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Jagati Yadagiri
Depertment of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore, Madhya Pradesh, India

NK Gupta
Depertment of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore, Madhya Pradesh, India

Deeksha Tembhre
Depertment of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore, Madhya Pradesh, India

Sheela Verma
Depertment of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore, Madhya Pradesh, India

Correspondence
Jagati Yadagiri
Depertment of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore, Madhya Pradesh, India

Genetic variability, correlation studies and path coefficient analysis in bitter gourd (*Momordica charantia* L.)

Jagati Yadagiri, NK Gupta, Deeksha Tembhre and Sheela Verma

Abstract
A field experiment was conducted at Vegetable Research Farm, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Indore (M.P.) during the *kharif* season in the year 2012-13. The present investigation was undertaken with 20 genotypes of bitter gourd for evaluating their performance for various horticultural characters. There was a great deal of significant correlation for all the characters among the genotypes. Correlation analysis revealed that Length of vine (0.640), number of branches per vine (0.577), number of male flowers per vine (0.594), number of female flowers per vine (0.529), number of fruits per vine (0.649), length of fruit (0.724), weight of fruit (0.961), number of seeds fruit (0.360), seed weight per fruit (0.380) had significant positive correlation for yield. Further, path coefficient analysis partitioned the correlation into direct and indirect effects. Yield was found to be directly correlated with crop duration (0.004), length of vine (0.030), number of seeds per fruit (0.045) and length of fruit (0.094) hence selection based on these characters would be more rewarding.

Keywords: *Momordica charantia* L., Correlation, Yield characters, Path analysis

Introduction
Bitter gourd (*Momordica charantia* L) is an important gourd having wide range of uses and is largely cultivated in the tropical and sub-tropics for its edible fruits. The assessment of correlation and path coefficient analysis present in any crop species is an essential pre-requite for formulating an effective breeding programme, as the existing correlation and path coefficient analysis can be used to enhance the yield level of cultivars following appropriate breeding strategies (Sharma and Bhutani 2001, Bhave 2003, Singh *et al*. 2008, Islam 2009) [13, 2, 15, 7]. Bitter gourd is monoecious and highly cross-pollinated in nature. Such pollination mechanism can be exploited for hybrid seed production commercially. In cucurbitaceous vegetables only male flowers appear in the beginning and the female flower appears later while growth, flowering and sex expression was come up by their genetic makeup. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Further path coefficient analysis is an efficient tool to elucidate the direct and indirect effect of each character towards yield. The present study was, for such motives, undertaken with the objective to find out and determine the study on correlation and path coefficient analysis in bitter gourd (*Momordica charantia* L).

Materials and Methods
The experiment was conducted at Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Indore (M.P.) during the kharif season of 2012-13. The experimental materials of comprised 20 diverse genotypes viz Jhalri, MC- 84, Long Jhalri (S-71), MC-23, Swasti, G-323, Jhalandhar Spl, PDM, NS-1024, VRBT-1, White Long, DVBTG-5, Green Long, DRBS-36, PBIG-1, IC-505208, Muland Local, VRBT-04, Chhuha type and VRBT-37 of bitter gourd, which were collected from different parts of India. The experiment was laid down in randomized block design (RBD) with three replications. The crop was managed as per recommended package of practices to raise the crop during kharif season. In each replication, seeds of each genotype were sown in 3 m long rows at 1 m distance between lines and 1 m between plants. Five plants of each genotype were randomly selected from each replication for recording horticultural traits viz length of vine (LV), number of branches per vine (NB), Internodal distance per vine (ID), number of male flowers per vine (NMF), number of female flower per vine (NFF), days to 50% male flower initiation (D50% MFI), days to 50%

female flower initiation (D50% FFI), number of fruits per vine (FV), length of fruit (LF), diameter of fruit (DF), weight of fruit (WF), number of seeds per fruit (NSF), seed weight per fruit (SWF), yield per vine (YV), days to marketable yield (DMY) and crop duration (CD). The correlations were worked out as per methods suggested by Johnson *et al.* (1955) [8], Al-Jibouri *et al.* (1958) [1] and path analysis was calculated according to Dewey and Lu (1959) [4].

