Original Research Article

Evaluating Genotypic and Phenotypic Relationships and Their Impact on Yield Traits of Brinjal (*Solanum melongena* L.)

Abstract

The study was conducted to assess genotypic and phenotypic correlation coefficients and path coefficient analysis among various yield and yield attributing traits for 42 genotypes of brinjal at the Horticulture Research Centre, SVPUA&T, Meerut (U.P.), India, over two consecutive *Kharif* seasons in 2022 and 2023. The research was carried out using a Randomized Complete Block Design with three replications. The analysis of variance indicated significant variability across all the traits examined. In general, magnitudes of genotypic correlation coefficient were higher than their corresponding phenotypic correlation coefficient, implying a significant inherent relationship in different pair of traits. Based on the correlation coefficient analysis, fruit yield per plant had significant and positive association with fruit yield per plot, fruit yield per hectare, fruit weight, number of fruits per plant, fruit length and fruit girth both at genotypic and phenotypic levels. Path coefficient analysis showed that the traits *viz*., number of fruits per plant, fruit weight, fruit girth and fruit length exhibited highest direct effects on fruit yield and also indirectly influenced by the other yield contributing traits of brinjal. It was concluded from the study that these traits may be used as key indices towards the direct selection of elite genotypes for the successful breeding programme for yield improvement of brinjal germplasm.

Keywords: Brinjal, Analysis of variance, Correlation Coefficient, Path coefficient, Yield.

1. Introduction:

Brinjal (*Solanum melongena* L.), a member of the Solanaceae family, typically exists as a diploid with a chromosome count of 2n=2x=24. However, despite efforts to cultivate polyploid varieties with chromosome numbers of 2n=36 and 48, these variants have not shown significant economic relevance. The crop is a native of India and Sri Lanka. The genus Solanum encompasses nearly 2000 species, including both tuber-bearing and non-tuber-bearing forms. Among the important edible species in the non-tuber-bearing category are *Solanum melongena, S. torvum, S. nigrum, S. macrocarpon, S. ferox* and *S. aethiopicum*. A wild type of brinjal with deeply variegated leaves, S. *siymbriifolium* Lam., is considered the ancestral species of *S.*

melongena. Based on growth habit and fruit shape, four botanical varieties are recognized within *S. melongena*- *S. melongena* var. *melongena* (includes cultivars with round and egg-shaped fruits), *S. melongena* var. *serpentinum* Desf. (includes long and slender-fruited cultivars, often referred to as "snake brinjal" due to the presence of spiny leaves) and *S. melongena* var. *depressum* (encompasses early and dwarf cultivars) (Kumar *et al.,* 2020).

The plant is described as an annual herbaceous species with inflorescences that can be solitary or form clusters of 2-5 flowers, depending on the variety. The flowers are complete, actinomorphic, and hermaphrodite, featuring a five-lobed, gamosepalous calyx and a five-lobed, gamopetalous corolla with incurved margins. The flowers are categorized based on style length into four types: long-styled, medium-styled, pseudo-short-styled, and true short-styled. Long-styled flowers have a high fruit-setting rate (70%-85%) due to a large ovary, while medium-styled flowers have a 12%-55% fruit-setting rate with a medium-sized ovary. However, short-styled flowers, with smaller stigmas and underdeveloped papillae, do not set fruit at all (Ram, 2022).

Brinjal has a healthy nutritional profile. The fruits are low in calories and contain a good amount of minerals like potassium, calcium, sodium, iron, zinc and copper as well as dietary fibre (USDA, 2014). Besides this, brinjal fruits are reported to be a rich source of ascorbic acid and phenolics (Somawathi *et al.*, 2014; Tripathi *et al.*, 2014). Brinjal is a fair source of fatty acids and has got de-cholesterolizing property, due to the presence of 65.1 per cent linoleic and lenolenic poly-3-unsaturated fatty acids (Shafeeq, 2005). White brinjal is said to be good for diabetic patients (Tripathi *et al.*, 2014).

