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Character Association and Path Analysis in Bitter Gourd (*Momordica charantia* L.) for Yield and Its Attributes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was carried out in Department of Vegetable Science, College of Horticulture at Banda University of Agriculture and Technology during *kharif* to evaluate the 15 bitter gourd genotypes with three replications in randomized block design were to correlation and path coefficient for yield and its component traits. At phenotypic level fruit yield per plot displayed positive

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and highly significant correlation with internodal length, number of fruits per plant, average fruit weight, fruit length, vine length and number of primary branches per plant. At genotypic level fruit yield per plot exhibited positive and significant correlation with number of primary branches per plant, intermodal length, number of fruits per plant, vine length, average fruit weight and fruit length.

Path analysis at phenotypic level have highest positive direct effect on yield per plot was exerted by average fruit weight followed by number of fruits per plant, days to first male flower anthesis, node number to first pistillate flower, fruit length, intermodal length and node number to first stamin ate flower. At genotypic level, highest positive direct effect on yield per plot was exerted by average fruit weight followed by number of fruits per plant, internodal length, node number to first pistillate flower, TSS and days to first female flower anthesis.

Keywords: Bitter gourd; correlation; fruit yield; path analysis; phenotypic and genotypic.

1. INTRODUCTION

Bitter gourd, alternatively named bitter melon and botanically known as *Momordica charantia* L, fruit is a green, elongated vegetable characterized by its unique bitter flavour. Beinga member of cucurbitaceous family having a somatic chromosome no 2n=22, short life period and has high yielding capacity. It is a monoecious plant, characterized by a higher ratio of male flowers compared to female flowers. The genus name is derived from the Latin word "MORDICUS," which means bitten. It is a versatile, underutilized high-value vegetable in India (Ojha et al., 2009). Its have high nutritional and medicinal importance. The bitter gourd improvement focusses on enhancing production and quality attributing characters. An analysis of the correlation among different quantitative features provides a information of association of different characters. It can be used to develop effective selection strategies for increasing production and quality (Behera et al., 2010). The path coefficient identifies both direct and indirect sources of association and assesses the relevance of each item. Partitioning total correlation into direct and indirect effects would be beneficial for effective results.

2. MATERIALS AND METHODS

15 genotypes including some released varieties were evaluated at College of Horticulture at Banda University of Agriculture and Technology. Healthy and pure seeds were collected from different regions of Uttar Pradesh. Genotypes were evaluated using Randomised Block Design with three replications. Plants were grown at a spacing of 2m between rows and 0.5 m between plants. Observations were recorded on five randomly selected plants of each genotype in each replication for fifteen characters viz, Node number to first staminate flower, Node number to first pistillate flower, Days to first male flower anthesis, Days to first female flower anthesis, Number of primary branches per plant, Vine length (m), Internodal length (cm), Days to first picking, TSS (Brix), Number of seeds per fruit, Fruit length (cm), Fruit diameter (cm), Number of fruits per plant, Average fruit weight (g), Fruit yield per plot (kg).Genotypic and phenotypic correlations were calculated as per Al-Jabouri et al. (1958) using an ANOVA and covariance matrix in which total variability was split into replications, genotypes and errors. The genotypic and phenotypic correlation coefficients were used to determine direct and indirect contribution toward yield per plot. The direct and indirect paths were estimated by according to the method of Dewey and Lu (1959).

3. RESULTS AND DISCUSSION

Variability studies measure the level of progress in many characters, but do not reveal the relationship between contributing and economically relevant characters. The phenotypic and genotypic correlation studies were conducted to determine the nature of the link between yield and its component features, and as per results are provided in Tables 1 and 2, respectively. At phenotypic correlation level the fruit yield per plot displayed positive and highly significant correlation with internodal length (0.749), number of fruits per plant (0.648), average fruit weight (0.618), fruit length (0.581), vine length (0.553) and number of primary branches per plant (0.537) whereas negative and significant correlation was exhibited by days to first picking (-0.643),node number to first stamin ate flower (-0.324), average fruit weight, fruit length (0.730), internodal length (0.364)whereas exhibited negative and significant effect on TSS (-0.385). number of fruits per plant showed positive and significant correlation with internodal length (0.615), vine length (0.460) and number of primary branches per plant (0.425) and exhibited negative and significant effect on days to first picking (-0.651), node number to first staminate flower (-0.466) and fruit diameter (-0.328).Fruit length showed positive and significant effect on internodal length (0.591), vine length (0.422) and fruit diameter (0.381).Fruit diameter showed negative and significant correlation with number of seeds per fruit (-0.480). Days to first picking showed positive and significant correlation with node number to first staminate flower (0.622), days to female flower anthesis (0.447) and node number to first pistillate flower (0.402) and showed negative and significant correlation with number of primary branches per plant (-0.481), internodal length (-0.443) and vine length (-0.370).Internodal length showed positive and significant correlation with vine length (0.532) and number of primary branches per plant (0.473) while exhibited negative and significant correlation with node number to first staminate flower (-0.327) and node number to first pistillate flower (-0.305). Number of primary branches per plant showed negative and significant correlation with days to female flower anthesis (-0.443).Days to first female flower anthesis showed positive and significant correlation with node number to first staminate flower (0.401).Node number to first pistillate flower showed positive and significant correlation with node number to first staminate flower (0.647).

