Morphological diversity and character associationstudies in Snake gourd (*Trichosanthesanguina* L.)

Comment [ag1]: Title can be more challenging.

ABSTRACT

The present investigation was carried out at the experimental plot, of the Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India, during the kharif season of 2023. The study followed a randomized complete block design with two replications. Morphological diversity and character association were studied in 26 genotypes of snake gourd. The diversity studies revealed that the genotypes were grouped into five clusters in which the cluster I holds twenty genotypes followed by cluster III with three genotypes and cluster II, IV and cluster V comprised of one genotype in each cluster. The Intra cluster D^2 values were ranged from 0.00 to 1350.62. Among the five clusters, cluster III with three genotypes had maximum intra cluster diversity (D^2 = 1350.62) followed by cluster I (D^2 = 1199.42). Correlation studies revealed that traits such as fruit width, seeds per fruit, average fruit weight, number of fruits per plant, and total number of female flowers were significantly and positively correlated towards the fruit yield per plant and considered as the important traits for enhancing quantitative traits in snake gourd. The path coefficient analysis indicated that average fruit weight, number of fruits per plant, node at the appearance of the first female flower, and days to first fruit setting had the highest direct influence on fruit yield per plant. Consequently, these traits should be prioritized in selection for future improvements.

Keywords: Snake gourd, diversity, correlation, path analysis and yield

INTRODUCTION

Snake gourd (*Trichosanthesanguina*) is a tropical climbing plant belonging to the Cucurbitaceae family. It is native to Southeast Asia and is widely cultivated in tropical and subtropical regions of the world (Ahmed *et al*.,2024). The plant is known for its long, slender, serpentine fruits, which resemble snakes, hence the name "snake gourd".The fruit is commonly eaten as a vegetable because of its excellent nutritional benefits. It is rich in Vitamin A, B and C and is known to enhance appetite, act as a tonic and stomach aid, and help alleviate biliousness. This plant is among the most genetically diverse food crops in the plant kingdom, with every part of it being utilized in traditional medicine to treat a variety of ailments (Devi,2017). Despite having a wide range of genetic resources, the overall productivity of the crop remains low due to the continuous cultivation of local cultivars. The significant morphological diversity of *T. anguina* provides considerable phenotypic variation,

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offering substantial potential for genetic enhancement and improving crop yield through varietal development (Rabbani *et al*., 2012; Khan *et al*., 2016).

To develop a superior variety, it is crucial to enhance the yield components. However, yield is a complex trait influenced by several other factors which are tend to inherit directly. (Rao *et al*., 1990)Studies on variability components and heritability do not fully clarify the extent and nature of the relationship between yield and its contributing traits. Therefore, correlation and path analysis are valuable tools for plant breeders, helping them to prioritize the selection of yield-related traits. The correlation coefficient analysis assesses the interrelationship between various plant characteristics, identifying key traits that can be targeted for yield improvement (Fisher, 1918). Path analysis, on the other hand, allows for the identification of both direct and indirect factors influencing these relationships and helps determine the relative importance of each trait, guiding breeders in creating effective breeding programmes. Additionally, understanding the genetic divergence within the available germplasm is crucial for breeders in selecting diverse parent plants. This diversity enables the exploitation of high heterotic effects and enhances variability in segregating generations (Arunachalam, 1981). Hence, the present study was conducted to explore the morphological variation and relationships between various traits, as well as to assess the direct and indirect impact of these traits on the yield of snake gourd varieties.

