Correlation and path coefficient in F_3 generation Ramnad Mundu Chilli (*Capsicum annuum* L.) for growth, yield and quality

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Abstract

The F_3 generation progenies of the Mundu chilli cross PKM CA 20 x PKM CA 08 were evaluated for various yield-related traits at the Western Farm Experimental site of the Department of Vegetable Science, HC & RI, Periyakulam of Tamil Nadu Agricultural University. In accordance with the findings of correlation studies, the genotypic correlation coefficient was wider when compared to the corresponding phenotypic correlation coefficient for every attribute. The dry fruit yield per plant had high significance and positive association with fresh fruit yield per plant, fruit length, capsaicin, oleoresin and proline content at both genotypic and phenotypic levels, indicating that these traits play an important role in governing the yield attributing traits. The path coefficient analysis had represented the positive direct effect of dry fruit yield per plant with fresh fruit yield per plant, thousand seed weight, oleoresin and capsaicin content. The research findings are highlighted upon the positive direct effect on dry fruit yield of the genotypes having the maximum fresh fruit yield per plant, oleoresin, and capsaicin content, which have adequate importance throughout the selection process.

Keywords: Correlation, mundu chilli, path coefficient, quality, yield

Introduction

One of the most prominent vegetable cum spice crops worldwide is chilli. In India, chilli is the most significant commercial vegetable and spice crop with its profound insights on exports. The primary ingredient in any Indian cuisine is chillies which is an unavoidable spice since they add taste, colour, and fiery flavour. It is prized for its pungency, which results from the presence of the crystalline, caustic, volatile alkaloid capsaicin in fruit placenta. In both allopathic and ayurvedic medicine, capsaicin has a variety of preventive and therapeutic benefits (Sumathy Kutty and Mathew, 1984) and has several uses in the culinary and pharmaceutical industries. In addition to being a good source of vitamin C, it also includes significant amounts of provitamin A carotene, vitamin E, vitamins B1 (thiamine), B2 (riboflavin), and B3 (niacin), as well as trace amounts of proteins, lipids, carbohydrates, and minerals (Hosmani, 1993).

The Mundu chilli (*Capsicum annuum* spp.) is an indigenous oblong / round chilli which is raised as a rainfed crop only for spice. The Mundu chilli has received its Geographical indication (GI tag) in 2023 for its unique fiery and spicy flavour and it is cultivated in saline belt regions of Viruthunagar, Tuticorin and Ramanathapuram districts, where soils possess moderate to extreme levels of alkalinity (pH 7.5-9.5) and limited annual rainfall (460 mm). Several kinds of mundu chilli, such as *"Oosi mundu"*, *"Chatti mundu"* and *"Sathurai mundu"* are available with

distinct variations in shape. However, no systematic breeding programme has been implemented so far to select or develop a genetically superior type of mundu chilli. As, no systematic breeding programme on Mundu chilli till 2016-17, a research program was formulated during 2017-18 by assembling forty seven genotypes from the dryland districts of Tamil Nadu including Virudhnagar, Tuticorin and Ramanathapuram. The research was carried out to breed a suitable variety / hybrid of mundu chilli with high yield and quality up to F_2 generation from 2018-2021. The present study on F_3 generation of Mundu chilli is a follow up research study (2021-23) at the Department of Vegetable Science, HC & RI, TNAU, Periyakulam, Tamil Nadu, with the best performing five parents from the forty-seven genotypes assembled and their respective four crosses, which is being evaluated for yield and quality.

Early flowering often predicts early harvest, which is what farmers seek in order to obtain the high market price that prevails in the early cropping season and alleviate the risk of crop maintenance in the late harvest (Patil *et al.* 2012). Given that, yield is a complicated character with many complex traits. To create the best selection index for increasing yield, it is critical to understand how yield and its component qualities interact with one another. In order to organize a connection between the predictor and response variables, Wright (1921) suggested correlation and path analysis. While path coefficient analysis enables the division of correlation into direct effects (path coefficient) and indirect effects (effects exerted through other variables), correlation only evaluates the link between yield and other attributes. Therefore, the present study is designed to investigate the character correlations and the direct and indirect effects of several independent traits on the dependent traits on the production of F_3 generation mundu chilli progenies.

