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Research Article

Genetic analysis of snake gourd (*Trichosanthes anguina* L.) germplasms

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Abstract
The present experiment was conducted with 16 germplasms and two varieties of snake gourd. The yield contributing traits such as node order of first male flower, node order of first female flower, days to first male flowering, days to first female flowering, internodal length, days to first harvest, single fruit weight, fruit length, fruit girth, number of fruits per plant, were studied to assess the genetic variability, heritability and genetic advance besides correlation and path coefficient analysis. The study of GCV and PCV in snake gourd germplasms exhibited variability for the traits *viz*., node order of first male flower, fruit length, number of fruits per plant, single fruit weight and fruit yield per plant including yield characteristics. Heritability and genetic advance as a percentage of mean indicated that the variation is due to a high degree of additive effect and hence the traits can be improved further through selection. Correlation and path analysis results showed that single fruit weight, number of fruits per plant and days to first harvest had a significant positive direct effect on number of fruits per plant. Hence these traits could be considered for yield improvement programmes in snake gourd.

Keywords: *Trichosanthes*, snake gourd, correlation, heritability path analysis, variability

INTRODUCTION

Trichosanthes anguina L., often known as the snake gourd, is a member of the tribe Trichosantheae and is native to Southern India. It belongs to Cucurbitaceae family with chromosome number 2n=22(Chakrabarti, 1982).The snake gourd or snake tomato is also known by the regional names like *Pudalankaai* in Tamil and *Padavalanga* in Malayalam. Temperatures between 30 and 35 ° C are ideal for this vital summer vegetable, whereas temperatures below 20 ° C hinders plant growth and fruit production.(Gildemacher *et al*.,1993). Currently, it is grown throughout the tropical and subtropical regions of the world (Ahmed *et al*., 2000). It is a nutritious plant that could be useful to rural residents as a supplement for those who cannot afford milk or other relatively expensive dietary supplements (Idowu *et al*., 2019). Many different varieties with varying fruit colour, shape, and size are commercially available in India. However, there is a need to evolve more hybrids and varieties for production of fruits during the lean season (Kamaluddin, 1996). The availability of different morphological variations among snake gourd cultivars in India, results in a relatively wide phenotypic variation of species. So there is a significant potential for genetic improvement by increasing crop productivity through varietal development. For the selection and development of superior varieties, knowledge of genetic variability, heritability, genetic progress, as well as the association between yield and its related traits, is a prerequisite (Ilakiya *et al.,* 2022). For a breeder, it is vital to evaluate the type and extent of genetic variability across snake gourd genetic stocks. The current study was undertaken to assess the genetic variability, heritability and correlation between yield and yield related traits for 16 germplasms and two local varieties found in Tamil Nadu.

MATERIALS AND METHODS

The current investigation was conducted during 2021 at College Orchard of Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experiment site is located in Tamil Nadu's Western Zone and recorded 883 mm of rainfall in 2021. Based on morphological variations, 16 snake gourd germplasm , which had been collected from several districts of Tamil Nadu during the year 2020-2021(**Table 1**) and two varieties (CO-2 and PKM-1) were selected as the experimental materials for this study. Biometrical traits include, node order of first male flower, node order of first female flower, days to first male flowering, days to first female flowering, internodal length(cm), days to first harvest, fruit length (cm), single fruit weight (g), number of fruits per plant, fruit yield per plant (g) were studied for genetic interpretation. Recommended crop management practices were undertaken for better crop growth. The various genetic variability parameters *viz.,* genetic advance (GA) as percent of mean(GAM), heritability (h^2), genotypic coefficient of variation (GCV), and phenotypic coefficient of variation (PCV) were estimated as per Johnson *et al*. (1955).

