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Analysis of Correlation and Path in Sponge Gourd (*Luffa cylindrica* L. Roem.)

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ABSTRACT: The analysis correlation and path coefficient for yield and yield atributes was investigation at Regional Horticulture Research and Extension Centre (RHREC), Dharwad, university of Horticultural Sciences, Bagalkote (Karnataka) during the year 2022-2023 with twenty-eight genotypes of sponge gourd (*Luffa cylindrica* L. Roem.) laying in two replications in Randomized Complete Block Design (RCBD). Significant amount of variation was observed for all the attributes in the genotypes in the experiment. Correlation revealed number of fruit per vine had a significant and positive correlation with vine length at 90 DAT, number of primary branches at 90 DAT, average fruit weight, fruit length and fruit diameter. It was observed that with increase in vine length, there is corresponding increase in number of primary branches at 90 DAT, average fruit weight, fruit length and fruit diameter. Path coefficient analysis for yield and yield contributing traits on number of fruit per vine exhibited positive direct and indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter and average fruit weight as these characters play a major role in recombination breeding and suggested that direct selection based on these traits will be beneficial for crop improvement of Sponge gourd.

Keywords: Sponge gourd, genotypes, correlation, path analysis, traits.

INTRODUCTION

Sponge gourd [*Luffa cylindrical* (Roem.) L.] is a tropical member of Cucurbitaceous family and *Luffa genus*. Luffa is originated in subtropical Asian region particularly India (Kalloo, 1993) and is an annual vine with tendrils and large, cylindrical fruits that are edible when young. It is commonly called as Sponge gourd, loofah, vegetable Sponge and dish cloth, having diploid chromosome number 2n = 26. It is known by wide vernacular names like kali tori, ghia tori, dundul, bhol, tarada and ghiraula (Nath and Swamy 2016) in different parts of India.

It is used as a vegetable either prepared like squash or eaten raw like Cucumber. The fruit contains white inner flesh which is fibrous and have flavors similar to Bitter melon. The fruit attains the length of 1-2 feet. Fully ripened Sponge gourd contains high fiber, which is used as cleansing agent, for making table mats, shoe-soles and primer in door and windows by Nepal farmers and dried Sponge fibers are used in commercial filters and for insulation (Bal *et al.*, 2004). Sponge gourd is regarded as an important medicinal plant that needs to be conserved as it is used in the traditional Chinese medicine as an anthelmintic, stomachic and antipyretic phytomedicinal drug. Saponins from the leaves and fruits possess effect on anoxia and fatigue. Fresh juice of the leaf is used for healing wounds. Additionally, the luffin, a ribosome-inactivating protein isolated from Luffa seeds is effective against growth of parasites, protozoa, insects, fungi and HIV. The seeds yield colorless, odourless and tasteless oil that can be used in cooking. In many developing countries, old fruits have wide applications such as bath Sponge for scrubbing body skin as it increases blood circulation, utensil cleaning Sponges and adsorbent for heavy metal in waste water. Thus, Sponge gourd is not only known as a vegetable but, also in industrial and science researching materials.

Cucurbits is the largest producer of biological water, it is easily digestible and is recommended for patients suffering from poverty or other diseases. Among the vegetables, cucurbit constitutes the importance of cultivated plants, the area they cover and the production and use of products worldwide. The Cucurbitaceae family is the largest group of summer vegetables. In total, there are two major subfamilies, eight groups, approximately 118 genera and 825 species. Approximately 20 species belonging to nine genera are cultivated (Jeffery, 1990).

It was initially commercially cultivated in Japan during the early 1890s. This crop has a rich history of being grown in tropical regions across Asia and Africa. Presently, it is extensively cultivated for its medicinal properties in countries such as Malaysia, Korea, Japan, India, Central America, Thailand, the Philippines, Indonesia, Taiwan, and China. Japan serves as the primary exporter of Sponge gourd, while Brazil and the United States are the major importers. In India, this crop is widely grown in regions including Uttar Pradesh, Bihar, West Bengal, Orissa, Assam, Andhra Pradesh, and Kerala (Arya and Prakash 2002). Given its preference for warm climates, it exhibits a remarkable ability to thrive in hot conditions, which renders it suitable for widespread cultivation in tropical areas.

The tender fruits are rich in vitamin A, vitamin C and iron (Yawalkar, 2004). They can also be used for cleaning floors or cars without scratching. The cellulose content varies from 55 to 90 per cent, the lignin content is within the range of 10 to 23 per cent, and the hemicelluloses content is around 8 to 22 per cent and ash of about 2.4 per cent. Sponge gourd is also a highly nutritive vegetable that contains moisture (93.2g), protein (1.2g), fat (0.20g), carbohydrate (2.9g), vitamins like thiamine (0.02 mg), riboflavin (0.06 mg), niacin (0.4 mg), carotene (120 mg), minerals like calcium (36 mg), phosphorus (19 mg), ferrous (1.1 mg) and fibers (0.20 g) per 100 g of edible portion (Gopalan *et al*., 1999; More and Shinde 2001). This crop is characterized as monoecious and primarily subject to cross-pollination, leading to a significant degree of variation in various economically significant traits. Notably, the most prominent variations are evident in the shape, size, and color of the fruits, as highlighted by Singh *et al*., 2009.

Variability within the Cucurbitaceous crop family is manifested through land races, traditional cultivars and non-edible wild weed species. Both qualitative and quantitative characteristics have received relatively little attention in terms of genetic enhancement for Sponge gourd. This is despite the availability of numerous varieties in India; only a few exhibits promise, prompting plant breeders to focus on its improvement.