Materials and Methods

The present investigation was carried out at Horticulture College and Research Institute, Periyakulam, during 2021–22, with distinct progenies of Mundu chilli cross PKM CA 20 x PKM CA 08, along with 5 parental accessions. The seeds of this cross and five parents were sown at the Western block, Farm of Department of Vegetable Science, HC & RI, Periyakulam, during second week of March 2022. Healthy seedlings that were thirty-five days old were transplanted to the main field by third week of April 2022, at a spacing of 60 x 45 cm. All the recommended practices for chilli cultivation were followed to raise the Mundu Chilli crop. Observations were recorded at 30, 60 and 90 days after transplanting and at harvest.

Results and Discussion

The correlation coefficient at both genotypic and phenotypic levels in Table 1 indicated that the dry fruit yield per plant was significantly and positively correlated with primary branches per plant (0.260 G, 0.256 P), number of fruits per plant (0.337 G, 0.327 P), fresh fruit yield per plant (0.276 G, 0.272 P), oleoresin (0.312 G, 0.313 P), proline content (0.267 G, 0.273 P), fruit length (0.289 G, 0.286 P) and capsaicin content (0.271 G, 0.274 P).

The primary branches per plant showed positive correlation at both phenotypic and genotypic levels with plant height (0.257 G, 0.250 P) and the single fresh fruit weight showed positive correlation with fruit length (0.327 G, 0.324 P). The days to 50% flowering showed positive significance with plant height (0.336 G, 0.338 P) and primary branches per plant (0.338 G, 0.337 P). The number of fruits showed highly significant positive correlation with fruit length (0.408 G, 0.394 P) and the primary branches per plant (0.340 G, 0.333 P), whereas the fresh fruit yield per plant showed highly significant positive correlation with plant height (0.460 G, 0.450 P) and fruit girth (0.288 G, 0.282 P).

Thousand seed weight showed highly significant positive correlation with fruit girth (0.469 G, 0.467 P), single fruit fresh weight (0.410 G, 0.406 P) and positive significant correlation with plant height (0.285 G, 0.281 P) and number of seeds per fruit (0.213 G, 0.212 P). The

capsaicin content showed highly significant positive correlation with fruit length (0.479 G, 0.476 P), number of fruits per plant (0.443 G, 0.444 P), number of seeds per fruit (0.407 G, 0.403 P) and significant positive correlation with fresh fruit yield per plant (0.350 G, 0.349 P) and single fresh fruit weight (0.273 G, 0.272 P).

The oleoresin content showed highly significant positive correlation with single fresh fruit weight (0.404 G, 0.402 P) and positive correlation with fruit girth (0.269 G, 0.270 P). The ascorbic acid also showed significant positive correlation with fruit yield per plant (0.395 G, 0.384 P) and positive significant correlation with fruit girth (0.237 G, 0.235 P) and primary branches per plant (0.208 G, 0.202 P). The colour value had a positive correlation with days to 50% flowering (0.357 G, 0.356 P), fruit length (0.318 G, 0.315 P) and fruit girth (0.357 G, 0.355 P). Proline showed positive significant correlation with fruit length (0.304 G, 0.300 P) and number of fruits per plant (0.209 G, 0.207 P). Highly significant but negative correlation was seen in number of seeds per fruit with days to 50% flowering (-0.559 G, -0.565 P), capsaicin with days to 50% flowering (-0.417 G, -0.419 P) and colour value with number of seeds per fruit (-0.433 G, -0.435 P).

The significant negative correlation was found in fruit girth with plant height (-0.370 G, -0.372 P) and days to 50% flowering (-0.240 G, -0.239 P), single fresh fruit weight with days to 50% flowering (-0.220 G, -0.224 P), fresh fruit yield per plant with days to 50% flowering (-0.287 G, -0.295 P), capsaicin content with days to 50% flowering (-0.417 G, -0.419 P), number of seeds per fruits with plant height (-0.346 G, -0.357 P) and primary branches per plant (-0.346 G, -0.356 P), thousand seed weight with fruit length (-0.256 G, -0.257 P), number of fruits per plant (-0.255 G, -0.260 P), fresh fruit yield per plant (-0.255 G, -0.226 P), proline with fruit girth (-0.201 G, -0.205 P).