Each quantitative trait was subjected to ANOVA using the R programme version 4.2.1 (R core team, 2021), and treatment mean squares were analyzed for significance at the 5% and 1% probability levels. The coefficient of variation at phenotypic and genotypic level were calculated using the method proposed by Burton (1952). Phenotypic and genotypic variance and heritability (h^2) in percentage, were calculated using Lush's technique (1949). The heritability percentage was categorized as suggested by Robinson (1965). The standard method proposed by Miller *et al*. (1958) was used to estimate the correlation coefficients at phenotypic and genotypic levels utilizing the corresponding variance and covariance components. Using path coefficient analysis, as outlined by Dewey and Lu (1959), the direct effects and indirect effects of various components on yield were calculated. The correlation chart and path coefficient diagram was prepared using R software version 4.2.1 (R core team, 2021).

RESULTS AND DISCUSSION

The mean performance of yield and yield attributing traits of snake gourd germplasms were analyzed and the same is furnished in **Table 2**. It was found to be significant at 5% and 1% probability levels.

The results of variability parameters, broad sense heritability and genetic advance as per cent of mean of the traits are presented in **Table 3**. The phenotypic

Table 1. List of snake gourd germplasm used in the study

Accessions	Germplasm	Source
TA01	Pallapatti	Karur
TA02	Vilathikulam short	Thoothukudi
TA03	Kariyapatty	Virudhunagar
TA04	Musiri (Long)	Trichy
TA05	Madurai (Long)	Madurai
TA06	Kamudhi	Ramanathapuram
TA07	Madurai (Short)	Madurai
TA08	Kalappal	Thiruvarur
TA09	Trichy Short	Trichy
TA10	Trichy Long	Trichy
TA11	Olakkur	Villupuram
TA12	Tanjore	Tanjore
TA13	Kaduvaguli	Kerala
TA14	Poondhurai	Erode
TA15	Sivagiri	Erode
TA16	Gobichettipalayam	Erode
	CO-2	TNAU, Coimbatore
	PKM- 1	HC&RI,TNAU, Periyakulam

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Table 2 . Mean performance of yield and yield attributing traits of snake gourd genotypes

Genotypes	Days to 1st male flower anthesis	Days to first female flower anthesis	Node order of first male flower	Node order of first female flower	Internodal length (cm)	Days to first harvest	Fruit length	Fruit girth	Number of fruits per plant	Single fruit weight	Fruit yield per plant
TA01	31.63c	36.50b	3.75p	16.25p	12.50c	52.63i	46.69k	14.14i	17.00p	193.94b	3224.75g
TA02	35.63l	40.25f	7.38e	14.88j	16.45l	52.50h	28.13e	19.90r	7.75j	421.01i	3362.88h
TA03	30.38b	47.38m	4.63l	15.50g	12.81d	60.25o	54.25n	19.44q	7.50g	521.03l	3883.68m
TA04	38.13n	45.50l	8.63c	16.50l	16.81n	55.38l	71.56p	7.66a	8.50l	312.93f	2656.85d
TA05	33.38g	43.50j	9.50a	16.63k	13.94f	54.75k	116.94q	11.26c	8.25k	870.40o	7269.45q
TA06	35.00j	41.50i	3.75q	13.50a	17.94q	52.75j	46.25j	16.02n	5.38a	675.45n	3621.75l
TA07	33.63h	38.88d	4.50n	13.13o	13.13e	49.38b	26.19c	14.32j	14.00o	256.30c	3617.20k
TA08	33.13f	39.63e	8.75b	13.25e	16.63m	51.88g	47.19l	17.06p	7.25e	899.50q	6524.45p
TA09	42.50p	50.50p	5.25j	13.75h	11.88b	62.63p	26.94d	15.30k	7.50h	454.64j	3409.75i
TA10	23.25a	35.63a	4.38o	13.63c	15.75i	47.63a	42.31i	16.95o	6.50c	876.25p	5695.74o
TA11	33.00e	43.50k	4.63m	10.38i	14.63g	51.00e	47.94m	12.89f	7.50i	331.71h	2487.21b
TA12	33.75i	40.50g	8.00d	15.50d	16.25k	50.50c	37.38g	15.90m	6.50d	319.79g	2017.81a
TA13	32.75d	38.50c	5.63h	14.50b	18.69r	51.50f	33.13f	15.36l	5.63b	571.05m	3214.87f
TA14	35.25k	40.63h	3.50r	14.63m	16.94o	50.63d	22.50b	13.55g	9.38m	275.61d	2587.98c
TA15	46.13q	59.1q	4.75k	18.00q	11.38a	69.13q	22.38a	12.39e	17.00q	170.46a	2914.45e
TA16	56.75r	66.75r	6.00g	18.50f	14.75h	77.75r	62.41o	13.84h	7.38f	486.34k	3504.68j
CO 2	36.50m	47.50n	5.50i	11.63r	16.00j	58.50n	41.47h	9.50b	19.25r	278.63e	5038.80n
PKM 1	41.25o	50.00o	7.00f	12.50n	17.75p	58.25m	125.76r	11.85d	10.50n	1165.63r	10759.82r
SEd	**0.54**	**0.30**	**0.16**	**0.58**	**0.16**	**0.78**	**0.48**	**0.22**	**0.58**	**1.79**	**225.36**
CD(0.01)	**1.59**	**0.87**	**0.46**	**1.68**	**0.47**	**1.66**	**1.41**	**0.66**	**1.68**	**5.19**	**653.20**
CV%	**1.51**	**0.68**	**2.74**	**6.05**	**1.07**	**1.41**	**0.97**	**1.59**	**6.05**	**0.36**	**5.35**