MATERIAL AND METHODS

The experiment was conducted at the experimental plot of the Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India, during the kharif season of 2023. It involved twenty-six distinct snake gourd genotypes sourced from various regions across the country. The study followed a randomized complete block design with two replications. The inter- and intra-row spacing was set at 2 m x 2 m, with raised beds of 1 meter width, 20 cm height, and suitable length, spaced 2 meters apart. Lateral pipes were installed along the sides of the beds, which were then covered with silver-black polythene mulch (25-micron thickness), with the edges sealed using soil. The beds were irrigated to field capacity and prepared for transplanting the following day. Healthy, vigorous, 16-day-old seedlings, grown in cocopeat-based protrays and free from pests and diseases, were used for transplantation. During the grand vine growth stage, before flowering, the snake gourd plants were staked using bamboo poles in a trellis system supported by galvanized iron wires. A basal dose of 25 t/ha of FYM, along with half the recommended nitrogen dose and the full doses of phosphorus and potassium (70:30:30 kg NPK/ha), was applied during the final land ploughing. The remaining nitrogen was applied in two split doses at 30-day intervals during the growth and flowering stages. Other intercultural practices were carried out according to the crop production guidelines provided by the Tamil Nadu Agricultural University, Coimbatore (Anon., 2020). Five tagged plants from each treatment per replication were selected for observation, and various parameters were recorded.

The observations like node at first female flower appearance, total number of female flowers, days to first female flower opening, days to first fruit setting, days to first harvest, fruit length, fruit width, average fruit weight, number of fruits per plant, fruit yield per plant, number of seeds per fruit, total soluble solids, ascorbic acid, phenol content, calcium, magnesium and phosphorous contents of the fruits were recorded in the five tagged plants. Among various methods to assess diversity, Mahalanobis generalized distance, calculated using the D^2 statistics (Rao, 1952), is considered an excellent index for estimating genetic diversity. Phenotypic and genotypic correlation coefficients were estimated by implementing the formulas suggested byAl-Jibouri*et al.*, 1958. The path co-efficient analysis was worked by using the methods of Wright (1921) and Dewey and Lu (1959).

Comment [ag3]: Recheck the spacing.

RESULTS AND DISCUSSION

The results of the present study indicated that the twenty six genotypes were grouped into five clusters which holds high intra and inter cluster D^2 values (Table 1). Among the five clusters, cluster I holds twenty genotypes followed by cluster III with three genotypes and cluster II, IV and cluster V comprises only one genotype in each. The results from the clustering indicates that the genotypes were grouped regardless of their geographic divergence which implies no affinity between geographic distribution and genetic diversity. Khatun *et al*. (2010) and Devi and Marriyappan (2013) reported four clusters, Islam *et al*. (2020) reported six clusters and Yadav (2020) reported four clusters in snake gourd in their studies. However, the number of genotypes assessed and used in these studies are entirely different from the present study. In the present study, the intra cluster D^2 values were ranged from 0.00 to 1350.62. Among the five clusters, cluster III with three genotypes had maximum intra cluster diversity (D^2 = 1350.62) followed by cluster I (D^2 = 1199.42). Clusters II, IV, V comprised of single genotype in each of them therefore, intra cluster distance was zero or no cluster distance were recorded. The inter cluster D^2 values were ranged from 940.90 to 14175.68. The clustering pattern results showed that the genotypes collected from the same place didn't fall in the same cluster. The maximum cluster divergence was observed between cluster III and V (D^2 = 14175.68) followed by cluster IV and V (D^2 = 13815.90), cluster II and V (D^2 =13573.02), cluster I and V (D^2 =6959.57), cluster I and IV (D^2 =2594.47), cluster I and III (D^2 = 2594.31), cluster I and II (D^2 = 2253.13), Cluster III and IV (D^2 =2058.41), cluster II and IV (D^2 =2032.17). Whereas, cluster II and III (D^2 =940.90) produced minimum inter cluster distance (Table 2).In the Table 3 the inter cluster distance between cluster III and V (D^2 = 14175.68) was recorded highest along with the high cluster means for the traits like total number of primary branches, average fruit weight, fruit width, fruit yield per plant, total phenols, magnesium content. Inter cluster distance between cluster IV and V (D^2 = 13815.90) along with the high cluster means for the traits like node at first female flower appearance, total number of female flowers, fruit length, number of fruits per plant, TSS, ascorbic acid, phosphorous, fruit width, fruit yield per plant, total phenols and magnesium content. Inter cluster distance between cluster I and V (D^2 =6959.57) along with the high cluster means for the traits like days to first female flower opening.