There was significant negative correlation for oleoresin content with plant height (-0.250 G, -0.258 P), number of fruits per plant (-0.200 G, -0.207 P), thousand seed weight (-0.242 G, -0.245 P) and capsaicin content (-0.229 G, -0.230 P). Also, significant negative correlation was found in ascorbic acid with plant height (-0.212 G, -0.211 P), single fresh fruit weight (-0.221 G, -0.218 P), thousand seed weight (-0.224 G, -0.225 P) and colour value with single fresh fruit weight (-0.224 G, -0.229 P) and thousand seed weight (-0.355 G, -0.229 P). The genotypic and phenotypic shaded correlation matrix for dry fruit yield per plant (g) is illustrated in Figure (1) & (2) respectively.

Path-coefficient analysis

Direct effect of various characters on dry fruit yield per plant of the cross PKM CA 20 X PKM CA 08

In the cross PKM CA 20 X PKM CA 08, critical estimation of path coefficient analysis in which diagonal values represented in Table 2 has direct effects, indicating that the primary branches per plant (0.604, 0.585) had the highest direct and positive effect on dry fruit yield per plant, followed by fresh fruit yield per plant (0.558, 0.539), 1000 seed weight (0.313, 0.294), oleoresin content (0.256, 0.251). The high and positive direct effect of fruit yield with primary branches per plant with fresh fruit yield was observed by Leaya Jose and Abdul Khader (2002) in chilli.

Similarly, on the other hand capsaicin content (-0.350, -0.335), single fresh fruit weight (-0.317, -0.295), fruit length (-0.256, -0.257), number of fruits per plant (-0.226, -0.236) had negative direct effect on dry fruit yield per plant at both phenotypic and genotypic levels respectively. Leaya Jose and Abdul Khader (2002) also observed the negative direct effect on fruit length and fruit weight with fresh fruit yield in chilli. The results of negative direct effects on number of fruits per plant and capsaicin with fruit yield in chilli were supported by the findings of Vani *et al.* (2007) and Pandit *et al.* (2009) respectively.

Indirect effects of various characters on dry fruit yield per plant of the cross PKM CA 20 X PKM CA 08

In the cross PKM CA 20 X PKM CA 08, both phenotypic and genotypic path analysis in Table 2, showed that, the plant height had positive indirect effect on dry fruit yield per plant through primary branches per plant (0.151, 0.150), 1000 seed weight (0.088, 0.084), and negative indirect effect through fresh fruit yield (-0.257, -0.243). Primary branches per plant had positive indirect effect on dry fruit yield per plant through proline (0.029, 0.030), fruit length (0.010, 0.011) and negative indirect effect through number of fruits per plant (-0.075, -0.080), days to 50% flowering (-0.069, -0.067). Days to 50% flowering had positive indirect effect on dry fruit yield per plant through primary branches per plant (0.204, 0.198), capsaicin content (0.147, 0.139) and negative indirect effect through fresh fruit yield (-0.165, -0.154). The positive indirect effects of primary branches per plant and days to 50% flowering has been reported by Singh and Singh (2004) and Sharma *et al.* (2010) in chilli.

Fruit length had positive indirect effect on dry fruit yield per plant through single fresh fruit weight (0.103, 0.096), fresh fruit yield (0.094, 0.086) and negative indirect effect through capsaicin content (-0.167, -0.159), number of fruits per plant (-0.092, -0.093). Fruit girth had positive indirect effect on dry fruit yield per plant through fresh fruit yield (0.160, 0.152), oleoresin content (0.069, 0.067), dry fruit yield per plant (0.082, 0.079). Single fresh fruit weight had positive indirect effect on dry fruit yield per plant through 1000 seed weight (0.128, 0.119), number of seeds per fruit (0.015, 0.012) and negative indirect effect through oleoresin content (-0.103, -0.101). Number of fruits per plant had positive indirect effect on dry fruit yield per plant through primary branches per plant (0.201, 0.198) and negative indirect effect through capsaicin content (-0.155, -0.148) and fruit length (-0.104, -0.101). Such results were also confirmed by Datta and Jana (2010) and Shabarish and Dharmatti (2014) on number of fruits per plant with dry fruit yield per plant in chilli and cluster bean respectively.

Fresh fruit yield per plant had positive indirect effect on dry fruit yield per plant through days to 50% flowering (0.061, 0.057) and negative indirect effect through capsaicin content (-0.122, -0.117) and ascorbic acid (-0.096, -0.087). Number of seeds per fruit had positive indirect effect on dry fruit yield per plant through days to 50% flowering (0.116, 0.111) and negative indirect effect through primary branches per plant (-0.215, -0.203), capsaicin content (-0.141, -0.135) and 1000 seed weight had positive indirect effect on dry fruit yield per plant through fruit length (0.065, 0.066), number of fruits per plant (0.058, 0.060) and negative indirect effect through single fresh fruit weight (-0.130, -0.120), fresh fruit yield per plant (-0.126, -0.121). These findings were supported by Bijalwan and Mishra (2013), Singh (2014) and Yatung *et al.* (2014) on number of seeds per fruit and fresh fruit yield per plant in chilli.

