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Character Association Studies, Direct and Indirect Effects on Fruit Yield in Segregating Generation of Ridge gourd (*Luffa acutangula* (L.) Roxb.)

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ABSTRACT: The current exploration was carried out to determine the correlation among the yield and its attributing traits in ridge gourd and also the path analysis among four crosses of F_2 population. The traits *viz.*, number of fruits per vine, rind thickness, flesh thickness (cross 1, 2, 3 and 4), fruit set percentage, fruit length, fruit girth and fruit weight (cross 1, 2 and 3), number of male flowers per vine and number of seeds per fruit (cross 3 and 4) and days to male flowering, node of first male flower, node of first female flower and TSS (cross 4) had significant positive association with fruit yield per vine. A very high positive direct effect on fruit yield per vine was exerted by the traits *viz.*, rind thickness and flesh thickness (cross 1, 3 and 4) and fruit girth (cross 2); high positive direct effect showed by average fruit weight (cross 1, 2, 3 and 4), per cent fruit set (cross 1, 2 and 4), number of female flowers per vine (cross 2) and number of fruits per vine (cross 3) in F_2 generation of all the four crosses. Hence, direct selection of these traits would be rewarding.

Keywords: Ridge gourd, Correlation, Path analysis and Population.

INTRODUCTION

Ridge gourd (*Luffa acutangula* (L.) Roxb.) being a cucurbitaceous vegetable grown throughout India. It is originated in Tropical Africa and South-East Asian region including India. Ridge gourd has a diploid chromosome number of 26. The genus *luffa* derived from the word loofah. The fibre in the ridge gourd has been used commercially in making pillows, door mats, bathing sponges and brushes for cleaning utensils. Out of the seven species included in the genus luffa two are commonly cultivated vegetables *viz.*, ridge (*Luffa acutangula* (L.) Roxb.) and sponge gourd (*Luffa cylindrica* L.).

Nutritionally 100 g of edible quantity of ridge gourd consists fibre (0.5 g), protein (0.49 %), carbohydrates (0.36 %), carotene (39 mg), vitamin-C (52 mg), Ca (18 mg) and Fe (0.5 mg).

Cucurbitaceous vegetables has uniqueness among cross pollinated especially in crop improvement. Besides it has varied sex forms and sex expression which favours cross pollination they are also self pollinated upto some extent. This group also have distinct characteristic interms of inbreeding depression which is negligible unlike other out breeding crops (Seshadri and More 2004).

To increase the yield of the crop, it is primary to select the traits which are excel in their performance and contributing to enhanced yield. The fluctuation in one character brings a series of changes in the other characters, since they are interrelated. Therefore, the correlation studies has significance in any selection programme as they provide magnitude and direction of relationship between two or more component traits. The cause and effect relationship is well defined in path coefficient analysis. It is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects *i.e.* the direct and indirect contribution of various independent characters on a dependent character.

Vaidya *et al.* (2020) observed significant high positive correlation for yield per vine with sex ratio, node at which first female flower appeared, average length of fruit, fruit diameter at pedicel, fruit diameter at center, fruit diameter at stylar end and number of fruits per vine both at phenotypic and genotypic level in bottle gourd.

Vijayakumar *et al.* (2020) reported that fruit yield was significantly and positively correlated with fruit weight

and sex ratio. Path coefficient analysis indicated positive direct effect on vine length, days to first harvest, fruit weight, fruit length, rind thickness and number of fruits per plant. Of these traits, fruit weight exhibited the maximum positive direct effect on yield in F6 generation of ridge gourd.

Bhusnar (2019) observed significant positive correlation between fruit yield per vine and the yield contributing characters such as vine length, number of primary branches per vine, number of fruits per vine, average weight of fruit, average length of fruit and average diameter of fruit at both phenotypic and genotypic level in F3 and F4 generations of ridge gourd.

Kannan *et al*. (2019) investigated on genetic variability, correlation and path analysis in F4 generation of ridge gourd. The trait fruit yield was found to be significantly and positively correlated with node to first male flower, node to first female flower, fruit weight, fruit length, number of fruits per plant, fruit diameter and flesh thickness. Path coefficient analysis showed that fruit length and fruit diameter have contributed the maximum positive direct effect on yield per plant.

Kannan and Rajamanickam (2019) reported that fruit yield of cross L3 × T1 had significant positive correlation with node to first male flower, node to first female flower, days to first harvest, fruit weight, number of fruits per plant and flesh thickness whereas cross L3 × T2, fruit yield was found to be significantly and positively correlated with node to first male flower, node to first female flower, fruit weight, fruit length and fruit diameter. Path coefficient analysis showed that fruit weight in thecross L3 × T1 has contributed the maximum positive direct effect whereas in cross L3 × T2, fruit diameter has contributed the maximum positive direct effect in F5 generation of ridge gourd.

Hong and Thao (2019) studied the inheritance of some morphological traits and observed positive correlations between the fruit yield per plant, fruit weight, diameter and number of fruits per plant in F2 population of sponge gourd.

The studies of Alekar *et al.* (2019) in bitter gourd revealed that fruit yield per hectare had highly significant positive correlation with yield and yield contributing characters in F4 generation. It was suggested that the characters *viz*., number of female flower per vine, number of fruits per vine, average weight of fruit, crop duration, average length of fruit and average diameter of fruit should be given priority for selecting high yielding genotypes.

Gupta *et al.* (2018) carried out correlation studies in F2 generation of pumpkin, they observed that, number of fruits per vine, average fruit weight, fruit length, fruit diameter, flesh thickness, number of seeds per fruit and hundred seed weight exhibited strong significant and positive correlation with fruit yield per plant. Path analysis revealed that, the number of fruits per vine and average fruit weight showed positive direct effect with fruit yield per plant.

In bitter gourd, fruit yield per vine was positively and significantly correlated with days to last fruit harvest and fruits per vine at phenotypic level while positive significant correlation with sex ratio, fruit weight, number of node bearing first male flower, days to last fruit harvest, fruits per vine and primary branches per vine at genotypic level. Similarly, fruits per vine, number of node bearing first male flower, fruit weight, days to initiation of first female flower, days to last fruit harvest, primary branches per vine and fruit girth in order of merits imposed positive direct effect on fruit yield per vine in F3 population of bitter gourd (Pooja, 2018).

Kanimozhi *et al.* (2015) studied F2 population of ash gourd for correlation and path analysis and results revealed that earliness, sex ratio, number of fruits per vine, individual fruit weight, flesh thickness had significant positive correlation and high direct positive effect on yield. These characters were further improved through selection.

Rani *et al*. (2015) carried out studies to find out the nature and magnitude of genetic variability and character association in F2 segregating population of bitter gourd for yield and its attributing traits. A significant negative correlation of yield was observed with days to first male and female flowering, node of the first male or female flower and sex ratio. The path analysis study revealed that most of the characters indirectly influenced the yield through number of fruits/vine, average fruit weight and fruit length towards the favourable direction which had positive direct effect on yield per vine.

Arunkumar *et al.* (2010) observed significant positive correlation of fruit yield with total number of fruits per vine, average fruit weight, fruit length and fruit diameter in F2 population of cucumber. Path analysis revealed that total fruits per vine had positive and direct effect on total fruit yield followed by average fruit weight, days to first male flower and fruit length.

Rao *et al.* (2000) conducted correlation and path coefficient analysis in the segregating population of ridge gourd. The magnitude of genotypic correlation coefficient was higher than the phenotypic coefficients indicating strong inherent association among the various characters studied. Path analysis revealed that yield improvement could be achieved by direct selection for days to 50 % flowering.