Table 3. Variability parameters, broad sense heritability and genetic advance as per cent of mean of the traits in snake gourd genotypes

Traits	GCV(%)	PCV(%)	h^2(heritability)	GA as % of mean
NMF	32.68	32.77	99.42	67.12
NFF	14.67	14.71	99.41	30.14
DMF	19.30	19.38	99.18	39.60
DFF	18.11	18.13	99.82	37.28
IL	14.50	14.53	99.57	29.81
DFH	13.74	13.79	98.94	28.20
FL	70.28	70.30	99.95	144.75
FG	19.44	19.49	99.45	39.93
SFW	48.77	48.77	99.99	100.46
NOF	42.07	42.51	97.91	85.75
FY/P	42.76	42.88	98.92	87.84

NMF-Node order of Male Flower
FL-Fruit length
DFF-Days to first female flowering
NOF-Number of fruits per plant
DFH-Days to first fruit harvest
DMF-Days to first male flowering
SFW-Single fruit weight
FY/P-Fruit yield per plant
NFF- Node order of Female Flower
FG-Fruit girth
IL-Internodal Length

coefficient of variation (PCV) for the traits under study was significantly higher than the genotypic coefficient of variation (GCV), suggesting that the expression of traits was influenced by genetic and environmental factors. This is concordant with the view that environment generally have an impact on quantitative traits. (Rana and Pandit, 2011, Shah *et al.,* 2018). In accordance with Deshmukh *et al*. (1986), the coefficient of variation at the phenotypic and genotypic level is categorized as high (more than 20%), medium (between 10% and 20%), and low (less than 10%). High GCV and PCV values were observed for node order of first male flower, fruit length, number of fruits per plant, single fruit weight and fruit yield per plant in the present study, whereas node order of first female flower, days to first male flowering, day to first female flowering, internodal length, days to first harvest and fruit girth exhibited medium GCV and PCV values. This is in accordance with the findings of Rajkumar (2011) in snake gourd. This suggests that variability was present for majority of the parameters, including yield characteristics in snake gourd germplasms. Previous studies on snake gourd by Devi and Mariappan, (2013), Ahsan *et al*., (2014), Khan *et al*., (2016) provided good support for genotypic and phenotypic coefficient of variation.