Capsaicin content had positive indirect effect through fresh fruit yield per plant (0.194, 0.188) and negative indirect effect through fruit length (-0.122, -0.122), number of fruits per plant (-0.100, -0.105). Oleoresin content had positive indirect effect through single fresh fruit weight (0.128, 0.119) and negative indirect effect through primary branches per plant (-0.119, -0.113). Ascorbic acid had positive indirect effect through fresh fruit yield per plant (0.220, 0.207), primary branches per plant (0.105, 0.118) and negative indirect effect through proline (-0.029, -0.031). Colour value had positive indirect effect through primary branches per plant (0.093, 0.090) and negative indirect effect through 1000 seed weight (-0.110, -0.104). Proline had positive indirect effect through primary branches per plant (0.105, 0.098) and negative indirect effect through fruit length (-0.076, -0.078). Similar findings were reported by Bijalwan and Mishra (2013) and Abraham *et al.* (2017) for the negative indirect effect of oleoresin, ascorbic acid and colour value of chilli. The genotypic and phenotypic path diagram for dry fruit yield per plant (g) is illustrated in Figure (3) & (4) respectively.

Conclusion

The results of this study implies that, the growth, yield and quality traits should be properly taken into account for direct selection, in order to create high yielding varieties of Mundu Chilli through plant breeding. Statistically significant positive correlation was found for the dry fruit yield per plant with number of fruits per plant and number of primary branches per plant. Also, 1000 seed weight showed significantly positive correlation with number of fruits per plant, fresh fruit yield per plant and number of seeds per fruit. Therefore, an appropriate selection could potentially be made based on these traits to boost the selection of Mundu Chilli progenies for genetic improvement.

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Table 1. Estimate of genotypic (G) and phenotypic (P) correlation co-efficient between dry fruit yield and its components in F_3 generation Mundu Chilli PKM CA 20 x PKM CA 08

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	G	0.257*	0.336*	-0.118	-0.370*	0.176	0.119	0.460**	-0.346*	0.285*	-0.184	-0.250*	-0.211*	-0.093	0.133	-0.110
	P	0.250*	0.338*	-0.117	-0.372*	0.179	0.112	0.450**	-0.357*	0.281*	-0.186	-0.258*	-0.212*	-0.090	0.138	-0.111
2	G		0.338*	-0.043	0.084	0.109	0.340*	0.015	-0.346*	-0.149	0.120	-0.192	0.208*	0.153	0.167	0.260*
	P		0.337*	-0.039	0.087	0.108	0.333*	0.008	-0.356*	-0.153	0.119	-0.197	0.202*	0.154	0.174	0.256*
3	G			-0.127	-0.240*	0.220*	0.161	-0.287*	-0.559**	-0.108	-0.417**	0.048	-0.144	0.357*	0.051	-0.007
	P			-0.124	-0.239*	0.224*	0.156	-0.295*	-0.565**	-0.107	-0.419**	0.048	-0.140	0.356*	0.056	-0.011
4	G				0.101	0.327*	0.394**	0.159	0.111	-0.256*	0.476**	0.159	0.003	0.314*	0.304*	0.289*
	P				0.099	0.324*	0.408**	0.169	0.116	-0.257*	0.479**	0.161	-0.002	0.318*	0.300*	0.286*
5	G					0.137	0.065	0.282*	0.011	0.467**	0.082	0.269*	0.237*	0.355*	-0.201*	0.079
	P					0.140	0.070	0.288*	0.013	0.465**	0.083	0.270*	0.235*	0.357*	-0.205*	0.082
6	G						-0.015	0.015	0.129	0.406**	0.273*	0.404**	-0.221*	-0.224	-0.096	-0.102
	P						-0.021	0.009	0.127	0.410**	0.272*	0.402**	-0.218*	-0.229*	-0.092	-0.106
7	G							0.173	-0.066	-0.255*	0.443**	-0.200*	0.075	0.079	0.209*	0.337*
	P							0.162	-0.078	-0.260*	0.444**	-0.207*	0.086	0.078	0.207*	0.327*
8	G								0.020	-0.225	0.350*	-0.048	0.384**	0.052	0.089	0.276*
	P								0.012	-0.226*	0.349*	-0.051	0.395**	0.049	0.099	0.272*
9	G									0.213*	0.407**	0.171	-0.001	-0.433**	0.062	-0.055
	P									0.212	0.403**	0.169	0.003	-0.435**	0.069	-0.059
10	G										0.095	-0.242*	-0.224*	-0.355*	0.094	0.065
	P										0.095	-0.245*	-0.225*	-0.354*	0.095	0.067
11	G											-0.229*	0.043	-0.169	0.132	0.274*
	P											-0.230*	0.041	-0.170	0.135	0.271*
12	G												-0.050	0.201*	0.141	0.312*
	P												-0.048	0.200*	0.144	0.313*
13	G													0.115	-0.172	0.069
	P													0.118	-0.179	0.074
14	G														-0.125	-0.037
	P														-0.123	-0.040
15	G															0.267*
	P															0.273*