Yield is a complex character influenced by several genetic factors interacting with environment. Success of any breeding programme for its improvement depends on the existing genetic variability in the base population and on the efficiency of selection. For a successful selection, it is necessary to study the nature of association of the character in question with other relevant traits and also the genetic variability available for them. Correlation and path coefficient analysis are the important biometrical tools, which are being effectively used for determining the rate of various yield components in different crops and leading to selection of superior genotypes. A study of correlation and path analysis between different quantitative and qualitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components (Fisher, 1918). For any effective selection programme, it would be desirable to consider the relative magnitude of association of various characters with yield. In this context the correlation studies assume special importance as it helps us about the genetic association of different characters with yield but correlation measures do not employ cause and effects of inter relationship between yields. Path coefficient analysis as suggested by Wright (1921), on the other hand, gives a clear picture about cause and effect as it splits the correlation into the estimates of direct and indirect contribution of each character towards yield

MATERIAL AND METHODS

The study was conducted during the year 2022-2023 at Regional Horticulture Research and Extension Centre (RHREC), Dharwad, University of Horticultural Sciences, Bagalkote (Karnataka). The location of experimental site is situated at an altitude of 678 meter above MSL at 15º28′34″N latitude and 74º58′40″E longitude in Northern Transition Zone of Karnataka. The site of experiment comprises of light red sandy loam (Alfisol) soil with a uniform fertility over all. The materials utilized for investigation comprised of twenty-eight genotypes of Sponge gourd collected from Regional Horticulture Research and Extension Centre (RHREC), Dharwad and locally collected cultivar which were laid in two replications in Randomized Complete Block Design (RCBD)

A. Statistical analysis

(i) Correlation analysis. Genotypic (r_g) and Phenotypic (r_p) correlation coefficients were estimated as reported by Al-Jibourie *et al*. (1958)

$$\text{Genotypic correlation} = r_{xy}(g) = \frac{Cov_{xy}(G)}{\sqrt{V_x(P)\,V_v(P)}}$$

$$\text{Phenotypic correlation} = r_{xy}(p) = \frac{Cov_{xy}(G)}{\sqrt{V_x(P)\,V_v(g)}}$$

Where,

$Cov_{xy}(G)$ = Genotypic covariance between x and y
$Cov_{xy}(P)$ = Phenotypic covariance between x and y
$V_x(G)$ = Genotypic variance of character ‘x’
$V_x(P)$ = Phenotypic variance of character ‘x’
$V_y(G)$ = Genotypic variance of character ‘y’
$V_y(p)$ =Phenotypic variance of character ‘y’

The significance test for the association between characters was performed by comparing the tabulated "r" value at "n-2" degrees of freedom for phenotypic and genotypic correlations with their respective estimated values.

(ii) Path coefficient analysis. Path co-efficient analysis reported by Wright (1921) ; Dewey and Lu (1959) was carried out to analyze the indirect and direct effect of the morphological trait on plant yield. The following sets of simultaneous equations were formed and solved for estimation various indirect and direct effects.

r_{1y} = a+r_{12}b+r_{13}c+………………..+r_{1Ii}
r_{2y} = a+r_{21}b+r_{23}c+………………..+r_{2Ii}
r_{3y} = r_{31}a+r_{32}b+c +………………..+r_{3Ii}
r_{4y} = r_{11}a+r_{12}b+r_{13}c+………………+I
where,
r_{1y} to 1_{1y} = co-efficient of correlation between casual factor 1 to 1 with dependent characters y.
r_{12} to r_{11} = Co-efficient of correlation among causal factors
a, b, c…….i = Direct effect of character 'a' to 'I' on the dependent character 'y'
(iii) Residual effect (R) was computed as follows.
Residual effect (R) = 1 – $\sqrt{a^2+B^2+c^2+...i^2+2abr_{12}+2acr_{13}+....}$

RESULT AND DISCUSSION

A. Correlation analysis

Correlation coefficient is an indication of nature of association among the different characters. The traits which exhibit positive correlation with the yield are regarded as principal traits for breeder to carry out further selection. The genotypic and phenotypic correlation coefficients are presented in the Table 1 and 2.

(i) Genotypic correlation with fruit yield per vine. The genotypic correlation of twelve traits in twenty-eight genotypes was worked out and depicted in Table 1.

Fruit yield per vine showed a significant (at both P= 0.01 and P= 0.05) and highly positive correlation with average fruit weight (rG = 0.937), number of fruit per vine (rG = 0.817), vine length at 90 DAT (rG = 0.747), number of primary branches at 90 DAT (rG =0.709), fruit length (rG = 0.657) and fruit diameter (rG = 0.635) where as it exhibited negatively and significant (P = 0.05) correlation with node at which first male flower appears (rG = 0.620), node at which first female flower appears (rG = 0.612), days to first male flower appears (rG = 0.564), days to first harvest (rG = 0.513) and days to first female flower appears (rG = 0.511)

(ii) Inter genotypic correlation. Number of fruit per vine showed a significant (at both P = 0.01 and P = 0.05) and positive correlation with vine length at 90 DAT (0.699), number of primary branches at 90 DAT (0.657), average fruit weight (0.599), fruit length (0.507) and fruit diameter (0.474) while the negative and significant (0.05) correlation were noted in node at which first male flower appears (0.635), node at which first female flower appears (0.616), days to first male flower appears (0.611), days to first female flower appears (0.502) and days to first harvest (0.491).

The average fruit weight had a positive and significant correlation (at both P = 0.01 and P = 0.05) with vine length (0.642), fruit diameter (0.629), number of primary branches at 90 DAT (0.621) and fruit length (0.584), but it was negatively correlated to node at which first female flower appears (0.554), node at which first male flower appears (0.550), days to first male flower appears (0.472), days to first harvest (0.437) and Days to first female flower appears (0.428).

Fruit diameter exhibited positive and highly significant (at both P= 0.01 and P= 0.05) correlation with vine length at 90 DAT (0.522) and number of primary branches at 90 DAT (0.521) where it showed positive and significant correlation (rG = 0.05), with fruit length (0.403). Negative and significant (P = 0.05) correlation was recorded in days to first harvest (0.425), node at which first female flower appears (0.415), node at which first male flower appears (0.408), days to first female flower appears (0.376) and days to first male flower appears (0.356).