Table 1. Grouping of snake gourd genotypes into different clusters based on D^2 values

Cluster	Number of genotypes	Genotypes included in the cluster
I	20	G13, G21, G31, G30, G14, G27, G20, G28, G11, G15, T1, G8, G10, T3, G18, G23, G24, G2, G9 and G7
II	1	G3
III	3	G25, T2 and G4
IV	1	G26
V	1	G6

Table 2. Average intra and inter- cluster distances in snake gourd genotypes

Diagonal values indicate intra- cluster distances

Comment [ag4]: Align the tables properly.

Cluster	I	II	III	IV	V
I	**1199.42**	2253.13	2594.31	2594.47	6959.57
II		**0.00**	940.90	2032.17	13573.02
III			**1350.62**	2058.41	14175.68
IV				**0.00**	13815.90
V					**0.00**

Table 3. Cluster mean values for yield and its components in snake gourd genotypes

Sl. No.	Character	Cluster mean				
		I	II	III	IV	V
1	Node at first female flower appearance	19.99	19.17	20.36	15.00	28.00
2	Total number of female flowers	15.06	12.00	12.44	24.75	22.00
3	Total no. of primary branches	2.43	2.50	3.17	2.50	2.50
4	Days to first female flower opening	64.29	75.17	67.44	68.17	68.17
5	Days to first fruit setting	68.31	79.00	71.94	71.50	70.84
6	Days to first harvest	77.07	88.17	80.38	78.33	77.84
7	Fruit length	40.28	28.05	67.69	79.00	31.35
8	Fruit width	53.42	58.35	59.44	30.88	65.15
9	Average fruit weight	345.94	353.30	490.28	108.40	387.35
10	Number of fruits per plant	13.97	12.67	10.62	18.67	16.37
11	Fruit yield per plant	4.08	4.12	3.96	2.13	6.19
12	Number of seeds per plant	37.75	67.00	30.31	15.50	65.00
13	TSS	4.51	3.55	3.67	5.65	4.00
14	Ascorbic acid	8.13	7.52	7.59	9.59	9.38
15	Total phenols	63.60	26.44	44.94	56.73	101.29
16	Calcium	0.57	0.70	0.65	0.64	0.34
17	Magnesium	0.22	0.17	0.15	0.16	0.40
18	Phosphorous	0.24	0.23	0.25	0.27	0.18

days to first fruit setting, days to first harvest, fruit width, fruit yield per plant, total phenols and magnesium content. Inter cluster distance between cluster I and IV (D^2 =2594.47) along with the high cluster means for the traits like days to first female flower opening, days to first fruit setting, days to first harvest, fruit width, fruit yield per plant, total phenols, and magnesium content. Inter cluster distance between cluster I and III (D^2 = 2594.31) along with the high cluster means for the traits like days to first female flower opening, days to first fruit setting, days to first harvest, total number of primary branches and average fruit weight. Inter cluster distance between cluster I and II (D^2 = 2253.13) along with the high cluster means for the traits like days to first female flower opening, days to first fruit setting, days to first harvest, number of seeds per fruit and calcium. The hybridization programme can be performed between the genotypes allotted in these clusters for improving the particular trait whose mean values are recorded high. Parallel findings were observed from the studies of Devi *et al*. (2017), Kumar *et al*. (2024) and Islam *et al*. (2020) in snake gourd, Purushottama (2022) and Chithra (2023) in sponge gourd, Manoj *et al*. (2018) and Shilpashree *et al*. (2022) in ridge gourd.

The yield is an intricate trait (economical character) where several other traits directly or indirectly linked or contributes to the yield of the crop. Correlation co-efficient analysis is the powerful tool to understand the natural relationship between each trait and its contribution towards the economical character and also it helps to select the traits which improves performance of the economical trait. In general run of things, genotypic correlation is higher than the phenotypic correlation, the reduction in the phenotypic correlation values is because of the influence of the environment. Genotypic correlations offer an estimate of the natural relationship between the genes that govern two specific traits. In this study, it was observed that the genotypic correlation was higher than the phenotypic correlation, suggesting that environmental influences had a minimal effect and indicating a strong inherent relationship between the traits. In all cases, greater emphasis should be placed on the genotypic correlations. The pattern of genotypic correlations closely mirrored that of the phenotypic correlations observed in the study.