It is easily cultivated in almost all parts of India except higher altitudes. Orissa, West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, and Andhra Pradesh are the major brinjal growing states. Brinjal thrives in a warm, long growing season, with the main crop grown in autumn-winter. It grows best at 25-30°C and below 15°C its growth is adversely affected. The optimum temperature is 25°C for seed germination while seeds may germinate at 15°C to 30°C. Seedlings are transplanted best when the temperature is around 20°C (Swarup, 2014).

The primary aim of crop improvement programs is to boost yield potential. To achieve this, it's crucial to understand the physiological characteristics of the current plant genetic pool and identify key traits that impact yield. While yield is the ultimate goal for breeders, selecting genotypes based solely on yield is ineffective because yield is a complex trait influenced by many factors. Therefore, understanding the relationship between yield and its contributing traits is important for making informed selections and developing effective selection criteria.

The correlation coefficient helps measure the relationships between different traits, highlighting which characteristics should be targeted for genetic improvement. Additionally, path coefficient analysis is useful for distinguishing between the direct and indirect effects of various traits on yield. This study aims to explore the relationship between traits and yield, as well as the direct and indirect effects of yield-related attributes, to identify and select the best genotypes for improving brinjal.

2. Materials and Methods:

The experiment was conducted with 42 genotypes of brinjal during two consecutive *Kharif* season of 2022 and 2023 at Horticulture Research Centre (HRC), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) India. Meerut is located in the semi-arid region and agro-climatic plain zone of Uttar Pradesh, India. It is situated in the North West Plain Zone, with coordinates of 28.99° N and 77.7° E, at an elevation of 220 meters above mean sea level.

Seedlings were grown in trays using a mix of coco peat and vermicompost (2:1) under careful management, achieving a high survival rate, at the College of Horticulture's shade net house in June. They were then transplanted in the third week of July. Each genotype's seedlings were planted on 15 cm raised ridges with a spacing of 60×45 cm and evaluated using a Randomized Complete Block Design with three replications. To support optimal crop growth and development, the recommended intercultural practices and doses of fertilizers (RDF) were applied.

To analyse the relationships between the examined traits and fruit yield, phenotypic and genotypic correlation coefficients were first calculated using the formulae of Johnson et al. (1955) based on the mean values of the traits. Subsequently, path coefficient analysis, as described by Dewey and Lu (1959), was conducted to determine the direct and indirect effects of the traits on fruit yield per plant.

Results and Discussion:

Character association study was conducted in order to know how various traits are correlated with yield and inter-correlated among each other, on which selection can be used for genetic improvement in the fruit yield. The genotypic and phenotypic correlation coefficient for fruit yield and its component traits in brinjal are presented in table 1 and 2. The present study indicated a strong inherent relationship between the traits, because the magnitude of genotypic correlation coefficient was generally higher than their corresponding phenotypic. During pooled season of 2022 and 2023, in phenotypic correlation, fruit yield per plant (kg) has showed positive and significant correlation with fruit yield per hectare (0.984), fruit yield per plot (0.983), fruit weight (0.713), number of fruits per plant (0.495), fruit length (0.404) and fruit girth (0.285). It exhibited a significant negative correlation with no. of primary branches (-0.276), 1000 seed weight (-0.315) and days to 50% flowering (-0.481). In case of genotypic correlation fruit yield per plant showed a significant positive correlation with fruit yield per plot (0.812), yield per hectare (0.781), fruit weight (0.727), no. of fruits per plant (0.510), fruit length (0.417) and fruit girth (0.289). It exhibited a significant negative correlation with days to 50 % flowering (-0.535), 1000 seed weight (-0.327) and no. of primary branches (-0.290). Similar trends of positive and significant correlation were reported by Gupta *et al.* (2017), Saha *et al.* (2019), Singh *et al*. (2020), Gangadhara *et al*. (2023) and Kumar *et al*. (2021). This suggested that fruit yield per plant can be enhanced by the selecting genotypes with a greater value of no. of fruits per plant, fruit length and fruit weight. The number of fruits per plant exhibited a significant positive phenotypic and genotypic correlation with fruit yield. Thus, the number of fruits per plant seems to have predominated effect on fruit yield per plant. There is ample scope in the enhancement of yield by selecting a genotype having a higher number of fruits since they are highly correlated..