MATERIAL AND METHODS

Four crosses (Swarna Manjari × VRG-16, Arka Prasan × VRG-16, VRG-24 × VRG-13 and Swarna Manjari × Arka Prasan) in F_2 generation are under study where each cross had hundred plants and planted with a spacing of 1m × 1m.

The observations on days to male flowering, days to female lowering, node to first male flower, node to first female flower, number of male flowers per vine, number of female flowers per vine, sex ratio, fruit set per cent, average fruit weight, fruit girth, number of fruits per vine, flesh thickness, rind thickness, fruit length, number of seeds per fruit, fibre content and

TSS. Correlation coefficients was calculated as reported by Al-Jibouri *et al.* (1958) and path analysis estimates were done as suggested by (Dewey and Lu 1959).

RESULTS AND DISCUSSION

A. Correlation Studies

The idea about the mutual relationship between various traits which helps in selection of those traits for genetic improvement of the crop yield. If the improvement in one character results in a decrease in other character, it also help the breeder in the selection of characters if necessary. Selection based on yield contributing character to be successful, knowledge of interrelationships among yield attributing characters is necessary as it gives more reliable information for effective selection.

Number of fruits per vine, rind thickness, flesh thickness (cross 1, 2, 3 and 4), fruit set percentage, fruit length, fruit girth and fruit weight (cross 1, 2 and 3), number of male flowers per vine and number of seeds per fruit (cross 3 and 4), days to male flowering, node of first male flower, node of first female flower and TSS (cross 4) had significant positive association with fruit yield per vine. Thus, the improvement of these traits may result in improvement of fruit yield per vine. Similar results were obtained by Arunkumar *et al*. (2010) in cucumber, Kanimozhi *et al.* (2015) in ash gourd, Gupta *et al.* (2018) in pumpkin, Pooja (2018) in bitter gourd, Bhusnar (2019); Vijayakumar *et al.* (2020) in ridge gourd.

The characters that showed significant negative association with fruit yield pervine were days to female flowering (cross 1, 2, 3 and 4), node of first female flower (cross 1 and 3), number of male flowers per vine (cross 2 and 4), sex ratio (cross 2), number of female flowers per vine, fruit set percentage, fruit length, fruit weight and number of seeds per fruit (cross 4) and TSS (cross 1). These findings are in agreement with the results reported by Rani *et al*. (2014) in bitter gourd and are contradictory with the findings of Vaidhya *et al.* (2020) in bottle gourd. This indicates that the improvement in these traits may result in decrease the fruit yield per vine.

Days to male flowering, node of first male flower and number of female flowers per vine (cross 1, 2 and 3), fibre content (cross 1, 3 and 4), number of seeds per fruit (cross 1 and 2), number of male flowers per vine and sex ratio (cross 1), fruit girth (cross 4), node of first female flower and fruit length (cross 2) and TSS (cross 3) did not record significant association with fruit yield per vine indicating that improvement of these characters might have not affected the fruit yield per vine of ridge gourd in the present study.

Thus, improvement of these traits may not result in improvement of yield. These results are similar to the findings of Rani *et al*. (2014) in bitter gourd and Vaidhya *et al.* (2020) in bottle gourd.

B. Path coefficient analysis

From observations recorded in F_2 generation of all the four crosses *viz.*, cross 1 (Swarna Manjari × VRG-16), cross 2 (Arka Prasan × VRG-16), cross 3 (VRG-24 × VRG-13) and cross 4 (Swarna Manjari × Arka Prasan), very high positive direct effects on fruit yield per vine were recorded by the traits *viz.*, rind thickness and flesh thickness (cross 1, 3 and 4) and fruit girth (cross 2); high positive direct effects showed by average fruit weight (cross 1, 2, 3 and 4), per cent fruit set (cross 1, 2 and 4), number of female flowers per vine (cross 2) and number of fruits per vine (cross 3). Hence, direct selection of these traits would be rewarding. Similar results were reported by Kannan and Rajamanickam (2019) in ridge gourd and contradictory to these results, by Rani *et al*. (2014) in bitter gourd, Gupta *et al.* (2018) in pumpkin and Vijayakumar *et al.* (2020) in ridge gourd reported fruit girth exhibited very high negative direct effect on the fruit yield per vine.

The residual effect permits precise explanation about the pattern of interaction of other possible components of yield. In other words, residual effect measures the role of the possible independent variables which were not included in the study on the dependent variable. In the present study, the low residual effects (0.192 and 0.123) in cross 1 and 4 respectively and negligible residual effects (0.084) in cross 3 indicate that the characters included in present investigation are the major contributors towards the variability pertaining to the dependent variable *i.e.*, fruit yield per vine.

Moderate residual effects (0.207) indicated that the characters included in present investigation are not only the major contributors towards the variability pertaining to the dependent variable *i.e.*, fruit yield per vine and other characters which were not in the present study should be included in F_2 generation of the cross Arka Prasan × VRG-16.

Table 1: Correlation among yield and yield contributing characters in F_2 population of cross 1 Swarna Manjari × VRG -16.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	N.F.V	F.W.	R.T.	F.T.	N.S.F	F.C.	T.S.S.	F.Y.
DMF	1	0.242	0.076	0.267*	0.062	-0.028	0.107	-0.126	-0.071	-0.198	-0.184	-0.15	-0.041	-0.214	-0.073	0.081	0.061	-0.236
DFF		1	-0.021	0.894**	0.257*	-0.045	0.254*	-0.208	-0.565**	-0.466**	-0.267*	-0.835**	-0.529**	-0.413**	-0.154	-0.217	0.301*	-0.925**
NMF			1	-0.116	0.066	-0.153	0.17	-0.025	0.104	0.072	-0.097	0.172	0.031	0.075	-0.199	-0.093	-0.09	0.144
NFF				1	0.187	-0.032	0.182	-0.184	-0.430**	-0.383**	-0.24	-0.747**	-0.441**	-0.338**	-0.097	-0.204	0.357**	-0.845**
MFV					1	0.2	0.806**	-0.225	-0.127	-0.047	-0.19	-0.178	-0.109	-0.03	-0.05	-0.247*	0.315*	-0.24
FFV						1	-0.386**	-0.655**	0.093	0.079	-0.193	0.036	0.003	0.088	0.192	-0.219	0.059	-0.067
S.R							1	0.206	-0.19	-0.068	-0.018	-0.197	-0.118	-0.051	-0.159	-0.106	0.233	-0.173
F.S.								1	-0.081	-0.177	0.854**	-0.125	-0.136	-0.17	-0.288*	0.343**	-0.209	0.301*
F.L.									1	0.099	-0.073	0.613**	0.260*	0.057	0.242	0.051	-0.114	0.541**
F.G.										1	-0.177	0.581**	0.654**	0.987**	0.027	-0.113	-0.053	0.435**
N.F.V.											1	-0.172	-0.192	-0.158	-0.238	0.327**	-0.241	0.320**
F.W.												1	0.600**	0.528**	0.241	0.015	-0.330**	0.854**
R.T.													1	0.525**	-0.008	0.005	-0.318*	0.452**
F.T.														1	0.032	-0.129	0.008	0.395**
N.S.F															1	-0.03	0.066	0.112
F.C.																1	-0.129	0.211
T.S.S.																	1	-0.416**
F.Y.																		1

DMF - Days to male flowering; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine ; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG- Fruit girth (cm); NFV - Number of fruits per vine; FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm); NSF - Number of seeds per fruit; FC - Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY- Fruit yield per vine (kg)

