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Correlation and Path Analysis Study in Chilli (*Capsicum annuum* L.) Genotypes

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Authors' contributions

This work was carried out in collaboration among all authors. Author JS designed the study, performed the statistical analysis and wrote the protocol. Authors KRR and PS managed the analyses of the study. Authors KA, SRP and MB wrote the first draft of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation on study of Correlation and path analysis study in chilli (*Capsicum annuum* L.) genotypes was carried out during during *rabi crop are that sown in winter season*, in the year 2016-17. The study was under taken on 30 genotypes of chilli using randomized block design (RBD) with three replication. The result on phenotypic and genotypic correlation coefficient revealed that fresh fruit yield per plant was significantly and positively correlated with total number of fruits per plant, fruit diameter, fruit pedicel length, fresh fruit weight, dry fruit weight, seed content, ascorbic acid content, oleoresin content, capsanthin content and capsaicin content. However anthracnose resistance, number of primary branches per plant, number of flowers per axil and fruit length showed significantly and negatively correlated with Fresh fruit yield per plant. The

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path coefficient analysis different yield and yield contributing traits on fruit diameter, length of fruit, fruits per plant and fresh weight of fruit exhibited positive direct effects on Fresh fruit yield per plant these characters play a major role in recombination breeding and suggested that direct selection based on these traits will be rewarded for crop improvement of chilli.

Keywords: Chilli; genotypes; correlation; path coefficient; traits.

1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important valuable commercial spice-cum-vegetable crop belonging to the family Solanaceae and originated in Latin American regions of New Mexico, Guatemala and Bulgaria [1]. It was first introduced in India from Brazil by the Portugese towards the end of 15th century and its cultivation became popular in the 17th century.

India is the major producer, consumer and exporter of chilli, covering an area of dry chilli 0.75 million hectares with a production of 2.1 million tonnes averaging a productivity of 1.93 metric tonnes per hectare [2]. The genus capsicum consists of a diverse range of plants and fruits, and varies enormously with respect to morphology, yield and nutrition related parameters. Chillies are grown as annual crop, although it can also be grown as perennial shrub in suitable climatic conditions. Among the five cultivated species, *Capsicum annuum* L. is the most widely cultivated species for its pungent (hot pepper) and non pungent (sweet pepper) fruits throughout the world [3], Pozzobon et al. [4].

Immature chilli fruits contain phytonutrients, ascorbic acid, caretenoids and rutin which are valued for pharmaceutical needs [5]. Chillies have two important qualities; biting pungency and attractive red colour attributed to capsaicin and capsanthin, respectively. Capsaicin, a crystalline acrid volatile alkaloid present in the placenta of fruit, carries diverse prophylactic and therapeutic uses in allopathic and ayurvedic medicines [6]. Red coloured pigment is used as a natural colour additive in food, drugs and cosmetics. These pigments are also rich in bioflavonoids, which are powerful antioxidants and inhibit the progression of chronic diseases such as muscular degeneration, cardiovascular diseases and cancer [7].

The presence of capsaicinoids is specific to the genus *capsicum*, which varies widely among the varieties, seasons, places of origin, etc [8]. The chilli fruits are consumed at different ripening stage (green, red or partial red-ripe). Besides, it is used in many processing industries for various products such as pepper sauce, pickled pepper, ground pepper and dried pepper.

Yield is a complex quantitative character governed by large number of genes and is greatly influenced by environmental factors. Hence, selection of superior genotypes based on yield alone may not be effective. So to make selection effective, it is necessary to separate genetic variability from total variability that enables the breeder to adopt suitable breeding programme. Variability studies will not be of much help for improvement of yield as it is associated with number of component characters. Therefore, knowledge of genetic correlations among the characters contributing to the yield is necessary to plan a sound selection programme for improvement in yield through indirect selection of component traits. However, the correlation between the yield and its component characters are not often real because of interrelationship existing between the component characters themselves. Therefore, analysis of inter component correlation is very essential to expose the direct and indirect contribution of each component which is there in determined by path-coefficient analysis [9].

2. MATERIALS AND METHODS

The present investigation was carried out at College of Horticulture, Rajendranagar, Hyderabad, Sri Konda Laxman Telangana state Horticultural University, Mulugu, Siddipet, Telangana, during *rabi crop are that sown in winter season*, of the year 2016-17. The plot was selected on the basis of suitability of the land for cultivation of Chilli. The site of the experiment is situated in semi arid tropical zone at an altitude of 542.6 m above sea level. Geographically, it lies at latitude of 17°.19' N and a longitude of 79°.23' E. The meteorological data recorded at the meteorological observatory of Agricultural Research Institute, Rajendranagar, Hyderabad for the period of experimentation the annual rain fall 391.6 mm to 2.0 mm and temperature 19.1 to 30.2°C.