Path Coefficient Analysis

The components of a complex trait like yield can be found using correlation coefficients, but the relative importance of each component trait's direct and indirect effect cannot be determined from these results. Due to the fact that these assessments only give the kind and amount of the association rather than the cause, such studies do not provide each component characteristic. For dividing the correlation coefficient into the direct and indirect effects of a single causative factor in such circumstances, path coefficient analysis is essential (Wright,1921 and Dewey and Lu, 1959). The direct and indirect effects of different characters on fruit yield per plant were presented in Table 3. In genotypic correlation (Table 3), the higher magnitude of a positive direct effect on fruit yield per plant was exerted by fruit yield per hectare (0.6354), fruit yield per plot (0.3636), fruit weight (0.0536), 1000 seed weight (0.0388), no. of fruits per plant (0.0025), pedicle length (0.0325) and no. of primary branches (0.0072). The negative direct effect on yield was shown by the days to 50% flowering (-0.0163), fruit length (-0.0256), plant height (-0.0241). and fruit girth (-0.0549). Similarly, in phenotypic correlation (Table 4)**,** the higher magnitude of a positive direct effect on fruit yield per plant was exerted by the fruit yield per hectare (0.5872), followed by fruit yield per plot (0.3306), fruit weight (0.079), no. of fruits per plant (0.0409), pedicle length (0.0392), 1000 seed weight (0.0246), fruit length (0.0034) and no. of primary branches (0.0024). The negative direct effect on yield was shown by the fruit girth (-0.0123), days to 50% flowering (-0.0242) and plant height (-0.0314). The results are in confirmation with the findings of Angadi *et al.* (2017), Yadav *et al.* (2018), Taru et al (2021), Saha *et al.* (2019), Singh *et al*. (2020) and Gangadhara *et al*. (2023). In genotypic path, fruit yield per plant has indirect positive effect on fruit yield per plot (0.812), yield per hectare (0.781), fruit weight (0.727), number of fruits per plant (0.510), fruit length (0.417), fruit girth (0.289) and plant height (0.0041). The negative indirect effect on fruit yield per plant was shown by the days to 50% flowering (-0.535), number of primary branches (-0.284), pedicle length (-.0.1672) and 1000 seed weight (-0.327). Similarly, in phenotypic path, fruit yield per plant has indirect positive effect on yield per hectare (0.984), fruit yield per plot (0.983), fruit weight (0.713), number of fruits per plant (0.495), fruit length (0.404), fruit girth (0.285) and plant height (0.0005). The negative indirect effect on fruit yield per plant was shown by the days to 50% flowering (-0.481), number of primary branches (-0.276), pedicle length (-.0.1602) and 1000 seed weight (-0.315). These results are in agreement with the findings of Bansal and Mehta (2008), Singh *et al.* (2011) and Singh *et al.* (2017), Singh *et al*. (2020) and Kumar *et al*. (2021). The path analysis revealed that traits such as the number of fruits per plant, fruit weight, fruit length, and fruit girth are the most crucial for yield, due to their significant direct effects and their indirect effects through other traits. Traits that show a strong positive association with fruit yield and a high direct impact at the genotypic level are valuable for selection. Therefore, these traits should be prioritized, as direct selection based on them will be effective in developing high-yielding brinjal varieties. This indicates that plant breeders should focus on traits with high significant correlations and both direct and indirect effects on fruit yield when selecting elite genotypes for further improvement.

Table 1: Pooled estimates of Genotypic correlation co-efficient between yield and yield contributing traits of brinjal