Fruit length recorded positive and highly significant (at both P = 0.01 and P= 0.05) correlation with vine length at 90 DAT (0.554) and number of primary branches at 90 DAT (0.494) while negative and significant correlation (rG = 0.05) was associated with days to first male flower appears (0.350), node at which first male flower appears (0.374), days to first harvest (0.380), node at which first female flower appears (0.397) and Days to first female flower appears (0.406).

Day to first harvest recorded positive and highly significant (at both P= 0.01 and P= 0.05) correlation with days to first female flower appears (0.927), days to first male flower appears (0.708), node at which first female flower appears (0.579) and node at which first male flower appears (0.522) where, the negative and highly significant correlation was observed in number of primary branches at 90 DAT (0.655) and vine length at 90 DAT (0.731).

Table 1: Genotypic correlation coefficient among growth and yield parameter in Sponge gourd.

	VL90	NPB90	NMF	NFF	DFM	DFF	DFH	FL	FD	AFW	NFPV	rG
VL90	**1.0000**	0.777**	-0.714**	-0.718**	-0.689**	-0.711**	-0.731**	0.554**	0.522**	0.642**	0.699**	0.747**
NPB90		**1.0000**	-0.776**	-0.707**	-0.677**	-0.699**	-0.655**	0.494**	0.521**	0.621**	0.657**	0.709**
NMF			**1.0000**	0.895**	0.635**	0.574**	0.522**	-0.374*	-0.408*	-0.550**	-0.635**	-0.620**
NFF				**1.0000**	0.737**	0.620**	0.579**	-0.397*	-0.415*	-0.554**	-0.616**	-0.612**
DFM					**1.0000**	0.768**	0.708**	-0.350*	-0.356*	-0.472**	-0.611**	-0.564**
DFF						**1.0000**	0.927**	-0.406*	-0.376*	-0.428**	-0.502**	-0.511**
DFH							**1.0000**	-0.380*	-0.425*	-0.437**	-0.491**	-0.513**
FL								**1.0000**	0.403*	0.584**	0.507**	0.657**
FD									**1.0000**	0.629**	0.474**	0.635**
AFW										**1.0000**	0.599**	0.937**
NFPV											**1.0000**	0.817**
FYPV												**1.0000**

Critical rG value at 5 % = **0.2632** ; Critical rG value at 1 % = **0.4280** ; *Significant at 5 % ; ** Significant at 1 %

1. VL90 - Vine length at 90 DAT
2. NPB90 -Number of primary branches at 90 DAT
3. NMF -Node at which first male flower appears
4. NFF - Node at which first female flower appears
5. DFM - Days to first male flower appears
6. DFF - Days to first female flower appears
7. DFH - Days to first harvest
8. FL- Fruit length
9.FD - Fruit diameter
10. AFW- Average fruit weight
11. NFPV - Number of fruits per vine
12. rG - Genotypic correlation with Fruit yield per vine

Days to first female flower appears recorded positive and highly significant (at both P= 0.01 and P= 0.05) correlation with days to first male flower appears (0.768), node at which first male flower appears (0.620) and node at which first male flower appears (0.574) whereas negative and highly significant (at both P= 0.01 and P= 0.05) correlation was shown in number of primary branches at 90 DAT (-0.699) and vine length at 90 DAT (-0.711).

Days to first male flower appears recorded positive and highly significant (at both P= 0.01 and P= 0.05) correlation with node at which first female flower appears (0.737) and node at which first male flower appears (0.635) but it exhibited negative and highly significant (at both P= 0.01 and P= 0.05) correlation with number of primary branches at 90 DAT (-0.677) and vine length at 90 DAT (-0.689).

Node at which first female flower appears recorded positive and highly significant (at both P= 0.01 and P= 0.05) correlation with node at which first male flower appears (0.895) but it exhibited negative and highly significant (at both P= 0.01 and P= 0.05) correlation with number of primary branches at 90 DAT (-0.707) and vine length at 90 DAT (- 0.718).

Node at which first male flower appears recorded negative and highly significant (for both P= 0.01 and P= 0.05) correlation with vine length at 90 DAT (-0.714) and number of primary branches at 90 DAT (-0.776).

Number of primary branches at 90 DAT showed positive and highly significant (at both P= 0.01 and P= 0.05) correlation with vine length at 90 DAT (0.777).

B. Phenotypic correlation with fruit yield per vine

The phenotypic correlation of twelve traits in twenty-eight genotypes was worked out and depicted in Table 2.

The fruit yield per vine displayed a positive and highly significant (both P=0.01 and P=0.05) correlation with average fruit weight (rP=0.944), number of fruits per vine (rP= 0.819) ,vine length at 90 DAT (rP= 0.765), number of primary branches at 90 DAT (rP= 0.704), fruit length (rP= 0.651) and fruit diameter (rP= 0.647) but it was negatively correlated with days to first female flower appears (rP= 0.527), days to first harvest (rP= 0.550), days to first male flower appears (rP= 0.559), node at which first male flower appears (rP= 0.615) and node at which first female flower appears (rP= 0.618).

(ii) Inter phenotypic correlation. The number of fruit per vine displayed a positive and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (0.746), number of primary branches at 90 DAT (0.648), average fruit weight (0.619), fruit diameter (0.504) and fruit length (0.489), while negative and highly significant (both P=0.01 and P=0.05) correlation with days to first female flower appears (-0.543), days to first harvest (-0.567) days to first male flower appears (-0.610), node at which first male flower appears (-0.632) and node at which first female flower appears (-0.641).

Average fruit weight was observed with a positive and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (0.644), fruit diameter (0.630), number of primary branches at 90 DAT (0.628) and fruit length (0.591). While the negative and highly significant (at both P=0.01 and P=0.05) correlation with days to first female flower appears (0.430), days to first harvest (-0.445), days to first male flower appears (-0.474), node at which first male flower appears (- 0.553) and node at which first female flower appears (-0.554).

Fruit diameter was observed with a positive and highly significant (at both P=0.01 and P=0.05) correlation with number of primary branches at 90 DAT (0.536) and vine length at 90 DAT (0.520). Where, a positive and significant (P=0.01) correlation was observed in fruit length (0.418). Negative and significant (at both P=0.01) correlation with days to first male flower appears (-0.363), days to first female flower appears (-0.373), node at which first female flower appears (-0.415), node at which first male flower appears (-0.417) and days to first harvest (-0.423).