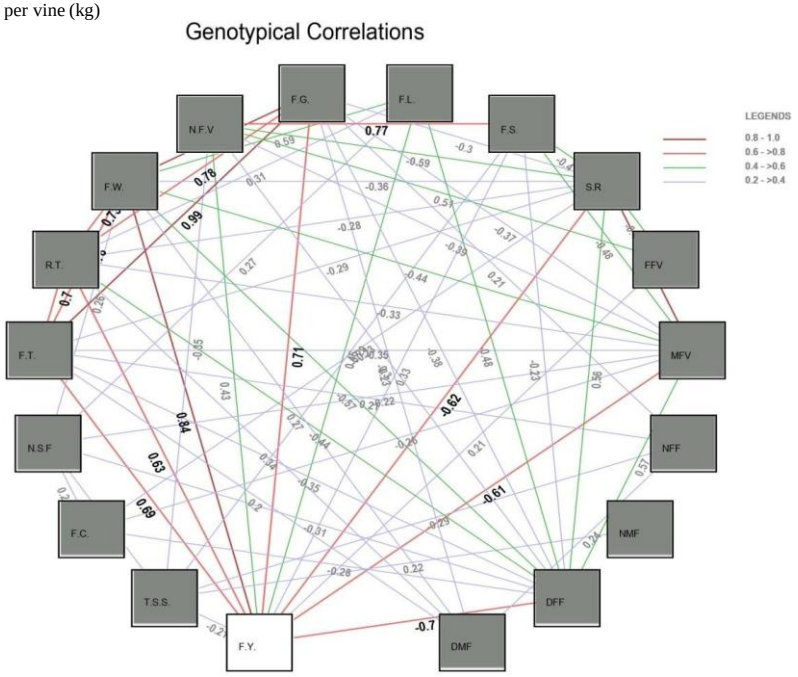

Fig. 1. Genotypic correlation diagram among yield and its component traits in F_2 population of cross 1 Swarna Manjari × VRG -16.

Table 2: Correlation among yield and yield contributing characters in F_2 population of cross 2 Arka Prasan × VRG – 16.

	DMF	DFF	Able 2 :	NFF	MFV	FFV	S.R.	F.S.	F.L.	F.G.	N.F.V	F.W.	R.T.	F.T.	N.S.F	F.C.	T.S.S.	F.Y.
DMF	1	0.107	0.124	0.237	-0.066	0.023	-0.055	-0.216	0.113	0.231	-0.186	0.264*	0.340**	0.2	0.015	-0.054	-0.08	0.126
DFF		1	-0.091	0.06	0.568**	-0.11	0.562**	-0.179	-0.479**	-0.377**	-0.228	-0.571**	-0.444**	-0.348**	-0.306*	-0.275*	0	-0.695**
NMF			1	-0.145	-0.02	-0.013	0.015	-0.126	0.082	-0.029	-0.128	0.051	-0.002	-0.032	-0.076	-0.025	0.224	0.029
NFF				1	-0.076	0.127	-0.1	-0.052	0.027	0.213	0.035	0.123	0.171	0.211	0.112	-0.143	-0.292*	0.142
MFV					1	0.039	0.897**	-0.432**	-0.185	-0.365**	-0.343**	-0.434**	-0.332**	-0.355**	-0.215	-0.256*	-0.003	-0.615**
FFV						1	-0.381**	-0.185	0.018	-0.08	0.458**	-0.095	-0.046	-0.082	-0.055	-0.036	-0.129	0.142
S.R							1	-0.349**	-0.154	-0.296*	-0.529**	-0.346**	-0.276*	-0.286*	-0.176	-0.233	0.05	-0.618**
F.S.								1	-0.151	-0.06	0.780**	-0.152	-0.101	-0.05	-0.094	0.099	-0.264*	0.270*
F.L.									1	0.166	-0.112	0.586**	0.315*	0.132	0.269*	-0.11	-0.021	0.491**
F.G.										1	-0.111	0.813**	0.777**	0.993**	0.109	0.056	-0.136	0.716**
N.F.V											1	-0.201	-0.12	-0.105	-0.135	0.023	-0.353**	0.328**
F.W.												1	0.742**	0.788**	0.267*	0.071	-0.037	0.831**
R.T.													1	0.701**	0.152	0.085	-0.01	0.634**
F.T.														1	0.096	0.048	-0.152	0.697**
N.S.F															1	0.236	0.24	0.196
F.C.																1	0.05	0.108
T.S.S.																	1	-0.218
F.Y.																		1

DMF - Days to male flowering; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); NFV - Number of fruits per vine; FW - Average fruit weight (g); RT - Rind thickness (mm)' FT - Flesh thickness (mm); NSF - Number of seeds per fruit; FC - Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY- Fruit yield per vine (kg)

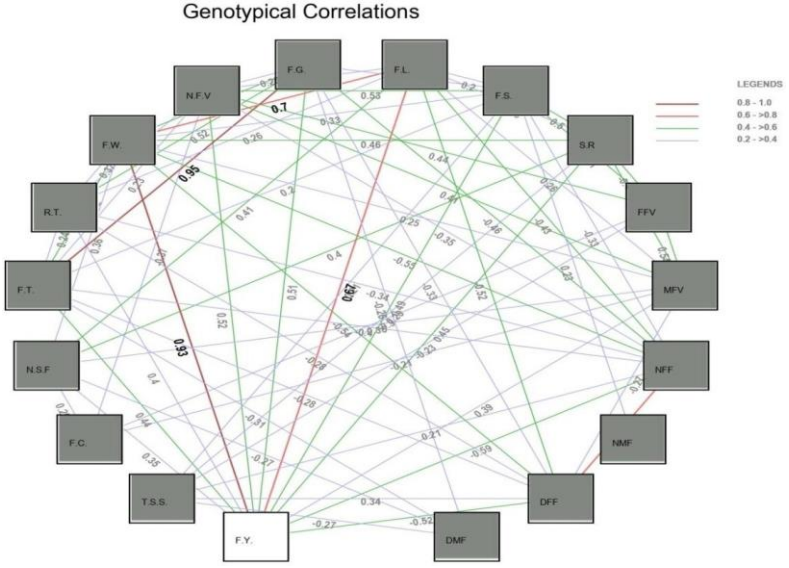

Fig. 2. Genotypic correlation diagram among yield and its component traits in F_2 population of cross 2 Arka Prasan × VRG -16.

Table 3: Correlation among yield and yield contributing characters in F_2 population of cross 3 VRG - 24 × VRG – 13.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	N.F.V	F.W.	R.T.	F.T.	N.S.F	F.C.	T.S.S.	F.Y.
DMF	1	0.181	0.04	0.13	-0.122	-0.186	0.028	0.001	-0.147	-0.256	-0.158	0	0.045	-0.306*	-0.269	0.162	-0.266	-0.044
DFF		1	0.135	0.650**	-0.272	-0.138	-0.167	-0.063	-0.515**	-0.333*	-0.186	-0.542**	-0.278	-0.281	-0.174	0.112	0.343*	-0.521**
NMF			1	0.062	0.046	-0.132	0.194	0.233	0.158	-0.166	0.097	-0.156	-0.068	-0.164	0.196	-0.161	0.013	-0.098
NFF				1	0.005	-0.046	-0.013	-0.326*	-0.427**	-0.455**	-0.348*	-0.545**	-0.341*	-0.398**	-0.122	0.098	0.207	-0.589**
MFV					1	0.544**	0.458**	-0.102	0.259	0.04	0.411**	0.255	0.044	0.031	0.359*	-0.206	-0.058	0.394**
FFV						1	-0.481**	-0.515**	0.026	0.016	0.439**	-0.163	0.029	0.008	0.012	-0.298*	-0.235	0.007
S.R							1	0.504**	0.264	0.045	0.032	0.461**	0.031	0.04	0.400**	0.11	0.226	0.451**
F.S.								1	0.203	0.223	0.535**	0.328*	0.151	0.2	0.05	-0.082	0.207	0.486**
F.L.									1	0.194	0.259	0.704**	0.255	0.131	0.408**	-0.153	-0.079	0.674**
F.G.										1	0.264	0.482**	0.516**	0.955**	0.002	-0.028	-0.066	0.510**
N.F.V											1	0.19	0.207	0.228	0.039	-0.373*	-0.043	0.519**
F.W.												1	0.370*	0.419**	0.361*	0.054	0.028	0.930**
R.T.													1	0.238	-0.046	0.046	-0.079	0.396**
F.T.														1	0.019	-0.048	-0.047	0.441**
N.S.F															1	0.288	0.168	0.349*
F.C.																1	0.174	-0.054
T.S.S.																	1	0.025
F.Y.																		1

