Assessment ofpath co-efficient analysis for yield and yield attributing traits in sponge gourd (*Luffa cylindrica* (L.) Roem.)

ABSTRACT

This investigation is conducted to determine path coefficient analysis using 40 genotypes of sponge gourd at the experimental plot of Department of Vegetable Science, College of Horticulture, UHS, Bagalkot (Karnataka) in RBD design along with two replications during the year 2020-2021. Path co-efficient analysis considered as one of the best statistical methods which can help breeders to characterize the genotypes during the parent selection program and select the desirable genotypes for higher yield production. Path coefficients analysis showed thatthe traits like number of fruits per vine, average fruit weight, fruit length, number of branches per vine and vine length had positive direct effect on fruit yield per vine. Thus the higher magnitude of positive direct effect of these traits explains the higher value of association between these traits on yield per vine. Therefore, direct selection for these traits would reward for yield improvement in sponge gourd.

Keywords:*Sponge gourd, fruit yield, phenotypic and genotypic path co-efficient*

1. INTRODUCTION

Cucurbits form an important and big group of vegetable crops and sponge gourd (*Luffa cylindrica* Roem Syn. *Luffa aegyptiaca*) is one of the important members of this group. Sponge gourd has been cultivated for centuries in the Middle East and India, China, Japan and Malaysia (Porterfield, 1955). Sponge gourd is native to Tropical Asia, probably India and South East Asia.

The tender or immature fruits of sponge gourd are eaten as cooked vegetable, used in the preparation of chutneys and curries. The tender fruits are easily digestible and increase appetite when consumed(Okusanya *et al.,* 1981).. It is nutritive vegetable rich in vitamin A, vitamin C and minerals (Mg, Ca, Na, K, Fe, Cu, Zn and Mn). It contains moisture of 93.2 g, protein 1.2 g, fat 0.2 g, carbohydrates 2.9 g and vitamins like, thiamine (0.02 mg), riboflavin (0.06 mg) and fibres (0.20 g) per 100 g of edible portion. The fruits of sponge gourd also have higher levels of protein and carotene than the ridge gourd (More and Shinde, 2001).

The sponge gourd fruits contains multiple bioactivators, such as alkaloids, flavonoids, sterols, glycosides, glycoproteins and thus possesses ani-inflamation, anti-fungal, anti-bacterial, anti-mycordical, sedative and analgesic activities. Fruits of this crop are best for the treatment of fever, jaundice, diabeties and hypertension. The presence of ribosome-inactivating protein in

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Porterfield is not in the bibliography of this paper.

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the seeds of sponge gourd said to be had anti-HIV activity. The oil extracted from the seeds of this crop is used for industrial purpose, treatment of leprosy and against many skin diseases (Partap *et al.*, 2012).

The mature dry fruits of this crop consists of dense network of cellulose fibers called as sponge or luffa which is used as filter and cleaning the motor car, glass wares, kitchen utensils and preparation of bathing accessories which increases the blood circulation and it is also credited as relief for rheumatic and arthritic suffers (Kumar *et al*., 2013).

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Sponge gourd is an annual climber with branched tendrils. It is highly cross pollinated crop due to the presence of monoecious sex form, however, other sex forms like hermaphrodite, staminate and pistillate flowers were also found in nature

Breeding for high yield is the major objective in any crop improvement programme. The studies on components of variability and heritability do not throw light on the extent and nature of relationship existing between yield and various contributory characters. Hence, the correlation and path analysis are known to help the breeder in prioritizing the selection of yield and yield related characters. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield (Fisher, 1918). Path analysis permits identification of direct and indirect causes of association and measures the relative importance of each character to a plant breeder for initiating a judicious breeding programme. Hence the present investigation was under taken to study the path co-efficient analysis in sponge gourd genotypes.

2. MATERIAL AND METHODS

The experiment was carried out at the experimental plot of Department of Vegetable Science, College of Horticulture, UHS, Bagalkot (Karnataka) during rabi 2020-2021. The experiment was laid out in a RCBD design with two replications consisting of fourty sponge gourd genotypes collected from different locations. Data was recorded on five randomly selected plants in each of the treatment.

