



Analysis of Bitter Gourd Hybrids for Yield Traits by using Correlation and Path Coefficient Analysis

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Abstract: The correlation and path coefficients of 12 growth and yield parameters in bitter gourd was carried out at the Vegetable Experimental Farm, College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, Andhra Pradesh. For all traits, genotypic correlations were stronger than phenotypic correlations, suggesting innate relationships between various attributes. Captivatingly, at both the phenotypic and genotypic levels, yield per plant showed substantial positive associations with plant height, days to 1st male flower appearance, number of fruits per plant, average fruit weight, fruit length, fruit diameter, and internodal length and seed per fruit. The results of the path coefficient analysis showed that traits significantly and directly improved fruit yield are number of fruits per plant, plant height, days to 1st female flower appearance, sex ratio and fruit diameter. This implies that increasing fruit yield per plant in bitter gourd might be achieved by direct selection focused on these traits.

Keywords: Causation factors, Sex ratio, Fruit yield, *Momordica charantia* L.

Bitter gourd, botanically, *Momordica charantia* L., is a well-known herbaceous vine from the Cucurbitaceae family. *Momordica* is a genus of about 45 species, the majority of which are located in Africa (Mabberley 2017). Bitter gourd is a popular "tropical and subtropical" commercially important vegetable crop (Singh et al., 2013). The leading bitter gourd producing states are Maharashtra, Uttar Pradesh, Gujarat, Rajasthan, Punjab, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, West Bengal, Odisha, Assam and Bihar (NHB Database 2020-21). Yield is a complex trait heavily influenced by the environment, and relying solely on yield for selection may have limitations. On the other hand, yield component traits are less intricate in terms of inheritance and are influenced to a lesser degree by the environment. Consequently, effective improvement in yield can be achieved by selecting various yield component traits that exhibit associations among themselves and with yield. In the current study, phenotypic and genotypic correlations were utilized to ascertain the direct and indirect effects of both yield and yield-contributing characters in the selection of superior cross combinations among bitter gourd genotypes.

MATERIAL AND METHODS

The experiment was conducted at the Vegetable Experimental farm of the Department of Vegetable Science at Dr. Y.S.R. Horticultural University in V.R. Gudem, West Godavari, Andhra Pradesh during summer and *kharif* seasons of 2022. The 7 parents, 21 hybrids and commercial checks (Pragathi and Monarch) were evaluated in a

randomized complete block design with three replications. The location, situated at an elevation of 34 meters (112 feet) above sea level, falls within Agro-climatic zone 10, characterized by a humid East Coast Plain and Hills (Krishna-Godavari zone) climate, with an average annual rainfall of 900 mm. The region experiences hot and humid summers and pleasant winters. The spacing adopted between row to row and plant to plant is 1m x 1m. Recommended package of practices were followed to raise a healthy crop. Observations were recorded on 12 traits in bitter gourd, with 5 randomly selected plants from each parent and cross in each replication.

Statistical analysis: Statistical analysis was conducted using the SPAR-I software. Path analysis was carried out according to the approach proposed by Dewey and Lu (1959).

Coefficients of Correlation

Phenotypic coefficient of correlation:

$$r_p = \frac{V_{pxy}}{\sqrt{V_{px} V_{py}}}$$

V_{pxy} = Phenotypic covariance between X and Y
 V_{px} = Phenotypic variance of X
 V_{py} = Phenotypic variance of Y

Genotypic coefficient of correlation: $r_g = \frac{V_{gxy}}{\sqrt{V_{gpx} V_{gpy}}}$

Path coefficient analysis: Path coefficient analysis for traits exhibiting significant correlations with yield was conducted using the approach outlined by Dewey and Lu (1959). The path coefficients were derived through the simultaneous selection of equations that articulate the fundamental

connection between genotypic correlation (r) and path coefficient (P).

