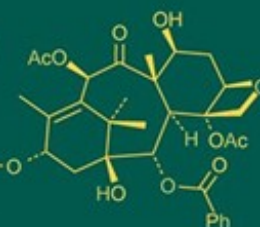
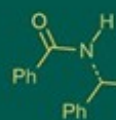


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Correlation and path analysis studies in cherry tomato (*Solanum lycopersicum* L. var. *cerasiformae*) grown under protected structure

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ABSTRACT

The present study was conducted during the Rabi season of 2025–26 in Raipur, Chhattisgarh. Twenty-two treatments were evaluated at a spacing of 60 × 45 cm in a Randomized Block Design (RBD) with three replications under protected cultivation. The study was undertaken to determine correlation coefficients and path analysis among yield and its contributing traits in cherry tomato. Highly significant and positive correlations were observed between fruit yield per hectare and several yield-contributing traits, including number of primary branches, number of fruits per cluster, number of flowers per cluster, number of fruits per plot, and plant height. In contrast, fruit yield per hectare showed negative correlations with fruit diameter, pericarp thickness, and fruit length. Path analysis further partitioned the genotypic correlations into direct and indirect effects. Number of flowers per cluster exhibited the highest positive direct effect on yield, whereas number of fruits per cluster showed the highest negative direct effect, reflecting their strong mutual correlation. Average fruit weight and number of fruits per plot also showed substantial positive direct effects on yield. Although number of primary branches had a strong positive correlation with yield, it had a negative direct effect, indicating that its association with yield was mainly expressed through other traits. In summary, number of flowers per cluster, number of fruits per cluster, number of primary branches, average fruit weight, and plant height should be taken into key consideration while selecting genotypes for improved yield under protected cultivation.

Keywords: Cherry tomato, Protected cultivation, Correlation coefficient, Path analysis

Introduction

Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme*) is a small sized tomato often resembling a cherry in size and is regarded as a likely precursor of the modern day cultivated tomato. It has gained considerable commercial importance in recent years on account of its attractive fruit colour, sweet taste, pleasant aroma, high content of vitamin-A and vitamin-C, sugars, and low caloric value, coupled with good fruit set even under high-temperature conditions (Vijaylaxmi *et al.*, 2021) [1]. Owing to its high market value, suitability for salads, garnishing and premium retail chains, cherry tomato has emerged as a remunerative alternative crop particularly for small and marginal farmers (Rocha *et al.*, 2009) [2]. Cherry tomatoes are grown across several regions in India, primarily under protected cultivation and in open fields too.

Open-field cultivation is however challenged by erratic rainfall, temperature extremes and pest and disease infestation, which in turn limit both productivity and market value. Protected cultivation systems such as naturally ventilated polyhouse, greenhouses and net houses provide a controlled or partially controlled growing environment that helps reduce the effects of adverse conditions. These structures facilitate off-season production while contributing to better fruit quality and yield (Krishna *et al.*, 2023) [3]. Studies have shown that tomatoes grown under polyhouse conditions generally produce higher yields and more fruits per plant than those grown in open fields, along with better uniformity in fruit size, colour and shelf life (Kanwar, 2011) [4]. These advantages have made protected structures an increasingly preferred option for high value and low volume crops such as cherry tomato.

Potential of cherry tomato under protected conditions is enormous and a well-planned breeding strategy aimed at simultaneous improvement of fruit yield and its component traits is needed. Since yield is a polygenic character controlled by several interrelated contributing traits, direct selection based on yield alone is often unreliable, inaccurate and slow. Correlation analysis of yield and its component traits provides valuable information on the nature and strength of associations among important characters. Such relationships help identify traits that can be effectively utilized as selection criteria for improving yield and overall performance in crop breeding programmes. However, simple correlation coefficients merely indicate the degree and direction of association between two variables and do not reveal the actual contribution of a particular trait to yield when several interrelated traits act together. This limitation is overcome through path coefficient

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cient analysis, a statistical technique originally proposed by Wright (1921) [5] and later adapted for use in plant breeding by Dewey *et al.* (1959) [6], which partitions the genotypic correlation coefficient into direct and indirect effects of the component traits on yield (Singh *et al.*, 1985) [7].