2.1 Source of Seed Materials

The 30 genotypes of chilli in different region were collected from NBPGR and AVRDC Regional stations, Hyderabad. EC-399569, EC-390033, IC-255916, EC-399535, EC-391083, IC-255944, IC-208591, IC-255958, IC-25913, EC-391088, IC-214966, IC-208534, EC-399572, AAT-22, SR-3429, NIC-19967, PSR-7074, LCA-625, LCA-999, LCA-620, Bydagi, Devanur Deluxe, Warangal Chapata, EC-246019, AVPP0514, AVPP9813, EC-334182, EC-382175, IC-214965, EC-399533. The data was recorded on following the quantitative and qualitative parameters.

2.2 Experimental Design

The study was under taken on 30 genotypes of chilli using randomized block design (RBD) with three replication at college of horticulture, SKLTSHU, Rajendranagar, Hyderabad. During *Rabi crop is that sown in winter season*, in the year 2016-17. Each treatment was randomly replicated thrice.

2.3 Nursery Raising

Seeds of each genotype were sown in protrays on 04th August, 2016 and water was sprinkled regularly. The seeds germinated within a week after sowing. The mulches were removed after germination of seeds and beds were kept free from weeds. The six weeks old uniform and healthy seedlings from each accession were used for transplanting in the main experimental plots.

2.4 Preparation of Experimental Plot

The experimental field was brought to fine tilth by ploughing thrice followed by harrowing. Before final harrowing, FYM @ 25 tonnes/ha was applied with recommended fertilizer doses of 120:60:50 kg NPK/ha in the form of urea, single super phosphate and muriate of potash, respectively. Urea and muriate of potash were applied in three equal splits during the crop growth period at the time of transplanting, 30 DAT and 60 DAT, whereas single super phosphate was applied as a basal dose.

2.5 Transplanting and After Care

Six weeks old healthy seedlings were transplanted to the main field after allotting entries randomly in each replication. Each treatment or a genotype in each replication was represented by a single row plot of 5 m length. The field was irrigated and the seedlings were transplanted by maintaining a spacing of 60 cm between the rows and 50 cm between the plants with in the row. Immediately after transplanting the field was irrigated lightly. The plots were kept free of weeds and irrigated as and when required depending on soil moisture content. Need based plant protection measures were taken up to keep the plot free from pests and diseases.

2.6 Correlation Analysis

To determine the degree of association of characters with yield and also among the yield components, the correlation coefficients were calculated.

Both genotypic and phenotypic coefficients of correlation between two characters were determined by using the variance and covariance components as suggested by Al-Jibouri *et al.* (1958).

$$r_g(xy) = \frac{Cov_g(xy)}{\sqrt{\sigma_g^2(x) \,.\, \sigma_g^2(y)}}$$

$$r_p(xy) = \frac{Cov_p(xy)}{\sqrt{\sigma_p^2(x) \,.\, \sigma_p^2(y)}}$$ Where,

r_g (xy), r_p (xy) are the genotypic and phenotypic correlation coefficients respectively.
Cov_g, Cov_p are the genotypic and phenotypic covariance of xy, respectively.
σ^2_g and σ^2_p are the genotypic and phenotypic variance of x and y, respectively.

The calculated value of 'r' was compared with table 'r' value with n-2 degrees of freedom at 5% and 1% level of significance, where, n refers to number of pairs of observation.

2.7 Path Coefficient Analysis

Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as suggested by Wright [9] and illustrated by Dewey and Lu [10]. Standard path coefficients are the standardized partial regression coefficients and the obtained using statistical software packages called GENRES. These values were obtained by solving the

following set of 'p' simultaneous equation using above package.

$$P_{01} + P_{02}\, r_{12} + \text{---------} + P_{0P}\, r_{1P} = r_{01}$$
$$P_{01} + P_{12}\, r_{02} + \text{---------} + P_{0P}\, r_{2P} = r_{02}$$

$$\downarrow$$

$$P_{01} + r_{1P} + P_{02}\, r_{2P} + \text{---------} + P_{0P} = r_{0P}$$

Where, $P_{01,}\ P_{02,}$ ---------- P_{0P} are the direct effects of variables 1,2,--------p on the dependent variable 0 and $r_{12,}\ r_{13,}$ ---------- r_{1P}--------- $r_{P(P-1)}$ are the possible correlation coefficients between various independent variables and r_{01}, r_{02}, r_{03} ---- r_{0P} are the correlation between dependent and independent variables.

The indirect effects of the i^{th} variable *via* j^{th} variable is attained as (P_{oj} x r_{ij}). The contribution of remaining unknown factor is measured as the residual factor, which is calculated and given below.

$$P^2ox = 1-[P^2_{01}+2P_{01}P_{02}r_{12}+2P_{01}P_{03}r_{13}+ \text{----------}+ P^2_{02}+ 2P_{02}P_{03}r_{13}+ \text{--------}+P^2_{0P}]$$

Residual factor = $\sqrt{(P^2_{ox})}$

Negligible - 0.00 to 0.09; Low - 0.10 to 0.19; Moderate 0.20 to 0.29; High - 0.30 to 1.0; Very high - >1.00

3. RESULTS AND DISCUSSION

3.1 Inter Relationship Study in Growth and Yield Parameters

3.1.1 Correlation studies

In order to find out the association between yield and yield contributing characters, the genotypic and phenotypic correlation coefficients were estimated and presented in Table 1.