The observations were recorded for 17 quantitative and qualitative traits namely, vine length at harvest, number of branches per vine, days to first female flower, node at first female flower, days to first harvest, fruit length, fruit diameter, average fruit weight, number of fruits per vine, number of seeds per fruit, sponge yield, TSS, ascorbic acid, potassium content, phenol content, crude fiber and fruit yield per vine. The data was analyzed statistically for path-coefficient analysis which was suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

3. RESULTS

The correlation would only indicate the overall relationship of independent trait with dependent trait but does not provide cause and effect relationship. Using path analysis, it is possible to resolve the correlations, which provide clue about such relationship. In sponge gourd seventeen important growth, yield and quality parameters were subjected to genotypic and phenotypic path coefficient analysis by considering fruit yield as dependent variable on sixteen other are independent variables.

3.1 Phenotypic path co-efficient analysis

The data pertaining to the phenotypic path co-efficient for different characters of sponge gourd are presented in Table 1.Among all characters studied yield per vine had exhibited positive direct effect through number of fruits per vine (0.721) followed by average fruit weight (0.487), fruit length (0.092), sponge yield (0.080), number of seeds per fruit (0.060), number of branches per vine (0.047), crude fibre content (0.019), ascorbic acid (0.015) and vine length (0.014). Whereas, node at first female flower (-0.098), phenol content (-0.040), days to first female flower (-0.029), TSS (-0.024), fruit diameter (-0.022), days to first harvest (-0.021) and potassium content (-0.011) had negative direct effect on fruit yield per vine.

The vine length had positive and direct effect on fruit yield per vine (0.014) but it also had indirect and positive effect via through number of fruits per vine(0.007), fruit length (0.006), sponge yield (0.006), number of branches per vine (0.004), node at first female flower (0.003), number of seeds per fruit (0.002), TSS (0.002), average fruit weight (0.001) and potassium content (0.001).

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Number of branches per vine showed positive direct effect (0.047) on yield per vine via sponge yield (0.023), number of fruits per vine(0.019), fruit length (0.017), vine length (0.013), potassium content (0.004), number of seeds per fruit (0.003), TSS (0.003) and average fruit weight (0.002).

Days to appearance of first female flower had negative direct impact (-0.029) on yield per vine through indirect effect of average fruit weight (-0.011), phenol content (-0.004), fruit diameter (-0.003) and ascorbic acid (-0.002)

The character, node at first female flower appearance had exerted negative direct effect on yield per vine (-0.098) but it also had negative and indirect effect (which is desirable) via days to first female flower (-0.004), number of seeds per fruit (-0.003), fruit diameter (-0.002), phenol content (-0.002) and TSS (-0.001).

Days to first harvest had negative direct impact (-0.021) on yield per vine through indirect negative effect of vine length (-0.009), number of fruits per vine (-0.009), sponge yield (-0.009), fruit length (-0.005), number of branches per vine (-0.004), number of seeds per fruit (-0.004), TSS (-0.003), potassium content (-0.004) and crude fibre content (-0.002).

Fruit length recorded positive direct effect on fruit yield per vine (0.092) via indirect effect through vine length (0.042), sponge yield (0.040), number of branches per vine (0.034), number of fruits per vine(0.029), average fruit weight (0.021), node at first female flower (0.013), number of seeds per fruit (0.007) and phenol content (0.006).

Fruit diameter observed negative direct effect on fruit yield per vine (-0.022) but it had very little positive indirect effect via fruit length (0.007), vine length (0.004), phenol content (0.004), number of branches per vine (0.003), sponge yield (0.003), node at first female flower (0.002) and average fruit weight (0.002).

The trait average fruit weight had high positive direct effect (0.487) on fruit yield per vine through its indirect effect of days to first harvest (0.146), days to first female flower (0.180), fruit length (0.112), vine length (0.033), node at first female flower (0.029), phenol content (0.026), number of branches per vine (0.021) and crude fibre content (0.010).

