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Estimate of Genotypic and Phenotypic Correlation and Path Coefficients in Chilli (*Capsicum annuum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. 'All authors read and approved the final manuscript.

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ABSTRACT

The significant positive correlation of phenotypic and genotypic performance as well as path correlation of crops helps in selection of the superior cultivars. Based upon important significance of these estimates, it was applied in our research. For this an experiment was conducted on different genotypes of chilli during winter season of 2021-22, with the aim of estimate correlation coefficient among the growth and yield traits and elucidate the direct and indirect effect of different traits on yield through path coefficient analysis. The experimental material for the study consisted of 40 genotypes including one check (Kashi Anmol), laid in Randomized Complete Block Design with

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three replications. Observations were recorded on thirteen quantitative characters. The most important trait fruit yield per plant had exhibited highly significant and positive phenotypic correlation with average fruit weight (0.925), no. of fruits per plant (0.595) and fruit circumference (0.464). Path coefficient analysis revealed that average fruit weight (0.835) and no. of fruit per plant (0.385) were identified as most important traits which had positive direct on fruit yield per plant. The higher magnitude of negative direct effect on fruit yield per plant was exerted by fruit circumference (-0.018) followed by secondary branches per plant (-0.011). While maximum positive indirect effect on total fruit yield per plant shown by fruit circumference (0.448), followed by no. of fruit per plant (0.216). while negative indirect effect shown by secondary branches per plant (-0.143) followed by plant height (-0.127) and days to mature red ripe stage (-0.124). Thus, it can be inferred from the data above that selecting for these qualities will effectively enhance the crop for increased production and contributing traits.

Keywords: Chilli (Capsicum annuum L.) correlation genotypic; phenotypic; path coefficient; quantitative trait.

1. INTRODUCTION

“Chilli is an important vegetable cum spice crop grown all over the world including India. It belongs to family Solanaceae with chromosome number 2n=24. Chilli is one of Asia's most significant and widely produced spice crops. Green chillies (spice) are cultivated on an area of 411 thousand hectares in India, with a production of 4363 thousand MT, and dried chillies (spice) on an area of 702 thousand ha, with a production of 2049 thousand MT” [1]. Green chillies are high in proteins, calcium, magnesium, potassium, copper, and sulphur, as well as vitamins such as thiamine, riboflavin, and vitamin C. Capsaicin is responsible for the chilli's pungency. The pigment (colour) of chilli is caused by capsanthin, although it also includes a variety of other oleoresins. It is also a good source of 'oleoresin,' which allows for better dispersion of colour and flavor in dishes (Chattopadhyay et al., 2011).

The primary goal of plant breeders is to develop high-yielding cultivars. It is therefore, need of plant breeder to know the extent of association between yield and its various components, which will facilitate desirable selection based on component traits.

Both genotypic and environmental factors contribute to phenotypic variability. Environmental conditions have little effect on genotypic variability. Two or more variables might have reciprocal linear connections, which are known as correlation coefficients. Characters have a correlation coefficient that might be high, low, positive, or negative. To determine the direction of selection and maximise yield in the least amount of time, estimation of the correlation coefficient is required. Path coefficients measure the relative importance of each causative element and provide an effective method of distinguishing between the primary and indirect causes of the selection relationship. “Correlation in grouping with path analysis would give a better insight into cause and effect relationship between different pairs of characters” [2]. “Partitioning of total correlation into direct and indirect effect by path analysis helps in making the selection more effective” [3]. The primary goal of plant breeders is to develop high-yielding cultivars. Plant breeders must thus understand the level of relationship between yield and its various components. Make suitable selection based on component attributes easier. The improvement in yield, a dependent variable, is determined by the direct impacts of numerous independent variables, namely the yield components, and the indirect effects via other components. Because of the complexity of the data, the total correlations are insufficient to explain the real link between the features. Path coefficient analysis assists in categorising overall correlations into direct and indirect impacts of various features on yield [4].