A higher proportion of the additive genetic variability results in high heritability and high genetic advance, which could result in large genetic gain. Heritability values are useful in determining the possible advancement that could be made by selection. In the current investigation, heritability varied from 97.91% to 99.99%, while GA as per cent of mean exhibited a larger gain between 28.20% and 144.75%. (**Table 3**). Singh (2000) categorized heritability values between 40 and 59% as medium, 60 and 80% as high, and less than 40% as low. The traits under study (**Table 3**) fell into the high heritability category because heritability ranged > 80%.Johnson *et al*. (1955) classified GAM into three groups *viz.,*low (0–10%), moderate (10–20%) and high (20% and above).This study showed high heritability with high GAM (ranged from 28.20% to 144.75%) (Johnson *et al*.,1955) and Panse , 1957).This is also similar with the findings of Kumar *et al*.(2013). The results of heritability and genetic advance as percentage of mean led to the conclusion that variation is primarily due to additive effect, enabling the selection to further enhance the traits. The current research findings on heritability and genetic advance as per cent of mean is in accordance with the findings of Devi and Mariappan, (2013), Ahsan *et al*.(2014) in snake gourd, Muttur *et al*. (2017) in pumpkin, Barataula *et al*.(2019) in cucumber.

Estimates of correlation coefficients on phenotypic and genotypic levels between yield and yield related traits in all possible combinations are represented in **Table 4** and **Fig.1**.The correlation chart depicts the distribution

Table 4. Genotypic and phenotypic correlation coefficient among important quantitative traits in snake gourd genotypes

		NMF	NFF	DMF	DFF	IL	DFH	FL	FG	SFW	NOF	FY/P
NMF	G	1 **	0.198	0.150	0.100	0.257	0.062	0.497*	-0.225	0.395	-0.279	0.383
	P		0.195	0.15	0.099	0.256	0.062	0.495**	-0.223	0.393*	-0.273	0.381*
NFF	G		1 **	0.45	0.448	-0.345^{NS}	0.544*	-0.015	-0.166	-0.191	0.056	-0.282
	P			0.452 **	0.446**	-0.345*	0.538**	-0.015	-0.165	-0.190	0.057	-0.278
DMF	G			1 **	0.91**	-0.213^{NS}	0.894**	0.133	-0.324	-0.271	0.150	-0.124
	P				0.916**	-0.212^{NS}	0.889**	0.132	-0.318	-0.271	0.149	-0.122
DFF	G				1 **	-0.347^{NS}	0.975**	0.183	-0.245^{NS}	-0.164	0.147	-0.010
	P					-0.345*	0.972**	0.183	-0.243^{NS}	-0.164	0.143	-0.011
IL	G					1 **	-0.424	0.214	0.030	0.366	-0.464	0.168
	P						-0.420*	0.214	0.031	0.366*	-0.456**	0.167
DFH	G						1 **	0.124	-0.161	-0.154	0.184	-0.007
	P							0.124	-0.160	-0.153	0.182	-0.007
FL	G							1 **	-0.434	0.466	-0.072	0.656**
	P								-0.432**	0.466**	-0.071	0.654**
FG	G								1 **	0.280^{NS}	-0.359	-0.028
	P									0.279^{NS}	-0.353*	-0.028
SFW	G									1 **	-0.5453*	0.737**
	P										-0.539**	0.735**
NOF	G										1 **	0.092
	P											0.100
FY/P												1 **

NMF	Node order of first male flower	DFF	Days to first female flowering	FL	Fruit Length
NFF	Node order of first female flower	IL	Internodal length	FG	Fruit girth
DMF	Days to first male flowering	DFH	Days to first harvest	SFW	Single fruit weight
NOF	Number of fruits per plant	FY/P	Fruit yield /plant		