In case of phenotypic correlation, it was found that the character fruit yield per plant had shown highly significant and positive correlation with the characters like fruit width, number of seeds per fruit, average fruit weight, number of fruits per plant and total number of female flowers.

Table 4. Estimates of phenotypic correlation coefficients for earliness, yield and yield attributing traits in snake gourd genotypes

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	**1.000**																
X_2	-0.035	**1.000**															
X_3	0.064	0.008	**1.000**														
X_4	0.157	-0.270	0.119	**1.000**													
X_5	0.121	-0.345^{*}	0.125	0.928^{**}	**1.000**												
X_6	0.135	-0.363^{**}	0.133	0.895^{**}	0.971^{**}	**1.000**											
X_7	-0.118	$^{-}0.415^{**}$	-0.082	-0.167	-0.147	-0.098	**1.000**										
X_8	0.205	0.230	0.057	-0.176	-0.190	-0.206	-0.204	**1.000**									
X_9	0.204	-0.293^{*}	0.008	-0.145	-0.144	-0.100	0.420^{**}	0.468^{**}	**1.000**								
X_{10}	-0.015	0.861^{**}	-0.074	-0.357^{**}	-0.425^{**}	-0.449^{**}	-0.502^{**}	0.201	-0.386^{**}	**1.000**							
X_{11}	0.132	0.293^{*}	-0.073	-0.083	-0.012	0.001	-0.419^{**}	0.603^{**}	0.106	0.286^{*}	**1.000**						
X_{12}	-0.206	-0.079	-0.024	-0.265	-0.207	-0.199	0.079	-0.089	-0.098	-0.096	-0.059	**1.000**					
X_{13}	0.009	-0.038	-0.337^{*}	-0.095	-0.135	-0.159	0.265	-0.138	-0.072	-0.101	-0.253	0.127	**1.000**				
X_{14}	0.349^{*}	0.098	-0.051	-0.213	-0.309^{*}	-0.299^{*}	-0.033	-0.207	-0.072	0.106	-0.156	-0.001	0.206	**1.000**			
X_{15}	-0.090	-0.320^{*}	-0.166	0.281^{*}	0.241	0.286^{*}	0.236	-0.311^{*}	0.069	-0.294^{*}	-0.408^{**}	-0.379^{**}	0.148	0.048	**1.000**		
X_{16}	-0.114	0.071	0.102	-0.257	-0.269	-0.229	0.043	-0.082	-0.069	0.075	-0.236	0.172	0.188	-0.125	-0.045	**1.000**	
X_{17}	0.183	0.408^{**}	-0.015	-0.282^{*}	-0.340^{*}	-0.322^{*}	-0.250	0.559^{**}	0.455^{**}	0.422^{**}	0.546^{**}	-0.100	0.272	0.137	-0.244	-0.209	**1.000**

* indicates significance at 5% ** indicates significance at 1%

X_1 = Node at first female flower appearance **X_2** = Total number of female flowers **X_3** = Total number of primary branches **X_4** = Days to first female flower
X_5 = Days to first fruit setting **X_6** = Days to first harvest **X_7** = Fruit length **X_8** = Fruit width
X_9 = Average fruit weight **X_{10}** = Number of fruits per plant **X_{11}** = Number of seeds per fruit **X_{12}**= TSS
X_{13} = Ascorbic acid **X_{14}** = Total phenols **X_{15}** = Calcium **X_{16}** = Phosphorous
X_{17} = Fruit yield per plant

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	**1.000**																
X_2	-0.028	**1.000**															

Table 5. Estimates of genotypic correlation coefficients for earliness, yield and yield attributing traits in snake gourd genotypes