At Genotypic level of correlation for fruit yield per plot exhibited positive and significant correlation with number of primary branches per plant (0.959), internodal length (0.846), number of fruits per plant (0.656), vine length (0.631), average fruit weight (0.623) and fruit length (0.615) whereas negative and significant correlation was exhibited by days to first picking (-0.738) and node number to first staminate flower (-0.387). Average fruit weight showedpositive and significant correlation with fruit length (0.752), number of primary branches per plant (0.467), internodal length (0.407) fruit diameter (0.342) and vine length (0.322) and negative and significant effect was exhibited by TSS (-0.403). Number of fruits per plant showedpositive and significant correlation, with internodal length (0.689), number of primary branches per plants (0.678), vine length (0.502) and TSS (0.299) and showed negative and significant correlation with days to first picking (-0.744), node number to first staminate flower (0.534), fruit diameter (-0.391) and days to female flower anthesis (-0.324).Fruit length showed positive and significant correlation with, internodal length (0.687), vine length (0.489), fruit diameter (0.482) and number of primary branches per plant on the other hand negative and significant effect was exhibited by days to female flower anthesis (-0.356) and days to male flower anthesis (-0.317).Fruit diametershowed positive and significant correlation with days to first picking (0.369) and days to female flower anthesis (0.345) while exhibited negative and significant correlation with number of seeds per fruit (-0.701) and days to male flower anthesis (-0.299).Days to first picking showed positive and significant correlation withdays to female flower anthesis (0.939), node number to first staminate flower (0.749) and node number to first pistillate flower (0.454) on the other hand it exhibited negative and significant correlation with number of primary branches per plant (-0.921), internodal length (-0.598) and vine length (-0.391). Internodal length showed positive and significant correlation with number of primary branches per plant (0.835) and vine length (0.637) while negative and significant correlation was exhibited by node number to first staminate flower (-0.450) and node number to first pistillate flower (-0.438).Vine length showed positive and significant effect on number of primary branches per plant (0.317).Number of primary branches per plant showedpositive and significant correlation with days to male flower anthesis (0.798) while negative and significant correlation was shown by node number to first staminate flower (0.774) and node number to first pistillate flower (-0.351).Days to first female flower anthesis showed positive and significant correlation withnode number to first staminate flower (0.630) and node number to first pistillate flower (0.521).Days to first male flower anthesis showed positive and significant correlation with node number to first pistillate flower (0.397).Node number to first pistillate flower showed positive and significant correlation withnode number to first staminate flower(0.768).Similar findings were observed by Srinivasulu et al. (2024), Mahesh et al. (2014),Maurya et al., (2018) Khan et al. (2015), Dalamu & Behera (2013), Sowmya et al. (2019) and Kumari et al., (2018).

Path Analysis at phenotypic level the data revealed that at phenotypic level, highest positive direct effect on yield per plot was exerted by average fruit weight (0.7134) followed by number of fruits per plant (0.6918), days to first male flower anthesis (0.0735), node number to first

Table 1. Estimates of phenotypic correlation coefficient among different characters of bitter gourd

