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Prediction of biophysical attributes for high yielding genotypes of bitter gourd (*Momordica charantia L.*) for rainfed condition

S. Raja*, H. K. Joshi, B. G. Bagle and S. K. Sharma[1]
Central Horticultural Experiment Station (CIAH), Vejalpur-389340 (Gujarat)
[1]Central Institute for Arid Horticulture, Bikaner-334006 (Rajasthan)
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Abstract

An investigation on prediction model to identify suitable genotype by character association and path analysis was undertaken with forty-six genotypes of bitter gourd. The results revealed that in general, the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficient level. The fruit yield per plot had a strong positive and significant association with number of female flowers per plot, number of fruits per plot, fruit girth, fruit length, number of primary branches and main vine length. Node of first female flower appeared and days to first fruit harvest showed negative association with yield. The path analysis revealed that fruit length, 100 seed weight, no. of female flower per plot, no. of fruits per plot, no. of primary branches per plant and main vine length exhibited strong positive direct effect on yield per plot. Days to first fruit harvest, no. of seeds per fruit, fruit girth had direct negative effect on yield. Hence the selection based on these characters will be effective in formulating selection indices for improvement of high yielding genotypes in bitter gourd for zero irrigation system.

Key words: *Biophysical attributes, high yield, bitter gourd, rainfed condition*

Introduction

Bitter gourd (*Momordica charantia* L.) is an important vegetable crop among cucurbitaceous vegetables grown in the country for its nutritionally rich green edible fruits having tremendous medicinal value, in addition seed oil is of having export potential (Chang *et al*., 1996) in the paint industry and seed protein said to inhibit the growth of immuno deficiency virus (HIV-1) in human cells cultures (Singh *et al*., 2001). Although the crop is cultivated widely in large parts of the country, the contribution from rainfed area is very meager due to lack of suitable variety, as yield is a polygenically controlled complex character affected by large number of components. Grafius (1959) suggested that there may not be one gene for yield per se, but rather for various components, the multiplicative interaction of which results in the artifact of yield. Inadequate moisture in the soil or loss of water through stomatal transpiration exceeds the plant capacity to compensate internal loss in the crop causes water stress and it affects plant survival, growth, flowering and produce quality lead the crop barren sometimes especially in the rain fed area (zero irrigation system), the farmers are compelled to prefer field crops rather to grow vegetables. A land race is a mixture of genotypes, which evolved largely as a result of natural selection over numerous generations, under the environmental conditions on which land races are presently grown. Rios Labrada *et al.* (1998) studied in this direction to assess the role of pumpkin land races for tolerance to marginal condition characterized by drought, high temperature and biotic stress interactions. Hence, the knowledge of correlation between yield and component characters and among component characters themselves and path analysis would give better appreciation of cause and effect relationship between pair of characters, are very much essential for a rational and directed improvement in yield under rain fed system.

*Corresponding author's email:
rajascientists@gmail.com

Material and methods

The present study was conducted at Central Horticultural Experiment Station (CIAH)(ICAR), Vejalpur (Gujarat), comprising forty-six diversified genotypes of bitter gourd collected from different parts of the country. The experimental site located at 22°41, 33" and 73°33'22" and lies between 110-115M above mean sea level. The annual rainfall mainly confined to three months (July to September) with an average of 35 rainy days a year. The annual maximum and minimum temperatures ranges from 42-43C in May and 6-7C in January respectively. The annual potential evapotranspiration ranged from 1500-1600mm against the annual precipitation 750mm.The genotypes were assessed in the field experiment under randomized block design and the treatments were replicated thrice. Six plants were maintained in each plot per replication spaced at 3.5 x 1.0m between rows and plants respectively. All Cultural practices including need based plant protective measures were followed. The data were recorded for main vine length (m), no. of primary branches, days to first female flower anthesis, node of first female flowers appeared, no of female flowers per plant, days to first fruit harvest, no. of fruits per plot, fruit weight (kg), fruit length (cm), fruit girth (cm), fruit flesh thickness (cm), 100 seed weight (g) , no. of seed per fruit and yield per

Table 1. Genotypic (rg), phenotypic (rp) and environmental (re) correlation coefficients among 14 characters in bitter gourd.