X_3	-0.044	-0.028	**1.000**														
X_4	0.179	-0.286*	0.210	**1.000**													
X_5	0.134	-0.354*	0.189	0.985**	**1.000**												
X_6	0.164	-0.370**	0.225	0.957**	0.979**	**1.000**											
X_7	-0.130	-0.477**	0.038	-0.185	-0.149	-0.092	**1.000**										
X_8	0.227	0.237	0.007	-0.209	-0.213	-0.211	-0.238	**1.000**									
X_9	0.250	-0.303*	0.167	-0.159	-0.157	-0.113	0.464**	0.506**	**1.000**								
X_{10}	-0.014	0.896**	-0.107	-0.386**	-0.428**	-0.462**	-0.569**	0.229	-0.415**	**1.000**							
X_{11}	0.139	0.312*	-0.056	-0.099	-0.020	-0.004	-0.488**	0.665**	0.107	0.291*	**1.000**						
X_{12}	-0.271	-0.089	-0.035	-0.281*	-0.241	-0.214	0.083	-0.126	-0.122	-0.106	-0.096	**1.000**					
X_{13}	0.032	-0.048	-0.504**	-0.091	-0.134	-0.163	0.278*	-0.157	-0.074	-0.102	-0.253	0.155	**1.000**				
X_{14}	0.371**	0.104	-0.081	-0.228	-0.321*	-0.311*	-0.031	-0.225	-0.081	0.110	-0.157	-0.016	0.207	**1.000**			
X_{15}	-0.094	-0.333*	-0.201	0.269	0.248	0.300*	0.276*	-0.356**	0.077	-0.294*	-0.458**	-0.404**	0.149	0.046	**1.000**		
X_{16}	-0.213	0.092	0.295*	-0.318*	-0.311*	-0.284*	0.068	-0.088	-0.147	0.083	-0.369**	0.244	0.258	-0.174	-0.079	**1.000**	
X_{17}	0.298*	0.469**	0.026	-0.435**	-0.450**	-0.432**	-0.288*	0.693**	0.551**	0.492**	0.604**	-0.105	-0.308*	0.159	-0.037*	-0.268	**1.000**

* indicates significance at 5% ** indicates significance at 1%

X_1 = Node at first female flower appearance **X_2** = Total number of female flowers **X_3** = Total number of primary branches **X_4** = Days to first female flower
X_5 = Days to first fruit setting **X_6** = Days to first harvest **X_7** = Fruit length **X_8** = Fruit width
X_9 = Average fruit weight **X_{10}** = Number of fruits per plant **X_{11}** = Number of seeds per fruit **$X_{12=}$** TSS
X_{13} = Ascorbic acid **X_{14}** = Total phenols **X_{15}** = Calcium **X_{16}** = Phosphorous
X_{17} = Fruit yield per plant

The early traits like days to first female flower opening, days to first harvest and days to fruit setting had shown negative and significant (p=0.05) correction. It also produced positive and non-significant correction towards ascorbic acid, node at first female flower opening and total phenols whereas, other traits like calcium, phosphorous and total number of primary branches are negative and non-significantly associated with fruit yield per plant at phenotypic level. In the genotypic correlation study fruit yield per plant had exhibited highly significant (p= 0.01) and positive correlation with five characters namely fruit width, number of seeds per fruit, number of fruits per plant, average fruit weight, total number of female flowers. While in other way it expressed positive and significant(p=0.05) corelation towards node at first female flower appearance. the early traits had produced highly significant but negative correlation (desirable) towards days to first female flower opening, days to first fruit setting, days to first harvest and also it showed significant and negative correlation to the traits like fruit length, ascorbic acid and calcium. Therefore, the character fruit yield per plant had shown highly significant (p= 0.01) and positive correlation with the characters like fruit width, number of seeds per fruit, average fruit weight, number of fruits per plant and total number of female flowers at both genotypic and phenotypic levels. These traits could be selected as the trait of interest to improve the fruit yield per plant in snake gourd. The above-mentioned parameters showed similar association with the fruit yield per plant in the findings of Padmaraja*et al*. (2014), Islam *et al*. (2014), Devi *et al*. (2017), Fathima *et al*. (2023) and Ahmed *et al*. (2024) in their studies with snake gourd.