Table 2: Phenotypic correlation coefficient among growth and yield parameter in Sponge gourd.

	VL90	NPB90	NMF	NFF	DFM	DFF	DFH	FL	FD	AFW	NFPV	rP
VL90	**1.0000**	0.801**	-0.729**	-0.719**	-0.703**	-0.709**	-0.731**	0.576**	0.520**	0.644**	0.746**	0.765**
NPB90		**1.0000**	-0.774**	-0.717**	-0.673**	-0.723**	-0.703**	0.483**	0.536**	0.628**	0.648**	0.704**
NMF			**1.0000**	0.902**	0.631**	0.589**	0.555**	-0.364*	-0.417*	-0.553**	-0.632**	-0.615**
NFF				**1.0000**	0.742**	0.621**	0.586**	-0.405*	-0.415*	-0.554**	-0.641**	-0.618**
DFM					**1.0000**	0.783**	0.743**	-0.341*	-0.363*	-0.474**	-0.610**	-0.559**
DFF						**1.0000**	0.931**	-0.427*	-0.373*	-0.430**	-0.543**	-0.527**
DFH							**1.0000**	-0.423*	-0.423*	-0.445**	-0.567**	-0.550**
FL								**1.0000**	0.418*	0.591**	0.489**	0.651**
FD									**1.0000**	0.630**	0.504**	0.647**
AFW										**1.0000**	0.619**	0.944**
NFPV											**1.0000**	0.819**
FYPV												**1.0000**

Critical rP value at 5 % = **0.2632** ; Critical rP value at 1 % = **0.4280** ; *Significant at 5 % ; ** Significant at 1 %

1. VL90 - Vine length at 90 DAT
2. NPB90 - Number of primary branches at 90 DAT
3. NMF -Node at which first male flower appears
4. NFF - Node at which first female flower appears
5. DFM -Days to first male flower appears
6. DFF -Days to first female flower appears
7. DFH - Days to first harvest
8. FL- Fruit length
9.FD - Fruit diameter
10. AFW- Average fruits weight
11. NFPV - Number of fruits per vine
12. rP- Phenotypic correlation with Fruit yield per vine

Fruit length was observed with a positive and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (0.576) and number of primary branches at 90 DAT (0.483) but it was negative and significant (at both P=0.01) correlation with days to first male flower appears (-0.341), node at which first male flower appears (-0.364), node at which first female flower appears (-0.405), days to first harvest (-0.423) and days to first female flower appears (-0.427).

Days to first harvest shows positive and highly significant (at both P=0.01 and P=0.05) correlation with days to first female flower appears (0.931), days to first male flower appears (0.743), node at which first female flower appears (0.586) and node at which first male flower appears (0.555), whereas the negative and highly significant (at both P=0.01 and P=0.05) correlation was displayed with number of primary branches at 90 DAT (-0.703) and length at 90 DAT (-0.731).

Days to first female flower appears shows positive and highly significant (at both P=0.01 and P=0.05) correlation with days to first male flower appears (0.783), node at which first female flower appears (0.621)) and node at which first male flower appears (0.589), whereas negative and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (-0.709) and number of primary branches at 90 DAT (-0.723).

Days to first male flower appears shows positive and highly significant (at both P=0.01 and P=0.05) correlation with node at which first female flower appears (0.742) and node at which first male flower appears (0.631), whereas negative and highly significant (at both P=0.01 and P=0.05) correlation with number of primary branches at 90 DAT (-0.631) and vine length at 90 DAT (-0.703)

Node at which first female flower appears shows positive and highly significant (at both P=0.01 and P=0.05) correlation with node at which first male flower appears (0.902), whereas negative and highly significant (at both P=0.01 and P=0.05) correlation with number of primary branches at 90 DAT (- 0.717) and vine length at 90 DAT (-0.719).

Node at which first male flower appears observed negative and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (-0.729) and number of primary branches at 90 DAT (-0.774).

Number of primary branches at 90 DAT shows positive and highly significant (at both P=0.01 and P=0.05) correlation with vine length at 90 DAT (0.801).

C. Path co-efficient analysis

The correlation co-efficient indicate the relationship of independent variables with the dependent variable without specifying the cause and effect. Path co-efficient analysis can be understand by utilize the correlation co-efficient, the characters are interpret as the direct and indirect effect by various ways. The results expound the direct and indirect effect on fruit yield per vine as shown in Table 3 and 4.

(i) Genotypic path coefficient analysis of fruit yield per vine. The genotypic path coefficient analysis of 12 traits in 28 genotypes was worked out and depicted in Table 3.

Direct effect on fruit yield per vine. Vine length at 90 DAT (0.0560), number of primary branches at 90 DAT (0.0366), node at which first male flower appears (0.0325), node at which first female flower appears (0.0394), day to first male flower (0.0207), days to first harvest (0.0130), fruit length (0.0605), fruit diameter (0.0027), average fruit weight (0.6608) and number of fruits per vine (0.3813) where as negative direct effect was shown by days to first female flower appears (-0.0171).

Indirect effect on fruit yield per vine. Vine length had positive indirect effect on number of primary branches at 90 DAT (0.0285), days to first female flower (0.0122), fruit length (0.0335), fruit diameter (0.014), average fruit weight (0.4244) and number of fruits per vine (0.2665) but it had negative indirect effect on node at which first male flower appears (-0.0232), node at which first female flower appears (-0.0283), day to first male flower (0.0142) and days to first harvest (-0.0095).

Number of primary branches at 90 DAT displayed positive indirect effect on vine length at 90 DAT (0.0436), days to first female flower appears (0.0120), fruit length (0.0299), fruit diameter (0.0014), average fruit weight (0.4104) and number of fruits per vine (0.2505) but it had negative indirect effect on node at which first male flower appears (0.0252), node at which first female flower appears (0.0278), day to first male flower (0.0140) and days to first harvest (0.0085).