There is still limited information on pattern of association among traits and its effect on yield specifically under protected structures. Keeping this in view, the present study assessed genotypic and phenotypic associations of fruit yield with its component traits and partitioned their direct and indirect effects through path coefficient analysis to identify effective selection criteria for yield improvement in cherry tomato under protected cultivation.

Materials and Methods

Experimental site and design

The experiment was conducted during the *Rabi* season of 2025–26 under polyhouse conditions at the Centre of Excellence on Protected Cultivation and Precision Farming, Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. A total of twenty two cherry tomato genotypes were evaluated in a randomized block design (RBD) with three replications. Seedlings were transplanted at a spacing of 60 × 45 cm in straight rows, all cultural practices being followed appropriately.

Observations recorded

Observations were recorded on five randomly selected and tagged plants from each genotype in each replication for yield and its associated traits. The traits evaluated included plant height (cm), number of primary branches per plant, days to first flowering, days to 50% flowering, days to first fruit set, number of flowers per cluster, number of fruits per cluster, average fruit weight (g), fruit diameter (cm), fruit length (cm), number of fruits per plot, pericarp thickness (mm) and fruit yield per hectare (q). Measurements were recorded following standard procedures appropriate for each trait, and the mean values of the five sampled plants were used for statistical analysis.

Statistical analysis

Correlation and path coefficient analyses were performed for the evaluated traits to determine their relationships with fruit yield and to assess the direct and indirect contributions of associated traits. The statistical analyses were carried out using GRAPES (General R-based Analysis Platform for Experimental Statistics) developed by Kerala Agricultural University. (Gopinath *et al.*, 2020) [8]

Results and Discussion

Correlation analysis

Fruit yield per hectare exhibited highly significant and positive genotypic correlations with number of primary branches ($r_g = 0.959^{**}$), number of fruits per cluster ($r_g = 0.978^{**}$), number of flowers per cluster ($r_g = 0.953^{**}$) and number of fruits per plot ($r_g = 0.501^{**}$). A significant positive genotypic association was also observed between fruit yield per hectare and plant height ($r_g = 0.390^*$). Conversely, fruit yield showed significant negative genotypic correlations with fruit diameter ($r_g = -0.511^{**}$), pericarp thickness ($r_g = -0.434^{**}$) and fruit length ($r_g = -0.367^*$). The associations of fruit yield with days to first flowering, days to 50 per cent flowering, days to first fruit set and average fruit weight were non-significant at both genotypic and phenotypic levels. The strong positive associations of yield with branching and fruit-bearing traits suggest that variation in reproductive capacity, particularly the number of flowers and fruits borne per cluster, contributed substantially to yield differences among the genotypes evaluated. Similar findings were reported by Renuka *et al.* (2017) [9] in cherry tomato, Vijaylaxmi *et al.* (2021) [1] in tomato and Sudesh *et al.* (2025) [10] in tomato.

Among the other character associations, plant height exhibited a strong positive genotypic correlation with number of primary branches ($r_g = 0.824^{**}$), indicating that taller genotypes tended to develop a greater number of primary branches under the present experimental conditions. Since the crop was grown under protected cultivation, the available vertical space was effectively utilized by the indeterminate cherry tomato genotypes, facilitating greater vertical growth and enabling the plants to attain their maximum height. Days to first flowering was highly and positively associated with days to 50 per cent flowering ($r_g = 0.972^{**}$), while days to 50 per cent flowering showed a strong positive association with days to first fruit set ($r_g = 0.950^{**}$). The close association among these phenological traits is biologically reasonable because flowering and fruit-set events occur sequentially during plant development and are likely to be governed by related developmental processes. Comparable associations among flowering-related traits have been reported in cherry tomato by Thakur *et al.* (2025) [11], Maurya *et al.* (2020) [12] and Subhasmita *et al.* (2023) [13] in tomato.

Number of flowers per cluster and number of fruits per cluster exhibited an exceptionally strong positive genotypic association ($r_g = 0.988^{**}$), indicating that genotypes producing more flowers per cluster generally retained more fruits per cluster. This close relationship is expected because the number of fruits ultimately developed within a cluster is dependent on the number of flowers initiated and successfully retained. Similar associations between these traits have been reported by Thakur *et al.* (2025) [11], Sánchez *et al.* (2019) [14] and Kumar *et al.* (2024) [15].