The relationship between yield and its associated traits, as determined by the simple correlation coefficient, may not accurately reflect the true nature of their connection. In contrast path analysis is a systematized partial regression coefficient which divides correlation into the measures of direct and indirect effects and also measures direct and indirect association of each independent variable on the dependent variable (fruit yield per plant). In the phenotypic path coefficient study, fruit yield per plant expressed positive and direct effect through average fruit weight, number of fruits per plant, number of seeds per fruit, TSS, total phenols, days to first female flower opening, total number of primary branches, total number of female flowers and calcium. While, it has shown negative and direct effect towards node at first female flower appearance, days to first fruit setting, fruit length, fruit width, ascorbic acid and phosphorous. In the genotypic path coefficient study fruit yield per plant expressed positive and direct effect through days to first harvest, average fruit weight, number of fruits per plat, ascorbic acid,total phenols and phosphorous in other ways it had expressed negative but direct effect on node at first female flower appearance, total number of female flowers, total number of primary branches, days to first female flower opening, days to first fruit setting, fruit length, fruit width, number of seeds per fruit , TSS and calcium.

Table 6. Phenotypic path coefficient analysis for earliness, yield and yield attributing traits in snake gourd genotypes

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	rP
X_1	**-0.068**	-0.0002	0.002	0.043	-0.036	0.004	0.018	-0.021	0.157	-0.008	0.043	-0.019	-0.0006	0.055	-0.002	0.013	0.183
X_2	0.002	**0.007**	0.0003	-0.075	0.102	-0.011	0.066	-0.024	-0.226	0.477	0.096	-0.007	0.002	0.015	-0.008	-0.008	0.408**
X_3	-0.004	0.00005	**0.043**	0.033	-0.036	0.004	0.013	-0.005	0.006	-0.041	-0.023	-0.002	0.023	-0.008	-0.004	-0.012	-0.015
X_4	-0.010	-0.001	0.005	**0.280**	-0.275	0.029	0.026	0.018	-0.112	-0.197	-0.027	-0.025	-0.006	-0.034	0.007	0.030	-0.282*
X_5	-0.008	-0.002	0.005	0.259	**-0.297**	0.031	0.023	-0.111	-0.235	-0.003	-0.003	-0.020	0.009	-0.049	0.006	0.031	-0.340*
X_6	-0.009	-0.002	0.005	0.250	-0.288	**0.033**	0.015	0.021	-0.077	-0.249	0.0002	-0.019	0.011	-0.047	0.007	0.026	-0.322*
X_7	0.007	-0.002	-0.003	-0.046	0.043	-0.003	**-0.161**	0.021	0.324	-0.278	-0.137	0.007	-0.018	-0.005	0.005	-0.005	-0.250
X_8	-0.013	0.001	0.002	-0.049	0.056	-0.006	0.032	**-0.105**	0.361	0.111	0.197	-0.008	0.009	-0.033	-0.007	0.009	0.559**
X_9	-0.013	-0.001	0.0003	-0.040	0.042	-0.003	-0.067	-0.049	**0.774**	-0.214	0.034	-0.009	0.005	-0.011	0.001	0.008	0.455**
X_{10}	0.001	0.005	-0.003	-0.099	0.126	-0.014	0.080	-0.021	-0.298	**0.555**	0.093	-0.009	0.007	0.016	-0.007	-0.008	0.422**
X_{11}	-0.008	0.001	-0.003	-0.023	0.003	0.00003	0.067	-0.063	0.082	0.158	**0.327**	-0.005	0.017	-0.024	-0.010	0.027	0.546**
X_{12}	0.013	-0.0005	-0.001	-0.074	0.061	-0.006	-0.012	0.009	-0.075	-0.053	-0.019	**0.097**	-0.008	-0.0009	-0.009	-0.020	-0.100
X_{13}	-0.0005	-0.0002	-0.014	-0.026	0.040	-0.005	-0.042	0.014	-0.055	-0.055	-0.082	0.012	**-0.070**	0.032	0.003	-0.0221	0.272
X_{14}	-0.023	0.0006	-0.002	-0.059	0.091	-0.009	0.005	0.021	-0.055	0.058	-0.051	-0.0006	-0.014	**0.160**	0.001	0.014	0.137
X_{15}	0.006	-0.002	-0.007	0.078	-0.071	0.009	-0.037	0.032	0.053	-0.162	-0.133	-0.036	-0.010	0.007	**0.025**	0.005	-0.244
X_{16}	0.007	0.0004	0.004	-0.071	0.079	-0.007	-0.006	0.008	-0.053	0.041	-0.077	0.016	-0.0131	-0.020	-0.001	**-0.117**	-0.209