Sl.No.	Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Main vine length (cm)	rg	0.32	0.06	-0.29	0.49**	-0.06	0.26	0.28	0.19	0.20	0.12	0.30	0.26	0.38*
		rp	0.29	0.06	-0.24	0.46**	-0.04	0.23	0.26	0.18	0.14	0.11	0.25	0.23	0.36
		re	-0.01	0.04	-0.02	0.15	0.08	-0.14	-0.10	0.03	-0.02	-0.03	0.06	0.07	0.06
2	No of primary branches per plant		rg	0.06	-0.16	0.44**	-0.10	0.22	0.36	0.18	0.16	0.01	0.06	0.06	0.41*
			rp	0.05	-0.13	0.41*	-0.07	0.19	0.35	0.16	0.12	0.00	0.09	0.03	0.37
			re	-0.01	0.01	-0.00	0.09	-0.19	0.19	-0.03	0.01	-0.09	0.25	-0.14	-0.10
3	Days to first female flower anthesis			rg	0.05	0.21	-0.29	-0.05	0.11	-0.01	0.09	-0.15	0.02	-0.10	0.10
				rp	0.05	0.21	-0.22	-0.05	0.10	-0.01	0.08	-0.13	0.04	-0.02	0.08
				re	0.09	0.20	0.08	-0.04	0.03	-0.03	0.07	-0.01	0.08	0.26	-0.05
4	Node of first female flower appeared				rg	-0.01	0.43**	0.12	-0.61**	-0.27	-0.13	-0.05	-0.34	-0.48**	-0.12
					rp	0.01	0.35	0.11	-0.53**	-0.24	-0.04	-0.05	-0.22	-0.36	-0.12
					re	0.19	0.03	0.12	-0.08	-0.06	0.12	-0.05	0.06	-0.02	-0.13
5	No. of female flower per plant					rg	-0.07	0.55**	0.21	0.25	0.44**	0.27	0.10	0.06	0.61**
						rp	-0.07	0.52**	0.19	0.24	0.32	0.24	0.10	0.06	0.56**
						re	-0.11	0.00	-0.09	0.08	0.00	-0.11	0.14	0.07	-0.11
6	Days to first fruit harvest (Days)						rg	0.13	-0.21	0.07	-0.28	0.04	0.04	-0.05	-0.26
							rp	0.10	-0.20	0.04	-0.16	0.03	0.06	-0.04	-0.24
							re	-0.16	-0.12	-0.21	0.14	-0.05	0.12	-0.00	0.01
7	No. of fruits per plant							rg	0.08	0.25	0.32	0.34	0.22	0.08	0.52**
								rp	0.07	0.22	0.25	0.33	0.14	0.07	0.50**
								re	0.04	-0.19	0.10	0.11	-0.24	0.02	0.14
8	Fruit weight (kg)								rg	0.31	0.32	0.23	0.59**	0.59**	0.28
									rp	0.30	0.23	0.22	0.48**	0.50**	0.27
									re	0.01	-0.03	0.04	0.04	-0.00	-0.07
9	Fruit length (cm)									rg	0.02	0.37	0.24	0.50**	0.38*
										rp	0.00	0.35	0.20	0.40*	0.36
										re	-0.12	0.03	0.05	-0.10	0.11
10	Fruit girth (cm)										rg	0.40**	0.38*	0.02	0.47**
											rp	0.27	0.26	0.10	0.34
											re	-0.11	0.06	0.24	-0.01
11	Fruit flesh thickness (cm)											rg	0.41**	0.37	0.30
												rp	0.32	0.29	0.29
												re	-0.05	-0.10	0.11
12	100 seed weight (g)												rg	0.75**	0.19
													rp	0.55**	0.14
													re	0.05	-0.11
13	No. of seed per fruit													rg	0.05

Table 2. Estimates of (Direct and Indirect effects) path coefficients at genotypic level on yield of bitter gourd under zero irrigation condition.