DMF - Days to male flowering; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); NFV - Number of fruits per vine; FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm); NSF - Number of seeds per fruit; FC - Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY - Fruit yield per vine (kg)

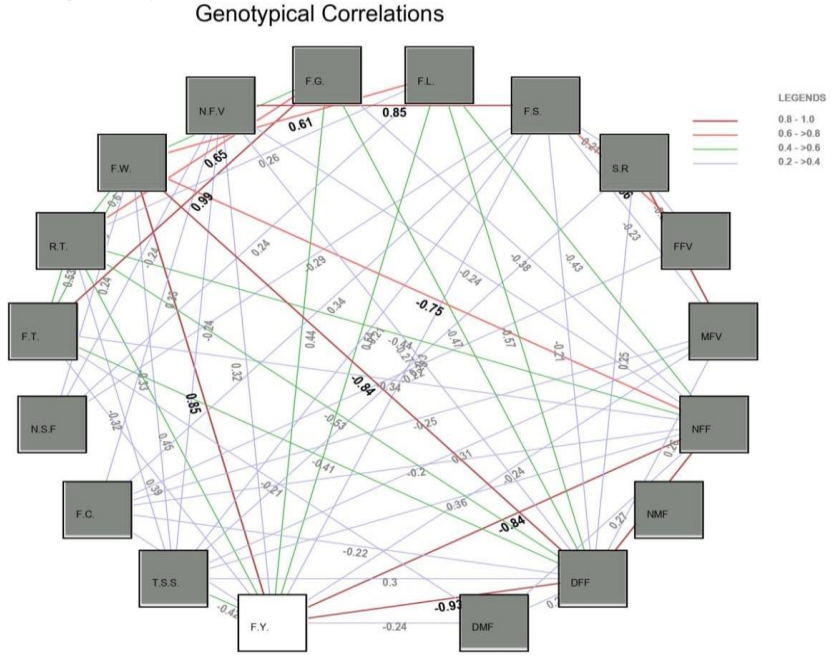

Fig. 3. Genotypic correlation diagram among yield and its component traits in F_2 population of cross 3 VRG-24 × VRG -13.

Table 4: Correlation among fruit yield and yield contributing characters in F_2 population of cross 4 Swarna Manjari ×Arka Prasan.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	N.F.V	F.W.	R.T.	F.T.	N.S.F	F.C.	T.S.S.	F.Y.
DMF	1	-0.260*	0.264*	0.474**	-0.380**	-0.382**	0.497**	-0.269*	-0.206	0.045	0.481**	-0.219	0.484**	0.466**	-0.185	0.122	0.339**	0.430**
DFF		1	-0.612**	-0.888**	0.768**	0.690**	-0.886**	0.494**	0.313**	-0.015	-0.777**	0.484**	-0.694**	-0.684**	0.452**	-0.156	-0.450**	-0.547**
NMF			1	0.702**	-0.666**	-0.578**	0.671**	-0.413**	-0.177	0.198	0.580**	-0.292*	0.615**	0.478**	-0.256*	0.045	0.263*	0.393**
NFF				1	-0.820**	-0.722**	0.974**	-0.636**	-0.400**	0.015	0.882**	-0.573**	0.802**	0.755**	-0.481**	0.172	0.536**	0.566**
MFV					1	0.848**	-0.786**	0.355**	0.208	-0.063	-0.690**	0.313**	-0.735**	-0.594**	0.406**	-0.073	-0.442**	-0.487**
FFV						1	-0.773**	0.164	0.115	0.027	-0.595**	0.199	-0.626**	-0.494**	0.305*	-0.041	-0.461**	-0.422**
S.R							1	-0.623**	-0.385**	-0.021	0.869**	-0.573**	0.808**	0.763**	-0.459**	0.153	0.544**	0.627**
F.S.								1	0.465**	0.017	-0.597**	0.543**	-0.517**	-0.569**	0.364**	-0.074	-0.262*	-0.439**
F.L.									1	0.121	-0.473**	0.589**	-0.260*	-0.421**	0.323**	0.019	-0.326**	-0.331**
F.G.										1	0.022	0.208	0.189	0.223	0.099	-0.154	-0.069	0.071
N.F.V											1	-0.651**	0.851**	0.942**	-0.537**	0.062	0.616**	0.818**
F.W.												1	-0.452**	-0.570**	0.480**	-0.102	-0.450**	-0.417**
R.T.													1	0.834**	-0.432**	0.006	0.504**	0.743**
F.T.														1	-0.478**	-0.023	0.562**	0.873**
N.S.F															1	0.101	-0.328**	-0.418**
F.C.																1	-0.08	-0.041
T.S.S.																	1	0.482**
F.Y.																		1

DMF - Days to male flowering; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS- Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); NFV - Number of fruits per vine; FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm); NSF - Number of seeds per fruit; FC - Fibre content (g/100g); TSS - Total soluble solids (^{0}Brix); FY - Fruit yield per vine (kg)

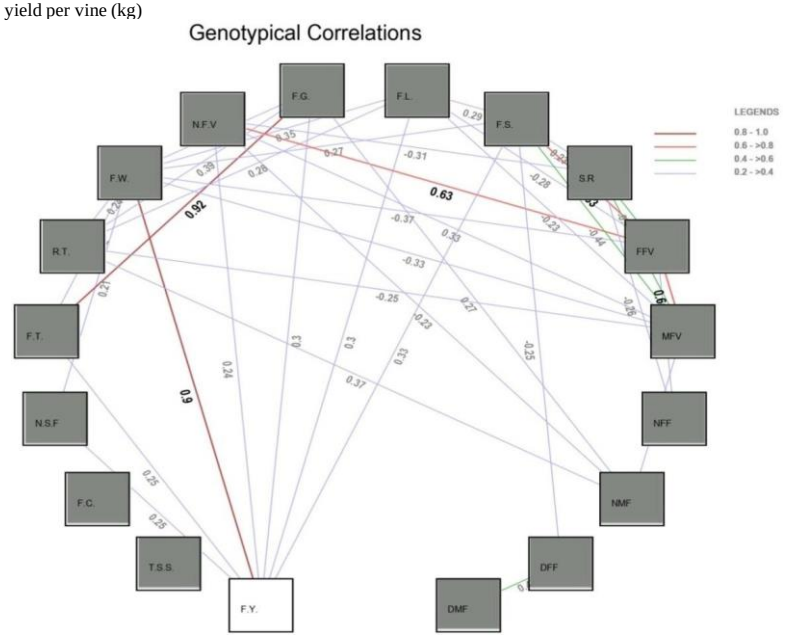

Fig. 4. Genotypic correlation diagram among yield and its component traits in F_2 population of cross 4 Swarna Manjari × Arka Prasan.