2. MATERIALS AND METHODS

The current study was conducted at the Main Experiment Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology (Narendra Nagar), Kumarganj, Ayodhya (U.P), during the Rabi season 2021- 22. Based on the analysis of 40 genotypes, the experiment was carried out in a Randomized Block Design with three replications in the autumn-winter season of 2021–2022. The goal was to determine the correlation between various features. Twelve plants in two rows, spaced 60 x 50 centimetres apart, made up each treatment, with a net plot of

3.0 x 1.8 metres. The seedlings were shown in last week of August, on the nursery bed and transplanted on first week of October, 2021. To produce a successful harvest, all the necessary agronomic practises and plant protection measures were implemented. Observations were recorded on thirteen quantitative characters *viz.,* days to 50% flowering, days to mature green fruit, days to mature red ripe stage, plant height (cm), primary branches per plant, secondary branches per plant, no. of fruit per plant, fruit length (cm), pedicel length (cm), fruit circumference (mm), average fruit weight (g), ascorbic acid (mg/100g), fruit yield per plant (kg).

The correlations between different characters at genotypic (g) and phenotypic (p) levels were worked out as suggested by Searle [5].

Table 1. Distinguishing features of the genotypes including in the study

S. No.	Name of genotypes	Source of origin
1.	2021/CHIVAR-1	A.N.D.U.A.&T., Ayodhya
2.	2021/CHIVAR- 2	A.N.D.U.A.&T., Ayodhya
3.	2021/CHIVAR- 3	A.N.D.U.A.&T., Ayodhya
4.	2021/CHIVAR- 4	A.N.D.U.A.&T., Ayodhya
5.	2021/CHIVAR- 6	A.N.D.U.A.&T., Ayodhya
6.	2021/CHIVAR- 7	A.N.D.U.A.&T., Ayodhya
7.	2021/CHIVAR- 8	A.N.D.U.A.&T., Ayodhya
8.	2021/CHIVAR- 9	A.N.D.U.A.&T., Ayodhya
9.	2021/CHIVAR- 10	A.N.D.U.A.&T., Ayodhya
10.	2021/CHIVAR- 11	A.N.D.U.A.&T., Ayodhya
11.	2021/CHIVAR- 12	A.N.D.U.A.&T., Ayodhya
12.	2021/CHIVAR- 13	A.N.D.U.A.&T., Ayodhya
13.	2021/CHIVAR- 14	A.N.D.U.A.&T., Ayodhya
14.	2020/CHIVAR- 1	A.N.D.U.A.&T., Ayodhya
15.	2020/CHIVAR- 2	A.N.D.U.A.&T., Ayodhya
16.	2020/CHIVAR- 3	A.N.D.U.A.&T., Ayodhya
17.	2020/CHIVAR- 4	A.N.D.U.A.&T., Ayodhya
18.	2020/CHIVAR- 6	A.N.D.U.A.&T., Ayodhya
19.	2020/CHIVAR- 7	A.N.D.U.A.&T., Ayodhya
20.	2020/CHIVAR- 8	A.N.D.U.A.&T., Ayodhya
21.	2020/CHVAR- 9	A.N.D.U.A.&T., Ayodhya
22.	2020/CHIVAR- 10	A.N.D.U.A.&T., Ayodhya
23.	2020CHIVAR- 11	A.N.D.U.A.&T., Ayodhya
24.	2020/CHIVAR- 12	A.N.D.U.A.&T., Ayodhya
25.	2020/CHIVAR- 13	A.N.D.U.A.&T., Ayodhya
26.	NDC-15	A.N.D.U.A.&T., Ayodhya
27.	NDC-17	A.N.D.U.A.&T., Ayodhya
28.	NDC-18	A.N.D.U.A.&T., Ayodhya
29.	NDC-20	A.N.D.U.A.&T., Ayodhya
30.	NDC-22	A.N.D.U.A.&T., Ayodhya
31.	NDC-23	A.N.D.U.A.&T., Ayodhya
32.	NDC-25	A.N.D.U.A.&T., Ayodhya
33.	NDC-26	A.N.D.U.A.&T., Ayodhya
34.	NDC-27	A.N.D.U.A.&T., Ayodhya
35.	NDC-28	A.N.D.U.A.&T., Ayodhya
36.	NDC-29	A.N.D.U.A.&T., Ayodhya
37.	NDC-31	A.N.D.U.A.&T., Ayodhya
38.	NDC-33	A.N.D.U.A.&T., Ayodhya
39.	NDC- 36	A.N.D.U.A.&T., Ayodhya
40.	Kashi Anmol (C)	I.I.V.R. Varanasi, (U.P.)