Characters	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	**1.000**	0.647**	0.033	0.401**	-0.443**	0.035	-0.327*	0.622**	0.175	0.129	-0.150	-0.038	-0.466**	0.057	-0.324*
C2		**1.000**	0.293	0.225	-0.294	-0.210	-0.305*	0.402**	-0.030	0.219	-0.231	-0.250	-0.245	0.044	-0.117
C3			**1.000**	0.120	0.172	0.042	-0.006	-0.007	0.030	-0.117	-0.164	-0.161	0.009	0.105	0.160
C4				**1.000**	-0.187	-0.038	-0.141	0.447**	-0.099	0.125	-0.168	0.042	-0.173	-0.103	-0.222
C5					**1.000**	0.153	0.473**	-0.481**	-0.113	-0.135	0.256	-0.095	0.425**	0.283	0.537**
C6						**1.000**	0.532**	-0.370*	0.119	-0.186	0.422**	0.257	0.460**	0.276	0.553**
C7							**1.000**	-0.443**	-0.189	-0.022	0.591**	0.021	0.615**	0.364*	0.749**
C8								**1.000**	0.062	0.222	-0.223	-0.030	-0.651**	-0.142	-0.643**
C9									**1.000**	-0.480**	-0.049	-0.013	-0.208	0.109	-0.114
C10										**1.000**	0.381**	0.019	-0.328*	0.273	-0.049
C11											**1.000**	0.006	0.058	0.730**	0.581**
C12												**1.000**	0.279	-0.385**	-0.100
C13													**1.000**	-0.172	0.648**
C14														**1.000**	0.618**

**** &** Significant at 5% & 1% Probability level respectively***

C1	*Node number to first staminate flower*	*C2*	*Node number to first pistillate flower*	*C3*	*Days to first male flower anthesis*
C4	*Days to first female flower anthesis*	*C5*	*Number of primary branches per plant*	*C6*	*vine length (m)*
C7	*Internodal length (cm)*	*C8*	*Days to first picking*	*C9*	*Number of seeds per fruit*
C10	*Fruit diameter (cm)*	*C11*	*Fruit length (cm)*	*C12*	*TSS (◦Brix)*
C13	*number of fruits per plant*	*C14*	*Average fruit weight (g)*	*C15*	*Fruit yield per plot (kg)*

Table 2. Estimates of genotypic correlation coefficient among different characters of bitter gourd

Characters	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	1.000	0.768**	0.287	0.630**	-0.774**	0.004	-0.450**	0.749**	0.226	0.249	-0.142	-0.036	-0.534**	0.058	-0.387**
C2		1.000	0.397**	0.521**	-0.351*	-0.207	-0.438**	0.454**	-0.072	0.208	-0.275	-0.331*	-0.266	0.029	-0.164
C3			1.000	0.117	0.798**	0.009	-0.016	-0.169	0.097	-0.299*	-0.317*	-0.326*	0.023	0.158	0.177
C4				1.000	-0.364*	-0.152	-0.120	0.939**	-0.173	0.345*	-0.356*	0.132	-0.324*	-0.184	-0.410**
C5					1.000	0.317*	0.835**	-0.921**	-0.187	-0.289	0.372*	-0.129	0.678**	0.467**	0.959**
C6						1.000	0.687**	-0.391**	0.174	-0.196	0.489**	0.334*	0.502**	0.322*	0.631**
C7							1.000	-0.598**	-0.153	-0.094	0.687**	0.002	0.689**	0.407**	0.846**
C8								1.000	0.118	0.369*	-0.248	-0.055	-0.744**	-0.161	-0.738**
C9									1.000	-0.701**	-0.052	-0.014	-0.190	0.133	-0.077
C10										1.000	0.424**	0.032	-0.391**	0.342*	-0.043
C11											1.000	-0.001	0.070	0.752**	0.615**
C12												1.000	0.299*	-0.403**	-0.119
C13													1.000	-0.182	0.656**
C14														1.000	0.623**

**** &** Significant at 5% & 1% Probability level respectively***

C1	*Node number to first staminate flower*	*C2*	*Node number to first pistillate flower*	*C3*	*Days to first male flower anthesis*
C4	*Days to first female flower anthesis*	*C5*	*Number of primary branches per plant*	*C6*	*vine length (m)*
C7	*Internodal length (cm)*	*C8*	*Days to first picking*	*C9*	*Number of seeds per fruit*
C10	*Fruit diameter (cm)*	*C11*	*Fruit length (cm)*	*C12*	*TSS (◦Brix)*
C13	*number of fruits per plant*	*C14*	*Average fruit weight (g)*	*C15*	*Fruit yield per plot (kg)*

Table 3. Direct and indirect effect of different characters on fruit yield at phenotypic level in bitter gourd genotypes