Number of fruits per vine shown positive direct effect on fruit yield per vine (0.721). It also exhibited positive and indirect effect through vine length (0.384), sponge yield (0.329), number of branches per vine (0.293), fruit length (0.228), TSS (0.196), node at first female flower (0.081), number of seeds per fruit (0.061), potassium content (0.026), fruit diameter (0.012) and crude fibre content (0.010).

The character number of seeds per fruit exhibited positive direct effect (0.721) on fruit yield per vine through its positive indirect effect of potassium content (0.012), sponge yield (0.011), TSS (0.010), fruit diameter (0.009), crude fibre content (0.009), vine length (0.008), number of fruits per vine (0.005), number of branches per vine (0.004) and fruit length (0.004).

Sponge yield observed positive direct effect (0.080) on fruit yield per vine, while it had positive indirect effect via number of branches per vine (0.040), number of fruits per vine (0.037), vine length (0.036), fruit length (0.035), node at first female flower (0.015), number of seeds per fruit (0.015), TSS (0.015) and potassium content (0.007).

The TSS even though reported to had negative direct effect (-0.024) on fruit yield per vine but it had positive indirect effect through phenol content (0.006), average fruit weight (0.005), days to first fruit harvest (0.003), days to first female flower (0.002), fruit length (0.002) and node at first female flower (0.001).

Ascorbic acid value in fruits reported to had positive but less direct effect (0.015) on fruit yield per vine through its indirect effect of phenol (0.004), fruit diameter (0.003), node at first female flower (0.002), days to first fruit harvest (0.002), potassium content (0.002), days to first female flower (0.001), TSS (0.001) and crude fibre content (0.001).

Percentage of potassium content in fruits had negative direct effect on fruit yield per vine (-0.011) but it had very negligible indirect effects (positively / negatively) through average fruit weight (0.003), node at first female flower (0.002), fruit length (0.001), days to first female flower (0.001), node at first female flower (-0.002), fruit diameter (-0.002), number of fruits per vine (-0.002), number of seeds per fruit (-0.002), TSS (-0.002), ascorbic acid (-0.002), vine length (-0.001), number of branches per vine (-0.001), sponge yield (-0.001), and crude fibre content (-0.001).

The amount of phenol content in the fruits exhibited negative direct effect (-0.040) on fruit yield per vine. While, the trait also exhibited positive and indirect association with number of fruits per vine (0.012), sponge yield (0.011), TSS (0.009), fruit diameter (0.007), crude fibre content (0.006), vine length (0.005), number of branches per vine (0.005), number of seeds per fruit (0.005), node at first female flower (0.003) and potassium content (0.001).

Crude fibre content in fruits had positive direct association with fruit yield per vine (0.019) through its positive indirect effects of fruit diameter (0.006), TSS (0.004), number of fruits per vine (0.003), number of seeds per fruit (0.003), node at first female flower (0.001), ascorbic acid (0.001) and potassium content (0.001).

3.2 Genotypic path co-efficient analysis

Genotypic path coefficient of fruit yield per vine had positive direct effect through number of fruits per vine (1.295) followed by phenol content (0.291), fruit diameter (0.271), average fruit weight (0.258), fruit length (0.219), number of branches per vine (0.159), TSS (0.110) and vine length (0.035). While, ascorbic acid (-0.515), node at first female flower (-0.405), sponge yield (-0.305), potassium content (-0.210), crude fibre content (-0.121), days to first harvest (-0.091), number of seeds per fruit (-0.027) and days to first female flower (-0.005) had exhibited negative direct effect on fruit yield per vine (Table 2).

The vine length had positive and direct effect on fruit yield per vine (0.035) but it had indirect positive effect through days to first harvest (0.019), days to first female flower (0.014), phenol content (0.006), node at first female flower (0.004), fruit diameter (0.003), ascorbic acid (0.003) and crude fibre content (0.002).

The trait, number of branches per vine showed positive direct effect on fruit yield per vine (0.196) via days to first harvest (0.084), days to first female flower (0.078), fruit diameter (0.037), ascorbic acid (0.032), phenol content (0.024), crude fibre content (0.018) and TSS (0.002).

Days to appearance of first female flower indicated negative direct effect on fruit yield per vine (-0.005) through indirect effect of days to first harvest (-0.006), average fruit weight (-0.002), fruit diameter (-0.001) and phenol content (-0.001).