*indicates significance at 5% **indicates significance at 1% Residual effect = 0.202 rP= dependent character

X_1 = Node at first female flower appearance **X_2** = Total number of female flowers **X_3** = Total number of primary branches **X_4** = Days to first female flower
X_5 = Days to first fruit setting **X_6** = Days to first harvest **X_7** = Fruit length **X_8** = Fruit width
X_9 = Average fruit weight **X_{10}** = Number of fruits per plant **X_{11}** = Number of seeds per fruit **X_{12}**= TSS
X_{13} = Ascorbic acid **X_{14}** = Total phenols **X_{15}** = Calcium **X_{16}** = Phosphorous
X_{17} = Fruit yield per plant

Table 7. Genotypic path coefficient analysis for earliness,yield and yield attributing traits in snake gourd genotypes

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	rG
X_1	**-1.184**	0.027	0.043	-0.323	-0.171	0.762	0.093	-0.065	0.622	-0.032	-0.106	1.150	0.00008	0.403	0.146	-0.067	0.298^{*}
X_2	0.033	**-0.974**	0.027	0.515	0.454	-1.717	0.341	-0.068	-0.755	2.138	-0.238	0.049	-0.0001	0.113	0.519	0.029	0.469^{**}
X_3	0.052	0.027	**-0.988**	-0.378	-0.242	1.045	-0.026	-0.002	0.415	-0.256	0.042	0.019	-0.0001	-0.087	0.313	0.093	0.026
X_4	-0.212	0.278	-0.207	**-1.804**	-1.265	4.437	0.132	0.060	-0.396	-0.922	0.075	0.156	-0.0002	-0.247	-0.418	-0.100	-0.435^{**}
X_5	-0.158	0.344	-0.186	-1.777	**-1.284**	4.542	0.106	0.061	-0.391	-1.021	0.015	0.133	-0.0003	-0.349	-0.385	-0.098	-0.450^{**}
X_6	-0.194	0.360	-0.222	-1.726	-1.257	**4.638**	0.066	0.061	-0.280	-1.101	0.003	0.118	-0.0004	-0.338	-0.467	-0.090	-0.432^{**}
X_7	0.154	0.464	-0.037	0.334	0.191	-0.428	**-0.716**	0.069	1.154	-1.358	0.372	-0.046	0.0007	-0.033	-0.429	0.021	-0.288^{*}
X_8	-0.268	-0.231	-0.007	0.376	0.274	-0.980	0.170	**-0.290**	1.260	0.546	-0.507	0.069	-0.0004	-0.244	0.553	-0.028	0.693^{**}
X_9	-0.296	0.295	-0.165	0.287	0.202	-0.523	-0.332	-0.146	**2.490**	-0.990	-0.081	0.067	-0.0001	-0.087	-0.120	-0.046	0.551^{**}
X_{10}	0.016	-0.872	0.106	0.697	0.549	-2.140	0.407	-0.066	-1.033	**2.388**	-0.222	0.058	-0.0002	0.119	0.458	0.026	0.492^{**}
X_{11}	-0.164	-0.303	0.055	0.178	0.025	-0.018	0.349	-0.193	0.265	0.695	**-0.764**	0.053	-0.0006	-0.170	0.713	-0.117	0.604^{**}
X_{12}	0.320	0.086	0.034	0.507	0.309	-0.993	-0.059	0.036	-0.304	-0.252	0.073	**-0.555**	0.0004	-0.017	0.629	0.077	-0.105
X_{13}	-0.037	0.047	0.498	0.164	0.172	-0.754	-0.199	0.045	-0.185	-0.243	0.193	-0.085	**0.003**	0.225	-0.232	0.081	-0.308^{*}
X_{14}	-0.439	-0.101	0.0799	0.410	0.412	-1.442	0.022	0.065	-0.200	0.263	0.120	0.008	0.0005	**1.087**	-0.071	-0.055	0.159
X_{15}	0.111	0.324	0.198	-0.484	-0.318	1.392	-0.197	0.103	0.192	-0.702	0.350	0.224	0.0003	0.050	**-1.558**	-0.025	-0.037^{*}
X_{16}	0.252	-0.090	-0.291	0.573	0.399	-1.31	-0.048	0.025	-0.365	0.197	0.282	-0.135	0.0006	-0.189	0.123	**0.318**	-0.268