$$r_{14} = P_{14} + P_{24}r_{12} + P_{34}r_{13}$$

$$r_{24} = P_{14}r_{21} + P_{24} + P_{34}r_{23}$$

$$r_{34} = P_{14}r_{31} + P_{24}r_{32} + P_{34}$$

where, r_{14} , r_{24} and r_{34} are genotypic correlations of component characters with yield (dependent variable) and r_{12} , r_{13} and r_{23} are the genotypic correlations among component characters (independent variables). The direct effects were calculated by the following set of equations:

$$P_{14} = C_{11}r_{14} + C_{12}r_{24} + C_{13}r_{34}$$

$$P_{24} = C_{21}r_{14} + C_{22}r_{24} + C_{23}r_{34}$$

$$P_{34} = C_{31}r_{14} + C_{32}r_{24} + C_{33}r_{34}$$

where, C_{11} , C_{22} , C_{23} and C_{33} are constants and

$r_{12}P_{24}$, $r_{13}P_{34}$, $r_{21}P_{14}$, $r_{23}P_{34}$, $r_{31}P_{14}$, $r_{32}P_{24}$ are indirect effects.

RESULTS AND DISCUSSION

Correlation analysis: The observed associations are predominantly impacted by genetic variables, as evidenced by the fact that genotypic correlations are generally greater than phenotypic correlations. At the genotypic and phenotypic levels, there was a significant positive connection between plant height and yield per plant. The internodal length, fruit diameter, and average fruit weight all showed significant positive correlations with this characteristic (Table 1, 2). There may be a chance for these traits to be selected for at the same time based on the concurrent growth in one attribute that influences another. In terms of phenotypic

relationships, plant height and fruit number per plant showed a strong positive correlation suggesting that advantageous environmental factors as well as genes have a role in the relationship between this feature and fruit output. The yield per plant and seed per fruit showed a strong positive connection with internodal length. The literature on bitter gourds has demonstrated a consistent pattern of positive associations between vine length, internodal length, and fruit yield. Earlier researcher also observed similar trends (Kumari et al., 2015, Durga et al., 2017, Vivek et al., 2018, Alekar et al., 2019).

The characteristic days to first male flower appearance showed a negative association with fruit length and yield per plant. On the other hand, there was a non-significant negative relationship found between days to first female flower appearance and fruit length, average fruit weight, sex ratio and yield per plant. This implies that choosing fruit production based on when male and female flowers bloom may not be a reliable method. When it came to days to first picking at the genotypic and phenotypic levels, there was a non-significant negative connection with average fruit weight and a significant negative correlation with sex ratio. In bitter gourd, Talukder et al. (2018), Alekar et al. (2019) and Triveni et al. (2021) have also reported significant negative correlation between days to the first male and female flower appearance and fruit yield, demonstrating the consistency of these observations across different studies.

At the phenotypic and genotypic levels, there was a strong and positive correlation between the number of fruits

Table 1. Genotypic correlations among fruit yield and yield contributing characters in bitter gourd

Character	Plant height	Day to 1 st male flower appearance	Day to 1 st female flower appearance	Days to 1 st picking	Number of fruits per plant	Average fruit weight	Fruit length	Fruit diameter	Internodal length	Seed per fruit	Sex ratio	Yield per plant
Plant height	1.00	0.202	-0.228	0.110	0.191	0.278**	-0.348**	0.411**	0.411**	0.107	-0.332**	0.338**
Day to 1 st male flower appearance		1.00	0.609**	0.027	0.043	0.485**	-0.046	0.154	0.148	0.193	0.410**	0.407**
Day to 1 st female flower appearance			1.00	0.042	0.017	-0.071	-0.154	0.053	0.056	0.189	-0.029	-0.091
Days to 1 st picking				1.00	0.235**	-0.001	0.173	0.209*	0.208*	0.144	-0.343*	0.066
Number of fruits per plant					1.00	0.112	0.163	0.307**	0.303**	0.111	-0.550**	0.492**
Average fruit weight						1.00	0.376**	0.240*	0.239	0.417**	-0.695**	0.920**
Fruit length							1.00	0.085	0.083	0.520***	-0.398	0.386**
Fruit diameter								1.00	0.007**	0.282*	-0.339*	0.330**
Internodal length									1.00	0.280*	-0.339*	0.328**
Seed per fruit										1.00	-0.349*	0.404**
Sex ratio											1.00	-0.807**
Yield per plant												1.00

*Significant at 5% level, **significant at 1% level.