3.2 Phenotypic and Genotypic Correlation Coefficient

This trait recorded positive and significant correlation with character like plant height (0.471 P, 0.520 G), number of primary branches per plant (0.021 P), days to first flowering (0.496 P, 0.542 G), number of flowers per axil (0.053 P), and days to first fruiting (0.574 P, 1.599 G), days to maturity (0.541 P, 0.571 G), duration of the crop (0.419 P, 1.473 G), total number of fruits per plant (0.171 P, 1.170 G), fruit diameter (0.322 P, 0.384 G), fruit pedicel length (0.278 P, 0.335 G), fresh fruit weight (0.193 P, 0.220 G), dry fruit weight (0.072 P, 0.078 G), seed content (0.663 P, 0.750 G), ascorbic acid content (0.598 P, 0.639 G), oleoresin content (0.454 P, 0.483 G), capsanthin content (0.048 P, 0.061 G) and capsaicin content (0.394 P, 0.477 G) (Table 1).

It also registered significant negative correlation with anthracnose resistance (-0.033 P, -0.028 G), number of primary branches per plant (-0.047 G), number of flowers per axil (-0.028 G) and fruit length (-0.310 P, -0.356 G).

Similar results were reported in chilli for different components *viz*., association of fruit yield with fresh fruit weight, fruit length, total number of fruits, fresh fruit yield, fruit diameter [11], days to maturity, fresh fruit yield per plant [12].

Fruit yield per plant with fruit length, number of primary branches per plant, fruit weight, fruit length, seed content observed positive and significant correlation. The result similar was found with Sharma et al. [13].

Number of fruits per plant, fruit length and fruit diameter observed significant and positive correlation. These results were conformity with Gupta et al. [14].

Fruit weight showed positive and significant correlation with seed content, capsanthin content, capsaicin content Choudary and Samadia [15] and Khurana et al. [16].

Oleoresin content, capsanthin content, capsaicin content with plant height showed positive and non significant Devi and Arumugam [17].

3.3 Indirect Effects on Growth and Yield Parameters

Number of primary branches per plant showed low negative direct effect on fruit yield at both genotypic and phenotypic level (-0.005) and (-0.006). Further, negligible negative indirect effect on fruit yield was exhibited through total number of fruits per plant at both phenotypic and genotypic -0.001 and -0.001 respectively (Table 2 & Fig. 1 and Fig. 2).

Table 1. Phenotypic (P) and genotypic (G) correlation coefficients of yield and yield attributes in thirty genotypes of chilli