Node at which first male flower appears recorded positive indirect effect on node at which first female flower appears (0.0353), day to first male flower (0.0131) and days to first harvest (0.0068) but it had negative indirect effect on vine length at 90 DAT (-0.0400), number of primary branches at 90 DAT (-0.0284), days to first female flower appears (-0.0098), fruit length (-0.0226), fruit diameter (-0.0011), average fruit weight (-0.3633) and number of fruits per vine (-0.2421).

Node at which first female flower appears recorded positive indirect effect on node at which first male flower appears (0.0291), day to first male flower (0.0152) and days to first harvest (0.0075) but had negative indirect effect on vine length at 90 DAT (-0.0402), number of primary branches at 90 DAT (-0.0259), days to first female flower appears (-0.0106), fruit length (0.0240), fruit diameter (-0.0011), average fruit weight (-0.3662) and number of fruit per vine (-0.2349).

Days to first male flower appears had positive indirect effect on node at which first male flower appears (0.0206), node at which first female flower appears (0.0290) and days to first harvest (0.0092). While negative indirect effect on vine length at 90 DAT (-0.0386), number of primary branches at 90 DAT (-0.0248), days to first female flower appears (-0.0132), fruit length (-0.0212), fruit diameter (-0.0009), average fruit weight (-0.3118) and number of fruits per vine (-0.2330).

Days to first female flower appears shows positive indirect effect on node at which first male flower appears (0.0187), node at which first female flower appears (0.0244), days to first harvest (0.00121) and days to first male flower appears (0.0159), where as negative indirect effect on vine length at 90 DAT (-0.0399), number of primary branches at 90 DAT (-0.0256), fruit length (-0.0246), fruit diameter (-0.0010), average fruit weight (-0.2829) and number of fruits per vine (-0.1912).

Table 3: Genotypic path coefficient analysis for yield and yield components in Sponge gourd.

	VL90	NPB90	NMF	NFF	DFM	DFF	DFH	FL	FD	AFW	NFPV	rG
VL90	**0.0560**	0.0436	-0.0400	-0.0402	-0.0386	-0.0399	-0.0410	0.0310	0.0292	0.0360	0.0392	0.747**
NPB90	0.0285	**0.0366**	-0.0284	-0.0259	-0.0248	-0.0256	-0.0240	0.0181	0.0191	0.0227	0.0240	0.709**
NMF	-0.0232	-0.0252	**0.0325**	0.0291	0.0206	0.0187	0.0170	-0.0122	-0.0133	-0.0179	-0.0206	-0.620**
NFF	-0.0283	-0.0278	0.0353	**0.0394**	0.0290	0.0244	0.0228	-0.0156	-0.0164	-0.0218	-0.0243	-0.612**
DFM	-0.0142	-0.0140	0.0131	0.0152	**0.0207**	0.0159	0.0146	-0.0072	-0.0073	-0.0097	-0.0126	-0.564**
DFF	0.0122	0.0120	-0.0098	-0.0106	-0.0132	**-0.0171**	-0.0159	0.0070	0.0064	0.0073	0.0086	-0.511**
DFH	-0.0095	-0.0085	0.0068	0.0075	0.0092	0.0121	**0.0130**	-0.0049	-0.0055	-0.0057	-0.0064	-0.513**
FL	0.0335	0.0299	-0.0226	-0.0240	-0.0212	-0.0246	-0.0230	**0.0605**	0.0244	0.0353	0.0307	0.657**
FD	0.0014	0.0014	-0.0011	-0.0011	-0.0009	-0.0010	-0.0011	0.0011	**0.0027**	0.0017	0.0013	0.635**
AFW	0.4244	0.4104	-0.3633	-0.3662	-0.3118	-0.2829	-0.2888	0.3857	0.4154	**0.6608**	0.3957	0.937**
NFPV	0.2665	0.2505	-0.2421	-0.2349	-0.2330	-0.1912	-0.1870	0.1933	0.1807	0.2283	**0.3813**	0.817**
FYPV	0.747**	0.709**	-0.620**	-0.612**	-0.564**	-0.511**	-0.513**	0.657**	0.635**	0.937**	0.817**	**1.0000**

Diagonal indicates direct effect ; *Significant at 5 % ; ** Significant at 1 % ; Residual effect = 0.117

1. VL90 - Vine length at 90 DAT
2. NPB90 - Number of primary branches at 30 DAT
3. NMF -Node at which first male flower appears
4. NFF - Node at which first female flower appears
5. DFM - Days to first male flower appears
6. DFF - Days to first female flower appears
7. DFH - Days to first harvest
8. FL- Fruit length
9. FD - Fruit diameter
10. AFW- Average fruit weight
11. NFPV - Number of fruit per vine
12. rG- Genotypic correlation with Fruit yield per vine

Days to first harvest shows positive indirect effect on node at which first male flower appears (0.0170), node at which first female flower appears (0.0228) and days to first male flower appears (0.0146). Whereas negative indirect effect on vine length at 90 DAT (-0.0410), number of primary branches at 90 DAT (-0.0240), days to first female flower appears (-0.0159), fruit length (-0.0230), fruit diameter (-0.0011), average fruit weight (-0.2888) and number of fruits per vine (-0.1870).

Fruit length exhibited positive indirect effect on vine length at 90 DAT (0.0310), number of primary branches at 90 DAT (0.0181), days to first female flower appears (0.0070), fruit diameter (0.0011), average fruit weight (0.3857), number of fruits per vine (0.1933) and negative indirect effect on node at which first male flower appears (-0.0122), node at which first female flower appears (-0.0156), days to first male flower appears (-0.0072) and days to first harvest (-0.0049).

Fruit diameter exhibited positive indirect effect on vine length at 90 DAT (0.0292), number of primary branches at 90 DAT (0.0191), days to first female flower appears (0.0064), fruit length (0.0244), average fruit weight (0.4154), number of fruits per vine (0.1807) and negative indirect effect on node at which first male flower appears (-0.0133), node at which first female flower appears (-0.0164), days to first male flower appears (-0.0073) and days to first harvest (-0.0055).