Results and Discussion

The estimates of genotypic correlation were slightly higher than their corresponding phenotypic correlation for all the characters (Table 1). This could be interpreted on the basis that there was a strong inherent genotypic relationship between the characters studied, but their phenotypic expression was impeded by the influences of environmental factors. Correlation co-efficient analysis revealed that fruit yield per vine showed positive and significant correlation with weight of fruit (gm) (0.967), number of fruits per vine (0.762), length of fruit (cm) (0.759), number of branches per vine (0.663), length of vine (cm) (0.654), number of female flowers per plant (0.617), number of male flowers per plant (0.601), seed weight per fruit (gm) (0.421), internodal distance per vine (cm) (0.417) at genotypic level. Whereas weight of fruit (gm) (0.961), length of fruit (cm) (0.724), number of fruits per vine (0.649), length of vine (cm) (0.640), number of male flowers per plant (0.594), number of branches per vine (0.577), number of female flowers per plant (0.529) at phenotypic level. Since, these association characters are in the desirable direction, selection for these traits may improve the yield per vine.

These results are in confirmed with Singh *et al.* (2012) [14], Islam *et al.* (2009) [7], Singh *et al.* (2008) [15], Dey *et al.* (2007) [5], Bhave *et al.* (2003) [2]. Length of vine had significant and positive correlation with number of branches per vine, number of male flowers per plant, number of female flowers per plant, number of fruits per vine, length of fruit (cm), weight of fruit (gm), yield per vine (kg) and crop duration. Number of branches per vine had significant and positive correlation with number of fruits per vine, length of fruit (cm), weight of fruit (gm) and yield per vine (kg). Number of male flowers per plant had significant and positive correlation with Number of female flowers per plant, weight of fruit (gm), number of seeds per fruit, seed weight per fruit (gm), yield per vine (kg) and crop duration. Number of female flowers per plant had significant and positive correlation with weight of fruit (gm), seed weight per fruit (gm), yield per vine (kg) and crop duration. Days to 50% female flower initiation had significant and positive correlation with days to marketable yield. Number of fruits per vine had significant and positive correlation with length of fruit (cm), weight of fruit (gm) and yield per vine (kg). Length of fruit (cm) had significant and positive correlation with weight of fruit (gm) and yield per vine (kg). Weight of fruit (gm) had significant and positive correlation with number of seeds per fruit, seed weight per fruit (gm), yield per vine (kg) and crop duration. Number of seeds per fruit had significant and positive correlation with seed weight per fruit (gm). Yield per vine (kg) had significant and positive correlation with crop duration both at phenotypic and genotypic level.

Internodal distance per vine (cm) had significant and negative association with fruit yield per vine both at phenotypic and genotypic level. Days to 50% male flower initiation had non-significant and negative association with fruit yield per vine both at phenotypic and genotypic level. The results are in conformity with Dalamu-Behera (2013) [3], Dora *et al.* (2002) [6], Singh *et al.* (2008) [15], Kumar *et al.* (2007) [9], Kutty *et al.* (2004) [10], Pandey *et al.* (2013) [11].

Path analysis revealed that among 16 traits, few traits namely, number of branches per vine (0.81), weight of fruit (0.79), length of fruit (0.09), number of fruits per vine (0.08) and number of seeds per fruits (0.04) exhibited positive direct effects on fruit yield per vine. Internodal distance per vine (-0.08), seed weight per fruit (-0.06), days to 50%nmale flower initiation (-0.05) and diameter of fruit (-0.01) were found to be negatively associated with total yield per vine but in desirable direction because negative values of these traits are beneficial and contribute positively to the yield per vine (Table 2). The characters, that is, weight of fruit, length of fruit, number of fruits per vine, number of seeds per fruits and number of branches per vine was positively correlated with total yield per vine (Rajput *et al.* 1996) [12].