Characters		Plant height (cm)	No. of primary branches per plant	Days to first flowering	N0. of flowers per axil	Days to first fruiting	Days to maturity	Duration of the crop	Total number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit pedicel length (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Seed content (%)	Ascorbic acid content (mg / 100g of fruit)	Oleoresin content (%)	Capsanthin content (ASTA units)	Capsaicin content (%)	Anthracnose resistance	Fresh fruit yield per plant (g)
Plant height (cm)	P	1.0000	0.1212	0.2011	0.1145	0.4546***	0.4506***	0.3954***	0.3001**	-0.0964	0.1827	0.3723***	-0.0139	0.0325	0.4727***	0.3088**	0.1481*	0.00728	0.0000	0.1955	0.4714
	G	1.0000	0.1762	0.2043	-0.1469	0.4883***	0.4804***	0.4192***	0.3559**	-0.1120	0.2292	0.4583***	-0.0069	0.0345	0.5373***	0.3181**	0.1594*	0.0931	-0.0249	0.2082	0.5209
Number of primary branches per	P		1.0000	0.0174	0.1623	-0.0227	0.0823	-0.0376	0.3027**	0.1960	-0.2623*	-0.0685	-0.0204	-0.0324	0.0721	-0.0515	-0.2319	0.0163	-0.0066	-0.0223	0.0213
	G		1.0000	0.0255	0.7344	-0.0421	0.1106	-0.0470	0.3684**	0.2992	-0.362***	-0.2415	-0.0969	-0.0375	0.0543	-0.0674	-0.4132	0.0213	-0.0109	-0.0417	-0.0477
Days to first flowering	P			1.0000	-0.1335	0.6977***	0.6977***	0.4251***	-0.0089	-0.1305	0.3038**	0.0807	0.3920***	0.2762**	0.2184*	0.3450***	0.1723	-0.0804	0.1691	-0.1026	0.4964
	G			1.0000	0.4192	0.7589***	0.7107***	0.4801***	-0.0087	-0.1381	0.3529**	0.1318	0.4355***	0.2956**	0.2508*	0.3640***	0.2001	-0.0795	0.2382	-0.1052	0.5423
Number of flowers per axil	P				1.0000	-0.0843	-0.0697	-0.0633	0.1886	-0.0458	0.0021	0.1188	-0.1202	-0.1316	0.0419	0.0232	0.0037	-0.0378	-0.0622	-0.0069	0.0535
	G				1.0000	0.2046	0.1962	0.1246	-0.1802	0.2153	-0.0151	-0.4489	0.3663	0.3685	-0.0711	-0.0806	0.0525	0.0394	-0.2345	0.0602	-0.0283
Days to first fruiting	P					1.0000	0.8967***	0.7618***	0.2749**	-0.0700	0.1339	0.1261	0.0556	-0.0112	0.2415	0.4118***	0.2208*	-0.1394	-0.0859	0.2269*	0.5747
	G					1.0000	0.9389***	0.8333***	0.2914**	-0.2020	0.0151	0.1411	0.0589	0.0103	0.2540	0.4305***	0.2231*	-0.1370	-0.0641	0.2333*	0.5993
Days to maturity	P						1.0000	0.8023***	0.3081	-0.0823	0.0628	0.1853	-0.0231	-0.0380	0.1975	0.4070***	0.1263	-0.0796	-0.0823	0.1755	0.5416
	G						1.0000	0.8723***	0.3356	-0.0948	0.1578	0.1965	-0.0230	-0.0177	0.2145	0.4245***	0.1249	-0.0809	-0.0958	0.1760	0.5717
Duration of the crop	P							1.0000	0.2392*	-0.0729	-0.0505	0.05663	-0.1636	-0.1420	0.2071	0.2660*	0.1372	-0.0821	-0.1027	0.3143**	0.4199
	G							1.0000	0.3075*	-0.0777	0.0558	0.0586	-0.1969	-0.1663	0.2317	0.2955*	0.1579	-0.0936	-0.1914	0.3353**	0.4739
Total number of fruits per plant	P								1.0000	0.1165	-0.377***	-0.0619	-0.4504	-0.4326	0.0087	-0.0917	-0.2067	0.0002	-0.0926	0.2473*	0.1751
	G								1.0000	0.1291	-0041***	-0.0608	-0.5048	-0.4854	0.0012	-0.0898	-0.2581	0.0158	-0.0912	0.2565*	0.1700
Fruit length (cm)	P									1.0000	-0.1948	0.1016	0.1125	-0.0013	-0.307**	-0.0675	0.0225	0.2370*	-0.2330*	-0.0893	-0.310***
	G									1.0000	-0.2277	0.0823	0.15048	0.0485	-0.358***	-0.1089	-0.0234	0.2538*	-0.2881*	-0.1073	-0.356***
Fruit diameter (cm)	P										1.0000	0.1199	0.6086***	0.5991***	0.2849	0.1240	0.3734***	-0.0063	0.2401*	-0.1054	0.3226
	G										1.0000	0.1391	0.1509***	0.7786***	0.3264	0.1439	0.4467***	-0.0078	0.3149*	-0.1215	0.3842
Fruit pedicel length (cm)	P											1.0000	0.1456	-0.0725	0.2313*	0.5074***	0.2977**	0.2752**	0.0415	-0.3182	0.2789
	G											1.0000	0.7408	-0.0933	0.2827*	0.5989***	0.3405**	0.3095**	0.264	-0.3732	0.3350
Fresh fruit weight (g)	P												1.0000	0.7132***	0.1581	0.2466*	0.3394	0.0781	0.1965	-0.1953	0.1935
	G												1.0000	0.8579***	0.1675	0.2517*	0.4269	0.0697	0.2525	-0.2198	0.2205
Dry fruit weight (g)	P													1.0000	0.0527	0.0151	0.1818	0.0403	0.0901	0.0247	0.0728
	G													1.0000	0.0602	0.0151	0.2110	0.0346	0.1044	0.0315	0.0780

Characters		Plant height (cm)	No. of primary branches per plant	Days to first flowering	N0. of flowers per axil	Days to first fruiting	Days to maturity	Duration of the crop	Total number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit pedicel length (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Seed content (%)	Ascorb ic acid content (mg / 100g of fruit)	Oleoresin content (%)	Capsanthin content (ASTA units)	Capsaicin content (%)	Anthracnose resistance	Fresh fruit yield per plant (g)
Seed content (%)	P														1.0000	0.2615*	0.2137*	0.1438	0.2610*	-0.0534	0.6631
	G														1.0000	0.2913*	0.2461*	0.1777	0.3542*	-0.0596	0.7509
Ascorbic acid content (mg / 100g of fruit)	P															1.0000	0.4630***	0.2835***	0.1970	-0.1712	0.5988
	G															1.0000	0.5011***	0.2923***	0.2776	-0.1775	0.6393
Oleoresin content (%)	P																1.0000	0.0336	0.4219***	-0.1264	0.4541
	G																1.0000	0.0282	0.5549***	-0.1418	0.4839
Capsanthin content (ASTA)	P																	1.0000	0.0552	-0.1123	0.0482
	G																	1.0000	0.0840	-0.1178	0.0615
Capsaicin content (%)	P																		1.0000	-0.1529	0.3948
	G																		1.0000	-0.1795	0.4770
Anthracnose resistance	P																			1.0000	-0.0339
	G																			1.0000	-0.0283
Fresh fruit yield per plant	P																				1.0000
	G																				1.0000