Node at first female flower appear exhibits negative direct effect on fruit yield per vine (-0.405) but it also had negative and indirect effect (which is desirable) via number of branches per vine (-0.159), days to first female flower (-0.102), fruit diameter (-0.066), number of seeds per fruit (-0.056), phenol content (-0.054), vine length (-0.026) and days to first harvest (-0.025).

The character days to first fruit harvest reported to have negative direct effect on yield per vine (-0.091) through indirect effects of sponge yield (-0.112), number of fruits per vine (-0.110), number of branches per vine (-0.091), vine length (-0.090), TSS (-0.076), number of seeds per fruit (-0.049), potassium content (-0.049), crude fibre content (-0.029) and node at first female flower (-0.016).

Fruit length showed positive direct effect on fruit yield per vine (0.219) via indirect effect of vine length (0.129), number of seeds per fruit (0.118), number of branches per vine (0.113), number of fruits per vine(0.098), average fruit weight (0.055), node at first female flower (0.043) and phenol content (0.014).

Fruit diameter had positive direct impact on fruit yield per vine (0.271) but it had indirect positive effects through via crude fibre content (0.099), TSS (0.079), potassium content (0.075) number of seeds per fruit (0.065), ascorbic acid (0.064), days to first female flower (0.047) and days to first harvest (0.008).

Average fruit weight had positive direct effect on fruit yield per vine (0.258) through its indirect effects of days to first harvest (0.120), days to first female flower (0.116), fruit length (0.065), node at first female flower (0.033), vine length (0.024), number of branches per vine (0.014), phenol content (0.014) and crude fibre content (0.005).

The character number of fruits per vine exhibited positive direct effect on fruit yield per vine (1.295). It also exhibited positive and indirect effects through vine length (1.109), sponge yield (0.811), number of branches per vine (0.718), fruit length (0.580), node at first female flower (0.466), TSS (0.416), potassium content (0.350), number of seeds per fruit (0.223), ascorbic acid (0.025) and crude fibre content (0.010).

Number of seeds per fruit indicated negative direct effect on fruit yield per vine (-0.027) while it had positive indirect effects through days to first harvest (0.008), node at first female flower (0.006), average fruit weight (0.006), days to first female flower (0.005), ascorbic acid (0.004) and phenol content (0.003).

The sponge yield reported to have negative direct effect on fruit yield per vine (-0.305) but it had positive indirect effect through days to first harvest (0.199), days to first female flower (0.164), ascorbic acid (0.113), phenol content (0.091), fruit diameter (0.059), crude fibre content (0.045) and average fruit weight (0.011).

TSS reported positive direct effect on fruit yield per vine (0.110) through its indirect effect via number of fruits per vine (0.036), fruit diameter (0.032), number of seeds per fruit (0.030), sponge yield (0.029), crude fibre content (0.025), potassium content (0.022), ascorbic acid (0.014) and node at first female flower (0.008).

Ascorbic acid content in fruits had negative direct effect (-0.515) on fruit yield per vine while it had positive indirect effects through sponge yield (0.192), average fruit weight (0.136), number of branches per vine (0.105), number of seeds per fruit (0.077), vine length (0.045) and fruit length (0.043).

The amount of potassium content in fruits exhibited negative direct effect on fruit yield per vine (-0.210) but it had very negligible positive indirect effects through average fruit weight (0.064), days to first harvest (0.060), days to first female flower (0.039), fruit length (0.023) and phenol content (0.005).

Phenol content in fruits noticed to have positive direct effect (0.291) on fruit yield per vine while it had positive indirect effect through ascorbic acid content (0.093), days to first harvest (0.076), days to first female flower (0.051), fruit length (0.019) and average fruit weight (0.016).

The crude fibre content in fruits had negative direct effect on fruit yield per vine (-0.121) while the trait also exhibited positive and indirect association with days to first harvest (0.020), phenol content (0.020), sponge yield (0.018), number of branches per vine (0.014), days to first female flower (0.014), vine length (0.008) and fruit length (0.007).