Average fruit weight exhibited a highly significant negative genotypic correlation with number of fruits per plot ($r_g = -0.859^{**}$). This association indicates a potential trade-off between fruit number and individual fruit size, whereby genotypes producing a greater number of fruits tended to have lower average fruit weight. Such an inverse relationship may reflect competition for assimilates among developing fruits and the consequent source-sink balance within the plant. A similar negative association between fruit number and individual fruit weight had been reported by Mahmood *et al.* (2021) [16] and Yadav *et al.* (2020) [17].

Fruit length and fruit diameter were positively and significantly correlated with pericarp thickness ($r_g = 0.655^{**}$ and 0.676^{**} , respectively), suggesting that genotypes producing larger fruits also tended to possess thicker pericarp. (Shekhar *et al.*, 2026) [18]. The association of fruit dimensions with pericarp thickness may have implications for fruit firmness and post-harvest keeping quality and shelf life. Comparable relationships among fruit morphological and quality attributes have been reported in tomato and cherry tomato by Islam *et al.* (2012) [19].

For most trait combinations, genotypic correlation coefficients (Table 1) were greater in magnitude than their corresponding phenotypic correlation coefficients (Table 2). This pattern is consistent with observations reported in tomato by Maurya *et al.* (2020) [12] and Sharma *et al.* (2021) [20]. The comparatively higher magnitude of genotypic associations suggests that the underlying genetic relationships among traits were stronger than those expressed phenotypically, with environmental variation contributing to the attenuation of these associations at the phenotypic level. Thus, genotypic correlations may provide a more reliable indication of the inherent association among yield and its component traits under the experimental conditions.

*, ** Significant at 5% and 1% probability levels, respectively. PH = Plant height (cm), NPB = Number of primary branches, DFF = Days to first flowering; D50 = Days to 50% flowering, DFFS = Days to first fruit set, NFLC = Number of flowers per cluster; NFC = Number of fruits per cluster, FL = Fruit length (cm), FD = Fruit diameter (cm); AFW = Average fruit weight (g), NFP = Number of fruits per plot; PT = Pericarp thickness (mm), FYH = Fruit yield per hectare (q).

Table 1. Genotypic correlation among yield and its attributing traits

Traits	PH	NPB	DFF	D50	DFFS	NFLC	NFC	FL	FD	AFW	NFP	PT	FYH
PH	1	0.824**	-0.318*	-0.721**	0.417**	0.297*	0.329*	0.114	0.225*	0.102	-0.08	0.139	0.39*
NPB		1	-0.298*	-0.456	-0.079	0.663**	0.751**	-0.48**	-0.163	0.229*	0.062	-0.21	0.959**
DFF			1	0.972**	0.506**	-0.126	-0.08	-0.202	-0.295*	-0.099	0.013	-0.986**	-0.142
D50				1	0.95**	-0.349*	-0.394*	-0.606**	0.095	0.017	-0.378*	-0.732**	-0.082
DFFS					1	-0.099	-0.08	0.068	0.319*	0.184	-0.258*	-0.02	-0.027
NFLC						1	0.988**	-0.206	-0.432**	-0.343*	0.55**	-0.214	0.953**
NFC							1	-0.24*	-0.448**	-0.343*	0.569**	-0.247*	0.978**
FL								1	0.409**	0.189	-0.273*	0.655**	-0.367*
FD									1	0.5**	-0.333*	0.676**	-0.511**
AFW										1	-0.859**	0.303*	-0.133
NFP											1	-0.318*	0.501**
PT												1	-0.434**
FYH													1

Table 2. Phenotypic correlation among yield and its attributing traits

Traits	PH	NPB	DFF	D50	DFFS	NFLC	NFC	FL	FD	AFW	NFP	PT	FYH
PH	1	0.373*	-0.123	-0.214	0.261*	0.2	0.239*	0.088	0.134	0.067	-0.007	0.1	0.217
NPB		1	-0.142	-0.208	-0.062	0.243*	0.281*	-0.276*	-0.201	0.134	0.079	-0.225*	0.381*
DFF			1	0.747**	0.18	-0.128	-0.133	-0.026	-0.074	-0.04	0.03	-0.305*	-0.034
D50				1	0.239*	-0.152	-0.147	-0.094	0.089	-0.011	-0.012	-0.157	-0.019
DFFS					1	-0.1	-0.093	0.047	0.284*	0.119	-0.224*	-0.009	0.048
NFLC						1	0.979**	-0.174	-0.378*	-0.308*	0.447**	-0.19	0.612**
NFC							1	-0.211	-0.368*	-0.306*	0.463**	-0.2	0.633**
FL								1	0.377*	0.18	-0.256*	0.578**	-0.268*
FD									1	0.436**	-0.334*	0.592**	-0.323*
AFW										1	-0.792**	0.274*	-0.149
NFP											1	-0.298*	0.346*
PT												1	-0.254*
FYH													1