* indicates significance at 5% ** indicates significance at 1%   Residual effect = -0.284   rP= dependent character

X_1 = Node at first female flower appearance **X_2** = Total number of female flowers **X_3** = Total number of primary branches **X_4** = Days to first female flower
X_5 = Days to first fruit setting **X_6** = Days to first harvest **X_7** = Fruit length **X_8** = Fruit width
X_9 = Average fruit weight **X_{10}** = Number of fruits per plant **X_{11}** = Number of seeds per fruit **$X_{12=}$** TSS
X_{13} = Ascorbic acid **X_{14}** = Total phenols **X_{15}** = Calcium **X_{16}** = Phosphorous
X_{17} = Fruit yield per plant

Importantly, the residual effect was 0.20 % for the phenotypic coefficient and -0.284 % for the genotypic coefficient indicating that about 99% of the genotypic and phenotypic total variations were contributed by the characters included in the path analysis. Therefore,the traits like average fruit weight, number of fruits per plant exhibited positive direct effect on fruit yield per plant. These results indicate that these two traits have higher affinity towards the fruit yield so the direct selection of these traits will lend desirable results on fruit yield per plant. Similar influence of these traits on fruit yield per plant was noticed by Islam *et al*. (2014), Devi *et al*. (2017), Upadhyay *et al*. (2019), Fathima *et al*. (2023) and Ahmed *et al*. (2024) in snake gourd. Other earliness traits like node at first female flower appearance, days to first fruit setting delivered negative and direct effect on fruit yield per plant (phenotypic and genotypic levels). The trait days to first female flower opening had delivered negative and direct effect on fruit yield per plant at genotypic levels. Similar negative effect of earliness traits was noticed in the studies of Devi *et al*. (2017) in snake gourd, Annigeri (2020), Chithra (2023) in sponge gourd and Harshitha *et al*. (2019).

CONCLUSION

Divergence studies deliver a chance to identify superior recombinants for different traits, thereby fostering increased variability in these traits in subsequent generations. Correlation studies indicated that the characters like fruit width, number of seeds per fruit, average fruit weight, number of fruits per plant and total number of female flowers should be considered as the traits of interest for improving quantitative traits in snake gourd. Path coefficient analysis further suggested that average fruit weight, number of fruits per plant, node at first female flower appearance, days to first fruit setting exhibited highest direct effect on fruit yield per plant therefore, these traits should be selected as desirable traits for the further improvement through selection.

DISCLAIMER

Authors hereby declare that NO generative AI technologies such as large language models and text-to-image generators have been used during writing or editing of this manuscript.

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Comment [ag5]: Ensure to provide DOI of every reference, if available.

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