TRAITS	Plant height(cm)	Days to 50% flowering	No. of primary branches	Fruit length(cm)	Fruit girth (cm)	Pedicle length (cm)	Fruit weight (g)	No. of fruits per plant	1000 seed weight (g)	Yield per plot (kg/ha)	Yield per ha	Yield per plant (kg)
Plant height(cm)	1	-0.218*	0.435**	-0.1227	0.202*	0.0975	-0.0472	0.0637	0.217*	0.0216	0.0196	0.0041
Days to 50% flowering		1	0.202*	-0.0816	-0.209*	0.222*	-0.397**	-0.320**	0.232*	-0.533**	-0.535**	-0.535**
No. of primary branches			1	-0.1493	-0.062	0.180*	-0.324**	0.0264	0.206*	-0.281*	-0.282*	-0.284*
Fruit length(cm)				1	-0.545**	0.231*	-0.0222	0.494**	-0.0707	0.405**	0.405**	0.417**
Fruit girth (cm)					1	-0.300**	0.733**	-0.407**	-0.0094	0.305**	0.304**	0.289*
Pedicle length (cm)						1	-0.128	-0.220*	0.12	-0.204*	-0.203*	-0.1672
Fruit weight (g)							1	-0.1611	-0.178*	0.720**	0.720**	0.727**
No. of fruits per plant								1	-0.249*	0.520**	0.520**	0.510**
1000 seed weight (g)									1	-0.355**	-0.355**	-0.327**
Yield per plot (kg/ha)										1	0.732**	0.812**
Yield per ha											1	0.781**
Yield per plant (kg)												1

Table 2: Pooled estimates of phenotypic correlation co-efficient between yield and yield contributing traits of brinjal

TRAITS	Plant height(cm)	Days to 50% flowering	No. of primary branches	Fruit length(cm)	Fruit girth (cm)	Pedicle length (cm)	Fruit weight (g)	No. of fruits per plant	1000 seed weight (g)	Yield per plot (kg/ha)	Yield per ha	Yield per plant (kg)
Plant height(cm)	1	-0.181*	0.410**	-0.115	0.191*	0.0942	-0.0351	0.0585	0.199*	0.0206	0.0243	0.0005
Days to 50% flowering		1	0.194*	-0.074	-0.187*	0.192*	-0.358**	-0.282*	0.204*	-0.478**	-0.476**	-0.481**
No. of primary branches			1	-0.1406	-0.0599	0.1748	-0.315**	0.0264	0.194*	-0.272*	-0.270*	-0.276*
Fruit length(cm)				1	-0.528**	0.223*	-0.0243	0.484**	-0.0794	0.396**	0.397**	0.404**
Fruit girth (cm)					1	-0.296**	0.714**	-0.390**	-0.0044	0.295**	0.297**	0.285*
Pedicle length (cm)						1	-0.1217	-0.220*	0.1138	-0.196*	-0.198*	-0.1602
Fruit weight (g)							1	-0.16	-0.177*	0.708**	0.708**	0.713**
No. of fruits per plant								1	-0.232*	0.512**	0.512**	0.495**
1000 seed weight (g)									1	-0.337**	-0.337**	-0.315**
Yield per plot (kg/ha)										1	0.993**	0.983**
Yield per ha											1	0.984**
Yield per plant (kg)												1

Table 3: Pooled Direct and indirect effects (genotypic) of yield components in brinjal

TRAITS	Plant height(cm)	Days to 50% flowering	No. of primary branches	Fruit length(cm)	Fruit girth (cm)	Pedicle length (cm)	Fruit weight (g)	No. of fruits per plant	1000 seed weight (g)	Yield per plot (kg/ha)	Yield per ha
Plant height(cm)	-0.0241	0.0053	-0.0105	0.003	-0.0049	-0.0024	0.0011	-0.0015	-0.0052	-0.0005	-0.0005
Days to 50% flowering	0.0035	-0.0163	-0.0033	0.0013	0.0034	-0.0036	0.0064	0.0052	-0.0038	0.0087	0.0087
No. of primary branches	0.0031	0.0015	0.0072	-0.0011	-0.0004	0.0013	-0.0023	0.0002	0.0015	-0.002	-0.002
Fruit length(cm)	0.0031	0.0021	0.0038	-0.0256	0.014	-0.0059	0.0006	-0.0126	0.0018	-0.0104	-0.0104
Fruit girth (cm)	-0.0111	0.0115	0.0034	0.0299	-0.0549	0.0164	-0.0402	0.0223	0.0005	-0.0167	-0.0167
Pedicle length (cm)	0.0032	0.0072	0.0059	0.0075	-0.0097	0.0325	-0.0042	-0.0072	0.0039	-0.0066	-0.0066
Fruit weight (g)	-0.0025	-0.0213	-0.0174	-0.0012	0.0393	-0.0069	0.0536	-0.0086	-0.0095	0.0386	0.0386
No. of fruits per plant	0.0002	-0.0008	0.0001	0.0013	-0.001	-0.0006	-0.0004	0.0025	-0.0006	0.0013	0.0013
1000 seed weight (g)	0.0084	0.009	0.008	-0.0027	-0.0004	0.0047	-0.0069	-0.0097	0.0388	-0.0138	-0.0138
Yield per plot (kg/ha)	0.0079	-0.1939	-0.1021	0.1474	0.1109	-0.074	0.2618	0.1892	-0.1291	0.3636	0.3649
Yield per ha	0.0124	-0.3397	-0.179	0.2571	0.193	-0.1288	0.4575	0.3305	-0.2254	0.6377	0.6354
Yield per plant (kg)	**0.0041**	**-0.535****	**-0.284***	**0.417****	**0.289***	**-0.1672**	**0.727****	**0.510****	**-0.327****	**0.812****	**0.781****