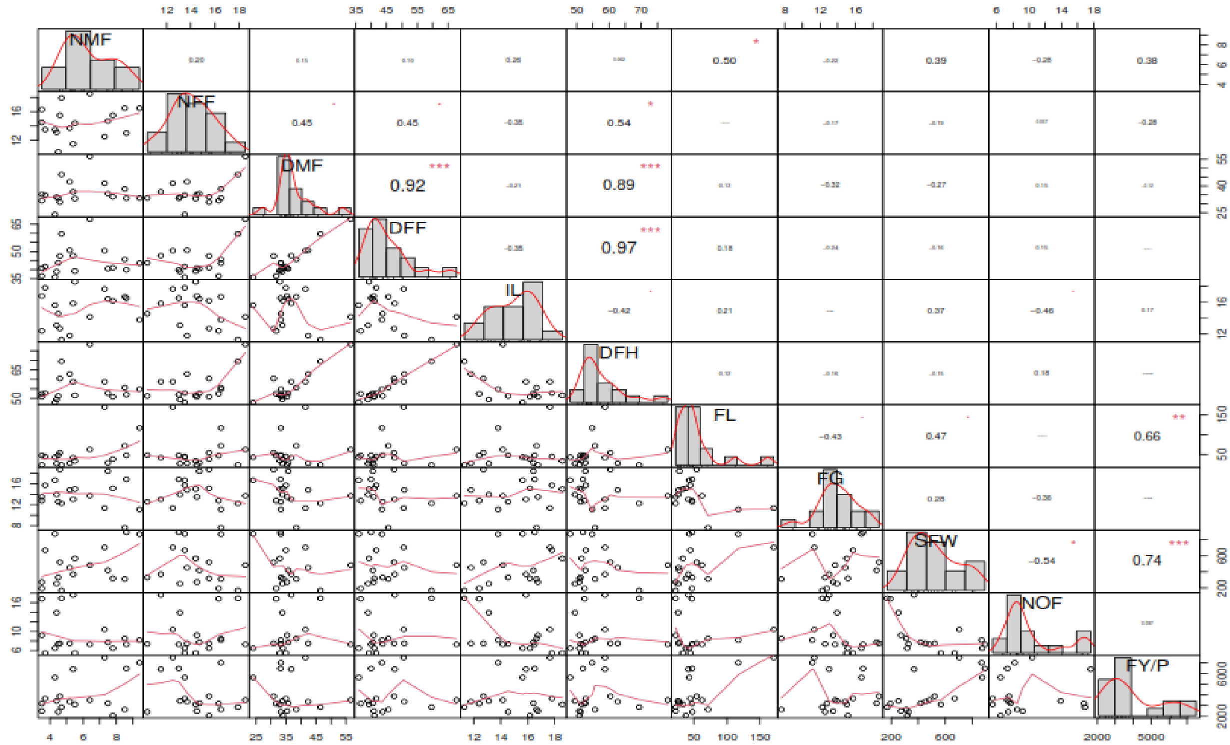

Fig. 1. Correlation Chart matrix between different traits in Snake gourd genotypes

of yield and yield-related features along the transverse matrix. The bottom of the transverse matrix exhibits bivariate scattergram of ten components with trend lines, while the top reveals correlation values and significant values. Arumugampillai *et al.,* (2019) showed a similar representation of a correlation chart matrix in F_2 derivatives of Rice. Many interdependent characteristics combine to produce yield. Since some of these characteristics are significantly connected with one another and with yield, breeders constantly seek for evolutionary divergence among the traits to select desired types. Analyzing the relationships between these traits and how they relate to yield is essential when determining genotype selection (Singh, 2000).The majority of correlation coefficients at genotypic level were considerably larger than their corresponding correlation coefficients at phenotypic level, revealing that the environment had a masking effect that altered character expression while repressing phenotypic expression (Haque *et al*., 2014; Gurve *et al*., 2021).

Fruit yield had significant positive genotypic (r_g=0.497) and phenotypic correlation with fruit length (r_p=0.4951) and significant positive phenotypic correlation with single fruit weight (r_p=0.3939). Similar results were reported by Narayanankutty *et al*. (2006), who found that total fruits yield by a plant was strongly correlated with fruit girth, fruit length, days to first fruit harvest, fruit weight, fruits/plant and days to first female flower opening. Rahman *et al.* (2002) discovered a strong positive phenotypic and genotypic association between fruit yield and the fruits/plant and fruit length. According to Manisha *et al*. (2021), there is a significant positive relationship between the number of fruits by an individual plant and fruit diameter in cucumber. The number of fruits produced per plant exhibited negative significant correlation with fruit girth (r_p=-0.539) and internodal length (r_p=-0.456) at the phenotypic level as well as with single fruit weight at the phenotypic and genotypic level (r_p=-0.539, r_g=-0.545,). At the phenotypic level, single fruit weight exhibited a positive significant association with node order of first male flower and internodal length, and a strong positive significant association with fruit length. Fruit weight exhibited significant positive correlation with fruit yield. This is in accordance to the results of Islam *et al*. (2016).