**Significant at 5 per cent level; ** Significant at 1 per cent level*

Table 2. Phenotypic (P) and genotypic (G) path coefficient analysis indicating direct and indirect effects of component characters on fruit yield in thirty genotypes of chilli

Characters		Plant height (cm)	No. of primary branches per plant	Days to first flowering	N0. of flowers per axil	Days to first fruiting	Days to maturity	Duration of the crop	Total number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit pedicel length (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Seed content (%)	Ascorbic acid content (mg / 100g of fruit)	Oleoresin content (%)	Capsanthin content (ASTA units)	Capsaicin content (%)	Anthracnose resistance	Correlation coefficient
Plant height (cm)	P	-0.0757	-0.0092	-0.0152	-0.0087	-0.0344	-0.0341	-0.0299	-0.0227	0.0073	-0.0138	-0.0282	0.0011	0.0025	-0.0358	-0.0234	-0.0112	-0.0055	0.0000	-0.0148	0.4714
	G	-0.0850	-0.0098	-0.0165	-0.0092	-0.0385	-0.0441	-0.0310	-0.0249	0.0062	-0.0178	-0.0310	0.0008	0.0015	-0.0388	-0.0269	-0.0125	-0.0066	-0.0001	-0.0186	0.4615
Number of primary	P	-0.0007	-0.0059	-0.0001	-0.0010	0.00001	-0.0005	0.0002	-0.0018	-0.0012	0.0015	0.0004	0.0001	0.0002	-0.0004	0.00003	0.00014	-0.0001	0.0000	0.0001	0.0213
branches per	G	-0.0008	-0.0062	-0.0002	-0.0020	0.0002	-0.0006	0.0001	-0.0019	-0.0014	0.0012	0.0003	0.000012	0.0001	-0.0006	0.00002	0.00011	-0.0003	-0.0025	0.00056	0.0189
Days to first flowering	P	0.00035	0.0003	0.0173	-0.0023	0.0121	0.0118	0.0074	-0.0002	-0.0023	0.0053	0.0014	0.0068	0.0048	0.0038	0.0060	0.0030	-0.0014	0.0029	-0.0018	0.4964
	G	0.00021	0.0045	0.0165	-0.0012	0.0114	0.0111	0.0064	-0.0001	-0.0055	0.0045	0.0012	0.0055	0.0034	0.0032	0.0050	0.0021	-0.0023	0.0016	-0.0029	0.3658
Number of flowers per axil	P	0.0024	0.0034	-0.0028	0.0208	-0.0017	-0.0014	-0.0013	0.0039	-0.0010	0.0000	0.0025	-0.0025	-0.0027	0.0009	0.0005	0.0001	-0.0008	-0.0013	-0.0001	0.0535
	G	0.0019	0.0022	-0.0069	0.0195	-0.0026	-0.0025	-0.0019	0.0022	-0.0020	-0.0005	0.0015	-0.0015	-0.0035	0.0008	0.0003	-0.0046	-0.0009	-0.0046	-0.0004	0.0456
Days to first fruiting	P	0.0409	-0.0020	0.0628	-0.0076	0.0901	0.0808	0.0686	0.0248	-0.0153	0.0121	0.0114	0.0050	-0.0010	0.0217	0.0371	0.0199	-0.0126	-0.007	0.0204	0.5747
	G	0.0395	-0.0039	0.0568	-0.0086	0.0801	0.0706	0.0526	0.0210	-0.0143	0.0110	0.0112	0.0041	-0.0020	0.0188	0.0288	0.0188	-0.0220	-0.008	0.0288	0.4589
Days to maturity	P	0.0628	0.0115	0.0947	-0.0097	0.1249	0.1393	0.1118	0.0429	-0.0115	0.0088	0.0258	-0.0032	-0.0053	0.0275	0.0567	0.0176	-0.0111	-0.0115	0.0244	0.5416
	G	0.0569	0.0112	0.0859	-0.0099	0.1233	0.1313	0.1112	0.0389	-0.0112	0.0066	0.0242	-0.0056	-0.0066	0.0288	0.0599	0.0165	-0.0215	-0.0219	0.0198	0.5316
Duration of the crop	P	0.0109	-0.0010	0.0117	-0.0017	0.0209	0.0220	0.0275	0.0066	-0.0020	-0.1034	0.0015	-0.0045	-0.0039	0.0057	0.0073	0.0038	-0.0023	-0.0028	0.0086	0.4199
	G	0.0105	-0.0020	0.0116	-0.0035	0.0188	0.0188	0.0188	0.0055	-0.0033	-0.2065	0.0019	-0.0055	-0.0089	0.0065	0.0055	0.0022	-0.0055	-0.0038	0.0069	0.4123
Total number of fruits per	P	0.0821	0.0828	-0.0024	0.0516	0.0752	0.0843	0.0655	0.2737	0.0319	-0.1034	-0.0169	-0.1233	-0.1184	0.0024	-0.0251	-0.0566	0.0000	-0.0253	0.0677	0.1751
plant	G	0.0751	0.0658	-0.0056	0.0456	0.0658	0.0758	0.0569	0.2614	0.0298	-0.1098	-0.0914	-0.1358	-0.13568	0.0035	-0.0352	-0.0658	-0.0563	-0.0356	0.0754	0.1638
Fruit length (cm)	P	0.0074	-0.0151	0.0101	0.0035	0.0131	0.0063	0.0056	-0.0090	-0.0770	0.0150	-0.0078	-0.0087	0.0001	0.0237	0.0052	-0.0017	-0.0183	0.0179	0.0069	-0.3108
	G	0.0065	-0.0142	0.089	0.0025	0.0124	0.0044	0.0046	-0.0099	-0.0886	0.0142	-0.0065	-0.0075	0.00001	0.0236	0.0044	-0.0056	-0.0205	0.0188	0.0072	-0.2956
Fruit diameter (cm)	P	0.0201	-0.0289	0.0334	0.0002	0.0147	0.0069	-0.0056	-0.0416	-0.0214	0.1100	0.0132	0.0670	0.0659	0.0313	0.0136	0.0411	-0.0007	0.0264	-0.0116	0.3226
	G	0.0189	-0.0356	0.0289	0.001	0.0138	0.0058	-0.0045	-0.0546	-0.0356	0.1025	0.0122	0.0569	0.0569	0.0256	0.0122	0.0389	-0.002	0.0199	-0.0114	0.2569
Fruit pedicel length (cm)	P	-0.090	0.0017	-0.0019	-0.0029	-0.0030	-0.0045	-0.0014	0.0015	-0.0025	-0.0029	-0.0241	-0.0035	0.0017	-0.0056	-0.0122	-0.0072	-0.0066	-0.0010	0.0077	0.2789
	G	-0.098	0.0016	-0.0020	-0035	-0.0040	-0.0059	-0.0056	0.0069	-0.0096	-0.0036	-0.0358	-0.0045	0.0012	-0.0069	-0.0139	-0.0089	-0.0089	-0.0026	0.0055	0.2698
Fresh fruit weight (g)	P	0.0007	0.0011	-0.0209	0.0064	-0.0030	0.0012	0.0087	0.0240	-0.0060	-0.0324	-0.0078	-0.0533	-0.0380	-0.0084	-0.0131	-0.0181	-0.0042	-0.0105	0.0104	0.1935
	G	0.0005	0.00123	-0.0256	0.0059	-0.0028	0.0011	0.0068	0.0234	-0.0078	-0.0256	-0.0069	-0.0658	-0.0458	-0.0098	-0.0214	-0.0215	-0.0066	-0.0166	0.0102	0.1896
Dry fruit weight (g)	P	0.0038	-0.0038	0.0322	-0.0154	-0.0013	-0.004	-0.0166	-0.0505	-0.0002	0.0699	-0.0085	0.0832	0.1167	0.0061	0.0006	0.0212	0.0047	0.0105	0.0029	0.0728
	G	0.0025	-0.0028	0.0258	-0.0269	-0.0025	-0.006	-0.0188	-0.0506	-0.0006	0.0569	-0.0088	0.0789	0.1155	0.0054	0.0005	0.0198	0.0032	0.0102	0.0022	0.0689
Seed content (%)	P	0.2071	0.0316	0.0957	0.0184	0.1058	0.0865	0.0908	0.0038	-0.1348	0.1248	0.1013	0.0693	0.0231	0.4382	0.1146	0.0937	0.0630	0.1144	-0.0234	0.6631
	G	0.2061	0.0289	0.0895	0.0178	0.1044	0.0789	0.0809	0.0023	-0.1456	0.1210	0.1010	0.0569	0.0210	0.4310	0.1136	0.0845	0.0598	0.1123	-0.0298	0.6621
Ascorbic acid content	P	0.1123	-0.0187	0.1255	0.0085	0.1498	0.1480	0.0967	-0.0333	-0.245	0.0451	0.1845	0.0897	0.0019	0.0951	0.3637	0.1684	0.1031	0.0716	-0.0622	0.5988
(mg / 100g of fruit)	G	0.1110	-0.0168	0.1245	0.0078	0.1369	0.1389	0.0895	-0.0458	-0.321	0.0312	0.1765	0.0789	0.0017	0.0854	0.2658	0.1589	0.1028	0.0699	-0.0589	0.6958