Characters	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	**0.0006**	0.0350	0.0024	-0.0007	0.0172	-0.0008	-0.0098	-0.0635	-0.0107	-0.0065	-0.0058	-0.0002	-0.3221	0.0409	-0.324*
C2	0.0004	**0.0541**	0.0215	-0.0004	0.0114	0.0046	-0.0091	-0.0410	0.0018	-0.0111	-0.0090	-0.0015	-0.1698	0.0312	-0.117
C3	0.0000	0.0158	**0.0735**	-0.0002	-0.0067	-0.0009	-0.0002	0.0008	-0.0019	0.0059	-0.0064	-0.0009	0.0064	0.0751	0.160
C4	0.0003	0.0122	0.0089	**-0.0017**	0.0073	0.0008	-0.0042	-0.0457	0.0061	-0.0063	-0.0065	0.0002	-0.1199	-0.0736	-0.222
C5	-0.0003	-0.0159	0.0127	0.0003	**-0.0388**	-0.0034	0.0141	0.0491	0.0069	0.0068	0.0099	-0.0006	0.2939	0.2021	0.537**
C6	0.0000	-0.0113	0.0031	0.0001	-0.0059	**-0.0219**	0.0159	0.0378	-0.0073	0.0094	0.0164	0.0015	0.3186	0.1969	0.553**
C7	-0.0002	-0.0165	-0.0005	0.0002	-0.0184	-0.0117	**0.0299**	0.0453	0.0115	0.0011	0.0230	0.0001	0.4253	0.2600	0.749**
C8	0.0004	0.0217	-0.0005	-0.0007	0.0187	0.0081	-0.0132	**-0.1021**	-0.0038	-0.0112	-0.0087	-0.0002	-0.4506	-0.1010	-0.643**
C9	0.0001	-0.0016	0.0022	0.0002	0.0044	-0.0026	-0.0056	-0.0064	**-0.0610**	0.0243	-0.0019	-0.0001	-0.1437	0.0780	-0.114
C10	0.0001	0.0118	-0.0086	-0.0002	0.0053	0.0041	-0.0007	-0.0227	0.0293	**-0.0505**	0.0148	0.0001	-0.2267	0.1951	-0.049
C11	-0.0001	-0.0125	-0.0121	0.0003	-0.0099	-0.0093	0.0177	0.0228	0.0030	-0.0192	**0.0389**	0.0000	0.0400	0.5210	0.581**
C12	0.0000	-0.0135	-0.0119	-0.0001	0.0037	-0.0056	0.0006	0.0031	0.0008	-0.0010	0.0002	**0.0058**	0.1929	-0.2746	-0.100
C13	-0.0003	-0.0133	0.0007	0.0003	-0.0165	-0.0101	0.0184	0.0665	0.0127	0.0165	0.0022	0.0016	**0.6918**	-0.1230	0.648**
C14	0.0000	0.0024	0.0077	0.0002	-0.0110	-0.0061	0.0109	0.0145	-0.0067	-0.0138	0.0284	-0.0022	-0.1193	**0.7134**	0.618**

R SQUARE = 0.9812 RESIDUAL EFFECT = 0.1371

Bold values show direct and normal values shows indirect effects

C1	*Node number to first staminate flower*	*C2*	*Node number to first pistillate flower*	*C3*	*Days to first male flower anthesis*
C4	*Days to first female flower anthesis*	*C5*	*Number of primary branches per plant*	*C6*	*vine length (m)*
C7	*Internodal length (cm)*	*C8*	*Days to first picking*	*C9*	*Number of seeds per fruit*
C10	*Fruit diameter (cm)*	*C11*	*Fruit length (cm)*	*C12*	*TSS (◦Brix)*
C13	*number of fruits per plant*	*C14*	*Average fruit weight (g)*	*C15*	*Fruit yield per plot (kg)*