4. DISCUSSION

Analysis of correlation indicates the association pattern of component traits with yield. It simply represents the general association of a particular trait with yield rather than providing cause and effect relationship. The technique of path coefficient analysis developed by Wright (1921) and demonstrated by Dewey and Lu (1959) facilitates partitioning the correlation coefficients into direct and indirect involvement of various component characters on yield.

Positive direct effect of this trait on fruit yield per plant is main cause for positive correlation of this trait with yield per plant. Hence, this trait proves to be a reliable character for improvement through selection.

Path coefficient analysis revealed that the traits like number of fruits per vine, average fruit weight, fruit length, number of branches per vine and vine length had positive direct effect on fruit yield per vine. Thus the higher magnitude of positive direct effect of these traits explains the higher value of association between these traits on yield per vine. Therefore, direct selection for these traits would reward for yield improvement in sponge gourd. Similar impact of these traits on fruit yield per plant was observed by Patidar (2014), Sharma *et al.* (2017), Yadav *et al.* (2017), Kumar *et al.* (2019), Parveen *et al.* (2019), Annigeri (2020) and Purushottama (2022) in sponge gourd. Whereas, node at first female flower, days to first harvest and days to first female flower had negative direct effect (desirable) at both genotypic and phenotypic levels. Similar negative impact of these parameters was found on fruit yield per vine by Patidar (2014), Kumar *et al.* (2019), Annigeri (2020) and (Ray, 2021) in sponge gourd.

The character number of fruits per vine exhibited high positive direct effect on fruit yield per vine. It also exhibited positive and indirect effects through vine length, sponge yield, number of branches per vine, fruit length, node at first female flower, TSS, potassium content, number of seeds per fruitand crude fibre content. These results are in compliance with the reports of Annigeri (2020), Yadav (2020) and Purushottama (2022) in sponge gourd.

Average fruit weight had positive direct effect on fruit yield per vine through its indirect effects of days to first harvest, days to first female flower, fruit length, node at first female flower, vine length, number of branches per vine, phenol content and crude fibre content. Similar results were reported by Annigeri (2020) and Purushottama (2022) in sponge gourd and Mitu *et al.* (2018) in ridge gourd.

Fruit length showed positive direct effect on fruit yield per vine via indirect effect of vine length, number of branches per vine, number of fruits per vine, average fruit weight, node at first female flower and phenol content. These results are in accordance with the reports of Annigeri (2020), (Ray, 2021) and Purushottama (2022) in sponge gourd.

The trait, number of branches per vine showed positive direct effect on fruit yield per vine via days to first harvest, days to first female flower, fruit diameter, ascorbic acid, phenol content, crude fibre content and TSS at genotypic level. The findings of Singh and Tiwari (2018) and Som *et al.* (2020) in sponge gourd are in conformity with present findings.

The vine length had positive and direct effect on fruit yield per vine but it had indirect positive effect through days to first harvest, days to first female flower, phenol content, node at first female flower, fruit diameter, ascorbic acid and crude fibre content at genotypic level.

Similar results were also reported by Singh and Tiwari (2018), Som *et al.* (2020) and Purushottama (2022) in sponge gourd.

Days to appearance of first female flower indicated negative direct effect on fruit yield per vine through indirect effect of average fruit weight, fruit diameter and phenol content. Node at first female flower appear exhibits negative direct effect on fruit yield per vine but it also had negative and indirect effect (which is desirable) via days to first female flower and number of seeds per fruit. The character days to first fruit harvest reported to have negative direct effect on yield per vine through indirect effects of sponge yield, number of fruits per vine, number of branches per vine, vine length, TSS, number of seeds per fruit, potassium content and crude fibre content. These results are in agreement with the findings of (Patidar, 2014), Som *et al.* (2020b) in sponge gourd and (Kumar and Singh, 2020) in ridge gourd.

CONCLUSION

Path co-efficient analysis is considered as one of the best statistical methods which can help breeders to characterize the genotypes during the parent selection program and select the desirable genotypes for higher yield production. The results of the current study exhibit that various traits such as number of fruits per vine, average fruit weight, fruit length, number of branches per vine and vine length can be used to create high yielding sponge gourd varieties under breeding or crop improvement programs.