Fruit girth showed strong negative correlation with fruit length at phenotypic level and also reported by Anandakumar *et al.* (2017) in snake gourd. At both the phenotypic and genotypic levels, a substantial positive correlation between fruit length and node order of first male flower (r_g=0.497, r_p=0.495) was observed. Days to first harvest was discovered to have a significant positive genotypic and phenotypic correlation with days to first male flowering, node order of first female flower and days to first female flowering. Bhoomika *et al*. (2021) obtained similar results for cucumber flowering traits.

The relationship among traits is determined by path analysis (**Table 5, Fig 2**). A precise relationship between yield and yield related components may not always be provided by character associations as defined by the simple correlation coefficient, hence path coefficient analysis was performed.

Path coefficient analysis evaluates contribution of each trait to the yield and exposes component's direct and indirect effects. In the present study, path coefficient analysis was carried out for different traits (Table 5). Single fruit weight (0.834), number of fruits per plant (0.646) and days to first harvest (0.347) showed direct positive effect on fruit yield per plant. This is in concordance with the results of Haque *et al*. (2014) who found that fruit weight and number of fruits per plant had positive direct effect on fruit yield and Anandakumar *et al.*(2017) who found that fruit yield showed significant positive phenotypic and genotypic correlation with number of fruits per plant in snake gourd. Node order of first female flower (-0.241), days to first male flowering (-0.095), days to first female flowering (-0.013) showed negative direct effect on yield of fruit. The remaining characters had moderate direct effect on fruit yield per plant. Node order of first male flower had positive indirect effect on fruit yield per plant through internodal length (0.016),days to first fruit harvest (0.021), fruit length (0.115), single fruit weight (0.329) and it had negative indirect effect on yield through node order of first female flower (-0.048), days to first male flowering (-0.014), days to first female flowering (-0.013), fruit girth (-0.013) and number of fruits per plant (-0.180). Gupta *et al.*(2018*)* observed direct effect of fruit weight on fruit yield in F_2 generation of Pumpkin. (2018) . Node order of first female flower showed positive indirect effect through node order of male flower (0.033), days to first harvest (0.188) and number of fruits (0.036) on yield per plant. Days to first harvest has positive indirect effect on yield per plant through node order of first male flower (0.010), fruit length (0.028) and number of fruits per plant (0.119) and had negative indirect effect through node order of first female flower, day to first male flowering, days to first female flowering, internodal length, fruit girth and single fruit weight. Fruit length showed positive indirect effect on fruit yield per plant through node order of first male flower, node order of first female flower, internodal length, days to first harvest and single fruit weight. Similar results have been reported by Islam *et al*. (2016) in snake gourd

Single fruit weight was observed to have positive indirect effect through node order of first male and node order of first female flower (0.067, 0.046), days to first male flowering (0.026), days to first female flowering (0.021), internodal length (0.023), fruit girth (0.016), fruit length (0.107) and indirect negative effect on fruit yield through days to first harvest (-0.053) and number of fruits per plant (-0.352). Number of fruits per plant had positive indirect effect on fruit yield per plant through days to first harvest (0.063).Similar report on indirect effect of days to female flowering on days to first harvest have been reported by Rana and Pandit (2011). The size of the residual effect was small, which shows that the characteristics that has been taken up for study contributed the most to the total yield of the snake gourd, while other characteristics contributed the least.