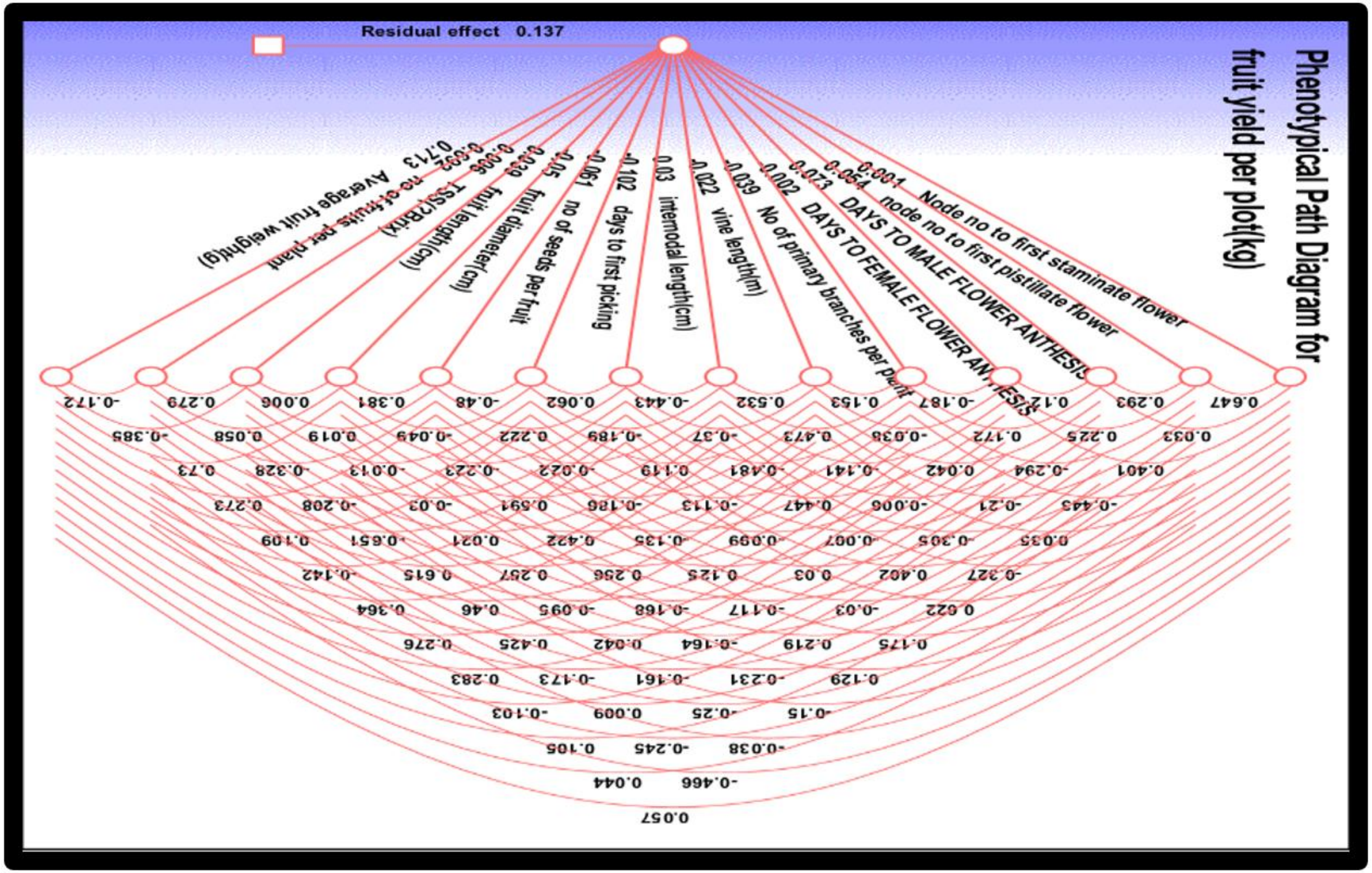

Fig. 1. Phenotypic path diagram for fruit yield per plot (kg)

Table 4. Direct and indirect effect of different characters on fruit yield at genotypic level in bitter gourd genotypes