Sl.No.	Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Main vine length (cm)	**0.118**	0.040	-0.009	-0.017	0.152	0.025	0.050	-0.010	0.079	-0.004	0.017	0.107	-0.180	0.338
2	No. of pri. branch / plant	0.038	**0.123**	-0.009	-0.010	0.138	0.038	0.042	-0.012	0.074	-0.003	0.001	0.024	-0.044	0.410*
3	Days to first female flower anthesis	0.008	0.008	**-0.138**	0.003	0.066	0.109	-0.011	-0.004	-0.006	-0.002	-0.021	0.009	0.067	0.101
4	Node of first female flower appeared	-0.035	-0.020	-0.006	**0.060**	-0.003	-0.163	0.023	0.021	-0.112	0.002	-0.008	-0.121	0.322	-0.128
5	No. of female flowers per plant	0.058	0.055	-0.029	-0.000	**0.309**	0.028	0.105	-0.007	0.101	-0.009	0.038	0.038	-0.041	0.613**
6	Days to first fruit harvest (Days)	-0.008	-0.012	0.040	0.026	-0.023	**-0.375**	0.025	0.007	0.028	0.005	0.006	0.015	0.033	-0.268
7	No. of fruits/ plant	0.031	0.027	0.008	0.007	0.171	-0.049	**0.190**	-0.002	0.101	-0.006	0.048	0.078	-0.058	0.524**
8	Fruit weight (Kg)	0.034	0.045	-0.015	-0.037	0.065	0.080	0.015	**-0.035**	0.126	-0.006	0.032	0.207	-0.396	0.285
9	Fruit length (cm)	0.023	0.022	0.002	-0.016	0.078	-0.026	0.047	-0.011	**0.403**	-0.000	0.052	0.087	-0.336	0.383*
10	Fruit girth (cm)	0.024	0.020	-0.013	-0.008	0.137	0.106	0.061	-0.011	0.010	**-0.020**	0.056	0.134	-0.018	0.475**
11	Flesh thickness (cm)	0.015	0.001	0.021	-0.003	0.086	-0.016	0.066	-0.008	0.150	-0.008	**0.139**	0.146	-0.253	0.306
12	100 seed weight (g)	0.036	0.008	-0.003	-0.020	0.033	-0.016	0.042	-0.020	0.100	-0.008	0.058	**0.351**	-0.504	0.194
13	No. of seed per fruit	0.031	0.008	0.013	-0.029	0.019	0.018	0.016	-0.021	0.202	-0.000	0.052	0.264	**-0.669**	0.055

*-Significant at 5% level and ** significant at 1 % level. Bold values are direct effects (Residual effect at genotypic level =0.575

plot (kg), The mean data were subjected for statistical analysis of genotypic ,phenotypic and environmental correlation coefficients following the method suggested by Al-Jibouri *et al.* (1958) and path coefficient analysis to partition the total correlation in to direct and indirect effects to assess the character association by following Deway and Lu(1959) method.

Results and discussion

The genotypic as well as phenotypic correlation coefficients among different pairs of characters are presented in Table 1. In general, values of correlations at the genotypic levels were higher than the corresponding characters at phenotypic level. This indicates an inherent association among various characters and the genotypic superiority through their phenotypic expression was lessened under the influence of environment. The yield had significant and positive relation with no of fruits per plant, no of female flowers per plot fruit length, fruit girth, no. of primary branches per plant and main vine length. Therefore, these characters should be given due care to improve the fruit yield per plant. This result suggested the effective improvement in bitter gourd yield could be achieved through these attributes by simple recurrent selection. This result is in concordance with the findings of Sharma and Bhutani (2001) in Bitter gourd, Pandey *et al* (2002) and Gopalkrishnan *et al.* (1980) in Pumpkin, Rolania *et al.* (2003) in watermelon, Rao *et al.*(2004) in cucumber. Node of first female flower appeared and days to first fruit harvest found to be negatively correlated with yield at genotypic and phenotypic levels despite of its non significant and it is contradicting with findings of Sharma and Bhutani(2001) in bitter gourd.

The vegetative characters appeared to be vital to consider with due emphasis to identify the best genotype at the early growth stage especially for zero irrigation system. In the present study, the main vine length had a significant positive correlation with no. of female flowers per plot and yield per plot. However, the no. of primary branches per plant, 100 seed weight and no. of seed per fruit, no. of fruits per plot and fruit weight associated positively and node to first female flower days to first fruit harvest showed negative and non- significant association with main vine length. Number of branches per plant had significant and positive correlation with no. of female flowers per plot, fruit weight and yield per plot. Prasad *et al.* (1993) and Gopal *et al.* (1996) have also reported similar results in watermelon. These results conclude the inclusion of number of branches per plant and main vine length could improve the higher no of female flowers and fruit weight under zero irrigation system to results higher yield per plot.