1. Plant height (cm) 2. Primary branches / plant 3. Days to 50% flowering 4. Number of fruits / plant 4. Fruit length (cm)
5. Fruit girth (cm) 6. Fresh fruit yield / plant (g) 7. Single fresh fruit weight (g) 8. Thousand seed weight (g) 9. Number of seeds / fruit
10. Capsaicin content (%) 11. Colour value (ASTA) 12. Oleoresin content (%) 13. Ascorbic acid (mg / 100g) 14. Proline (µg / g)
15. Dry fruit yield / plant (g)

Table 2. Estimation of PATH matrix of dry fruit yield per plant (Genotypic) of F_3 generation Mundu Chilli cross PKM CA 20 x PKM CA 08

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.016	0.004	0.005	-0.002	-0.006	0.003	0.002	-0.007	-0.005	0.004	-0.003	-0.004	-0.003	-0.001	0.002	-0.111
2	0.150	0.586	0.198	-0.026	0.050	0.064	0.199	0.009	-0.203	-0.087	0.071	-0.113	0.119	0.090	0.098	0.256*
3	-0.067	-0.067	-0.199	0.025	0.048	0.044	-0.032	0.057	0.111	0.022	0.083	-0.010	0.029	-0.071	-0.010	-0.008
4	0.031	0.011	0.033	-0.258	-0.026	0.084	-0.102	-0.041	-0.029	0.066	-0.123	-0.041	-0.001	-0.081	-0.078	-0.289*
5	-0.038	0.009	-0.025	0.011	0.104	0.014	0.007	0.029	0.001	-0.048	0.009	0.028	0.025	0.037	-0.021	0.079
6	-0.052	-0.032	0.065	0.097	-0.041	-0.296	0.005	-0.004	-0.038	-0.120	-0.081	0.119	0.066	0.067	0.029	-0.102
7	-0.028	-0.080	-0.038	-0.093	-0.015	0.004	-0.237	-0.041	0.016	0.061	-0.105	0.047	-0.018	-0.019	-0.046	-0.327*
8	-0.243	0.008	-0.155	0.086	0.152	0.008	0.094	0.540	0.011	-0.122	0.189	-0.026	0.207	0.029	0.048	0.276*
9	-0.034	-0.034	-0.055	0.011	0.001	0.013	-0.007	0.002	0.098	0.021	0.040	0.017	0.000	-0.043	0.006	-0.056
10	0.084	-0.044	-0.032	-0.075	-0.137	0.120	-0.075	-0.066	0.063	0.295	0.028	-0.071	-0.066	-0.105	0.028	0.066
11	0.062	-0.040	0.140	-0.159	-0.028	-0.092	-0.149	-0.117	-0.135	-0.032	-0.335	0.077	-0.014	0.057	-0.045	-0.271*
12	-0.063	-0.048	0.012	0.040	0.068	-0.101	-0.050	-0.012	0.043	-0.061	-0.058	0.251	-0.013	0.050	0.036	0.312*
13	0.049	-0.046	0.033	-0.001	-0.054	0.051	-0.017	-0.088	0.000	0.051	-0.010	0.011	-0.229	-0.027	0.040	0.070
14	0.000	0.000	0.001	0.001	0.001	-0.001	0.000	0.000	-0.001	-0.001	0.000	0.000	0.000	0.002	0.000	-0.037
15	0.024	0.030	0.009	0.055	-0.037	-0.017	0.035	0.016	0.011	0.017	0.024	0.026	-0.031	-0.023	0.181	0.267*
16	-0.111	0.256*	-0.008	-0.289*	0.079	-0.102	-0.327*	0.276*	-0.056	0.066	-0.271*	0.312*	0.070	-0.037	0.267*	1.000