Characters	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	**-0.026**	0.099	-0.009	0.016	0.037	0.000	-0.074	-0.134	-0.024	-0.032	0.011	-0.003	-0.295	0.047	-0.387**
C2	-0.020	**0.128**	-0.012	0.014	0.017	0.008	-0.072	-0.081	0.008	-0.027	0.022	-0.024	-0.148	0.024	-0.164
C3	-0.007	0.051	**-0.031**	0.003	-0.038	0.000	-0.003	0.030	-0.010	0.039	0.025	-0.024	0.013	0.130	0.177
C4	-0.016	0.067	-0.004	**0.026**	0.017	0.006	-0.020	-0.168	0.019	-0.045	0.028	0.010	-0.180	-0.151	-0.410**
C5	0.020	-0.045	-0.025	-0.010	**-0.048**	-0.013	0.138	0.165	0.020	0.037	-0.029	-0.010	0.375	0.382	0.959**
C6	0.000	-0.027	0.000	-0.004	-0.015	**-0.040**	0.114	0.070	-0.019	0.025	-0.039	0.025	0.278	0.264	0.631**
C7	0.012	-0.056	0.001	-0.003	-0.040	-0.028	**0.165**	0.107	0.017	0.012	-0.054	0.000	0.381	0.333	0.846**
C8	-0.019	0.058	0.005	0.025	0.044	0.016	-0.099	**-0.179**	-0.013	-0.048	0.020	-0.004	-0.412	-0.132	-0.738**
C9	-0.006	-0.009	-0.003	-0.005	0.009	-0.007	-0.025	-0.021	**-0.107**	0.091	0.004	-0.001	-0.105	0.108	-0.077
C10	-0.006	0.027	0.009	0.009	0.014	0.008	-0.016	-0.066	0.075	**-0.130**	-0.033	0.002	-0.216	0.280	-0.043
C11	0.004	-0.035	0.010	-0.009	-0.018	-0.020	0.114	0.044	0.006	-0.055	**-0.079**	0.000	0.039	0.616	0.615**
C12	0.001	-0.042	0.010	0.003	0.006	-0.014	0.000	0.010	0.002	-0.004	0.000	**0.073**	0.165	-0.330	-0.119
C13	0.014	-0.034	-0.001	-0.008	-0.032	-0.020	0.114	0.133	0.020	0.051	-0.006	0.022	**0.554**	-0.149	0.656**
C14	-0.002	0.004	-0.005	-0.005	-0.022	-0.013	0.067	0.029	-0.014	-0.044	-0.059	-0.030	**-0.101**	**0.818**	0.623**

R SQUARE = 1.0033 RESIDUAL EFFECT =SQRT (1- 1.0033)

C1	*Node number to first staminate flower*	*C2*	*Node number to first pistillate flower*	*C3*	*Days to first male flower anthesis*
C4	*Days to first female flower anthesis*	*C5*	*Number of primary branches per plant*	*C6*	*vine length (m)*
C7	*Internodal length (cm)*	*C8*	*Days to first picking*	*C9*	*Number of seeds per fruit*
C10	*Fruit diameter (cm)*	*C11*	*Fruit length (cm)*	*C12*	*TSS (◦Brix)*
C13	*number of fruits per plant*	*C14*	*Average fruit weight (g)*	*C15*	*Fruit yield per plot (kg)*