Table 5: Path coefficients among yield and yield contributing characters in F_2 population of cross 1 Swarna Manjari × VRG-16.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	F.W.	R.T	F.T	N.S.F	N.F.V	F.C	T.S.S.
DMF	**-0.002**	-0.0005	-0.0002	-0.0005	-0.0001	0.0001	-0.0002	0.0002	0.0001	0.0004	0.0003	0.0001	0.0004	0.0001	0.0004	-0.0002	-0.0001
DFF	-0.0287	**-0.1188**	0.0025	-0.1062	-0.0305	0.0053	-0.0302	0.0248	0.0671	0.0554	0.0992	0.0628	0.0491	0.0183	0.0317	0.0258	-0.0358
NMF	0.0044	-0.0012	**0.0577**	-0.0067	0.0038	-0.0088	0.0098	-0.0014	0.006	0.0042	0.0099	0.0018	0.0043	-0.0115	-0.0056	-0.0053	-0.0052
NFF	-0.0115	-0.0386	0.005	**-0.0432**	-0.0081	0.0014	-0.0079	0.0079	0.0186	0.0165	0.0323	0.0191	0.0146	0.0042	0.0103	0.0088	-0.0154
MFV	0.012	0.0502	0.0129	0.0366	**0.1953**	0.039	0.1573	-0.044	-0.0248	-0.0092	-0.0349	-0.0212	-0.0059	-0.0098	-0.0371	-0.0482	0.0615
FFV	-0.0016	-0.0025	-0.0086	-0.0018	0.0112	**0.0563**	-0.0217	-0.0369	0.0052	0.0044	0.002	0.0001	0.005	0.0108	-0.0109	-0.0123	0.0033
S.R	-0.0204	-0.0484	-0.0324	-0.0346	-0.1534	0.0735	**-0.1905**	-0.0393	0.0361	0.0129	0.0376	0.0225	0.0097	0.0303	0.0034	0.0202	-0.0444
F.S.	-0.0421	-0.0693	-0.0083	-0.0611	-0.075	-0.2179	0.0686	**0.3327**	-0.0269	-0.0589	-0.0416	-0.0452	-0.0567	-0.0957	0.2841	0.114	-0.0695
F.L	0.0018	0.0147	-0.0027	0.0112	0.0033	-0.0024	0.0049	0.0021	**-0.026**	-0.0026	-0.0159	-0.0068	-0.0015	-0.0063	0.0019	-0.0013	0.003
F.G.	12.5841	29.6125	-4.5767	24.3162	2.9868	-5.0047	4.2968	11.2352	-6.2993	**-63.499**	-36.9127	-41.5147	-62.6909	-1.7013	11.208	7.2054	3.3475
F.W.	-0.1216	-0.6747	0.1387	-0.6037	-0.1442	0.0288	-0.1594	-0.101	0.4953	0.4697	**0.8079**	0.4844	0.4264	0.1949	-0.1387	0.012	-0.267
R.T.	-0.4888	-6.2523	0.3633	-5.2186	-1.2846	0.0297	-1.3993	-1.6056	3.0793	7.7286	7.0875	**11.8213**	6.2078	-0.0958	-2.275	0.0571	-3.7613
F.T.	-12.0946	-23.3362	4.213	-19.0764	-1.6962	4.9699	-2.8857	-9.6193	3.2127	55.7434	29.7961	29.6501	**56.4619**	1.7951	-8.9234	-7.2626	0.4316
N.S.F	-0.0013	-0.0028	-0.0036	-0.0017	-0.0009	0.0034	-0.0029	-0.0052	0.0043	0.0005	0.0043	-0.0001	0.0006	**0.0179**	-0.0043	-0.0005	0.0012
N.F.V	-0.0281	-0.0408	-0.0149	-0.0367	-0.0291	-0.0295	-0.0027	0.1307	-0.0112	-0.027	-0.0263	-0.0294	-0.0242	-0.0364	**0.153**	0.0501	-0.0368
F.C.	0.0036	-0.0098	-0.0042	-0.0092	-0.0111	-0.0098	-0.0048	0.0154	0.0023	-0.0051	0.0007	0.0002	-0.0058	-0.0014	0.0147	**0.045**	-0.0058
T.S.S.	-0.0014	-0.0068	0.002	-0.008	-0.0071	-0.0013	-0.0052	0.0047	0.0026	0.0012	0.0074	0.0072	-0.0002	-0.0015	0.0054	0.0029	**-0.0225**
F.Y.	-0.2361	-0.9253	0.1439	-0.8447	-0.2398	-0.0672	-0.173	0.3011	0.5414	0.4354	0.8539	0.4522	0.3946	0.112	0.3204	0.2106	-0.4158

RESIDUAL EFFECT : 0.192

DMF - Days to male flowering DFF - Days to female flowering NMF - Node of first male flower NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm); NSF - Number of seeds per fruit; NFV - Number of fruits per vine; FC- Fibre content (g/100g) ; TSS - Total soluble solids (°Brix); FY - Fruit yield per vine (kg)

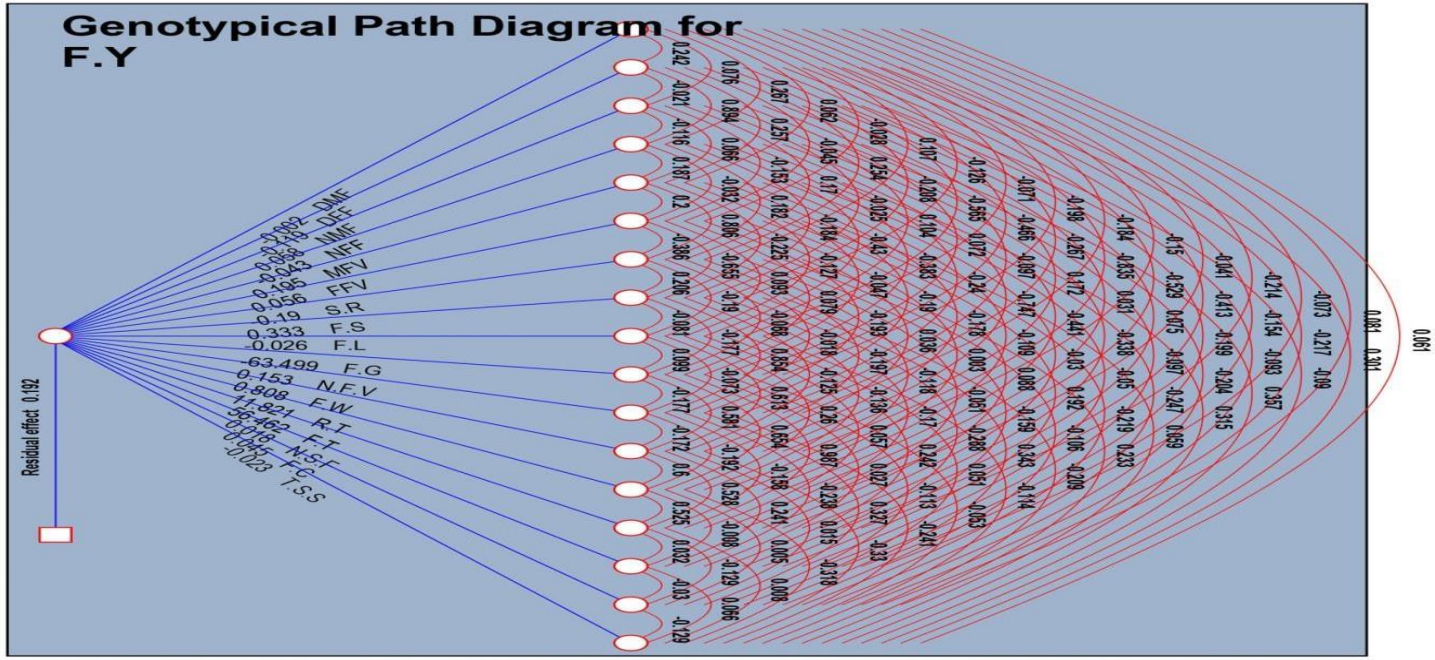

Fig. 5. Genotypical path diagram representing direct and indirect effects for fruit yield per vine (kg) in F_2 population of cross 1 Swarna Manjari × VRG-16.