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Table 1. Phenotypic path coefficient analysis for yield and its attributing characters in sponge 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	**0.014**	0.004	-0.004	-0.063	-0.005	0.006	-0.003	0.001	0.007	0.002	0.006	0.002	-0.001	0.001	-0.002	-0.001	0.532**
X_2	0.013	**0.047**	-0.012	-0.161	-0.007	0.017	-0.006	0.002	0.019	0.003	0.023	0.003	-0.010	0.004	-0.006	-0.003	0.453*
X_3	0.009	0.007	**-0.029**	0.005	0.023	0.008	-0.003	-0.011	0.011	0.005	0.012	0.003	-0.002	0.004	-0.004	0.003	-0.206
X_4	0.001	0.005	-0.004	**-0.098**	0.001	0.003	-0.002	0.001	0.003	-0.003	0.004	-0.001	0.003	0.004	-0.002	0.002	-0.178
X_5	-0.009	-0.004	0.017	0.001	**-0.021**	-0.005	0.001	0.007	-0.009	-0.004	-0.009	-0.003	0.003	-0.004	0.004	-0.002	-0.210
X_6	0.042	0.034	-0.027	0.013	-0.020	**0.092**	-0.028	0.021	0.029	0.007	0.040	-0.008	-0.003	-0.006	0.006	-0.005	0.508**
X_7	0.004	0.003	-0.002	0.002	-0.001	0.007	**-0.022**	0.002	0.000	-0.003	0.003	-0.004	-0.005	-0.004	0.004	-0.007	-0.096
X_8	0.033	0.021	0.180	0.029	0.146	0.112	-0.052	**0.487**	-0.044	-0.108	-0.017	-0.105	-0.103	-0.146	0.026	0.010	0.434*
X_9	0.384	0.293	-0.279	0.081	-0.281	0.228	0.012	-0.065	**0.721**	0.061	0.329	0.196	-0.004	0.150	-0.213	0.115	0.784**
X_{10}	0.008	0.004	-0.009	-0.007	-0.011	0.004	0.009	-0.013	0.005	**0.060**	0.011	0.010	-0.008	0.012	-0.007	0.009	0.033
X_{11}	0.036	0.040	-0.035	0.015	-0.032	0.035	-0.011	-0.003	0.037	0.015	**0.080**	0.015	-0.018	0.007	-0.023	-0.009	0.484*
X_{12}	-0.004	-0.001	0.002	0.001	0.003	0.002	-0.005	0.005	-0.007	-0.004	-0.004	**-0.024**	-0.002	-0.004	0.006	-0.005	0.097
X_{13}	-0.001	-0.003	0.001	0.002	0.002	-0.001	0.003	-0.003	0.000	-0.002	-0.003	0.001	**0.015**	0.002	0.004	0.001	-0.146
X_{14}	-0.001	-0.001	0.001	-0.002	0.002	0.001	-0.002	0.003	-0.002	-0.002	-0.001	-0.002	-0.002	**-0.011**	0.000	-0.001	0.011
X_{15}	0.005	0.005	-0.006	0.003	-0.007	-0.003	0.007	-0.002	0.012	0.005	0.011	0.009	-0.010	0.001	**-0.040**	0.006	-0.250
X_{16}	-0.001	-0.001	-0.002	0.001	-0.001	-0.001	0.006	0.000	0.003	0.003	-0.002	0.004	0.001	0.001	-0.003	**0.019**	0.133

rP = dependent character   Diagonal values indicates direct effect   Residual effect=0.305 *Indicates significant at p=0.05 **Indicates significant at p=0.01

X_1= Vine length at harvest X_2= Number of branches per vine X_3= Days to first female flower X_4= Node at first female flower
X_5= Days to first harvest X_6= Fruit length X_7= Fruit diameter X_8= Average fruit weight
X_9= Number of fruits per vine X_{10}= No. of seeds per fruit X_{11}= Sponge yield X_{12}= TSS
X_{13}= Ascorbic acid X_{14}=Potassium content X_{15}= Phenol content X_{16}= Crude fiber