per plant and yield per plant, fruit diameter, and internodal length. This suggests that selecting for fruit the number per plant would be very advantageous. At both the phenotypic and genotypic levels, average fruit weight showed similarly strong and positive associations with yield, fruit length, and seeds per fruit, suggesting that selecting for fruit weight would also increase yield. Fruit length showed a strong positive connection with the number of seeds per fruit, yield per plant at the genotypic and phenotypic levels. Similarly, at

both the phenotypic and genotypic levels, fruit diameter exhibited a strong and positive relationship to both yield per plant and the number of seeds per fruit. The consistency of these results across various studies has been confirmed by earlier studies in bitter melon (Gupta et al., 2015, Vivek et al., 2018, Triveni et al., 2021). There was similar associations of fruit number, average fruit weight, fruit length, and diameter with yield and other fruit characteristics in bitter melon. The strong and positive association was between the seeds per

Table 2. Phenotypic correlations among fruit yield and yield contributing characters in bitter melon

Character	Plant height	Day to 1 st male flower appearance	Day to 1 st female flower appearance	Days to 1 st picking	Number of fruits per plant	Average fruit weight	Fruit length	Fruit diameter	Internodal length	Seed per fruit	Sex ratio	Yield per plant
Plant height	1.00	0.194	-0.218	0.110	0.187	0.276*	-0.344*	0.405**	0.405**	0.103	-0.327*	0.334**
Day to 1 st male flower appearance		1.00	0.559***	0.033	0.048	0.470**	-0.046	0.145	0.144	0.188	0.398**	0.396**
Day to 1 st female flower appearance			1.00	0.033	0.022	-0.067	-0.150	0.052	0.053	0.179	0.029	-0.089
Days to 1 st picking				1.00	0.227**	-0.001	0.175	0.201*	0.202*	0.141	-0.333*	0.065
Number of fruits per plant					1.00	0.111	0.159	0.302**	0.301**	0.109	-0.545**	0.487**
Average fruit weight						1.00	0.374**	0.238	0.237*	0.416**	-0.693*	0.918**
Fruit length							1.00	0.084	0.083	0.517**	-0.396*	0.384**
Fruit diameter								1.00	0.001	0.279*	-0.338*	0.328**
Internodal length									1.00	0.279*	-0.337*	0.327**
Seed per fruit										1.00	-0.348*	0.403**
Sex ratio											1.00	-0.805**
Yield per plant												-0.069

*Significant at 5% level, **significant at 1% level.

Table 3. Path correlations (Direct and indirect effects) among fruit yield and yield contributing characters in bitter melon

Character	Plant height	Day to 1 st male flower appearance	Day to 1 st female flower appearance	Days to 1 st picking	Number of fruits per plant	Average fruit weight	Fruit length	Fruit diameter	Internodal length	Seed per fruit	Sex ratio	Yield per plant
Plant height	0.2000	0.0404	-0.0456	0.0221	0.0382	0.0557	-0.0696	0.0822	0.0821	0.0213	-0.0663	0.3383**
Day to 1 st male flower appearance	-0.0371	-0.1837	-0.1119	-0.0049	-0.0079	-0.0891	0.0085	-0.0283	-0.0273	-0.0354	0.0753	0.4068**
Day to 1 st female flower appearance	-0.0508	0.1357	0.2229	0.0093	0.0038	-0.0158	-0.0342	0.0117	0.0124	0.0421	0.0065	-0.0913
Days to 1 st picking	0.0008	0.0002	0.0003	0.0074	0.0017	0.000	0.0013	0.0015	0.0015	0.0011	-0.0025	0.0655
Number of fruits per plant	0.0796	0.0179	0.007	0.0978	0.4161	0.0466	0.0677	0.1278	0.1261	0.0463	-0.2288	0.4919**
Average fruit weight	0.299	0.521	-0.0759	0.0009	0.1202	0.0740	0.4037	0.2574	0.2564	0.4478	-0.7465	0.9203**
Fruit length	-0.0325	-0.0043	-0.0143	0.0161	0.0152	0.0351	0.0932	0.0079	0.0077	0.0485	-0.0371	0.3861**
Fruit diameter	-0.0495	-0.0185	-0.0063	0.0251	0.0369	0.0288	0.0102	0.1204	0.1212	0.0339	-0.0408	0.3303**
Internodal length	0.0467	0.0169	0.0063	-0.0237	-0.0345	-0.0272	0.0094	0.1146	0.1138	0.0319	0.0385	0.3277**
Seed per fruit	-0.0103	-0.0186	-0.0182	-0.0138	-0.0107	-0.0402	0.0501	0.0271	-0.027	-0.0963	0.0336	0.4041**
Sex ratio	-0.0404	0.0499	-0.0035	-0.0418	-0.067	-0.0847	-0.0485	-0.0413	-0.0412	-0.0425	0.1218	-0.8074**