Table 6: Path coefficients among yield and yield contributing characters in F_2 population of cross 2 Arka Prasan × VRG- 16.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	F.W.	R.T.	F.T.	N.S.F	N.F.V	F.C	T.S.S.
DMF	**-0.0358**	-0.0038	-0.0044	-0.0085	0.0024	-0.0002	0.002	0.0067	-0.004	-0.0083	-0.0095	-0.0121	-0.0072	-0.0005	0.0058	0.0019	0.0029
DFF	-0.0077	**-0.0726**	0.0066	-0.0043	-0.0413	0.0106	-0.0408	0.017	0.0348	0.0274	0.0417	0.0323	0.0252	0.0222	0.0217	0.02	0.0000
NMF	0.0081	-0.006	**0.0653**	-0.0094	-0.0013	-0.001	0.001	-0.0062	0.0054	-0.0019	0.003	-0.0001	-0.0021	-0.0049	-0.0063	-0.0016	0.0146
NFF	0.0068	0.0017	-0.0041	**0.0287**	-0.0022	0.003	-0.0029	-0.0006	0.0008	0.0061	0.0034	0.0049	0.006	0.0032	0.0014	-0.0041	-0.0084
MFV	0.0161	-0.1378	0.0048	0.0184	**-0.2425**	-0.0028	-0.2176	0.1156	0.045	0.0886	0.1064	0.0804	0.086	0.0522	0.0945	0.0622	0.0008
FFV	0.002	-0.051	-0.0052	0.037	0.0041	**0.3491**	-0.1424	-0.0519	0.0037	-0.0141	-0.0122	-0.0004	-0.016	-0.0101	0.1763	-0.0089	-0.0367
S.R	-0.0134	0.1366	0.0037	-0.0243	0.2179	-0.0991	**0.2429**	-0.0973	-0.0375	-0.0719	-0.0865	-0.0669	-0.0694	-0.0428	-0.1425	-0.0567	0.012
F.S.	-0.0649	-0.0806	-0.0328	-0.0075	-0.1639	-0.0511	-0.1379	**0.3439**	-0.0397	-0.0023	-0.021	-0.0175	0.0006	-0.035	0.2648	0.0266	-0.0986
F.L	0.0004	-0.0016	0.0003	0.0001	-0.0006	0.0000	-0.0005	-0.0004	**0.0033**	0.0006	0.002	0.001	0.0004	0.0009	-0.0002	-0.0004	-0.0001
F.G.	1.6614	-2.7151	-0.2065	1.5348	-2.6301	-0.2913	-2.1293	-0.0485	1.1981	**7.1965**	5.7802	5.5947	7.1496	0.7828	-0.2299	0.4003	-0.9777
F.W.	0.1924	-0.4168	0.0328	0.0859	-0.3185	-0.0253	-0.2585	-0.0442	0.4301	0.583	**0.7258**	0.5314	0.5649	0.1879	-0.0489	0.0412	-0.034
R.T.	-0.3844	0.5028	0.0018	-0.193	0.375	0.0013	0.3118	0.0575	-0.356	-0.8794	-0.8282	**-1.1312**	-0.7927	-0.1718	0.0435	-0.0961	0.011
F.T.	1.2535	2.1741	0.2005	-1.3199	2.2185	0.2859	1.7881	-0.01	-0.8239	-6.2152	-4.8691	-4.3838	**-6.2559**	-0.6001	0.1829	-0.2998	0.9532
N.S.F	0.0002	-0.005	-0.0012	0.0018	-0.0035	-0.0005	-0.0029	-0.0017	0.0044	0.0018	0.0042	0.0025	0.0016	**0.0164**	-0.002	0.0039	0.0039
N.F.V	-0.0094	-0.0173	-0.0056	0.0029	-0.0225	0.0292	-0.0339	0.0445	-0.0043	-0.0018	-0.0039	-0.0022	-0.0017	-0.007	**0.0578**	0.0004	-0.0202
F.C.	-0.0005	-0.0028	-0.0002	-0.0015	-0.0026	-0.0003	-0.0024	0.0008	-0.0011	0.0006	0.0006	0.0009	0.0005	0.0024	0.0001	**0.0102**	0.0005
T.S.S.	0.0025	0.0000	-0.0069	0.009	0.0001	0.0032	-0.0015	0.0088	0.0006	0.0042	0.0014	0.0003	0.0047	-0.0074	0.0107	-0.0015	**-0.0308**
F.Y.	0.1204	-0.6952	0.0488	0.1501	-0.611	0.2108	-0.6248	0.334	0.4597	0.7137	0.8383	0.6341	0.6947	0.1885	0.4297	0.0976	-0.2073

RESIDUAL EFFECT : 0.207

DMF - Days to male flowering ; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); FW - Average fruit weight (g); RT -Rind thickness (mm); FT - Flesh thickness (mm) ; NSF - Number of seeds per fruit; NFV - Number of fruits per vine; FC - Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY - Fruit yield per vine (kg)

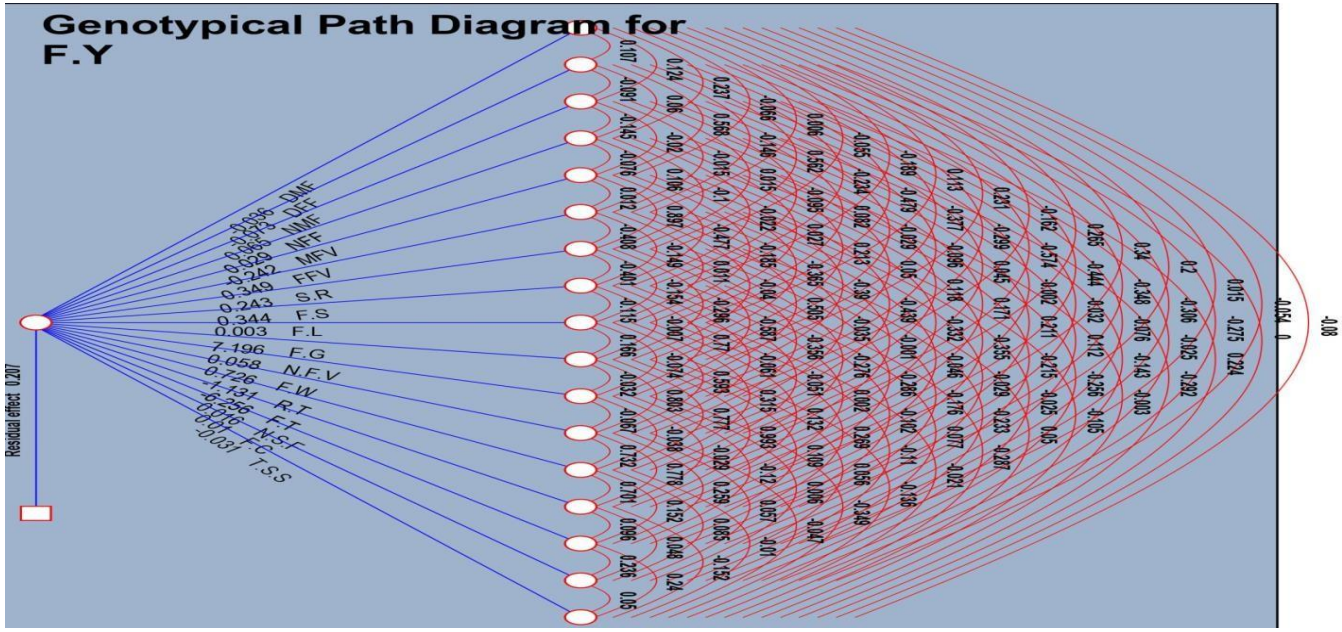

Fig. 6. Genotypical path diagram representing direct and indirect effects for fruit yield per vine (kg) in F_2 population of cross 2 Arka Prasan × VRG-16.