1. Plant height (cm) 2. Primary branches / plant 3. Days to 50% flowering 4. Number of fruits / plant 4. Fruit length (cm)
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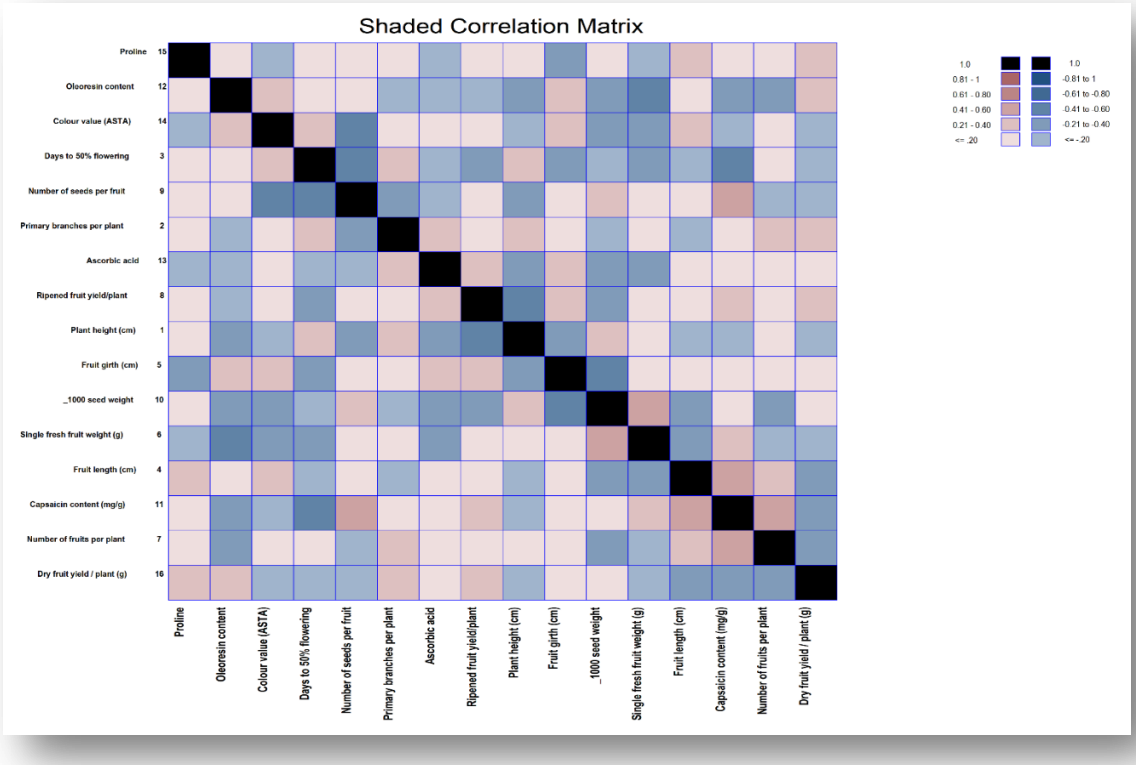
10. Capsaicin content (%) 11. Colour value (ASTA) 12. Oleoresin content (%) 13. Ascorbic acid (mg / 100g) 14. Proline (µg / g)
15. Dry fruit yield / plant (g)