Table 4: Pooled Direct and indirect effects (phenotypic) of yield components in brinjal

TRAITS	Plant height(cm)	Days to 50% flowering	No. of primary branches	Fruit length(cm)	Fruit girth (cm)	Pedicle length (cm)	Fruit weight (g)	No. of fruits per plant	1000 seed weight (g)	Yield per plot (kg/ha)	Yield per ha
Plant height(cm)	-0.0314	0.0057	-0.0129	0.0036	-0.006	-0.003	0.0011	-0.0018	-0.0063	-0.0006	-0.0008
Days to 50% flowering	0.0044	-0.0242	-0.0047	0.0018	0.0045	-0.0046	0.0087	0.0068	-0.0049	0.0116	0.0115
No. of primary branches	0.001	0.0005	0.0024	-0.0003	-0.0001	0.0004	-0.0008	0.0001	0.0005	-0.0007	-0.0007
Fruit length(cm)	-0.0004	-0.0003	-0.0005	0.0034	-0.0018	0.0008	-0.0001	0.0016	-0.0003	0.0013	0.0013
Fruit girth (cm)	-0.0023	0.0023	0.0007	0.0065	-0.0123	0.0036	-0.0088	0.0048	0.0001	-0.0036	-0.0037
Pedicle length (cm)	0.0037	0.0075	0.0068	0.0087	-0.0116	0.0392	-0.0048	-0.0086	0.0045	-0.0077	-0.0077
Fruit weight (g)	-0.0028	-0.0283	-0.0249	-0.0019	0.0564	-0.0096	0.079	-0.0126	-0.014	0.0559	0.0559
No. of fruits per plant	0.0024	-0.0115	0.0011	0.0198	-0.0159	-0.009	-0.0065	0.0409	-0.0095	0.0209	0.021
1000 seed weight (g)	0.0049	0.005	0.0048	-0.0019	-0.0001	0.0028	-0.0043	-0.0057	0.0246	-0.0083	-0.0083
Yield per plot (kg/ha)	0.0068	-0.1581	-0.0899	0.1309	0.0974	-0.0647	0.234	0.1691	-0.1113	0.3306	0.3282
Yield per ha	0.0143	-0.2793	-0.1587	0.2331	0.1744	-0.1161	0.4156	0.3006	-0.1979	0.583	0.5872
Yield per plant (kg)	**0.0005**	**-0.481****	**-0.276***	**0.404****	**0.285***	**-0.1602**	**0.713****	**0.495****	**-0.315****	**0.983****	**0.984****