i) Phenotypic correlation coefficient between characters X and Y

$$r_{xy(p)} = \frac{\text{Cov.}_{xy(p)}}{\sqrt{\text{Var. X (p). Var. Y (p)}}}$$

ii) Genotypic correlation between characters X and Y

$$r_{xy(g)} = \frac{\text{Cov.}_{xy(g)}}{\sqrt{\text{Var. X (g). Var. Y (g)}}}$$

Where,

r_{xy} =Correlation coefficients between X and Y.
Covariance XY=Co-variance between characters X andY
Var.X=Variance for X character
Var.Y=Variance for Y character

The significance of phenotypic correlation coefficients was tested against (n-2) degrees of freedom at 5% and 1% probability level. Where, n is the number of germplasm on which the observations were recorded.

According to Singh and Chaudhary [6], statistical analysis was performed on the data to determine the genotypic and phenotypic correlation coefficient. Following Dewey Lu's advice, the route analysis approach was used to quantify the direct and indirect impacts of component characteristics on yield [7].

3. RESULTS AND DISCUSSION

The type and degree of the relationship between yield and its constituent features is required for successful selection in future generations. The nature of the population under consideration, as well as the amount of the correlation coefficient, are frequently impacted by the people observed. Correlations between character pairs are caused by gene linkage or pleiotropy. As a result, choosing one attribute influences the other related or pleiotropically impacted qualities. Correlation studies have received a lot of attention in plant improvement since they aid with successful selection.

Tables 2 and 3 show the phenotypic and genotypic correlation coefficients obtained among the thirteen characteristics under consideration. The genotypic correlation coefficients were higher than phenotypic correlation coefficients for the characters studied and the results agree with the finding of Cheema et al. [8]; Sharma et al. [9]; Naresh et al. [10]. The most important trait fruit yield per plant had exhibited highly significant and positive phenotypic correlation with average fruit weight (0.925), no. of fruits per plant (0.595) and fruit circumference (0.464). Ascorbic acid had exhibited highly significant and positive phenotypic correlation with days to maturity of green fruit (0.211). Average fruit length had exhibited highly significant and positive phenotypic correlation with fruit circumference (0.536) and no. of fruit per plant (0.258). Pedicel length had exhibited highly significant and positive phenotypic correlation with fruit length (0.349). Fruit length had exhibited highly significant and positive phenotypic correlation with days to 50% flowering (0.374). Secondary branches per plant had exhibited highly significant and positive phenotypic correlation with plant height (0.239) and positive correlated with primary branches per plant (0.213). Primary branches per plant acid had exhibited highly significant and positive phenotypic correlation with plant height (0.257). Days to mature red ripe stage had exhibited highly significant and positive phenotypic correlation with days to mature green stage (0.537) and positive correlated with days to 50% flowering (0.218). Days to mature green stage had exhibited highly significant and positive phenotypic correlation with days to 50% flowering (0.431). Similar association of traits in chilli had also been reported by Pujar et al. [11]; Bundela et al. [12]; Vidya et al. [13]; Srinivas et al. [14]; Chavan et al. [15].

3.1 Path Coefficient Analysis

The path coefficient is simply a standardized partial regression coefficient that splits the correlation coefficient into direct and indirect effects of a set of independent factors on the dependent variable. This study created a mechanism for identifying the direct and indirect impacts of various variables on fruit yield per plant at the phenotypic and genotypic levels.