Characters		Plant height (cm)	No. of primary branches per plant	Days to first flowering	N0. of flowers per axil	Days to first fruiting	Days to maturity	Duration of the crop	Total number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit pedicel length (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Seed content (%)	Ascorbic acid content (mg / 100g of fruit)	Oleoresin content (%)	Capsanthin content (ASTA units)	Capsaicin content (%)	Anthracnose resistance	Correlation coefficient
Oleoresin content (%)	P	0.0159	-0.0249	0.0185	0.0004	0.0237	0.0136	0.0147	-0.0222	0.0024	0.0401	0.0320	0.0365	0.0195	0.0230	0.0497	0.1074	0.0036	0.0453	-0.0136	0.4541
	G	0.0148	-0.0356	0.0178	0.0003	0.02214	0.0132	0.0135	-0.0325	0.0013	0.0356	0.2583	0.0256	0.0188	0.0199	0.0356	0.1036	0.0025	0.0356	-0.0255	0.3569
Capsanthin content (ASTA)	P	-0.056	-0.0012	0.0061	0.0029	0.0106	0.0061	0.00063	0.0000	-0.0181	0.0005	-0.0210	-0.0060	-0.0031	-0.0110	-0.0216	-0.0026	-0.0763	-0.0042	0.0086	0.0482
	G	-0.069	-0.0056	0.0089	0.0039	0.0018	0.0051	0.00021	-0.0015	-0.0176	0.0004	-0.0189	-0.0058	-0.0089	-0.0214	-0.0245	-0.0058	-0.0856	-0.0056	0.0045	0.0357
Capsaicin content (%)	P	0.0000	-0.0011	0.0277	-0.0102	-0.0141	-0.0135	-0.0168	-0.0152	-0.0382	0.0394	0.0068	0.0322	0.0148	0.0428	0.0323	0.0692	0.0091	0.1640	-0.0251	0.3948
	G	-0.0056	-0.0025	0.0188	-0.0201	-0.0206	-0.0256	-0.0213	-0.0589	-0.0486	0.0256	0.0055	0.0246	0.0138	0.0356	0.215	0.0568	0.0071	0.1621	-0.0196	0.3916
Anthracnose resistance	P	-0.076	0.0009	0.0040	0.0003	-0.0088	-0.0068	-0.0123	-0.0096	0.00035	0.0041	0.0124	0.0076	-0.0010	0.0021	0.0067	0.0049	0.0044	0.0060	-0.0390	-0.0339
	G	-0.088	0.0008	0.0030	0.00020	-0.0098	-0.0088	-0.0256	-0.0098	0.00069	0.0058	0.0256	0.0089	-0.0052	0.0058	0.0089	0.0056	0.0059	0.0089	-0.0566	-0.0456

