phenotypic level depicted in Table 2 and Fig 2. Days to 50 percent flowering had negative direct effect (G = -0.2986, P= -0.691) on grain yield at genotypic and phenotypic level. Fe content (G = 0.0525, P = 0.0091), Zn content (G = 0.1259, P = 0.0150) had positive indirect effect on grain yield per plant through days to 50% flowering at both levels. Character days to maturity had positive direct effect (G = 0.2928, P = 0.0667) on grain yield per plant at both levels. However, days to 50 percent flowering (G = 0.2888, P = 0.0658), plant height (G = 0.0627, P = 0.0034), no of productive tillers (G = 0.0449, P = 0.0059) and panicle girth (G = 0.0632, P = 0.0087), 1000 grain weight (G = 0.0287, P = 0.0041), green fodder yield per plant (G = 0.0358, P = 0.0007), harvest index (G = 0.0509, P = 0.0043), grain yield per plot (G = 0.0290, P = 0.0051), green fodder yield per plot (G = 0.0331, P = 0.0010) had positive indirect effect on grain yield plant via days to maturity at both levels.

Plant height (G = 0.0765) had positive direct effect and (P = 0.0264) had negative direct effect on grain yield per plant at genotypic and phenotypic levels respectively. Days to 50% flowering (G =0.0133), days to maturity (G = 0.0164), no of productive tillers (G = 0.0616), panicle length (G = 0.0494), panicle girth (G = 0.0597), 1000 grain weight (G = 0.0647), green fodder yield per plant (G = 0.0809), harvest index (G = 0.0010), grain yield per plot (G = 0.0609) and green fodder yield per plot (G = 0.0811) had positive indirect effect on grain yield per plant via plant height at genotypic level.

No. of productive tillers per plant had positive direct effect (G = 0.1695, P = 0.0021) on grain yield per plant at both levels. However, days to 50 percent flowering (G = 0.0295, P = 0.0002), days to maturity (G = 0.0260, P = 0.0002), plant height (G = 0.1366, P = 0.0015), Panicle length (G = 0.1727, P = 0.0018), panicle girth (G = 0.1708, P = 0.0019), 1000 grain weight (G = 0.1634, P = 0.0019), green fodder yield per plant (G = 0.1417, P = 0.0016), harvest index (G = 0.1063, P = 0.0011), grain yield per plot (G = 0.1668, P = 0.0020), green fodder yield per plot (G = 0.1423, P = 0.0016) had positive indirect effect on grain yield plant via no. of productive tiller at both levels.

Panicle length (G = 0.0335) had positive direct effect and (P = -0.0345) on grain yield per plant at both levels. However, plant height (G = 0.0216), no of productive tillers per plant (G = 0.0341) and panicle girth (G = 0.0303), 1000 grain weight (G = 0.0336), green fodder yield per plant (G = 0.0177), harvest index (G =0.0239), grain yield per plot (G =0.0342), green fodder yield per plot (G =0.0179) had positive indirect effect on grain yield plant via panicle length.

Panicle girth (G = -0.0772) had negative direct effect at genotypic level and (P = 0.0101) had positive direct effect at phenotypic level on grain yield per plant. 1000 grain weight (G = -0.0309) had negative direct effect at genotypic level and (P = 0.0101) positive direct effect at phenotypic level on grain yield per plant. However, Days to 50% flowering (G = -0.0034), days to maturity (G = -0.0030), plant height (G = -0.0261), no. of productive tillers (G = -0.0298), panicle length (G = -0.0311), panicle girth (G = -0.0311), green fodder yield per plant (G = -0.0258), harvest index (G = -0.0199), grain yield per plot (G = -0.0304), green fodder yield per plot (G = -0.0261) had negative indirect effect on grain yield plant via 1000 grain weight at genotypic level.

Green fodder yield per plant had positive direct effect (G = 0.0399, P = 0.0245) on grain yield per plant at both levels. Harvest index (G = 0.0669, P = 0.0094) had positive direct effect on grain yield per plant at both levels. Grain yield per plot (G = 0.8219, P = 1.0047) had positive direct effect at genotypic level and phenotypic level on grain yield. Green fodder yield per plot (G = -0.0569 P= -0.0027) had negative direct effect at both levels on grain yield per plant. Fe content had (G = 0.0251, P = 0.0089) positive direct effect on yield per plant at both level. Zinc content (G = -0.0091, P = -0.0026) negative direct effect on grain yield per plant at both levels.