In fact, the relationship between earliness (node to first female flower appeared) and yield depends upon the timing of water stress. Node of first female flower appeared exhibited significant positive correlation with days to first fruit harvest and significant negative association with fruit weight and no. of seeds per fruit at genotypic and phenotypic levels. This result indicates the early appearance of first female flower found to facilitate early fruit harvest and delay or late appearance of flower would coincide with stress period and the plant might not produce marketable fruit size and less no. of seeds per fruit due to inadequate soil moisture, predicting the genotypes with longer node for first female flower tended to have lower yielder in the environment. Otherwise the earliness is preferred as it is considered as good drought escape mechanism in production area where the terminal drought is encountered because of early withdrawal of rains (1989). This result is in consonance with finding of Rajanarayanan *et al.* (1996) in bottle gourd. No. of female flowers per plot had strong significant positive correlation with no. of fruits per plot, main vine length, no. of primary branches per plant, fruit girth and yield per plot. This result is in consonance with Dahiya *et al.* (1989) in round melon. It is understood from the results that the higher number of female flower per plot and higher number of branches per plant is an indicator for early flowering as well as for higher number of fruits per plot.

Days to fruit harvest is an highly important character as for as zero irrigation system is concern, as the critical stage of the crop and the soil moisture deficit coincide together in this stage. Days to fruit harvest had significantly positive correlation with node of first female flower appeared and showed non-significant negative correlation with fruit weight, fruit girth, no. of seeds per fruit and yield per plot. From the results, it is understood that the late bearing genotype undergoes stress and thereby results lesser yield per plot. Hence early harvesting may boost the no of fruits per plant so as to ensure higher yield per plant. Dahiya *et al.* (1989) in round melon and Rao *et al* (2004) in cucumber also reported the similar results. Number of fruits per plot showed strong significant positive correlation with no. of female flowers per plot and yield per plot. Fruit weight showed positive significant correlation with 100 seed weight and no of seeds per fruit and significant negative association with node of first female flower appeared. Although, it showed positive correlation with fruit length, fruit girth, fruit flesh thickness and yield per plot, they were non significant. This result is in conformity with the findings of Sharma and Bhutani (2001) in bitter gourd, Mohanty (2001) in Pumpkin, Choudhary *et al.* (2003) in muskmelon and Rao *et al.* (2004) in cucumber.

Fruit length exhibited the positive significant association with no. of seeds per fruit and yield per plot. Fruit girth showed positive and significant correlation with fruit flesh thickness, 100 seed weight, no. of female flowers per plot and yield per plot. Flesh thickness had significant positive correlation with fruit girth and 100 seed weight. This result indicates the importance of plant health at fruit development stage to improve the flesh thickness under zero irrigation system. This result is in support with findings of Sharma and Bhutani (2001) in bitter gourd, Dhaliwal *et al.* (1996) and Choudhary *et al. (2003)* in muskmelon and Abusaleha and Dutta (1988) in cucumber. 100-seed weight had strong significantly positive correlation with fruit weight, fruit girth, fruit flesh thickness and no. of seeds per fruit. Cui shimao *et al.* (1996) also reported that 1000 seed weight had positive correlation with fruit weight, fruit width, fruit length, seed length and seed width in pumpkin.