Average fruit weight exhibited positive indirect effect on vine length at 90 DAT (0.0360), number of primary branches at 90 DAT (0.0227), days to first female flower appears (0.0073), fruit length (0.0353), fruit diameter (0.0017), number of fruits per vine (0.2283) and negative indirect effect on node at which first male flower appears (-0.00179), node at which first female flower appears (-0.0218), days to first male flower appears (-0.0097) and days to first harvest (-0.0057).

Number of fruits per vine exhibited positive indirect effect on vine length at 90 DAT (0.0392), number of primary branches at 90 DAT (0.0240), days to first female flower appears (0.0086), fruit length (0.0307), fruit diameter (0.0013), average fruit weight (0.03957) and negative indirect effect on node at which first male flower appears (-0.00206), node at which first female flower appears (-0.0243), days to first male flower appears (-0.00126) and days to first harvest (-0.0064).

(iii) Phenotypic path coefficient analysis of fruit yield per vine. Phenotypic path coefficient analysis was carried out for all the yield attributing characters in order to know the direct and indirect effects on pod yield and it is described in Table 4.

Direct effect on fruit yield per vine. Fruit yield per vine had positive in direct effect on vine length at 90 DAT (0.070), number of primary branches at 90 DAT (0.0267), node at which first male flower appears (0.0458), node at which first female flower appears (0.0218), days to first male flower appears (0.0334), fruit length (0.0525), fruit diameter (0.0043), average fruit weight (0.6706) and number of fruits per vine (0.3605). While negative indirect effect was shown by days to first female flower appears (-0.0165) and days to first harvest (-0.002).

Indirect effect on fruit yield per vine. Vine length at 90 DAT shows positive indirect effect on number of primary branches at 90 DAT (0.0214), days to first female flower appears (0.0117), days to first harvest (0.0001), fruit length (0.0302), fruit diameter (0.0022), average fruit weight (0.4321) and number of fruits per vine (0.2689). While negative indirect effect was shown by node at which first male flower appears (-0.0334), node at which first female flower appears (-0.0157) and days to first male flower appears (-0.0235).

Number of primary branches at 90 DAT shows positive indirect effect on vine length at 90 DAT (0.0566), days to first female flower appears (0.0119), days to first harvest (0.0001), fruit length (0.0253), fruit diameter (0.0023), average fruit weight (0.4211) and number of fruits per vine (0.2337). While negative indirect effect was shown by node at which first male flower appears (-0.0354), node at which first female flower appears (-0.0157) and days to first male flower appears (-0.0225).

Table 4: Phenotypic path coefficient analysis for yield and its components in Sponge gourd.

	VL90	NPB90	NMF	NFF	DFM	DFF	DFH	FL	FD	AFW	NFPV	rP
VL90	**0.0707**	0.0566	-0.0516	-0.0508	-0.0497	-0.0501	-0.0517	0.0407	0.0367	0.0455	0.0527	0.765**
NPB90	0.0214	**0.0267**	-0.0207	-0.0192	-0.0180	-0.0193	-0.0188	0.0129	0.0143	0.0168	0.0173	0.704**
NMF	-0.0334	-0.0354	**0.0458**	0.0413	0.0289	0.0270	0.0255	-0.0167	-0.0191	-0.0253	-0.0290	-0.615**
NFF	-0.0157	-0.0157	0.0197	**0.0218**	0.0162	0.0136	0.0128	-0.0088	-0.0091	-0.0121	-0.0140	-0.618**
DFM	-0.0235	-0.0225	0.0211	0.0248	**0.0334**	0.0262	0.0248	-0.0114	-0.0121	-0.0158	-0.0204	-0.559**
DFF	0.0117	0.0119	-0.0097	-0.0102	-0.0129	**-0.0165**	-0.0154	0.0070	0.0062	0.0071	0.0090	-0.527**
DFH	0.0001	0.0001	-0.0001	-0.0001	-0.0001	-0.0002	**-0.0002**	0.0001	0.0001	0.0001	0.0001	-0.550**
FL	0.0302	0.0253	-0.0191	-0.0212	-0.0179	-0.0224	-0.0222	**0.0525**	0.0219	0.0310	0.0257	0.651**
FD	0.0022	0.0023	-0.0018	-0.0018	-0.0016	-0.0016	-0.0018	0.0018	**0.0043**	0.0027	0.0022	0.647**
AFW	0.4321	0.4211	-0.3708	-0.3717	-0.3179	-0.2882	-0.2985	0.3964	0.4221	**0.6706**	0.4150	0.944**
NFPV	0.2689	0.2337	-0.2280	-0.2312	-0.2198	-0.1958	-0.2043	0.1765	0.1818	0.2231	**0.3605**	0.819**
FYPV	0.765**	0.704**	-0.615**	-0.618**	-0.559**	-0.527**	-0.550**	0.651**	0.647**	0.944**	0.819**	**1.0000**
Partial R^2	0.0541	0.0188	-0.0282	-0.0135	-0.0187	0.0087	0.0001	0.0342	0.0028	0.6328	0.2953	

Diagonal indicates direct effect ; *Significant at 5 % ; ** Significant at 1 % ; Residual effect = 0.117

1. VL90 - Vine length at 90 DAT
2. NPB90 - Number of primary branches at 30 DAT
3. NMF -Node at which first male flower appears
4. NFF - Node at which first female flower appears
5. DFM - Days to first male flower appears
6. DFF - Days to first female flower appears
7. DFH - Days to first harvest
8. FL- Fruit length
9.FD - Fruit diameter
10. AFW- Average fruit weight
11. NFPV - Number of fruit per vine
12. rG- Genotypic correlation with Fruit yield per vine

Node at which first male flower appears showed positive indirect effect on node at which first female flower appears (0.0197) and days to first male flower appears (0.0211). Negative indirect effect was shown by vine length at 90 DAT (-0.0516), number of primary branches at 90 DAT (-0.0207), days to first female flower appears (-0.0097), days to first harvest (-0.0001), fruit length (-0.0191), fruit diameter (-0.0018), average fruit weight (-0.3708) and number of fruits per vine (-0.2280).