Phenotypic Residual effect = 0.4112; Genotypic Residual effect=0.0456 ; Diagonal (under lined) values indicate direct effects

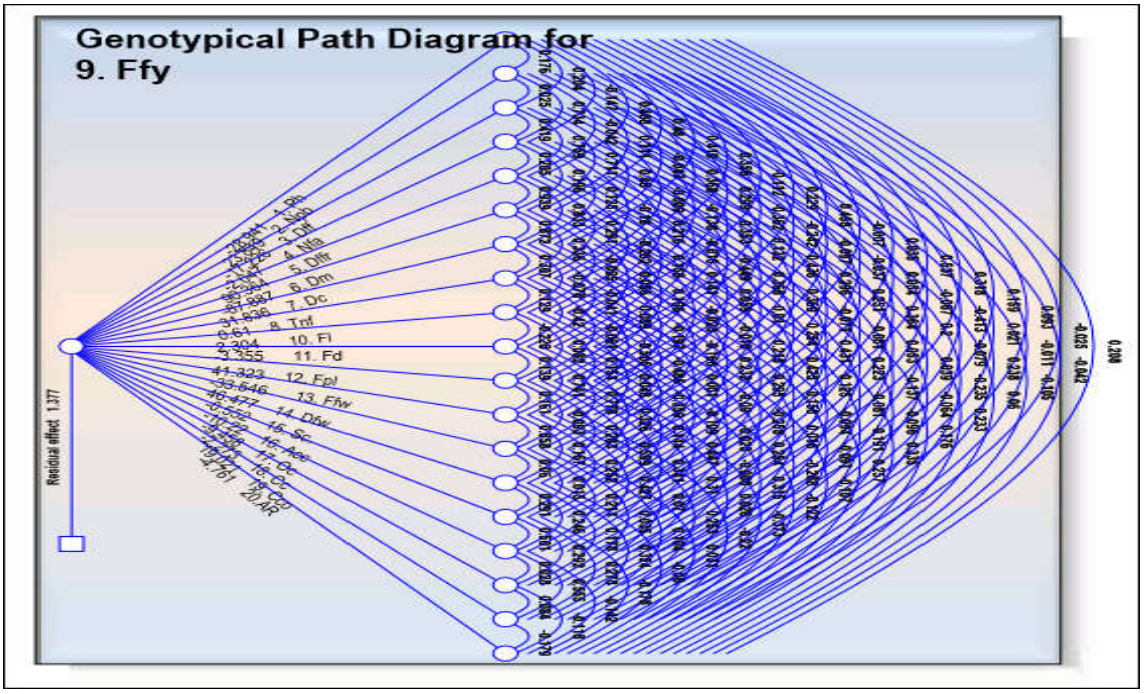

Fig. 1. Genotypic path diagram representing direct indirect effects for fresh fruit yield per plant (g) in chilli