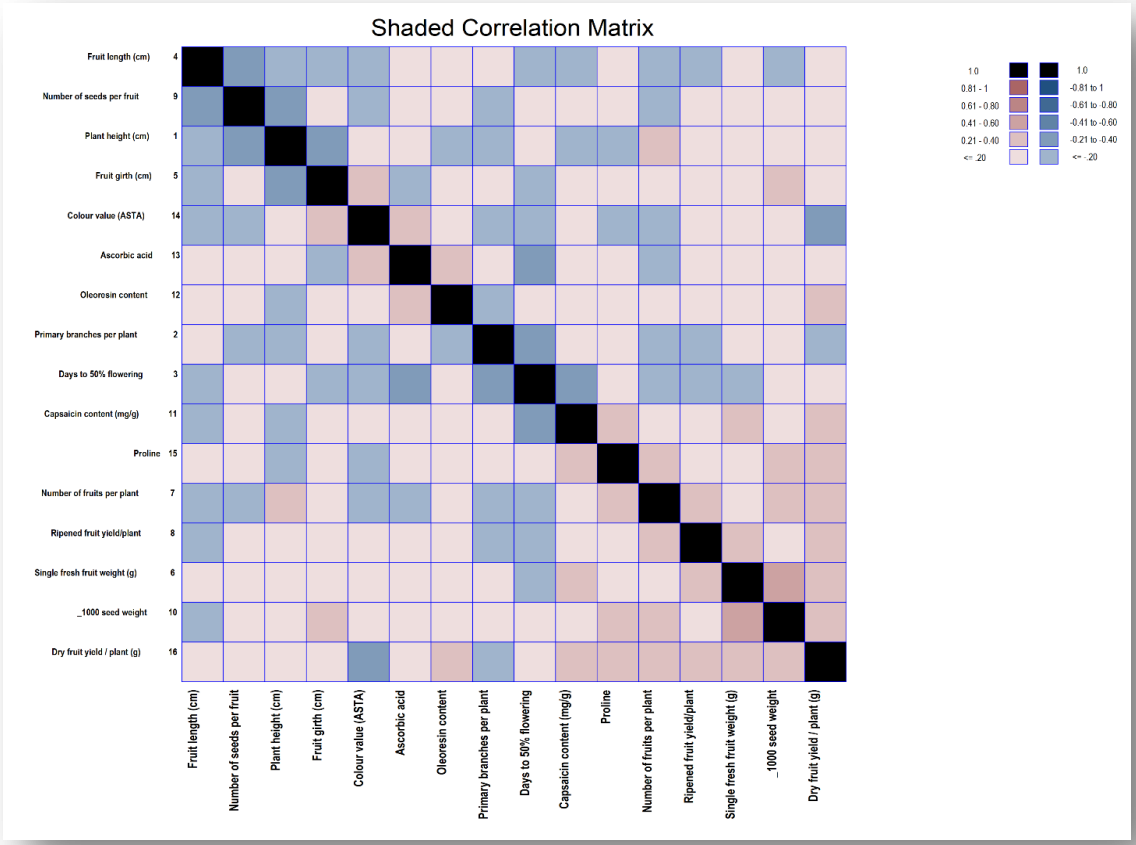


Fig. (1). Genotypic shaded correlation matrix of dry fruit yield per plant (g) of Mundu chilli

