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SN Jaybhaye
Msc. Scholar, Department of Genetics and Plant Breeding, College of Agricuture, Badnapur, Maharashtra, India

AB Bagade
Associate Professor, Department of Genetics and Plant Breeding, National Agriculture Research Project, Chh. Sambhajinagar, Maharashtra, India

SB Pawar
Director of Research, National Agriculture Research Project, Chh. Sambhajinagar, Maharashtra, India

Mahesssssh D Patil
Ph.D Scholar, Department of Genetics and Plant Breeding, Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author:
SN Jaybhaye
Msc. Scholar, Department of Genetics and Plant Breeding, College of Agricuture, Badnapur, Maharashtra, India

Path coefficient analysis of yield and its component traits in pearl millet (*Pennisetum glaucum* L.) germplasm

SN Jaybhaye, AB Bagade, SB Pawar and Mahesssssh D Patil

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Abstract
An experiment entitled "Genetic diversity studies in pearl millet [*Pennisetum glaucum* (L.) R. Br.]". was carried out during Kharif 2024 at the Research Farm of National Agriculture Research Project, Chhatrapati Sambhajinagar. The experiment was laid out in Randomized Block Design (RBD) with 42 genotypes and two replications to estimate the extent of genetic variability, heritability, genetic advance, correlation coefficient and path coefficient analysis among all the genotypes.
Path coefficient analysis revealed that direct effect was positive on grain yield per plant by number of productive tiller per plant, days to maturity, plant height, fodder yield per plot, 1000-grain weight. This revealed that true relationship of these characters with grain yield. Hence, direct selection for these traits could be rewarding for improvement of grain yield.

Keywords: Pearl millet, Genetic divergence, Correlation and Path analysis

Introduction
Pearl millet (*Pennisetum glaucum* L. R. Br.) is an annual, diploid (2n = 14), highly cross-pollinated cereal crop belonging to the family Poaceae, subfamily Panicoideae. Believed to have originated in West Africa (Vavilov, 1950) [11], it is now extensively cultivated in arid and semi-arid regions due to its exceptional drought tolerance, short growth cycle, and high photosynthetic efficiency (Bennett, 2000; Serba & Yadav, 2016) [2, 8]. In India, it is primarily grown during the kharif season, with Rajasthan, Maharashtra, Uttar Pradesh, Gujarat, and Haryana contributing the majority of production (Directorate of Economics and Statistics, 2024).
The crop performs well under 400-600 mm of annual rainfall and temperatures ranging from 15 °C to 40 °C, with optimum growth achieved at 30-35 °C (Yadav *et al*., 2021) [13]. It grows successfully in sandy loam to clay loam soils, tolerates marginal conditions, and is well adapted to low-input farming systems (Govindaraj *et al*., 2020) [4]. Nutritionally, pearl millet surpasses many staple cereals, offering high protein, dietary fiber, essential minerals such as iron and zinc, and health-promoting polyunsaturated fatty acids (Rao *et al*., 2017; Singh *et al*., 2018) [7, 10]. Its low glycemic index and high resistant starch content make it particularly beneficial for managing lifestyle-related disorders (Anuradha *et al*., 2021) [1].
Genetic improvement in pearl millet depends on understanding variability, heritability, and genetic advance for key traits, along with correlation and path coefficient analyses to identify traits exerting the greatest influence on yield (Johnson *et al*., 1955; Wright, 1921; Dewey & Lu, 1959) [6, 12, 3]. Assessing genetic diversity within germplasm is essential for identifying superior and genetically divergent parents for hybridization, thereby accelerating the development of high-yielding, climate-resilient, and nutrient-dense cultivars (Gupta *et al*., 2022; Singh *et al*., 2023) [5, 9].

Materials and Methods
The present study, entitled *"Genetic Diversity Studies in Pearl Millet Germplasm* [*Pennisetum glaucum* (L.) R. Br.]*"*, was conducted during *Kharif* 2024- 2025. The experimental material, selected from the germplasm maintained at the National Agricultural

Research Project, Chhatrapati Sambhajinagar, was evaluated in a Randomized Block Design (RBD) with two replications.

A total of 42 genotypes, comprising 40 inbred lines and two checks (ABPC 4-3 and AIMP 92901), were used. The genotypes were sown in two rows of 4 m length each, with a spacing of 45 cm between rows and 15 cm between plants. Standard agronomic practices, including timely weeding, irrigation, and other intercultural operations, were carried out as per the crop's growth stage and requirements. Fertilizer was applied at the recommended dose, and all crop management activities were performed according to standard guidelines.

The experimental material was selected to represent wider diversity for various morphological and yield-related traits, ensuring comprehensive assessment of genetic variability.