*Significant at 5% level, **significant at 1% level.

fruit and yield per plant. The results of the correlation study showed that there was a strong negative association between the sex ratio and fruit yield per plant. Radha et al. (2015) and Triveni et al. (2021) revealed similar results in bitter gourd.

Path coefficient analysis: Plant height showed a strong

positive association and positive direct influence with yield per plant and also had favourable indirect effects on the number of days until the first male flower appeared, the number of days until the first fruit was picked, the average fruit weight, the fruit diameter, internodal length, and number of seeds per fruit. Thus, this characteristic showed a

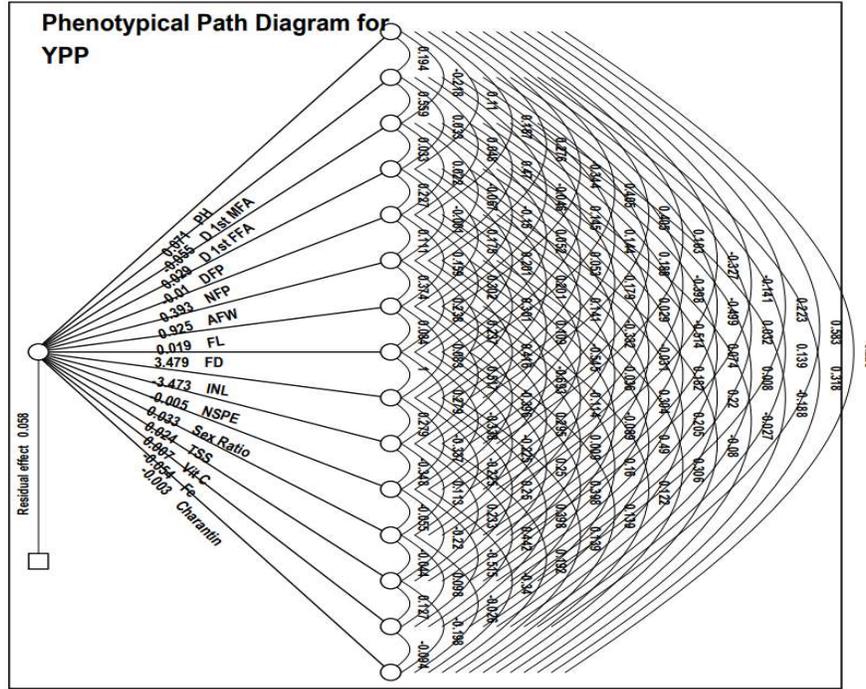


Fig. 1. Phenotypical path diagram for yield per plant (kg)