Table 2. Genotypic path coefficient analysis for yield and its attributing characters in sponge 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	**0.035**	-0.023	0.014	0.004	0.019	-0.022	0.003	-0.003	-0.031	-0.007	-0.028	-0.012	0.003	-0.004	0.006	0.002	0.769^{**}
X_2	-0.099	**-0.159**	0.078	-0.119	0.084	-0.082	0.037	-0.009	-0.088	-0.008	-0.104	0.002	0.032	-0.014	0.024	0.018	0.564^{**}
X_3	0.002	0.002	**-0.005**	0.002	-0.006	0.002	-0.001	-0.002	0.003	0.001	0.003	0.001	0.000	0.001	-0.001	0.001	-0.248^{*}
X_4	-0.026	0.196	-0.102	**-0.405**	-0.025	0.052	-0.066	0.034	0.136	-0.056	0.087	0.018	0.068	0.113	-0.054	0.013	-0.437^{*}
X_5	-0.090	-0.091	0.213	-0.016	**-0.091**	-0.071	0.005	0.080	-0.110	-0.049	-0.112	-0.076	0.030	-0.049	0.045	-0.029	-0.328^{*}
X_6	0.129	0.113	-0.085	0.043	0.171	**0.219**	-0.079	0.055	0.098	0.027	0.118	-0.028	-0.018	-0.024	0.014	-0.012	0.555^{**}
X_7	-0.019	-0.063	0.047	-0.068	0.008	-0.098	**0.271**	-0.039	-0.012	0.065	-0.052	0.079	0.064	0.075	-0.058	0.099	-0.127
X_8	0.024	0.014	0.116	0.033	0.120	0.065	-0.037	**0.258**	-0.027	-0.060	-0.009	-0.074	-0.068	-0.079	0.014	0.005	0.439^{*}
X_9	1.109	0.718	-0.759	0.466	-0.834	0.580	-0.057	-0.133	**1.295**	0.223	0.811	0.416	0.025	0.350	-0.454	0.223	0.914^{**}
X_{10}	-0.005	-0.001	0.005	0.006	0.008	-0.003	-0.007	0.006	-0.005	**-0.027**	-0.006	-0.008	0.004	-0.006	0.003	-0.005	0.048
X_{11}	-0.236	-0.198	0.164	-0.101	0.199	-0.164	0.059	0.011	-0.191	-0.066	**-0.305**	-0.079	0.113	-0.033	0.091	0.045	0.531^{**}
X_{12}	-0.037	-0.001	-0.030	0.008	-0.049	-0.014	0.032	-0.032	0.036	0.030	0.029	**0.110**	0.014	0.022	-0.033	0.025	0.130
X_{13}	0.045	0.105	-0.009	-0.134	-0.090	0.043	-0.122	0.136	-0.010	0.077	0.192	-0.066	**-0.515**	-0.114	-0.165	-0.052	-0.213^{*}
X_{14}	-0.021	-0.018	0.039	-0.090	0.060	0.023	-0.058	0.064	-0.057	-0.045	-0.022	-0.041	-0.046	**-0.210**	0.005	-0.017	0.012
X_{15}	-0.051	-0.044	0.051	-0.059	0.076	0.019	-0.062	0.016	-0.102	-0.035	-0.087	-0.087	0.093	-0.007	**0.291**	-0.048	-0.250^{*}
X_{16}	0.008	0.014	0.014	-0.006	0.020	0.007	-0.044	-0.003	-0.021	-0.022	0.018	-0.027	-0.012	-0.010	0.020	**-0.121**	0.147

rG = dependent character   Diagonal values indicates direct effect   Residual effect=0.209 *Indicates significant at p=0.05 **Indicates significant at p=0.01

X_1= Vine length at harvest X_2= Number of branches per vine X_3= Days to first female flower X_4= Node at first female flower
X_5= Days to first harvest X_6= Fruit length X_7= Fruit diameter X_8= Average fruit weight
X_9= Number of fruits per vine X_{10}= No. of seeds per fruit X_{11}= Sponge yield X_{12}= TSS
X_{13}= Ascorbic acid X_{14}=Potassium content X_{15}= Phenol content X_{16}= Crude fiber