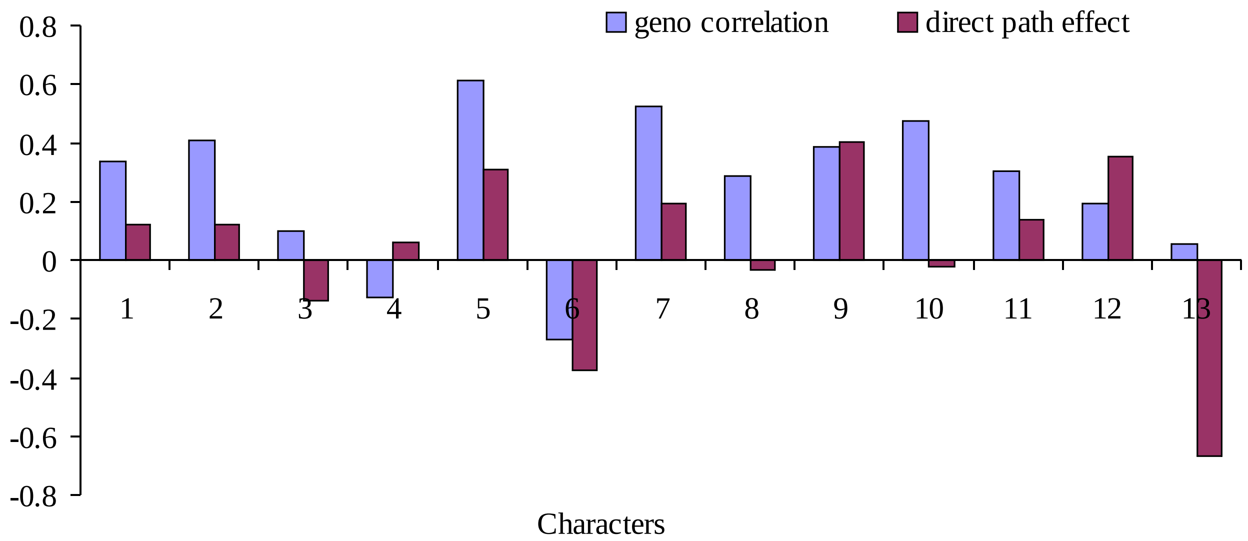

Fig. 1. Association of 13 yield components and their direct effects with yield at genotypic level in bitter gourd

The direct and indirect effects of various characters along with their genotypic correlation with yield are presented in Table 2. Correlation may not be much reliable and can misguide, as inclusion of more characters the indirect association becomes more complex, therefore to find out the actual dependence of yield on its components the path coefficient analysis is much essential which partition the correlation coefficients in to direct and indirect effects of various characters on yield. The results of path analysis revealed as that of highly significant correlation of yield with node of first female flower appeared (r=0.613), no. of fruits per plant (0.524), fruit length (0.383) and 100 seed weight (0.472) at genotypic level, the highest positive direct contribution (0.309, 0.190, 0.403 and 0.351 respectively) of these characters towards yield. This result is consonance with findings of Sharma and Bhutani (2001) in bitter gourd, Rao *et al.* (2004) in cucumber, Raj narayanan *et al.* (1996) in bottle gourd, Dahiya *et al.* (1989) in round melon and Kalloo *et al.* (1982) in muskmelon. Though, the no. of primary branches per plant and main vine length showed strong positive association (r=0.410 and r=0.338) with yield, the direct contribution towards yield was low (0.123 and 0.118) in path analysis .On the other hand it contributed indirectly via no. of female flowers per plot (0.138 and 0.152 respectively).

Days to first female flower anthesis (-0.138), days to first fruit harvest (-0.375) and no. of seeds per fruit (-0.669) showed direct negative effect on yield, although the days to first female flower anthesis and no of seeds per fruit exhibited non significant positive correlation, strongly indicates their negative direct effect contribute much in selecting genotypes with early flowering with lesser no. of seed per fruit as they indirectly contributed via days to first fruit harvest (0.109) and 100 seed weight (0.264) respectively. Fruit weight and fruit girth exhibited positive association with yield despite showed the negative direct effect indicating these two characters contributed indirectly via fruit length (0.126 and 0.105 respectively). This result is in conformity with report of Sharma and Bhutani (2001) in bitter gourd and Rajnarayanan *et al.* (1996) in bottle gourd. It is understood from the residual effect infers the total genotypic variability in yield has been explained by the characters associated in the study, however, some more factors, not considered here required to be included in the analysis to account fully for the variation in yield.

It is concluded (Fig. 1) that the high yielding genotype should possess higher main vine length with early days to first female flower anthesis and node of first female flower appeared, with optimum fruit weight with more flesh thickness are considered highly dependable and reliable for improving yield in bitter gourd under zero irrigation system.

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