At genotypic level, highest positive direct effect on grain yield per plant was recorded for grain yield per plot (0.8219) followed by days to maturity (0.2928), no. of productive tillers per plant (0.1695), harvest index (0.0669), green fodder yield per plant (0.0399), panicle length (0.0335) and Fe content (0.0251); whereas, highest negative direct effect was recorded for days to 50% flowering (-0.2986), panicle girth (-0.0772), green fodder yield per plot (-0.0529), 1000 grain weight (-0.0309) and Zn content (-0.0091). The results were similar to finding of Dehinwal *et al.* (2017) [2] and Yadav *et al.* (2022) [19] for days to 50% flowering. Kumar *et al.* (2014) [1], Singh *et al.* (2018) [16] and Talwar *et al.* (2017) for plant height. Dapke *et al.* (2014) [1], Dehinwal *et al.* (2017) [2] and Singh *et al.* (2018) [16] for no. of productive tillers per plant, Dapke *et al.* (2014) [1] and Singh *et al*. (2018) [16] for panicle length. Nehra *et al.* (2017) [8] for panicle girth. Singh *et al.* (2018) [16] and Yadav *et al*. (2022) [19] for 1000 grain weight, Ram *et al*. (2015) [11] and Nehra *et al.* (2017) [8] for green fodder yield per plant, Singh *et al*. (2014) [15] and Yadav *et al*. (2022) [19] for harvest index.

At phenotypic level, highest positive direct effect on grain yield per plants was observed for grain yield per plot (1.0047), days to maturity (0.0667), green fodder yield per plant (0.0245), 1000 grain weight (0.0101), panicle girth (0.0101), Fe content (0.0089), no. of productive tiller per plant(0.0021); whereas highest negative direct effect was recorded for days to 50% flowering (-0.0691), panicle girth(-0.0345), plant height (-0.0264), Zn content (-0.0126) in germplasm of pearl millet. The results were similar to finding of Pallavi *et al*. (2020) [9] and Rajpoot *et al*. (2023) [10] for days to 50% flowering and panicle girth. Rajpoot *et al*. (2023) [10] for days to maturity, plant height and harvest index. Kamble *et al.* (2022) [5] for no. of productive tillers per plant and panicle length Kamble *et al.* (2022) [5] and Rajpoot *et al*. (2023) [10] for 1000 grain weight.

Table 1: Direct and indirect effects of yield components on grain yield per plant at genotypic level in pearl millet

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of Productive Tillers Per Plant	Panicle Length (cm)	Panicle Girth (cm)	1000 Grain Weight (g)	Green Fodder Yield Per Plant (g)	Harvest Index (%)	Grain Yield Per Plot (kg/plot)	Green Fodder Yield Per Plot (kg/plot)	Fe Content (ppm)	Zn Content (ppm)	Grain Yield Per Plant (g)
Days to 50% Flowering	-0.2986	-0.2946	-0.0518	-0.0521	0.0033	-0.0631	-0.0331	-0.0307	-0.0755	-0.0331	-0.0276	0.0525	0.1259	0.1191
Days to Maturity	0.2888	0.2928	0.0627	0.0449	-0.0069	0.0632	0.0287	0.0358	0.0509	0.0290	0.0331	-0.0634	-0.1203	0.1098
Plant Height (cm)	0.0133	0.0164	0.0765	0.0616	0.0493	0.0597	0.0647	0.0809	0.0010	0.0609	0.0811	-0.0312	-0.0543	0.793**
No of Productive Tiller per Plant	0.0295	0.0260	0.1366	0.1695	0.1727	0.1708	0.1634	0.1417	0.1063	0.1668	0.1423	-0.0638	-0.1169	0.984**
Panicle Length (cm)	-0.0004	-0.0008	0.0216	0.0341	0.0335	0.0303	0.0336	0.0177	0.0239	0.0342	0.0179	-0.0133	-0.0279	0.812**
Panicle Girth (cm)	-0.0163	-0.0167	-0.0602	-0.0778	-0.0698	-0.0772	-0.0777	-0.0512	-0.0455	-0.0762	-0.0524	0.0323	0.0623	0.988**
1000 Grain Weight (g)	-0.0034	-0.0030	-0.0261	-0.0298	-0.0311	-0.0311	-0.0309	-0.0258	-0.0199	-0.0304	-0.0261	0.0114	0.0224	0.983**
Green Fodder Yield Per Plant (g)	0.0041	0.0049	0.0422	0.0334	0.0212	0.0265	0.0333	0.0399	-0.0049	0.0314	0.0405	-0.0152	-0.0299	0.785**
Harvest Index%	0.0169	0.0116	0.0009	0.0419	0.0478	0.0395	0.0430	-0.0082	0.0669	0.0434	-0.0087	-0.0122	-0.0338	0.644**
Grain Yield per Plot (kg/plot)	0.0910	0.0814	0.6548	0.8092	0.8409	0.8112	0.8089	0.6455	0.5339	0.8219	0.6484	-0.3152	-0.6013	0.712**
Green Fodder Yield per Plot (kg/plot)	-0.0053	-0.0064	-0.0603	-0.0477	-0.0304	-0.0386	-0.0481	-0.0576	0.0074	-0.0449	-0.0569	0.0211	0.0427	0.789**
Fe Content (ppm)	-0.0044	-0.0054	-0.0103	-0.0095	-0.0100	-0.0105	-0.0093	-0.0096	-0.0046	-0.0096	-0.0093	0.0251	0.0188	-0.379*
Zn Content (ppm)	0.0038	0.0037	0.0064	0.0063	0.0076	0.0073	0.0066	0.0068	0.0046	0.0066	0.0068	-0.0068	-0.0091	-0.721**
Grain Yield per Plant (g)	0.1191	0.1098	0.793**	0.984**	0.812**	0.988**	0.983**	0.785**	0.644**	0.712**	0.789**	-0.379*	-0.721**	1.0000