*, ** Significant at 5% and 1% probability levels, respectively. PH = Plant height (cm), NPB = Number of primary branches, DFF = Days to first flowering; D50 = Days to 50% flowering, DFFS = Days to first fruit set, NFLC = Number of flowers per cluster; NFC = Number of fruits per cluster, FL = Fruit length (cm), FD = Fruit diameter (cm); AFW = Average fruit weight (g), NFP = Number of fruits per plot; PT = Pericarp thickness (mm), FYH = Fruit yield per hectare (q).

Path coefficient analysis

Path coefficient analysis was performed to partition the genotypic correlations between component traits and fruit yield per hectare into direct and indirect effects (Table 3). Number of flowers per cluster exerted the largest positive direct effect on yield (3.437), whereas number of fruits per cluster exhibited the largest negative direct effect (-3.633). The contrasting direct effects of these two highly correlated traits highlight the importance of considering their interrelationships when interpreting their individual contributions to yield. A comparable substantial direct effect of number of fruits per cluster on yield had been reported by Mishra *et al.* (2019) [21].

Average fruit weight (2.697) and number of fruits per plot (2.449) also exhibited large positive direct effects on fruit yield, indicating their substantial contribution to yield variation when considered independently in the path model. Kumar *et al.* (2013) [22] and Sudesh *et al.* (2025) [10] likewise reported a substantial positive direct effect of average fruit weight on yield in tomato. Despite having genotypic correlation with fruit yield as non-significant, average fruit weight exhibited a large positive direct effect (2.697). This positive contribution was largely counteracted by its strong negative indirect effect through number of fruits per plot (-2.103), resulting in a weak overall association with yield. This relationship further demonstrates the compen-

satory interaction between fruit size and fruit number, wherein increased fruit number may reduce the assimilate availability per individual fruit and thereby constrain fruit size. Comparable findings, involving a substantial positive direct effect of average fruit weight being masked by a strong negative indirect effect through fruit number, have been reported in tomato by Khapte *et al.* (2014) [23] and Yadav *et al.* (2020) [17].

Plant height (1.068) also recorded a positive direct effect, which was consistent with its significant positive genotypic correlation with fruit yield ($r_g = 0.390^*$). In contrast, number of primary branches exhibited a negative direct effect (-0.789), despite showing a very strong positive genotypic correlation with fruit yield ($r_g = 0.959^{**}$). This discrepancy indicates that the strong positive association between number of primary branches and yield was predominantly mediated through its indirect relationships with other yield-associated traits rather than through a positive direct contribution. Similar contrasting results have been reported by Alam *et al.* (2019) [24] in tomato. Days to first flowering, days to 50 per cent flowering, days to first fruit set, fruit length and pericarp thickness exhibited negative or relatively small direct effects, which was broadly consistent with their weak, negative or non-significant correlation values with yield. These results suggest that these traits had limited independent contribution to yield variation under the conditions of the present study.

The occurrence of direct effects exceeding unity in magnitude, particularly for number of flowers per cluster (3.437) and number of fruits per cluster (-3.633), needs careful interpretation. Such estimates are mathematically possible in path coefficient analysis and may arise when predictor variables are strongly inter-correlated (Montgomery *et al.*, 1982) [25]. In the present study, for example, number of flowers

per cluster and number of fruits per cluster exhibited an exceptionally high genotypic correlation ($r_g = 0.988^{**}$). Consequently, the large positive direct effect of number of flowers per cluster was substantially counterbalanced by the large negative direct effect and associated indirect contribution of number of fruits per cluster. This pattern

is indicative of strong interdependence among explanatory variables and possible multi-collinearity within the path model rather than an unusually large independent biological effect of either trait. Similar contrasting direct and indirect effects among highly correlated flowering-related traits have been reported by Vijaylaxmi *et al.* (2021) [1].