Using phenotypic and genotypic correlation coefficients, path coefficient analysis was used to estimate the direct and indirect effect of thirteen characteristics on fruit yield per plant. Tables 4 and 5 indicate the direct and indirect effects of different traits on fruit yield per plant at the phenotypic and genotypic levels.

Table 2. Estimates of phenotypic correlation coefficients among thirteen characters in chilli

Traits	**Days to 50% flowering**	**Days to mature green fruit**	**Days to mature red ripe stage**	**Plant height**	**Primary branches per plant**	**Secondary branches per plant**	**No. of fruit per plant**	**Fruit length**	**Pedicel length**	**Fruit circumference**	**Average fruit weight**	**Ascorbic acid**	**Fruit yield per plant**
Days to 50% flowering	**1.000**	0.431**	0.218*	0.071	-0.095	0.053	0.015	0.374**	0.127	0.099	0.114	0.140	0.097
Days to mature green fruit		**1.000**	0.537**	0.014	-0.113	-0.011	-0.027	-0.018	0.011	0.008	-0.058	0.211*	-0.053
Days to mature red ripe stage			**1.000**	0.084	0.004	0.048	-0.202	-0.066	-0.018	-0.044	-0.148	0.160	-0.190*
Plant height				**1.000**	0.257**	0.239**	-0.136	0.015	0.075	-0.167	-0.152	-0.088	-0.170
Primary branches per plant					**1.000**	0.213*	-0.063	-0.128	-0.191*	0.007	-0.038	-0.186	-0.036
Secondary branches per plant						**1.000**	0.003	0.105	0.047	-0.199	-0.172	-0.128	-0.143
No. of fruit per plant							**1.000**	0.132	-0.011	0.080	0.258**	-0.173	0.595**
Fruit length								**1.000**	0.349**	-0.065	0.043	-0.216*	0.082
Pedicel length									**1.000**	0.113	0.067	-0.020	0.059
Fruit circumference										**1.000**	0.536**	0.137	0.464**
Average fruit weight											**1.000**	-0.105	0.925**
Ascorbic acid												**1.000**	-0.161

**, ** Significant at 5% & 1%*

Table 3. Estimates of genotypic correlation coefficient among thirteen characters in chilli

Traits	**Days to 50% flowering**	**Days to mature green fruit**	**Days to mature red ripe stage**	**Plant height**	**Primary branches per plant**	**Secondary branches per plant**	**No. of fruit per plant**	**Fruit length**	**Pedicel length**	**Fruit circumference**	**Average fruit weight**	**Ascorbic acid**	**Fruit yield per plant**
Days to 50% flowering	**1.000**	0.429**	0.287**	0.081	-0.113	0.012	0.135	0.511**	0.143	0.094	0.122	0.178	0.144
Days to mature green fruit		**1.000**	1.100**	0.031	-0.361	-0.018	-0.039	-0.074	0.059	-0.233**	-0.161	0.401**	-0.142
Days to mature red ripe stage			**1.000**	0.112	-0.054	0.080	-0.481**	-0.129	0.111	-0.296**	-0.279	0.307**	-0.386**
Plant height				**1.000**	0.458**	0.417**	-0.171	0.007	0.144	-0.215*	-0.150	-0.097	-0.182
Primary branches per plant					**1.000**	0.518**	-0.180	-0.286**	-0.179	-0.190*	-0.091	-0.278**	-0.106
Secondary branches per plant						**1.000**	0.115	0.179	0.248**	-0.523**	-0.285**	-0.234**	-0.187*
No. of fruit per plant							**1.000**	0.143	-0.052	0.068	0.287**	-0.188*	0.594**
Fruit length								**1.000**	0.445**	-0.149	0.075	-0.241**	0.105
Pedicel length									**1.000**	0.082	0.037	-0.041	0.013
Fruit circumference										**1.000**	0.696**	0.171	0.584**
Average fruit weight											**1.000**	-0.112	0.939**
Ascorbic acid												**1.000**	-0.171