On the basis of this study, it can be concluded that correlation study suggested that for improvement in yield, selection for such a plant having fruit yield per vine, weight of fruit, number of seeds per vine and length of fruit would be beneficial. weight of fruit, length of fruit, number of fruits per vine, number of seeds per fruit were found to be the important characters for increasing the yield potential in bitter gourd. Among the genotypes, Long Jhalri (S-1) (1294.10 kg), Jhaldhar Spl (1092.63 kg), White long (370.19 kg) and MC-23 (362.02 kg) were found to be higher in total yield per vine, which could be gainfully utilized in further breeding/improvement programme.

Table 1: Genotypic (rg) and phenotypic (rp) correlation coefficients between different characters in bitter gourd

Characters		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X1	Rg	1.00	0.816**	-0.386*	0.579**	0.551**	0.026	0.062	0.588**	0.801**	-0.359*	0.529**	0.158	0.247	0.654**	0.022	0.797**
	rp	1.00	0.709**	-0.318	0.564**	0.456**	-0.028	-0.032	0.486**	0.735**	-0.261	0.525**	0.163	0.219	0.640**	0.009	0.497**
X2	Rg		1.00	-0.334*	0.392*	0.500**	0.475**	0.104	0.588**	0.727**	-0.317	0.584**	0.295	0.453**	0.663**	0.066	0.590**
	Rp		1.00	-0.252	0.337 *	0.411 *	0.255	0.123	0.432**	0.607**	-0.186	0.506**	0.244	0.319	0.577**	0.117	0.404 *
X3	Rg			1.00	-0.027	-0.057	0.809**	0.280	-0.619**	-0.585**	-0.013	-0.264	0.208	0.272	-0.417*	0.292	-0.221
	Rp			1.00	-0.016	-0.046	-0.256	0.108	-0.470**	-0.528**	0.106	-0.234	0.175	0.251	-0.377	0.328	-0.139
X4	Rg				1.00	0.979**	-0.407*	0.091	0.297	0.231	0.171	0.612**	0.557**	0.717**	0.601**	0.127	0.968**
	Rp				1.00	0.827**	-0.133	0.047	0.234	0.208	0.105	0.603**	0.546**	0.637**	0.594**	0.076	0.581**
X5	Rg					1.00	-0.194	0.079	0.195	0.273	0.073	0.622**	0.523**	0.725**	0.617**	0.194	0.907**
	Rp					1.00	-0.189	0.079	0.134	0.218	0.012	0.528**	0.420 *	0.629**	0.529**	0.092	0.623**
X6	Rg						1.00	-0.312	-0.068	0.107	0.078	-0.026	-0.023	-0.013	-0.141	-0.238	-0.357*
	Rp						1.00	-0.076	0.022	0.040	-0.039	-0.253	0.066	-0.038	-0.064	-0.190	-0.045
X7	Rg							1.00	-0.244	0.314	0.577**	0.530**	0.546**	0.669**	0.357*	1.503**	0.086
	Rp							1.00	0.010	0.180	0.210	0.313	0.321	0.378 *	0.203	0.580**	0.223
X8	Rg								1.00	0.671**	0.123	0.644**	0.018	-0.021	0.762**	-0.285	0.398*
	Rp								1.00	0.558**	0.083	0.547**	-0.007	0.021	0.649**	-0.062	0.257
X9	Rg									1.00	-0.223	0.641**	0.017	-0.026	0.759**	0.194	0.677**
	Rp									1.00	-0.148	0.613**	-0.015	0.009	0.724**	0.148	0.429 *

X10	Rg										1.00	0.455**	0.250	0.309	0.251	0.345*	-0.078
	Rp										1.00	0.320	0.134	0.210	0.196	0.379 *	-0.007
X11	Rg											1.00	0.463**	0.539**	0.967**	0.427	0.877**
	Rp											1.00	0.451**	0.489**	0.961**	0.269	0.555**
X12	Rg												1.00	0.913**	0.275	0.550**	0.673**
	Rp												1.00	0.772**	0.360 *	0.260	0.390 *
X13	Rg													1.00	0.421*	0.731**	0.629**
	Rp													1.00	0.380 *	0.358 *	0.355 *
X14	Rg														1.00	0.253	0.893**
	Rp														1.00	0.178	0.571**
X15	Rg															1.00	0.115
	Rp															1.00	0.134
X16	Rg																1.00
	Rp																1.00