Table 3. Path coefficient analysis

Traits	PH	NPB	DFF	D50	DFFS	NFLC	NFC	FL	FD	AFW	NFP	PT	r_g with FYH
PH	1.068	-0.651	0.168	0.012	0.106	1.020	-1.196	-0.005	-0.307	0.275	-0.195	-0.055	0.39*
NPB	0.88	-0.789	0.157	0.023	-0.02	2.278	-2.728	0.021	0.222	0.618	0.152	0.083	0.959**
DFF	-0.339	0.235	-0.528	-0.018	0.128	-0.432	0.291	0.009	0.402	-0.267	0.031	0.39	-0.142
D50	-0.77	1.15	-0.578	-0.016	0.291	-1.200	1.431	0.026	-0.129	0.045	-0.925	0.29	-0.082
DFFS	0.445	0.062	-0.267	-0.018	0.253	-0.342	0.29	-0.003	-0.435	0.496	-0.633	0.008	-0.027
NFLC	0.317	-0.523	0.066	0.006	-0.025	3.437	-3.633	0.009	0.589	-0.924	1.348	0.085	0.953**
NFC	0.351	-0.593	0.042	0.006	-0.02	3.437	-3.633	0.01	0.611	-0.925	1.393	0.098	0.978**
FL	0.121	0.379	0.107	0.01	0.017	-0.708	0.872	-0.043	-0.557	0.51	-0.67	-0.259	-0.367*
FD	0.241	0.128	0.156	-0.002	0.081	-1.484	1.626	-0.018	-1.364	1.349	-0.815	-0.268	-0.511**
AFW	0.109	-0.181	0.052	0.001	0.047	-1.177	1.247	-0.008	-0.683	2.697	-2.103	-0.12	-0.133
NFP	-0.085	-0.049	-0.007	0.006	-0.065	1.892	-2.066	0.012	0.454	-2.316	2.449	0.126	0.501**
PT	0.149	0.165	0.52	0.012	-0.005	-0.738	0.899	-0.028	-0.923	0.82	-0.779	-0.396	-0.434**

Residual effect : 0.024

Diagonal bold values indicate direct effect of traits on yield.

*, ** Significant at 5% and 1% probability levels, respectively. PH = Plant height (cm), NPB = Number of primary branches, DFF = Days to first flowering; D50 = Days to 50% flowering, DFFS = Days to first fruit set, NFLC = Number of flowers per cluster; NFC = Number of fruits per cluster, FL = Fruit length (cm), FD = Fruit diameter (cm); AFW = Average fruit weight (g), NFP = Number of fruits per plot; PT = Pericarp thickness (mm), FYH = Fruit yield per hectare (q), r_g = genotypic correlation.

Conclusion

The correlation and path coefficient analyses provided a clear understanding of the strength and nature of the relationships between fruit yield per hectare and its component traits in cherry tomato. In most cases, genotypic correlation coefficients were higher than the corresponding phenotypic correlations, suggesting that the observed relationships were influenced more by genetic factors than by environmental conditions. Fruit yield showed strong positive associations with the number of primary branches, flowers per cluster, fruits per cluster, fruits per plot, and plant height. In contrast, fruit diameter, pericarp thickness, and fruit length exhibited negative associations with fruit yield.

Path coefficient analysis provided further insight into the relationships by separating the correlations into direct and indirect effects, which helped explain associations that could not be interpreted adequately from correlation coefficients alone. Number of flowers per cluster and number of fruits per cluster exhibited strong but contrasting direct effects, reflecting their close association with each other. Although number of primary branches showed a strong positive correlation with yield, its direct effect was negative, suggesting that its positive association with yield was largely mediated indirectly through other yield-related traits. Similarly, average fruit weight had a positive direct effect on yield despite its non-significant genotypic correlation, indicating that its contribution to yield was expressed partly through its association with other yield components, particularly number of fruits per plot.

Overall, the findings suggest that number of flowers per cluster, number of fruits per cluster, number of primary branches, average fruit weight, and plant height play an important role in determining fruit yield in cherry tomato. Therefore, these traits should be considered

together, with attention to both their direct effects and their indirect influence through other yield-related characters, when developing effective selection criteria for higher yield.

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