Node at which first female flower appears show positive indirect effect on node at which first male flower appears (0.0413) and days to first male flower appears (0.0248). Negative indirect effect was shown by vine length at 90 DAT (-0.0508), number of primary branches at 90 DAT (-0.0190), days to first female flower appears (-0.0102), days to first harvest (-0.0001), fruit length (-0.0212), fruit diameter (-0.0018), average fruit weight (-0.3717) and number of fruit per vine (-0.2312).

Days to first male flower appears shows positive indirect effect on node at which first male flower appears (0.0289) and node at which first female flower appears (0.0162). The negative indirect effect was shown by vine length at 90 DAT (-0.0497), number of primary branches at 90 DAT (-0.0180), days to first female flower appears (-0.0129), days to first harvest (-0.0001), fruit length (-0.0179), fruit diameter (-0.0016), average fruit weight (-0.3171) and number of fruits per vine (-0.2198).

Days to first female flower appears shows positive indirect effect on node at which first male flower appears (0.0270), node at which first female flower appears (0.0136) and days to first male flower appears (0.0262). Negative indirect effect was shown by vine length at 90DAT (-0.0501), number of primary branches at 90 DAT (-0.0193), days to first harvest (-0.0002), fruit length (-0.0224), fruit diameter (-0.0016), average fruit weight (-0.2882) and number of fruits per vine (-0.1958).

Days to first harvest shows positive indirect effect on node at which first male flower appears (0.0255), node at which first female flower appears (0.0128) and days to first male flower appears (0.0248). Negative indirect effect was shown by vine length at 90 DAT (-0.0517), number of primary branches at 90 DAT (-0.0188), days to first female flower (-0.0154), fruit length (-0.0222), fruit diameter (-0.0018), average fruit weight (-0.2985) and number of fruits per vine (-0.2043).

Fruit length shows positive indirect effect on vine length at 90 DAT (0.0407), number of primary branches at 90 DAT (0.0129), days to first female flower appears (0.0070), days to first harvest (0.0001), fruit diameter (0.0018), average fruit weight (0.3964) and number of fruit per vine (0.1765). While negative indirect effect was shown by node at which first male flower appears (-0.0167), node at which first female flower appears (-0.0088) and days to first male flower appears (-0.0114).

Fruit diameter shows positive indirect effect on vine length at 90 DAT (0.0367), number of primary branches at 90 DAT (0.0143), days to first female flower appears (0.0062), days to first harvest (0.0001), fruit length (0.0219), average fruit weight (0.4221) and number of fruit per vine (0.1818). While negative indirect effect was shown by node at which first male flower appears (-0.0191), node at which first female flower appears (-0.0091) and days to first male flower appears (-0.0121).

Average fruit weight observed positive indirect effect on vine length at 90 DAT (0.0455), number of primary branches at 90 DAT (0.0168), days to first female flower appears (0.0071), days to first harvest (0.0001), fruit length (0.0310), fruit diameter (0.0027) and number of fruit per vine (0.2231). While negative indirect effect was shown by node at which first male flower appears (-0.0253), node at which first female flower appears (-0.0121) and days to first male flower appears (-0.0158).

Number of fruits per vine observed positive indirect effect on vine length at 90 DAT (0.0527), number of primary branches at 90 DAT (0.0173), days to first female flower appears (0.0090), days to first harvest (0.0001), fruit length (0.0257), fruit diameter (0.0022) and average fruit weight (0.4150). While negative indirect effect was shown by node at which first male flower appears (-0.0290), node at which first female flower appears (-0.0140) and days to first male flower appears (-0.020).

Correlation studies. Correlation studies gives a view of the degree of inter-relation of plant characters for improvement of yield and yield attributes in a breeding programme. Correlation is the intense and direction of association among the characters. Investigation on both genotypic and phenotypic correlation were worked out in yield and yield contributing characters

Number of fruits per vine showed a significant and positive correlation with vine length at 90 DAT, number of primary branches at 90 DAT, average fruit weight, fruit length and fruit diameter while the negative and significant correlation were noted in node at which first male flower appears, node at which first female flower appears, days to first male flower appears, days to first female flower appears and days to first harvest. This implies that improvement of these traits simultaneously is impractical and is complex. Similar findings were quoted by Wani *et al.* (2008); Annigeri *et al.* (2020) in Sponge gourd.

The average fruit weight had a positive and significant correlation with vine length, fruit diameter, number of primary branches at 90 DAT and fruit length but it was negatively correlated to node at which first female flower appears, node at which first male flower appears, days to first male flower appears, days to first harvest and days to first female flower appears which implies that at genotypic and phonotypical level trait can be selected. These results were in accordance with Khan *et al.* (2015); Annigeri *et al.* (2020) in Sponge gourd.

Fruit diameter exhibited positive and high significant correlation with vine length at 90 DAT and number of primary branches at 90 DAT where it showed positive and significant correlation with fruit length. Negative and significant was recorded in days to first harvest, node at which first female flower appears, node at which first male flower appears, days to first female flower appears and days to first male flower appears. Suggesting that growth factor has an effect in fruit development. Similar results were found by Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd.

Fruit length recorded positive and high significant correlation with vine length at 90 DAT and number of primary branches at 90 DAT while Negative and significant correlation was associated with days to first male flower appears, node at which first male flower appears, days to first harvest, node at which first female flower appears and days to first female flower appears. This suggests that it is impracticable and selection for both traits can be comprised. These findings are in alike with Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd.

Day to first harvest recorded positive and high significant correlation with days to first female flower appears, days to first male flower appears, node at which first female flower appears and node at which first male flower appears where the negative and high significant correlation was observed in number of primary branches at 90 DAT and vine length at 90 DAT. This implies that phenotypic and genotypic effects are simultaneous and can be used for selection of these traits Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd

Days to first female flower appears recorded positive and high significant correlation with days to first male flower appears, node at which first male flower appears and node at which first female flower appears where as negative and highly significant correlation was shown in number of primary branches at 90 DAT and vine length at 90 DAT. This suggests that phenotypic and genotypic effect are simultaneous and can be used for selection of these traits by Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd.