X1- length of vine (cm) X2- Number of branches per vine X3- Internodal distance per vine (cm)
X4- Number of male flowers per plant X5- Number of female flowers per plant X6- Days to 50% male flower initiation
X7- Days to 50% female flower initiation X8- Number of fruits per vine X9- Length of fruit (cm)
X10- Diameter of fruit (cm) X11- Weight of fruit (gm) X12- Number of seeds per fruit
X13- Seed weight per fruit (gm) X14- Yield per vine (kg) X15- Days to marketable yield
X16- Crop duration

Table 2: Direct (diagonal) and indirect effect of different correlation characters on total yield per vine

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	R
X1	0.030	0.031	0.026	0.012	0.015	-0.002	-0.002	0.041	0.069	0.004	0.418	0.007	-0.014	0.000	0.002	0.363
X2	0.021	0.044	0.021	0.007	0.014	-0.015	-0.008	0.036	0.057	0.003	0.402	0.011	-0.020	0.002	0.002	0.423
X3	-0.010	-0.011	-0.083	0.000	-0.002	0.015	-0.007	-0.039	-0.050	-0.002	-0.186	0.008	-0.016	0.006	-0.001	1.378
X4	0.017	0.015	0.001	0.022	0.028	0.008	-0.003	0.020	0.020	-0.002	0.480	0.025	-0.039	0.001	0.002	0.153
X5	0.014	0.018	0.004	0.018	0.033	0.011	-0.005	0.011	0.020	0.000	0.420	0.019	-0.039	0.002	0.002	0.472
X6	0.001	0.011	0.021	-0.003	-0.006	-0.059	0.005	0.002	0.004	0.001	-0.042	0.003	0.002	-0.003	0.000	1.063
X7	0.001	0.005	-0.009	0.001	0.003	0.004	-0.068	0.001	0.017	-0.003	0.249	0.015	-0.023	0.010	0.001	0.796
X8	0.015	0.019	0.039	0.005	0.004	-0.001	-0.001	0.083	0.052	-0.001	0.436	0.000	-0.001	-0.001	0.001	0.351
X9	0.022	0.027	0.044	0.005	0.007	-0.002	-0.012	0.047	0.094	0.002	0.488	-0.001	-0.001	0.002	0.002	0.276
X10	-0.008	-0.008	-0.009	0.002	0.000	0.002	-0.014	0.007	-0.014	-0.016	0.254	0.006	-0.013	0.006	0.000	0.805
X11	0.016	0.022	0.019	0.013	0.018	0.003	-0.021	0.046	0.058	-0.005	0.796	0.020	-0.030	0.005	0.002	0.038
X12	0.005	0.011	-0.014	0.012	0.014	-0.004	-0.022	-0.001	-0.001	-0.002	0.359	0.045	-0.048	0.004	0.001	0.641
X13	0.007	0.014	-0.021	0.014	0.021	0.002	-0.026	0.002	0.001	-0.003	0.384	0.035	-0.062	0.006	0.001	0.625
X14	0.000	0.005	-0.027	0.002	0.003	0.001	-0.040	-0.005	0.014	-0.006	0.214	0.012	-0.022	0.017	0.001	0.831
X15	0.015	0.018	0.011	0.013	0.021	0.003	-0.015	0.021	0.040	0.000	0.442	0.018	-0.022	0.002	0.004	0.429

r- Residal effect, X1- length of vine (cm) X2- Number of branches per vine X3- Internodal distance per vine (cm)
X4- Number of male flowers per plant X5- Number of female flowers per plant X6- Days to 50% male flower initiation
X7- Days to 50% female flower initiation X8- Number of fruits per vine X9- Length of fruit (cm)
X10- Diameter of fruit (cm) X11- Weight of fruit (gm) X12- Number of seeds per fruit
X13- Seed weight per fruit (gm) X14- Days to marketable yield X15- Crop duration

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