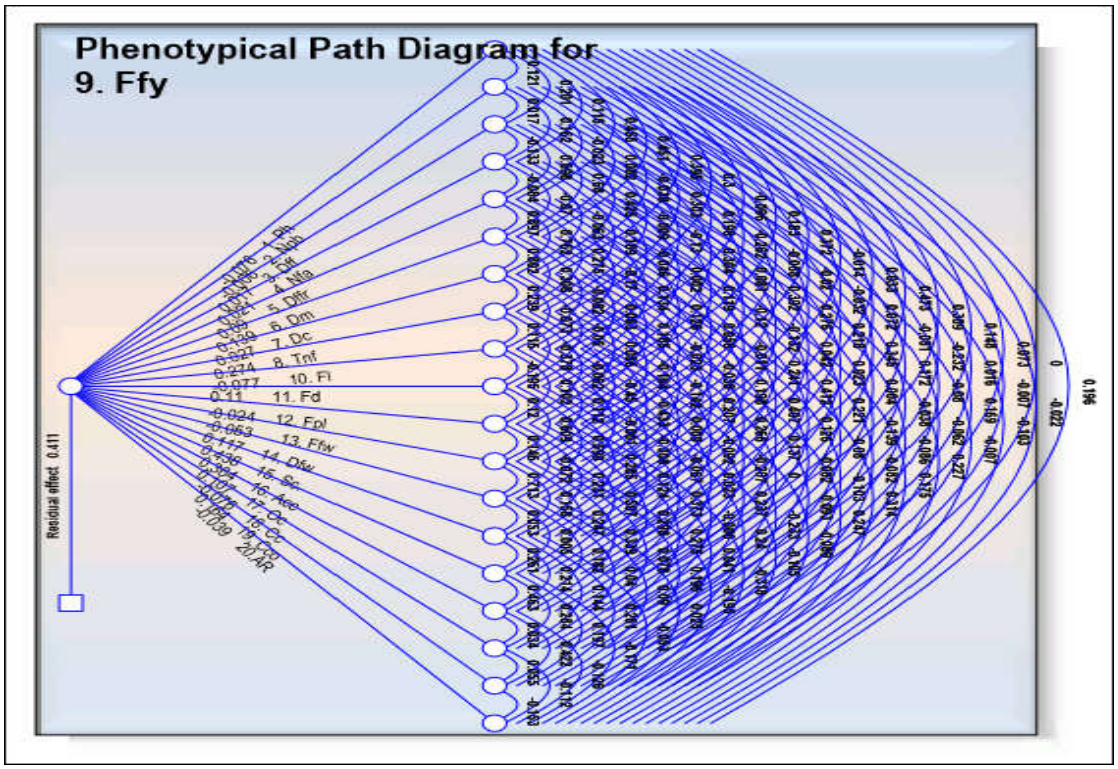

Fig. 2. Phenotypic path diagram representing direct indirect effects for fresh fruit yield per plant (g) in chilli

At phenotypic level, days to first fruiting exhibited negligible positive direct effect on plant fruit yield (0.090) and at genotypic level (0.080) respectively. Further, negligible positive indirect

effect on fruit yield was exhibited through days to maturity at phenotypic and genotypic level (0.080) and (0.070) respectively, reported that Nazir et al. [18].

At phenotypic and genotypic level, days to maturity recorded low positive direct effect(0.139 and 0.131) and negligible positive indirect effect on days to first fruiting was recorded at phenotypic and genotypic level (0.124 and 0.123) respectively. It is similar reported that Krishnamurthy et al. [12].

At phenotypic level, total number of fruits per plant was recorded positive direct effect on fruit yield per plant (0.273) and very high positive direct effect on fruit yield at genotype level (0.261) respectively. Further, indirect negligible positive effect was recorded through days to maturity at phenotypic level (0.084) and indirect very high positive effect at genotypic level (0.075), reported that Ahmed et al. [19]; Sharma et al. [20] and Hosamani and Shivkumar [21].

However, this character showed negligible negative direct effect (-0.077) and moderate negative direct effect (-0.088) on fruit yield per plant for both the phenotypic and genotypic levels. Further, indirect negligible negative effect was recorded through capsanthin content at phenotypic level (-0.018) and moderate negative indirect effect at genotypic level (-0.020) respectively.

Fresh fruit weight content recorded high and very high negative direct effect at both the phenotypic and genotypic level, on fruit yield per vine (-0.053) and (-0.065) respectively showed results from Kaur and Singh [22].

Ascorbic acid content recorded negligible direct effect at phenotypic level (0.363) and high positive direct effect at genotypic level (0.265) on fruit yield per vine respectively.

At phenotypic level, capsaicin content recorded high positive direct effect (0.164) and negligible positive direct effect on fruit yield was recorded at genotypic level (0.162) respectively.

4. CONCLUSION

Fresh fruit yield per plant had a positive and highly significant association with days to first fruiting, days to maturity, duration of the crop, total number of fruits per plant, fruit diameter, fruit pedicel length, fresh fruit weight, dry fruit weight, seed content, ascorbic acid content, oleoresin content and capsaicin content strong association of these traits revealed that the selection based on these traits would ultimately improve the fruit yield were positive and significant correlated with fresh fruit yield per plant. These characters play a major role in recombination breeding and suggested that direct selection based on these traits will be rewarded for crop improvement of chilli.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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