Table 1: List of Genotypes

Sr.No	Entry	Sr. No	Entry
1	AUBI-15333R	21	AUBI-15280R
2	AUBI-15452R	22	AUBI-15287R
3	AUBI-15313R	23	AUBI-15050R
4	AUBI-15448R	24	AUBI-15309R
5	AUBI-15352R	25	AUBI-15221R
6	AUBI-15387R	26	AUBI-15346R
7	AUBI-15262R	27	AUBI-15286R
8	AUBI-15260R	28	AUBI-15052R
9	AUBI-15279R	29	AUBI-18097R
10	AUBI-15241R	30	AUBI-15022R
11	AUBI-15348R	31	AUBI-15071R
12	AUBI-15245R	32	AUBI-15024R
13	AUBI-15233R	33	AUBI-15415R
14	AUBI-15265R	34	AUBI-16287R
15	AUBI-15385R	35	AUBI-15374R
16	AUBI-15358R	36	AUBI-15184R
17	AUBI-15453R	37	AUBI-15137R
18	AUBI-15468R	38	AUBI-16630R
19	AUBI-15230R	39	AUBI-15043R
20	AUBI-1549R	40	AUBI-18801R
Checks I	ABPC 4-3	Checks II	AIMP-92901

Result and Discussion

Phenotypic and Genotypic Path Coefficient Analysis

Path coefficient analysis was conducted to partition the significant genotypic and phenotypic correlation coefficients into their respective direct and indirect effects on grain yield per plant (Tables 2 and 3).

Direct Effects

At the genotypic level, the highest positive direct effect on grain yield per plant was observed for number of productive tillers per plant (0.5305), followed by days to maturity (0.4256), panicle girth (0.2674), plant height (0.2045), and 1000-grain weight (0.1037). The highest negative direct effects were recorded for days to 50% flowering (-0.4189), grain yield per plant (-0.3627), fodder yield per plot (-0.1835), harvest index (-0.0494), and panicle length (-0.0357). These findings align with earlier reports by Dehinwal *et al*. (2017) for days to 50% flowering, Kumar *et al*. and Talwar *et al*., for plant height, Dehinwal *et al*. (2017) and Singh *et al*. (2018) [10] for number of productive tillers per plant, Singh *et al*. (2018) [10] for panicle length, Singh *et al*. (2018) [10] and Yadav *et al*. (2022) [13] for 1000-grain weight, and Ram *et al*. (2015) and Singh *et al*., for harvest index.

At the phenotypic level, number of productive tillers per plant exhibited the highest positive direct effect (0.3691), followed by days to maturity (0.3092), plant height (0.1566), 1000-grain weight (0.0825), and fodder yield per plot (0.0169). The highest negative direct effects were recorded for grain yield per plant (-0.2476), days to 50% flowering (-0.2118), panicle length (-0.0377), and harvest index (-0.0162). These results are consistent with those of Pallavi *et al*. (2020) [14] and Rajpoot *et al*. (2023) [15] for days to 50% flowering and panicle girth, Kamble *et al*. (2022) [16] for number of productive tillers per plant and panicle length, and Kamble *et al*. (2022) [16] and Rajpoot *et al*. (2023) [15] for 1000-grain weight.

Indirect Effects

Days to 50% flowering showed a negative direct effect on grain yield at both levels (G = -0.4189; P = -0.2118). However, it exerted positive indirect effects via number of productive tillers per plant, panicle length, panicle girth, 1000-grain weight, and fodder yield per plot. Negative indirect effects were observed through days to maturity, plant height, and harvest index.

Days to maturity recorded a positive direct effect at both levels (G = 0.4256; P = 0.3092) and also contributed indirectly via days to 50% flowering, panicle girth, fodder yield per plot, and harvest index. Negative indirect effects were channelled through number of productive tillers per plant, panicle length, and 1000-grain weight.

Plant height had a positive direct effect (G = 0.2045; P = 0.1566) and positive indirect contributions through days to 50% flowering, number of productive tillers, and fodder yield per plot. Negative indirect effects occurred through panicle length, panicle girth, 1000-grain weight, and harvest index.

Number of productive tillers per plant exerted the highest positive direct effect at both levels and additionally influenced grain yield indirectly via plant height, panicle length, panicle girth, 1000-grain weight, fodder yield per plot, and harvest index.

Panicle length had a negative direct effect at both levels, with mostly negative indirect effects, except for small positive contributions via days to 50% flowering, days to maturity, and plant height.

Panicle girth recorded positive direct effects at both levels and positive indirect effects through days to maturity, number of productive tillers, panicle length, fodder yield per plot, 1000-grain weight, and harvest index, while negative indirect effects occurred via days to 50% flowering and plant height.