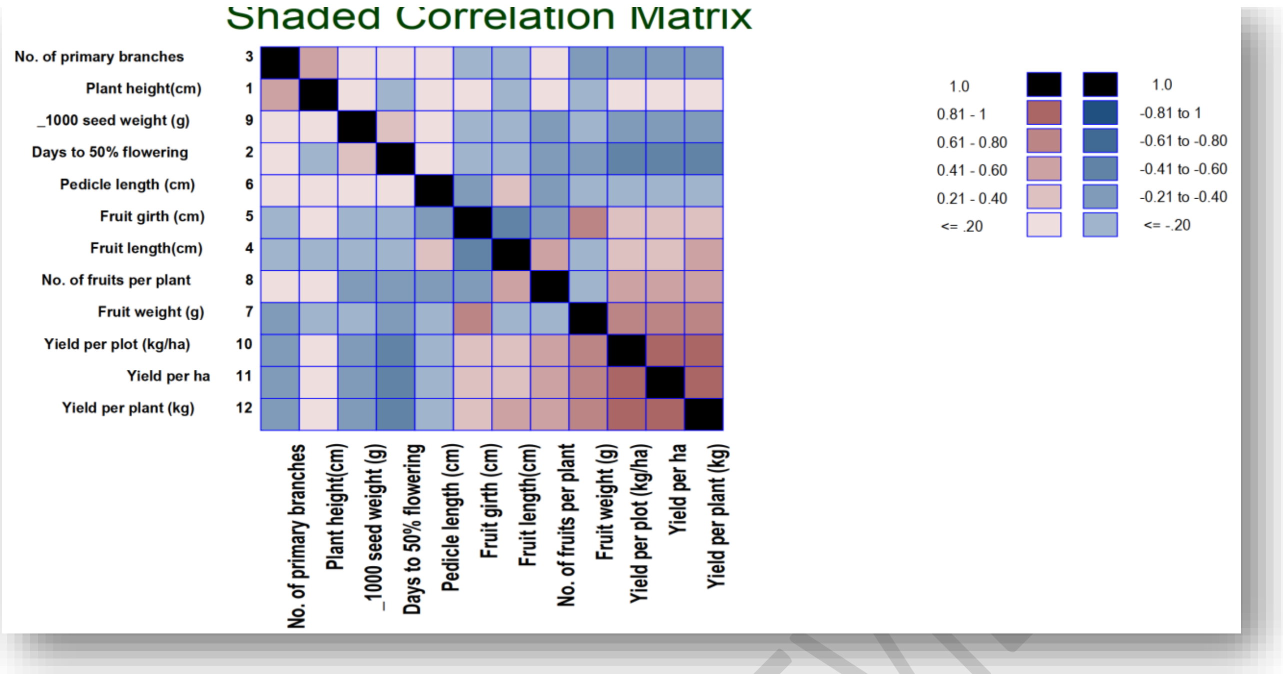

Fig. 1: Phenotypic Shaded Correlation matrix

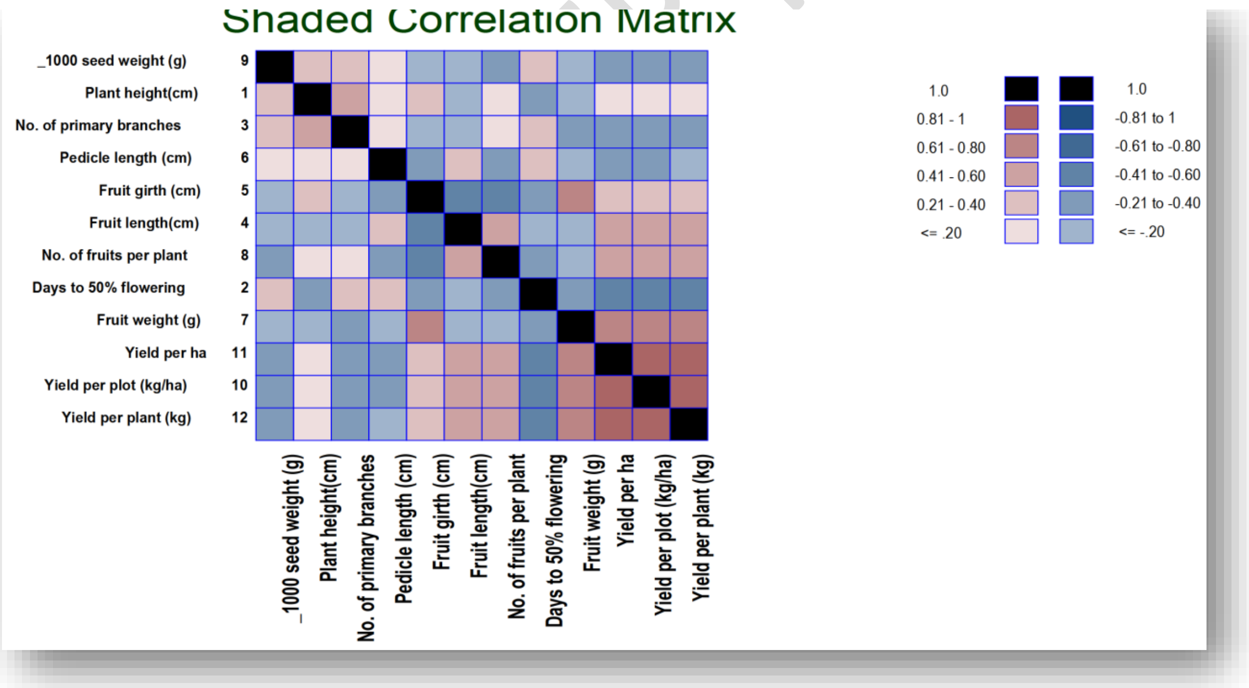

Fig. 2: Genotypic shaded correlation matrix

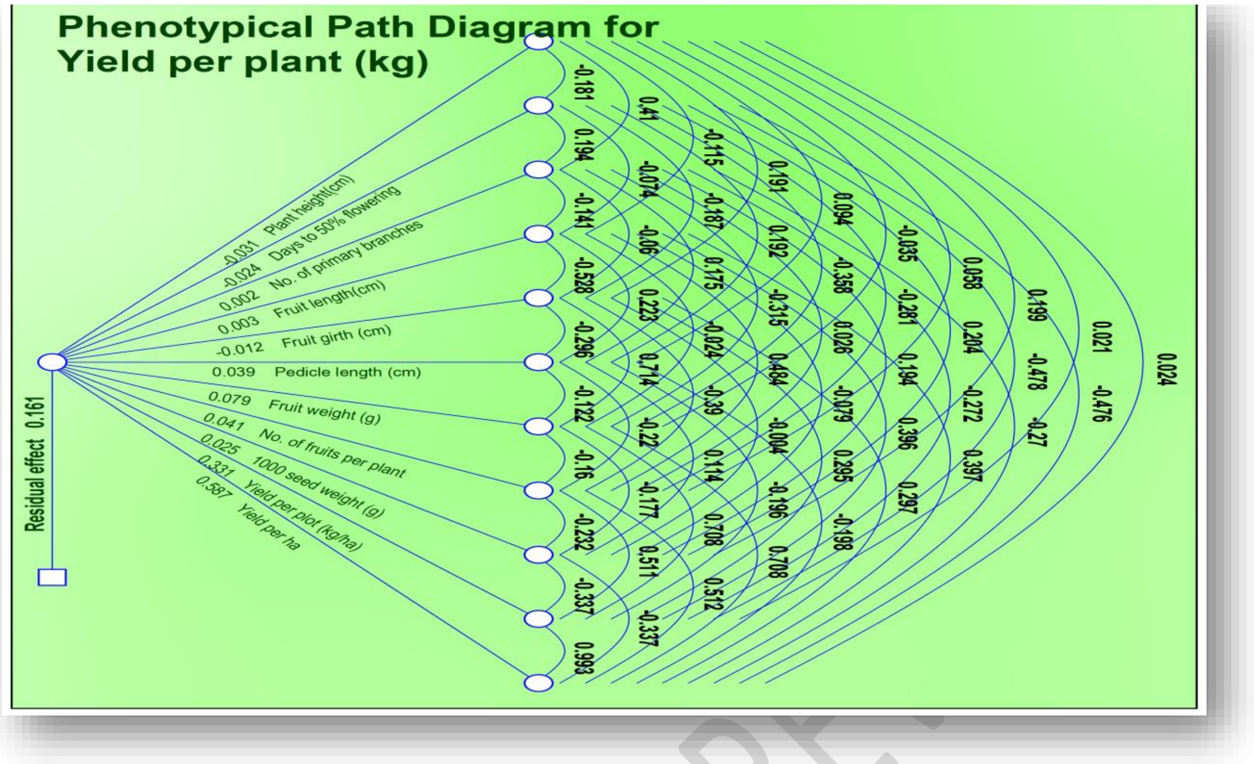

Fig. 3: Phenotypical Path Diagram

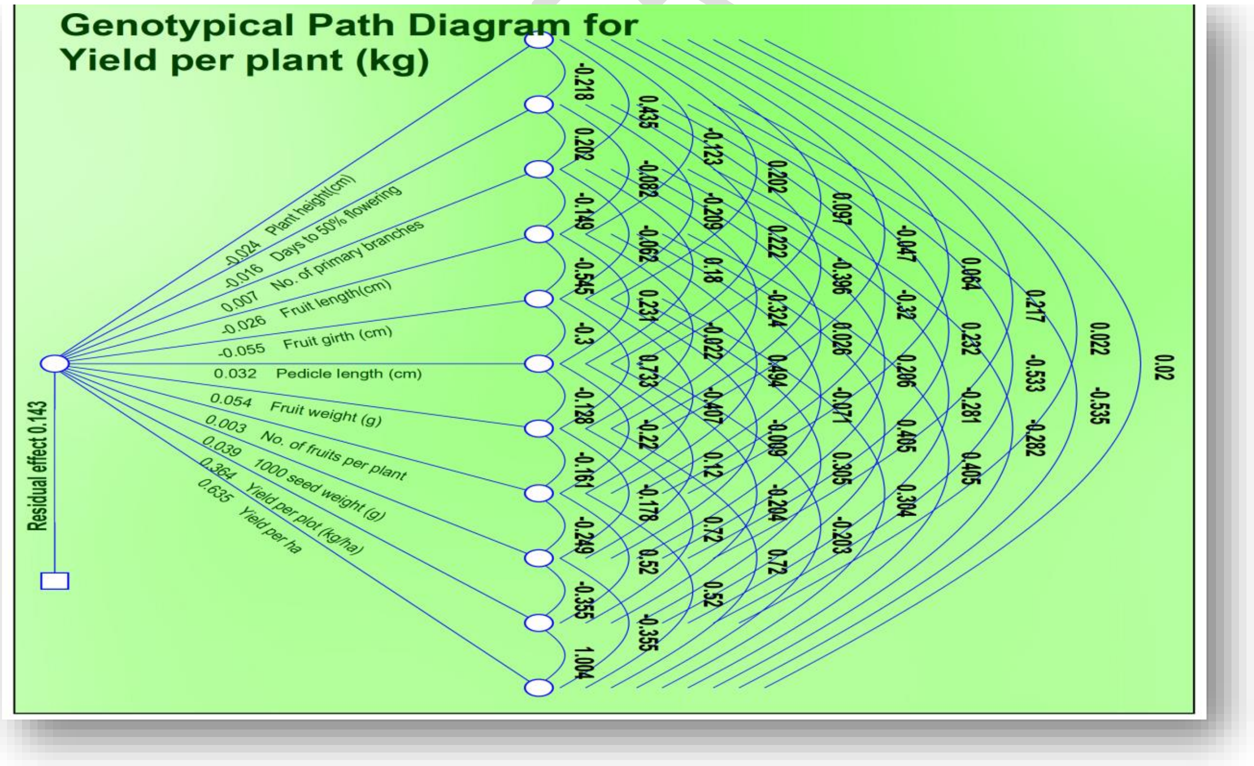

Fig. 4: Genotypic Path Diagram

Conclusion:

The comprehensive analysis of genotypic and phenotypic correlation coefficients, coupled with path coefficient analysis, provides valuable insights into the yield dynamics of brinjal genotypes. Fruit yield per plant demonstrated a significant positive association with fruit yield per plot, fruit yield per hectare, fruit weight, number of fruits per plant, fruit length and fruit girth at both genotypic and phenotypic levels. This indicates that improvement in these traits could substantially enhance overall fruit yield. The path coefficient analysis further revealed that number of fruits per plant, fruit weight, fruit girth, and fruit length had the highest direct effects on fruit yield. These traits also influenced other yield-contributing traits, suggesting their crucial role in the yield improvement of brinjal.

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