Days to first male flower appears recorded positive and high significant correlation with node at which first female flower appears and node at which first male flower appears but it exhibited negative and high significant correlation with number of primary branches at 90 DAT and vine length at 90 DAT. This suggested that phenotypic and genotypic effect are simultaneous and can be used for selection of these traits Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd).

Node at which first female flower appears recorded positive and high significant correlation with node at which first male flower appears but it exhibited negative and high correlation with number of primary branches at 90 DAT and vine length at 90 DAT. Implied higher genotypic influence on the earliness character and can considered for crop development. These findings are in agreement with Yadav *et al.* (2007); Rabbani *et al.* (2012).

Node at which male first flower appears recorded negative and high significant correlation with vine length at 90 DAT and number of primary branches at 90 DAT which indicates that node at first male flower increases and there is a decrease in yield Kumar *et al.* (2007); Singh *et al.* (2006) in Bottle gourd).

Number of primary branches at 90 DAT showed positive and high significant correlation with vine length at 90 DAT, indicating that growth and yield depends on the number of branches produced primarily, Chithra *et al.* (2023); Rabbani *et al.* (2012).

Path co-efficient analysis. Yield is a complex character comprising of different traits which contributes directly and indirectly. Since the character may not contribute alone the effect of other characters may affect yield and yields attributes, by path analysis it is possible to track down the direct and indirect effect on characters and yield.

Vine length had positive indirect effect on number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine. Similar observations were reported by Kumar *et al.* (2007).

Number of primary branches at 90 DAT displayed positive indirect effect on vine length at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine but had negative indirect effect for node at which first male flower appears, node at which first female flower appears, day to first male flower and days to first harvest, similar results were observed by Deepthi *et al.* (2016) Bottle gourd.

Node at which first male flower appears recorded positive indirect effect on node at which first female flower appears, day to first male flower and days to first harvest, but had negative indirect effect on vine length at 90 DAT (0.0400), number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine These results were similar with findings of Singh and Kumar (1998); Alok *et al.* (2007) in Bottle gourd.

Node at which first female flower appears recorded positive indirect effect on node at which first male flower appears, day to first male flower appears and days to first harvest but had negative indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine. These results were similar with findings of Singh and Kumar (1998) ; Alok *et al.* (2007) in Bottle gourd.

Days to first male flower appears had positive indirect effect on node at which first male flower appears, node at which first female flower appears and days to first harvest. While negative indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine (0.2330). Similar findings were reported by Khan *et al.* (2015) Bitter gourd.

Days to first female flower appears shows positive indirect effect on node at which first male flower appears, node at which first female flower appears, days to first harvest and days to first male flower appears. Whereas negative indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, fruit length, fruit diameter, average fruit weight and number of fruit per vine in conformity with results by Alok *et al.* (2007) Bottle gourd.

Days to first harvest shows positive indirect effect on node at which first male flower appears, node at which first female flower appears and days to first male flower appears. Where, negative indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and number of fruit per vine. Similar findings were reported by Deepthi *et al.* (2016) in Bottle gourd.

Fruit length exhibited positive indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit diameter, average fruit weight, number of fruit per vine and negative indirect effect on node at which first male flower appears, node at which first female flower appears, days to first male flower appears, days to first harvest. This was in a line with the findings of Mahapatra *et al.* (2019) in Bottle gourd. Similar findings reported by Khan *et al.* (2015) in Bitter gourd.

Fruit diameter exhibited positive indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, average fruit weight, number of fruit per vine and negative indirect effect on node at which first male flower appears, node at which first female flower appears, days to first male flower appears and days to first harvest. This was in alignment with findings of Mashilo *et al.* (2016) in Bottle gourd.

Average fruit weight exhibited positive indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, number of fruit per vine and negative indirect effect on node at which first male flower appears, node at which first female flower appears, days to first male flower appears and days to first harvest. This was in alignment with findings of Mashilo *et al.* (2016) in Bottle gourd.

Number of fruit per vine exhibited positive indirect effect on vine length at 90 DAT, number of primary branches at 90 DAT, days to first female flower appears, fruit length, fruit diameter, average fruit weight and negative indirect effect on node at which first male flower appears, node at which first female flower appears, days to first male flower appears and days to first harvest. Shows conformity with the findings of Yadagiri *et al.* (2017) in Bitter gourd.

CONCLUSIONS

Correlation reveled that number of fruit per vine had a significant and positive correlation with vine length at 90 DAT, number of primary branches at 90 DAT, average fruit weight, fruit length and fruit diameter while the negative and significant correlation were noted in node at which first male flower appears, node at which first female flower appears, days to first male flower appears, days to first female, and days to first harvest at both genotypic and phenotypic level. This implies that improvement of these traits simultaneously is impractical and is complex. But can be exploited for developing yield and yield attributes. Path coefficient analysis depicts that characters like vine length at 90 DAT, number of primary branches at 90 DAT, node at which first male flower appears, node at which first female flower appears, days to first male flower appears, days to first female flower appears, days to first harvest, fruit length, fruit diameter, average fruit weight, number of fruit per vine can be comprised for improve of fruit yield per vine since, these reflect positive direct and indirect effect and can be consider further for crop development in Sponge gourd.

FUTURE SCOPE

1. There is a need to screen a large number of Sponge gourd genotypes for high yield and quality traits within the same regions over a period for multiple season.
2. It is essential that the characteristics having desirable association with fruit yield to consider for improvement in yield in Sponge gourd.
3. Sponge gourd genotypes exhibiting high heritability along with high to moderate genetic advance can be targeted for yield improvement in Sponge gourd genotypes.
4. The study on physiochemical characteristics and characterization of molecular markers to be carried out for the further line of work.
5. The genotypes evaluated in this study demonstrate significant variation for several traits, making them promising candidates for further breeding programs.

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Conflict of Interest. None.

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