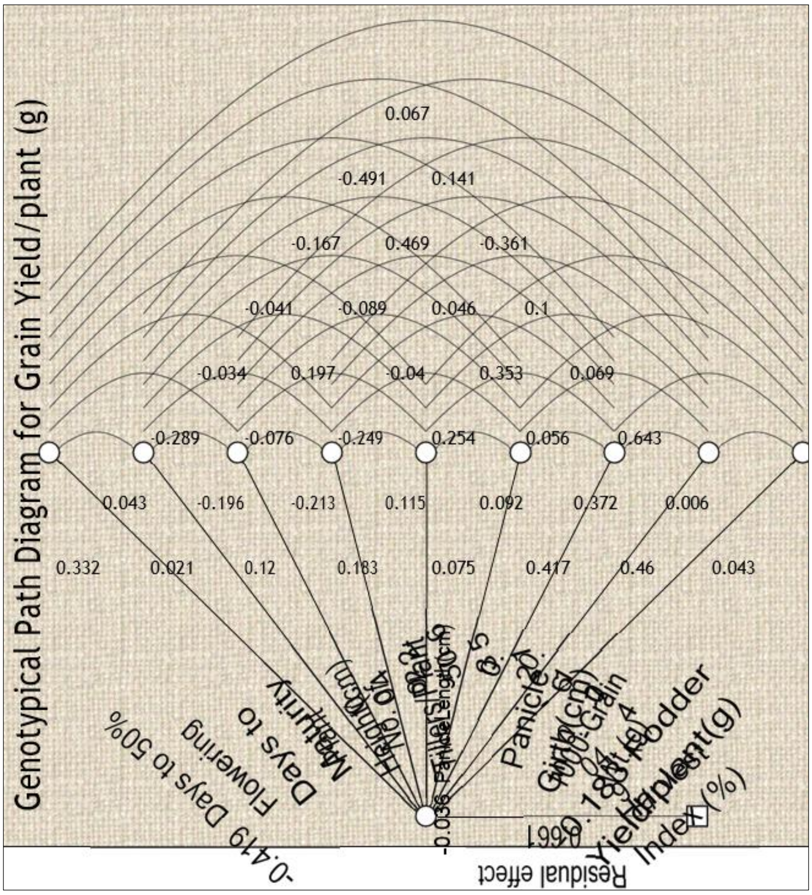
1000-grain weight contributed positively both directly and indirectly through number of productive tillers, panicle length, panicle girth, fodder yield per plot, and harvest index, though it showed negative indirect effects via flowering, maturity, and plant height.

Fodder yield per plot had a negative direct effect at the genotypic level but a small positive effect at the phenotypic level, with mixed indirect contributions depending on the trait pathway.

Harvest index showed a negative direct effect on grain yield at both levels, with mostly negative indirect effects except for plant height, which contributed positively.

Interpretation

Overall, the analysis revealed that number of productive tillers per plant and days to maturity were the most influential traits contributing positively to grain yield at both genotypic and phenotypic levels. The consistency of these results with previous reports indicates that these traits could be targeted in selection programmes to improve grain yield potential. Traits with negative direct effects, such as days to 50% flowering and harvest index, may require cautious consideration during breeding to avoid undesirable impacts on yield performance.



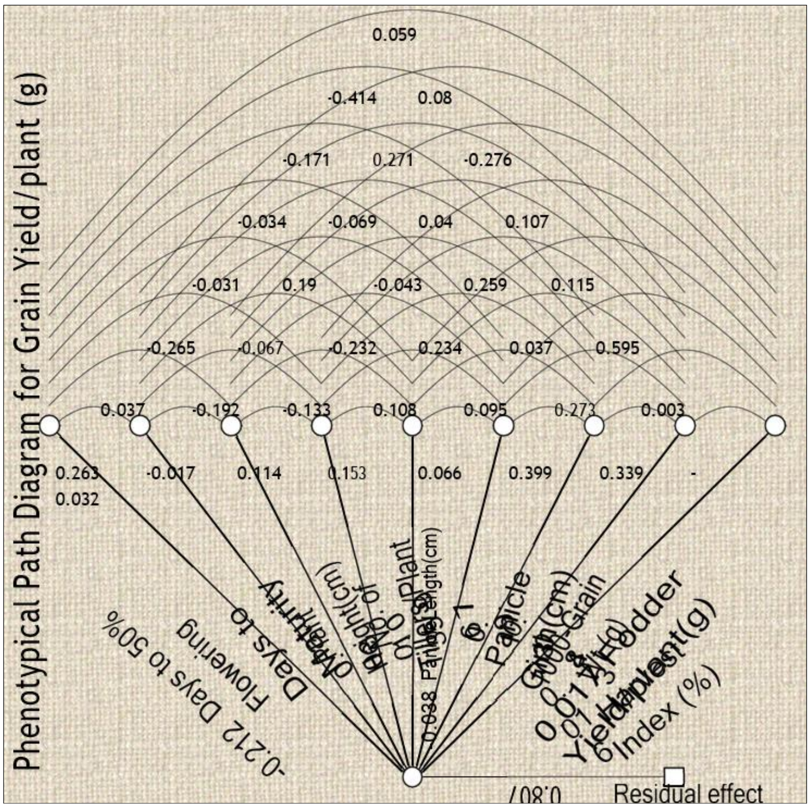


Table 2: Direct and indirect effect of yield and its components characters on grain yield and at Phenotypic level.