**, ** Significant at 5% & 1%*

Table 4. Direct and indirect effect of twelve characters on fruit yield per plant at phenotypic level in chilli

Traits	Days to 50% flowering	Days to mature green fruit	Days to mature red ripe stage	Plant height	Primary branches per plant	Secondary branches per plant	No. of fruit per plant	Fruit length	Pedicel length	Fruit circumference	Average fruit weight	Ascorbic acid	Fruit yield per plant
Days to 50% flowering	**-0.003**	0.002	0.002	0.000	-0.002	-0.001	0.006	-0.003	0.002	-0.002	0.095	-0.001	0.097
Days to mature green fruit	-0.001	**0.006**	0.005	0.000	-0.003	0.000	-0.010	0.000	0.000	0.000	-0.048	-0.001	-0.053
Day to first red ripe fruit harvesting	-0.001	0.003	**0.010**	0.000	0.000	-0.001	-0.078	0.001	0.000	0.001	-0.124	-0.001	-0.190*
Plant Height	0.000	0.000	0.001	**0.000**	0.006	-0.003	-0.053	0.000	0.001	0.003	-0.127	0.000	-0.170
Primary Branch	0.000	-0.001	0.000	0.000	**0.024**	-0.002	-0.024	0.001	-0.003	0.000	-0.032	0.001	-0.036
Secondary Branch	0.000	0.000	0.001	0.000	0.005	**-0.011**	0.001	-0.001	0.001	0.004	-0.143	0.001	-0.143
Fruit per plant	0.000	0.000	-0.002	0.000	-0.002	0.000	**0.385**	-0.001	0.000	-0.001	0.216	0.001	0.595**
Fruit length	-0.001	0.000	-0.001	0.000	-0.003	-0.001	0.051	**-0.007**	0.006	0.001	0.036	0.001	0.082
Pedicle length	0.000	0.000	0.000	0.000	-0.005	-0.001	-0.004	-0.003	**0.017**	-0.002	0.056	0.000	0.059
Fruit circumference	0.000	0.000	0.000	0.000	0.000	0.002	0.031	0.001	0.002	**-0.018**	0.448	-0.001	0.464**
Average fruit weight (g)	0.000	0.000	-0.001	0.000	-0.001	0.002	0.099	0.000	0.001	-0.010	**0.835**	0.001	0.925**
Ascorbic acid mg/100g	0.000	0.001	0.002	0.000	-0.005	0.001	-0.066	0.002	0.000	-0.003	-0.087	**-0.005**	-0.161

R^2= 0.9924, RESIDUAL EFFECT = 0.0873

Table 5. Direct and indirect effects of twelve characters on fruit yield per plant (g) at genotypic level in chilli