Residual effect = 0.0113 *, ** denotes significance at 5% and 1% respectively

Table 2.: Direct and indirect effect of yield components on grain yield per plant at phenotypic level in pearl millet

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of Productive Tillers Per Plant	Panicle Length (cm)	Panicle Girth (cm)	1000 Grain Weight (g)	Green Fodder Yield Per Plant (g)	Harvest Index (%)	Grain Yield Per Plot (kg/plot)	Green Fodder Yield Per Plot (kg/plot)	Fe Content (ppm)	Zn Content (ppm)	Grain Yield Per Plant (g)
Days to 50% Flowering	-0.0691	-0.0680	-0.0033	-0.0075	-0.0018	-0.0099	-0.0054	-0.0011	-0.0069	-0.0064	-0.0015	0.0091	0.0150	0.0932
Days to Maturity	0.0658	0.0667	0.0034	0.0059	0.0004	0.0087	0.0041	0.0007	0.0043	0.0051	0.0010	-0.0103	-0.0136	0.0787
Plant Height (cm)	-0.0013	-0.0014	-0.0264	-0.0193	-0.0162	-0.0186	-0.0189	-0.0239	-0.0041	-0.0187	-0.0239	0.0086	0.0107	0.705**
No of Productive Tiller per Plant	0.0002	0.0002	0.0015	0.0021	0.0018	0.0019	0.0019	0.0016	0.0011	0.0020	0.0016	-0.0007	-0.0011	0.966**
Panicle Length (cm)	-0.0009	-0.0002	-0.0212	-0.0304	-0.0345	-0.0309	-0.0314	-0.0236	-0.0221	-0.0325	-0.0235	0.0102	0.0143	0.938**
Panicle Girth (cm)	0.0014	0.0013	0.0071	0.0093	0.0090	0.0101	0.0092	0.0076	0.0057	0.0094	0.0075	-0.0032	-0.0043	0.931**
1000 Grain Weight (g)	0.0008	0.0006	0.0073	0.0095	0.0092	0.0092	0.0101	0.0075	0.0061	0.0098	0.0075	-0.0034	-0.0053	0.970**
Green Fodder Yield Per Plant (g)	0.0004	0.0002	0.0223	0.0186	0.0168	0.0184	0.0182	0.0245	0.0039	0.0180	0.0244	-0.0061	-0.0078	0.731**
Harvest Index%	0.0009	0.0006	0.0014	0.0052	0.0060	0.0053	0.0056	0.0015	0.0094	0.0060	0.0015	-0.0014	-0.0029	0.644**
Grain Yield per Plot (kg/plot)	0.0933	0.0775	0.7133	0.9709	0.9465	0.9360	0.9745	0.7377	0.6442	1.0047	0.7363	-0.3430	-0.5178	0.999**
Green Fodder Yield per Plot (kg/plot)	-0.0001	0.0000	-0.0025	-0.0021	-0.0019	-0.0020	-0.0020	-0.0027	-0.0004	-0.0020	-0.0027	0.0007	0.0009	0.730**
Fe Content (ppm)	-0.0012	-0.0014	-0.0029	-0.0031	-0.0026	-0.0028	-0.0029	-0.0022	-0.0013	-0.0030	-0.0022	0.0089	0.0058	-0.339*
Zn Content (ppm)	0.0027	0.0026	0.0051	0.0065	0.0052	0.0054	0.0066	0.0040	0.0039	0.0065	0.0040	-0.0082	-0.0126	-0.519**
Grain Yiled per Plant (g)	0.0932	0.0787	0.705**	0.966**	0.938**	0.931**	0.970**	0.731**	0.644**	0.999**	0.730**	-0.339*	-0.519**	1.0000