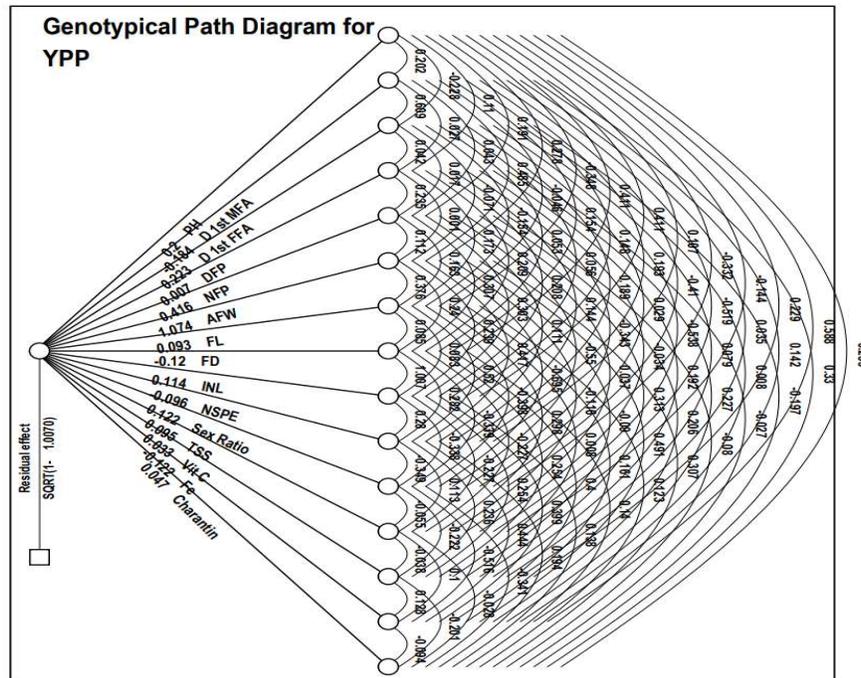


Fig. 2. Genotypical path diagram for yield per plant (kg).

significant beneficial direct influence as well as a positive connection with yield per plant. Likewise, there was a substantial positive correlation and a positive direct effect between internodal length and the dependent variable, which is yield per plant.

The parameter days to first male flower appearance showed a strong positive correlation and a negative direct influence on yield per plant. Plant height, days to first female appearance, days to first harvesting, number of fruits per plant, average fruit weight, fruit diameter, and internodal length were among the other indirect effects that demonstrated unfavourable results. On the other hand, there was a non-significant negative correlation and a positive direct impact between days to first female flower appearance and yield per plant. Additionally, it revealed detrimental indirect impacts via fruit length, average fruit weight, and plant height. The days to first male and female flower appearance showed a negative connection with yield per plant and a positive direct influence. The days to first picking showed a non-significant positive correlation and a positive direct impact at the genotypic and phenotypic levels, respectively.

There was a substantial positive correlation and positive direct impact between the number of fruits per plant and the yield per plant. The plant height, days to first male flower emergence, average fruit weight, internodal length, fruit length, fruit diameter, and seed per fruit all showed positive indirect effects for this characteristic. Similarly, yield per plant was positively correlated and positively affected directly by average fruit weight. Additionally, plant height, days to first male flower emergence, number of fruits per plant, fruit length, and fruit diameter all had a positive indirect impact for this characteristic. There was positive association between the average fruit weight and the number of fruits per plant, as well as a favourable direct influence on yield per plant.

Similarly, there was a substantial positive correlation and positive immediate effect between fruit length and yield per plant. The days to first picking, number of fruits per plant, average fruit weight, fruit diameter, internodal length, and number of seeds per fruit also shown favourable indirect effects. Fruit diameter similarly showed a substantial positive association and positive direct influence with yield per plant. Additionally, this trait showed positive indirect impacts in the following metrics: average fruit weight, internodal length, days to first picking, number of fruits per plant, and seed per fruit.

The number of seeds per fruit showed a strong positive association and a negative direct impact with the yield per plant. With the exception of fruit diameter, which showed a positive influence, this feature showed negative indirect

effects for every trait that was the subject of the analysis. Sex ratio, on the other hand, had a strongly negative association and a positive direct impact with respect to yield per plant. There was also adverse indirect impacts on yield for all characteristics, with the exception of days to male flower appearance.

The average fruit weight was found to have the highest positive direct effect when the path coefficient analysis of different characters that contribute to fruit yield per plant was performed. This was followed by the number of fruits per plant, plant height, days to female flower appearance, fruit length and diameter, internodal length, and sex ratio. It is desirable to choose direct selection based on features that exhibit strong positive direct effects. Studies on bitter gourd in earlier research are consistent with these results (Dubey and Maurya 2013, Pathak et al., 2014, Khan et al., 2015, Singh et al., 2015, Jatav et al., 2016, Alekar et al., 2019 and Triveni et al., 2021).

CONCLUSIONS

The genotypic correlations will exhibit higher magnitudes compared to their corresponding phenotypic correlations for most traits, suggesting that genotypes are superior, but their expression is diminished under environmental influence. Fruit yield displayed significant and positive correlations with plant height, number of fruits per plant, average fruit weight, fruit length, fruit diameter, internodal length, and seed per fruit. Path analysis further revealed that the traits viz., number of fruits per plant, plant height, days to 1st female flower appearance, sex ratio and fruit diameter exerted a direct positive effect on yield, emphasizing the importance of considering these traits collectively for enhancing yield in bitter gourd cultivation.

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