Traits	Days to 50% flowering	Days to mature green fruit	Days to mature red ripe stage	Plant height	Primary branches per plant	Secondary branches per plant	No. of fruit per plant	Fruit length	Pedicel length	Fruit circumference	Average fruit weight	Ascorbic acid	Fruit yield per plant
Days to 50% flowering	**-0.0313**	0.0089	0.0058	-0.0015	-0.0106	-0.0007	0.0523	0.0138	0.0041	-0.0042	0.1049	0.0026	0.144
Days to mature green fruit	-0.0135	**0.0206**	0.0221	-0.0006	-0.0342	0.0011	-0.0152	-0.0020	0.0017	0.0104	-0.1380	0.0058	-0.142
Days to mature red ripe stage	-0.0090	0.0227	**0.0201**	-0.0021	-0.0051	-0.0049	-0.1861	-0.0035	0.0032	0.0133	-0.2393	0.0044	-0.386**
Plant height	-0.0026	0.0006	0.0023	**-0.0183**	0.0433	-0.0254	-0.0662	0.0002	0.0042	0.0096	-0.1285	-0.0014	-0.182
Primary branches per plant	0.0035	-0.0075	-0.0011	-0.0084	**0.0946**	-0.0316	-0.0694	-0.0077	-0.0052	0.0085	-0.0778	-0.0040	-0.106
Secondary branches per plant	-0.0004	-0.0004	0.0016	-0.0076	0.0490	**-0.0609**	0.0443	0.0048	0.0072	0.0234	-0.2443	-0.0034	-0.187*
No. of fruit per plant	-0.0042	-0.0008	-0.0097	0.0031	-0.0170	-0.0070	**0.3867**	0.0039	-0.0015	-0.0030	0.2462	-0.0027	0.594**
Fruit length	-0.0160	-0.0015	-0.0026	-0.0001	-0.0270	-0.0109	0.0552	**0.0270**	0.0128	0.0067	0.0644	-0.0035	0.105
Pedicle length	-0.0045	0.0012	0.0022	-0.0026	-0.0169	-0.0151	-0.0201	0.0120	**0.0289**	-0.0037	0.0321	-0.0006	0.013
Fruit circumference	-0.0029	-0.0048	-0.0059	0.0039	-0.0180	0.0318	0.0263	-0.0040	0.0024	**-0.0448**	0.5975	0.0025	0.584**
Average fruit weight	-0.0038	-0.0033	-0.0056	0.0027	-0.0086	0.0173	0.1109	0.0020	0.0011	-0.0311	**0.8587**	-0.0016	0.939**
Ascorbic acid	-0.0056	0.0083	0.0062	0.0018	-0.0262	0.0142	-0.0728	-0.0065	-0.0012	-0.0076	-0.0961	**0.0145**	-0.171

R^2 = 0.9997, RESIDUAL EFFECT = 0.0163

The higer magnitude of positive direct effect on fruit yield per plant was exerted by average fruit weight (0.835) followed by no. of fruits per plant (0.385). The higher magnitude of negative direct effect on fruit yield per plant was exerted by fruit circumference (-0.018) followed by secondary branches per plant (-0.011). While maximum positive indirect effect on total fruit yield per plant shown by fruit circumference (0.448), followed by no. of fruit per plant (0.216). while negative indirect effect shown by secondary branches per plant (-0.143) followed by plant height (-0.127) and days to mature red ripe stage (-0.124).

The higher magnitude of positive direct effect on fruit yield at genotypic level was exerted by average fruit weight (0.859) and no. of fruit per plant (0.387). The higher magnitude of negative direct effect on fruit yield per plant was exerted by secondary branches per plant (-0.0609) and fruit circumference (-0.0448). while maximum positive indirect effect shown by fruit circumference (0.5975) and no. of fruit per plant (0.2462). The higher magnitude of negative indirect effect shown by secondary branches per plant (-0.2443) and days to mature red ripe stage (-0.2393). This indicated that direct selection based on average fruit weight and no. of no. of fruit per plant would result in an appreciable improvement of fruit yield per plant in chilli. Similar results were also reported by Meena et al. [16]; Ain et al. [17]; Lakshmidevamma et al. [18].

4. CONCLUSION

Based on the above result of correlation studies it could be concluded that characters like average fruit weight, no. of fruits per plant and fruit circumference showed highly positive significant correlation with the yield. Thus, this finding indicated that these traits could utilize in various breeding as well as improvement programmes. The information may further help the breeders in formulating appropriate strategy aimed at getting higher yield and character improvement in chilli.

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented in the conference: “International Conference on Emerging Trends in Agriculture & Allied Sector for Sustainable Developments” organized by Faculty of Agricultural Sciences & Allied Industries, Rama University, Kanpur Nagar, U.P., India on 8th and 9th December, 2023. Web Link of the proceeding: https://www.ramauniversity.ac.in/news-rama-university-hosts-successful-international-conference-on-emerging-trends-in-agriculture-12-49-5706

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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