Residual effect = 0.041 *, ** denotes significance at 5% and 1% respectively

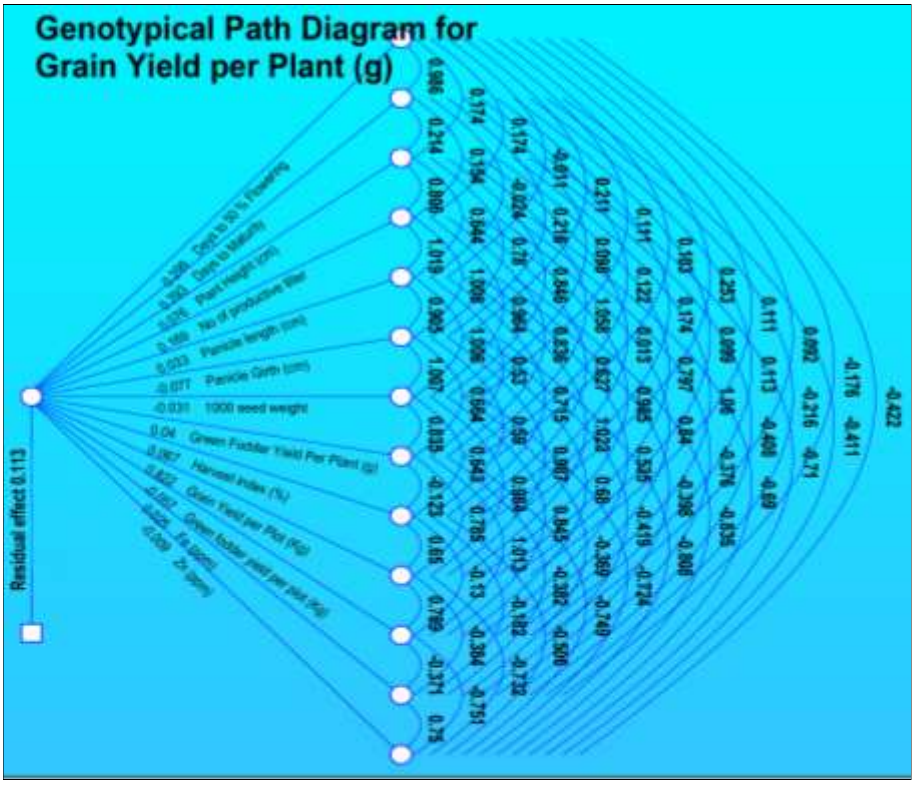

Fig 1: Direct and indirect effects of yield components on grain yield per plant at genotypic level in pearl millet

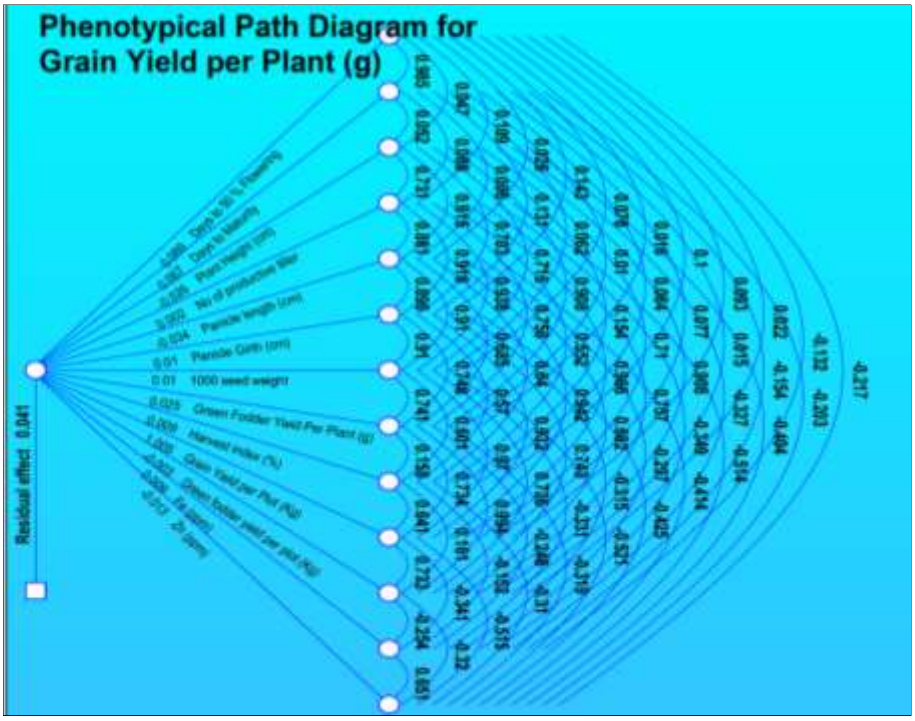

Fig 2: Direct and indirect effect of yield components on grain yield per plant at phenotypic level in pearl millet

Conclusion

Among all the characters, highest positive direct effects were observed for grain yield per plot, days to maturity, no. of productive tillers per plant, plant height, harvest index, panicle length, iron content and green fodder yield per plant on grain yield per plant at both levels. This revealed true relationship of these characters with grain yield per plant. Hence, direct selection for these traits could be rewarding for improvement of grain yield.

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