The study of GCV and PCV in snake gourd germplasms exhibited variability for the traits *viz*., node order of first male flower, fruit length, number of fruits per plant, single fruit weight and fruit yield per plant including yield characteristics. Based on the results of this study, it can be said that the weight of a single fruit, days to first harvest and the number of fruits per plant can be

Table 5. Path analysis showing direct and indirect effect of yield component traits on yield in snake gourd genotypes

	NMF	NFF	DMF	DFF	IL	DFH	FL	FG	SFW	NOF	FY/P
NMF	**0.169**	-0.048	-0.014	-0.013	0.016	0.021	0.115	-0.013	0.329	-0.180	0.383
NFF	0.033	**-0.241**	-0.043	-0.060	-0.022	0.188	-0.003	-0.009	-0.159	0.0362	-0.282
DMF	0.025	-0.110	**-0.095**	-0.123	-0.013	0.310	0.030	-0.018	-0.226	0.097	-0.124
DFF	0.0171	-0.108	-0.088	**-0.133**	-0.022	0.338	0.042	-0.014	-0.136	0.095	-0.010
IL	0.043	0.083	0.020	0.046	**0.064**	-0.147	0.049	0.001	0.306	-0.300	0.168
DFH	0.010	-0.131	-0.085	-0.130	-0.027	**0.347**	0.028	-0.009	-0.128	0.119	-0.007
FL	0.084	0.003	-0.012	-0.024	0.013	0.043	**0.231**	-0.025	0.389	-0.046	0.656
FG	-0.038	0.040	0.031	0.032	0.001	-0.056	-0.100	**0.058**	0.233	-0.232	-0.028
SFW	0.067	0.046	0.026	0.021	0.023	-0.053	0.107	0.016	**0.834**	-0.352	0.737
NOF	-0.047	-0.013	-0.014	-0.019	-0.029	0.063	-0.016	-0.020	-0.455	**0.646**	0.092

Residual effect: 0.019

NMF	Node order of first male flower	DFF	Days to first female flowering	FL	Fruit length
NFF	Node order of first female flower	IL	Internodal length	SFW	Single fruit weight
DMF	Days to first male flowering	DFH	Days to first harvest	NOF	Number of fruits per plant
NOF	Number of fruits per plant	FY/P	Fruit yield/plant		

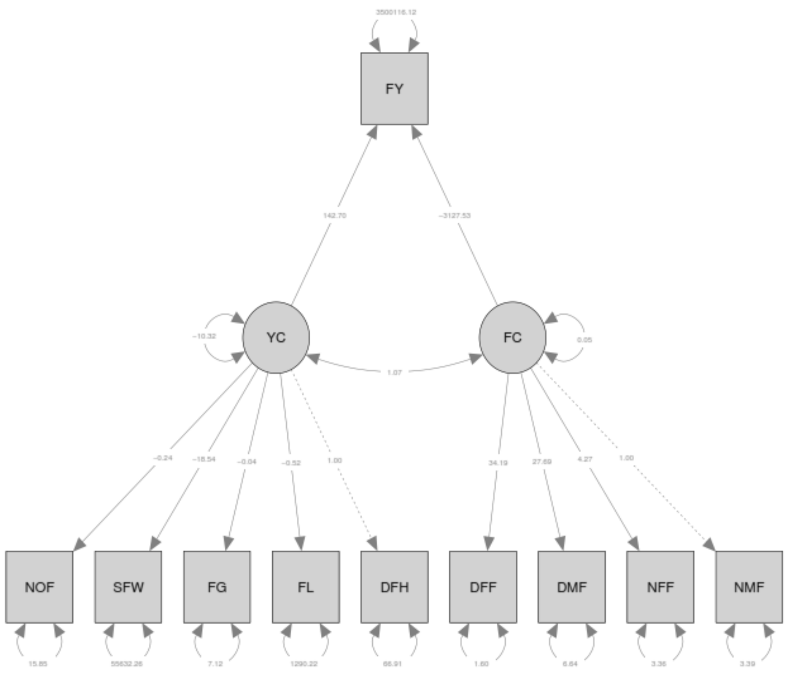

Fig. 2. Path coefficient analysis of snake gourd genotypes

chosen. Therefore these traits can be given importance for increasing yield potential of snake gourd in breeding program.

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