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of Tillers / Plant	Panicle Length (cm)	Panicle Girth (cm)	1000-GrainWt.(g)	Fodder Yield / plot (kg)	Harvest Index (%)	Grain Yield/ plant (g)
Days to 50%flowering	**-0.2118**	-0.0557	-0.0079	0.0560	0.0065	0.0071	0.0362	0.0877	-0.0126	-0.2476
Days to maturity	0.0814	**0.3092**	-0.0051	-0.0595	-0.0207	0.0586	-0.0213	0.0838	0.0248	0.2054
Plant height (cm)	0.0059	-0.0026	**0.1566**	0.0178	-0.0209	-0.0363	-0.0068	0.0063	-0.0433	0.1611
Number productive of tillers per plant	-0.0977	-0.0710	0.0420	**0.3691**	0.0564	0.0397	0.0865	0.0954	0.0395	0.4140
panicle length(cm)	0.0012	0.0025	0.0050	-0.0058	**-0.0377**	-0.0025	-0.0036	-0.0014	-0.0044	-0.0011
panicle girth (cm)	-0.0045	0.0254	-0.0310	0.0144	0.0088	**0.1339**	0.0535	0.0365	0.0797	0.2285
1000-Grain Wt.(g)	-0.0141	-0.0057	-0.0036	0.0193	0.0078	0.0329	**0.0825**	0.0279	0.0002	0.2326
Fodder Yield/plant(g)	-0.0070	0.0046	0.0007	0.0044	0.0006	0.0046	0.0057	**0.0169**	-0.0005	0.3538
Harvest Index (%)	-0.0010	-0.0013	0.0045	-0.0017	-0.0019	-0.0097	0.0001	0.0005	**-0.0162**	0.0672
Grain Yield/plant (g)	-0.2476	0.2054	0.1611	0.4140	-0.0011	0.2285	0.2326	0.3538	0.0672	**1.0000**

Residual effect = 0.8070. Bold figures present diagonally indicates direct effect; those present off diagonally indicates indirect effect.

Table 3: Direct and indirect effect of yield and its components characters on grain yield and at genotypic level.

Characters	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of Tillers / Plant	Panicle Length (cm)	Panicle Girth (cm)	1000-GrainWt.(g)	Fodder Yield / plant (g)	Harvest Index (%)	Grain Yield/ plant (g)
Days to 50%flowering	**-0.4189**	-0.1390	-0.0178	0.1211	0.0143	0.0173	0.0699	0.2056	-0.0280	-0.3627
Days to maturity	0.1412	**0.4256**	0.0088	-0.0834	-0.0323	0.0840	-0.0381	0.1997	0.0602	0.1400
Plant height (cm)	0.0087	0.0042	**0.2045**	0.0244	-0.0435	-0.0510	-0.0082	0.0095	-0.0739	0.2050
number productive of tillers per plant	-0.1533	-0.1039	0.0634	**0.5305**	0.0972	0.0611	0.1345	0.1871	0.0532	0.5736
panicle length(cm)	0.0012	0.0027	0.0076	-0.0065	**-0.0357**	-0.0027	-0.0033	-0.0020	-0.0025	0.0159
panicle girth (cm)	-0.0111	0.0528	-0.0667	0.0308	0.0202	**0.2674**	0.1115	0.0995	0.1721	0.3194
1000-Grain Wt.(g)	-0.0173	-0.0093	-0.0042	0.0263	0.0095	0.0433	**0.1037**	0.0477	0.0007	0.2854
Fodder Yield/plot(kg)	0.0900	-0.0861	-0.0085	-0.0647	-0.0102	-0.0683	-0.0844	**-0.1835**	-0.0079	0.5615
Harvest Index (%)	-0.0033	-0.0070	0.0178	-0.0049	-0.0034	-0.0318	-0.0003	-0.0021	**-0.0494**	0.1244
Grain Yield/plant (g)	-0.3627	0.1400	0.2050	0.5736	0.0159	0.3194	0.2854	0.5615	0.1244	**1.0000**

Bold figures present diagonally indicates direct effect; those present off diagonally indicates indirect effect.

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