Table 7: **Path coefficients among yield and yield contributing characters in F_2 population of cross 3 VRG - 24 × VRG -13.**

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	F.W.	R.T	F.T	N.S.F	N.F.V	F.C	T.S.S.
DMF	**0.0123**	0.0022	0.0005	0.0016	-0.0015	-0.0023	0.0003	0.0000	-0.0018	-0.0032	0.0000	0.0006	-0.0038	-0.0033	-0.0019	0.002	-0.0033
DFF	0.0024	**0.013**	0.0017	0.0084	-0.0035	-0.0018	-0.0022	-0.0008	-0.0067	-0.0043	-0.007	-0.0036	-0.0036	-0.0023	-0.0024	0.0015	0.0045
NMF	-0.0003	-0.001	**-0.0076**	-0.0005	-0.0003	0.001	-0.0015	-0.0018	-0.0012	0.0013	0.0012	0.0005	0.0012	-0.0015	-0.0007	0.0012	-0.0001
NFF	-0.003	-0.0152	-0.0014	**-0.0234**	-0.0001	0.0011	0.0003	0.0076	0.01	0.0107	0.0128	0.008	0.0093	0.0029	0.0082	-0.0023	-0.0048
MFV	0.0113	0.0252	-0.0042	-0.0004	**-0.0928**	-0.0505	-0.0425	0.0095	-0.0241	-0.0038	-0.0236	-0.0041	-0.0028	-0.0333	-0.0381	0.0191	0.0054
FFV	-0.0098	-0.0073	-0.007	-0.0024	0.0287	**0.0528**	-0.0254	-0.0272	0.0014	0.0008	-0.0086	0.0016	0.0004	0.0006	0.0232	-0.0157	-0.0124
S.R	0.0041	-0.0246	0.0286	-0.002	0.0675	-0.0709	**0.1474**	0.0744	0.0389	0.0066	0.0679	0.0046	0.0059	0.059	0.0047	0.0163	0.0333
F.S.	-0.0001	0.0052	-0.0194	0.0271	0.0085	0.0429	-0.042	**-0.0833**	-0.017	-0.0186	-0.0274	-0.0126	-0.0167	-0.0041	-0.0446	0.0068	-0.0172
F.L	0.0047	0.0165	-0.005	0.0136	-0.0083	-0.0008	-0.0084	-0.0065	**-0.0319**	-0.0062	-0.0225	-0.0082	-0.0042	-0.013	-0.0083	0.0049	0.0025
F.G.	13.9352	18.1324	9.0297	24.7914	-2.2013	-0.8596	-2.435	-12.1389	-10.5614	**-54.4603**	-26.2695	-28.0905	-52.0071	-0.1302	-14.3848	1.5197	3.5737
F.W.	0.0000	-0.4554	-0.1311	-0.4584	0.2141	-0.1369	0.3873	0.2759	0.5914	0.4055	**0.8407**	0.3109	0.352	0.3039	0.1596	0.0458	0.0237
R.T.	0.748	-4.63	-1.1343	-5.6822	0.7371	0.4906	0.5158	2.5152	4.251	8.5871	6.1569	**16.6481**	3.9678	-0.7703	3.4453	0.7723	-1.3127
F.T.	-14.6792	-13.5039	-7.8899	-19.1139	1.4683	0.3622	1.9306	9.631	6.3103	45.8816	20.1179	11.451	**48.0458**	0.894	10.939	-2.303	-2.2635
N.S.F	-0.0054	-0.0035	0.0039	-0.0024	0.0072	0.0002	0.008	0.001	0.0081	0.0000	0.0072	-0.0009	0.0004	**0.02**	0.0008	0.0057	0.0034
N.F.V	-0.068	-0.0805	0.0421	-0.1503	0.1774	0.1894	0.0138	0.2308	0.1119	0.114	0.082	0.0893	0.0983	0.0167	**0.4317**	-0.1612	-0.0187
F.C.	0.0051	0.0036	-0.0051	0.0031	-0.0065	-0.0095	0.0035	-0.0026	-0.0049	-0.0009	0.0017	0.0015	-0.0015	0.0091	-0.0119	**0.0317**	0.0055
T.S.S.	-0.0015	0.0019	0.0001	0.0012	-0.0003	-0.0013	0.0013	0.0012	-0.0004	-0.0004	0.0002	-0.0004	-0.0003	0.0009	-0.0002	0.001	**0.0056**
F.Y.	-0.0443	-0.5213	-0.0984	-0.5895	0.394	0.0066	0.4513	0.4856	0.6737	0.51	0.9297	0.3957	0.4411	0.349	0.5193	-0.0541	0.0248

RESIDUAL EFFECT : 0.084

DMF - Days to male flowering ; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm) ; NSF - Number of seeds per fruit; NFV - Number of fruits per vine; FC- Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY - Fruit yield per vine (kg)

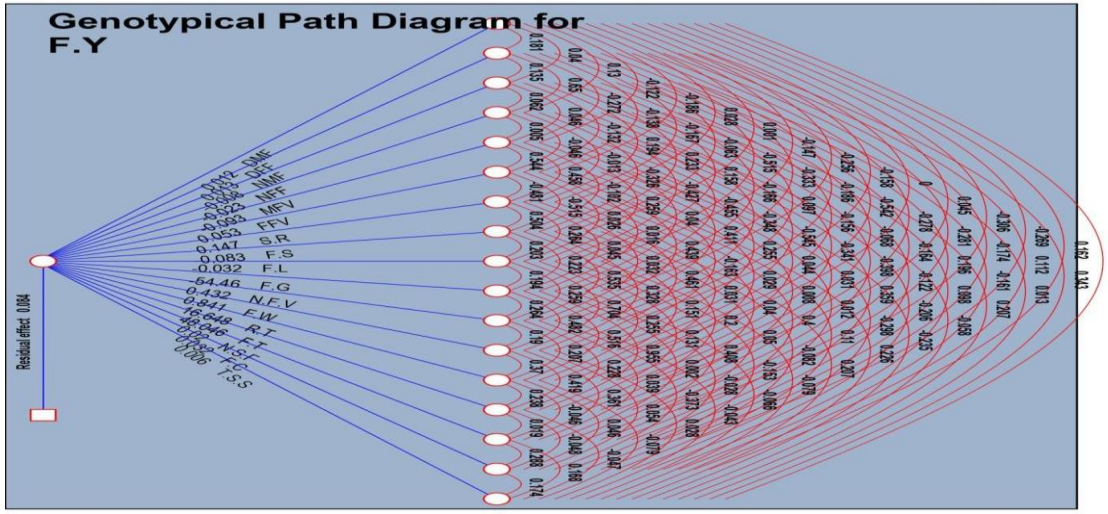

Fig. 7. Genotypical path diagram representing direct and indirect effects for fruit yield per vine (kg) in F_2 population of Cross 3 VRG-24 × VRG-13.

Table 8: Path coefficients among yield and yield contributing characters in F_2 population of cross 4 Swarna Manjari × ArkaPrasan.