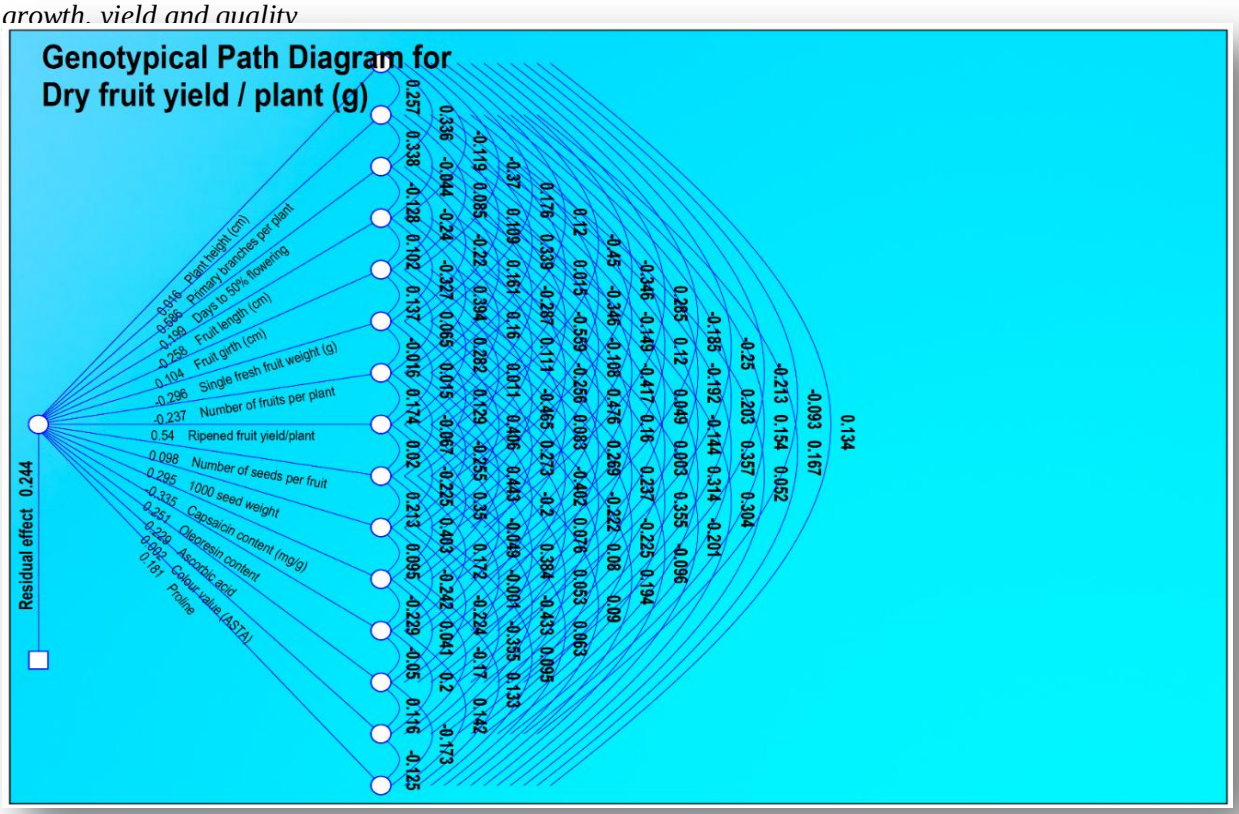


Fig. (2). Phenotypic shaded correlation matrix of dry fruit yield per plant (g) of Mundu chilli

Fig. (3). Genotypic path diagram of dry fruit yield per plant (g) of Mundu chilli

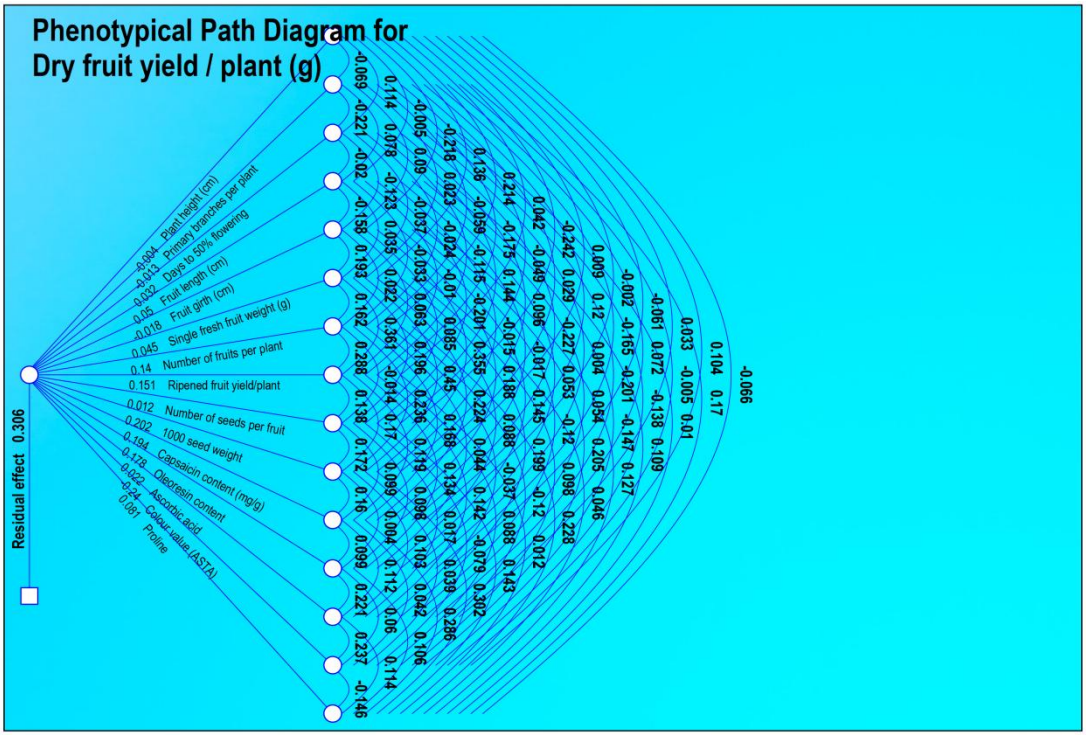


Fig. (4). Phenotypic path diagram of dry fruit yield per plant (g) of Mundu chilli