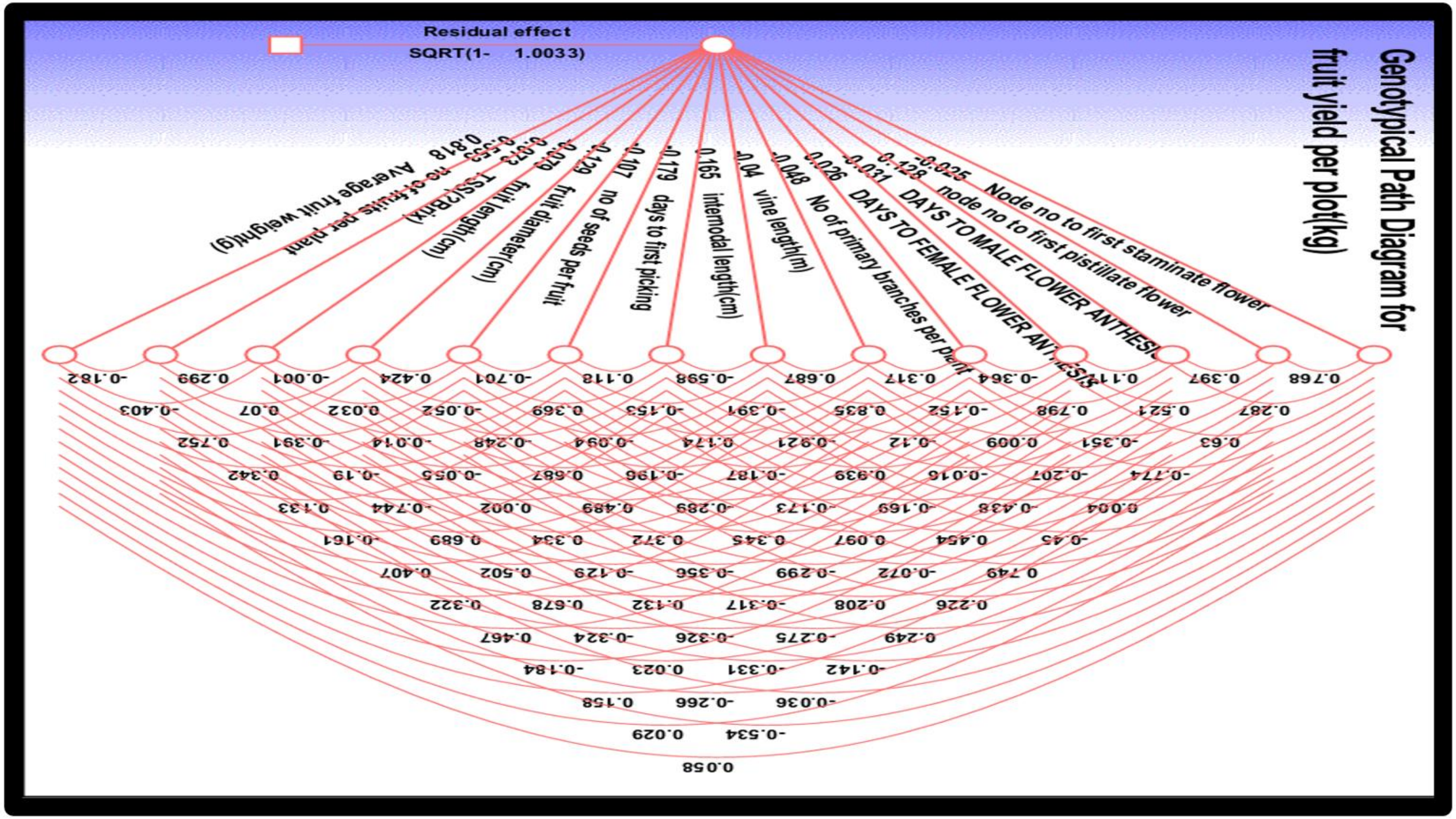

Fig. 2. Genotypic path diagram for fruit yield per plot (kg)

pistillate flower (0.0541), fruit length (0.0389), internodal length (0.0299), TSS (0.0058) and node number to first staminate flower (0.0006). Substantially too low negative and direct effect on yield per plot at phenotypic level, was reported by days to first female flower anthesis (-0.0017), vine length (-0.0219), number of primary branches per plant (-0.0388), fruit diameter (-0.0505), number of seeds per fruit (-0.0610) and days to first picking (-0.1021).

Path analysis at genotypic level the data revealed that at genotypic level, highest positive direct effect on yield per plot was exerted by average fruit weight (0.818) followed by number of fruits per plant Results 57 (0.554), internodal length (0.165), node number to first pistillate flower (0.128), TSS (0.073) and days to first female flower anthesis (0.026). Substantially low negative and direct effect on yield per plot at phenotypic level, was exhibited by node number to first staminate flower (-0.026), days to first male flower anthesis (-0.031), number of primary branches per plant (-0.048), vine length (-0.040), days to first picking (-0.179), number of seeds per fruit (-0.107), fruit diameter (-0.130) and fruit length (-0.079). Similar findings were observed by Maurya et al., (2018), Gupta et al. (2015), Islam et al. (2009) and Khan et al. (2015), Mahesh et al. (2014), Kumari et al., (2018), Dalamu& Behera (2013), Tyagi et al. (2018).

4. SUMMERY AND CONCLUSION

Correlation and Path analysis indicated a scope for improvement of bitter gourd fruit yield through selection emphasis should be given on the at phenotypic level Fruit yield per plot displayed positive and highly significant correlation with internodal length, number of fruits per plant, average fruit weight, fruit length, vine length and number of primary branches per plant. At genotypic level fruit yield per plot exhibited positive and significant correlation with number of primary branches per plant, internodal length, number of fruits per plant, vine length, average fruit weight and fruit length.

Path analysis at phenotypic level have highest positive direct effect on yield per plot was exerted by average fruit weight followed by number of fruits per plant , days to first male flower anthesis, node number to first pistillate flower, fruit length ,intermodal length andnode number to first staminate flowerandatgenotypic level, highest positive direct effect on yield per plot was exerted by average fruit weight followed by number of fruits per plant Results, internodal length, node number to first pistillate flower, TSSand days to first female flower anthesis.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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