	DMF	DFF	NMF	NFF	MFV	FFV	S.R	F.S.	F.L.	F.G.	F.W.	R.T	F.T	N.S.F	N.F.V	F.C	T.S.S.
DMF	**-0.0182**	-0.0087	0.002	0.0007	-0.0002	0.0008	-0.001	-0.0021	0.001	-0.0007	-0.0029	-0.0002	-0.0007	-0.0032	-0.0012	-0.0017	-0.0007
DFF	0.0216	**0.0449**	0.0009	-0.0006	0.0036	0.0033	0.0004	-0.0111	-0.006	-0.0005	-0.0033	0.0064	-0.0032	0.0054	-0.0058	-0.0013	0.0017
NMF	0.0007	-0.0001	**-0.0067**	-0.0012	0.0015	0.0008	0.0008	-0.0001	-0.0013	-0.0018	-0.0013	-0.0025	-0.001	-0.0007	0.0015	0.0011	0.0011
NFF	-0.0007	-0.0002	0.0032	**0.0177**	0.0008	0.0047	-0.0046	-0.0034	0.0008	-0.0004	0.0027	0.0017	-0.0011	-0.0011	0.0018	0.0011	-0.0011
MFV	-0.001	-0.0087	0.0241	-0.005	**-0.1096**	-0.0664	-0.0488	0.0485	0.0252	0.0157	0.0359	0.0272	0.0057	-0.0058	-0.0363	-0.0128	0.0056
FFV	0.0038	-0.0068	0.0111	-0.0242	-0.0552	**-0.0912**	0.0391	0.0579	0.0253	0.0014	0.0342	0.0146	-0.0046	0.0015	-0.0572	-0.0118	0.0179
S.R	0.0053	0.0009	-0.011	-0.0244	0.0417	-0.0402	**0.0937**	0.0213	0.006	-0.0169	0.0000	-0.0125	-0.0131	0.0087	-0.0294	0.0019	0.0159
F.S.	-0.0156	0.0337	-0.0018	0.026	0.0601	0.0862	-0.0309	**-0.1358**	-0.0395	-0.0051	-0.036	-0.0246	0.0046	-0.0095	-0.0242	0.0000	-0.0233
F.L	0.0008	0.002	-0.0029	-0.0007	0.0035	0.0042	-0.001	-0.0044	**-0.0152**	-0.0028	-0.0053	-0.0043	-0.0012	0.0003	0.001	-0.0021	-0.0005
F.G.	0.6321	-0.1797	4.5139	-0.3854	-2.3516	-0.2461	-2.9566	0.6217	3.0218	**16.416**	4.8396	6.3519	15.1693	2.1233	0.8411	-2.7748	-1.5955
F.W.	0.1546	-0.0725	0.1963	0.1506	-0.3216	-0.3682	0.0002	0.2607	0.3444	0.2897	**0.9827**	0.2334	0.2174	0.21	-0.1 804	-0.0667	-0.1002
R.T.	-0.0778	-0.8976	-2.3037	-0.5889	1.562	1.0036	0.8395	-1.141	-1.7913	-2.4324	-1.4931	**-6.2864**	-0.0318	0.1417	0.3408	0.5861	0.005
F.T.	-0.5558	1.0761	-2.2154	0.9725	0.7921	-0.756	2.1181	0.5146	-1.2345	-13.9886	-3.3491	-0.0767	**-15.1383**	-2.2656	-1.1839	2.1885	1.5914
N.S.F	0.0022	0.0015	0.0012	-0.0008	0.0007	-0.0002	0.0012	0.0009	-0.0003	0.0016	0.0027	-0.0003	0.0019	**0.0125**	0.0006	0.0019	-0.0006
N.F.V.	0.0384	-0.074	-0.13	0.0591	0.1897	0.3599	-0.1798	0.102	-0.038	0.0294	-0.1053	-0.0311	0.0448	0.0285	**0.5734**	0.0703	-0.0457
F.C.	0.001	-0.0003	-0.0018	0.0007	0.0013	0.0014	0.0002	0.0000	0.0015	-0.0019	-0.0007	-0.001	-0.0016	0.0016	0.0013	**0.011**	-0.0012
T.S.S.	0.0005	0.0005	-0.002	-0.0008	-0.0006	-0.0024	0.002	0.0021	0.0004	-0.0012	-0.0012	0.0000	-0.0013	-0.0005	-0.001	-0.0013	**0.012**
F.Y.	0.1919	-0.0891	0.0776	0.1953	-0.1819	-0.1056	-0.1275	0.3316	0.3002	0.3014	0.8995	0.1955	0.2459	0.2471	0.2423	-0.0107	-0.1181

RESIDUAL EFFECT: 0.123

DMF - Days to male flowering; DFF - Days to female flowering; NMF - Node of first male flower; NFF - Node of first female flower; MFV - Number of male flowers per vine; FFV - Number of female flowers per vine; SR - Sex ratio; FS - Fruit set percentage; FL - Fruit length (cm); FG - Fruit girth (cm); FW - Average fruit weight (g); RT - Rind thickness (mm); FT - Flesh thickness (mm); NSF - Number of seeds per fruit; NFV - Number of fruits per vine; FC- Fibre content (g/100g); TSS - Total soluble solids (°Brix); FY- Fruit yield per vine (kg)

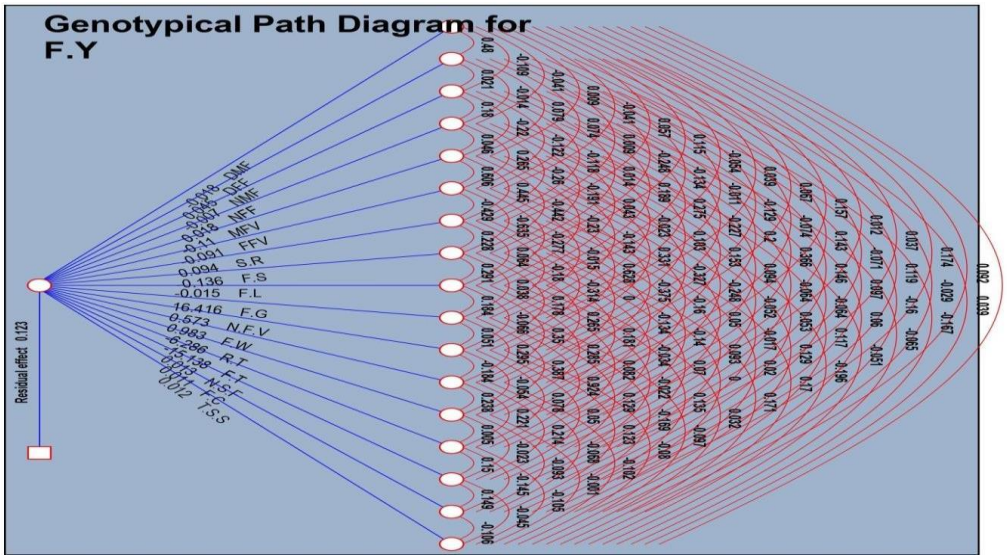

Fig. 8. Genotypical path diagram representing direct and indirect effects for fruit yield per vine (kg) in F_2 population of cross 4 Swarna Manjari × Arka Prasan.

CONCLUSIONS

The positive effects indicated the stable performance against the environmental fluctuations and more emphasis could be given to those characters in selection of genotypes for high yield. Hence, direct selection for the traits would be rewarding. The character association and path analysis prompted that selection for fruit weight, fruit girth, rind thickness, flesh thickness, fruit set percentage, number of female flowers per vine and number of fruits per vine could be beneficial for improvement in fruit yield of ridge gourd.

FUTURE SCOPE

Characters having desirable association and direct effects with fruit yield per vine may be further studied for confirmation and utilization in further ridge gourd breeding programme.

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