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Genetic variability for growth, yield and quality traits in bitter gourd

Gurleen Kaur Sidhu[1], Mamta Pathak[*] and Neena Chawla

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Abstract

The present study was conducted to determine genetic variability, broad sense heritability and genetic advance in thirty six diverse genotypes of bitter gourd. The differences observed between genotypes were highly significant for all the characters studied. Moisture content had lowest coefficient of variation (2.7) followed by anthesis of first female flower (8.4) and anthesis of first male flower (10.5); whereas, it was highest for fruit cavity (24.1). High estimates of PCV and GCV were found for total carotene content followed by yield. High heritability coupled with high genetic advance was observed for fruit number, anthesis of first male flower and vitamin C may be attributed to additive gene effects and could be improved through selection.

Keywords: *Momordica charantia*, heritibility, genetic advance, gene effects, reducing sugar

Introduction

Bitter gourd (*Momordica charantia* L.) is one of the most important vegetable grown throughout the country. Among the cucurbits, it is considered a prized vegetable because of its high nutritive value. It has immense medicinal value mainly due to its hypoglycemic properties. The origin of this crop is probably in India with secondary centre of diversity in China. Success of plant breeding depends upon the existence of genetic variability present in the breeding material. Genetic variability plays an important role for the development of improved genotype(s) for yield and other desirable traits. Some of these parameters include genotypic and phenotypic coefficients of variation. High value of these coefficients indicates wider diversity. Although a large number of bitter gourd varieties are available in India but only a few out of them are promising, thus selection of superior parent is prerequisite to know variability among them in any crop, including bitter gourd. Therefore, the present study was planned to investigate the extent of genetic variability in different bitter gourd genotypes as information on such aspects can be of great help in devising the appropriate breeding strategy for genetic enhancement of the crop.

Materials and Methods

The present study was carried out at Vegetable Research Farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana during spring season of 2013. Thirty Six diverse genotypes of bitter gourd were collected from different locations and evaluated. Seeds of all the genotypes were sown in the plug trays to get the seedlings. Ten seedlings per genotype were grown on raised beds of width 1.5 m and plant to plant spacing of 45 cm. The recommended NPK fertilizer doses, cultural practices and plant protection measures were followed to raise an ideal crop (Anonymous 2013). The observations were recorded for 14 agronomic (anthesis of first male and female flower, node at which first male and female flower appears, days to first fruit maturity, days to last harvest, fruit length and width weight, number of fruits per plant, total yield per plant, vine length, fruit cavity and number of seeds per fruit and 6 quality (i.e. moisture content, total soluble sugars, non-reducing sugars, vitamin C and carotene content) traits. The selection efficiency increases, when the traits are selected on the basis of high heritability along with high genetic advance. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (%) and genetic advance as percent of mean were worked out as per the method of Johnson et al. (1955).

Results and Discussion

Analysis of variance as shown in table 1 revealed significant difference among genotypes for all characters studied except for node to first male and female flower, fruit cavity and vine length. Similar results were reported

Department of Vegetable Science, Punjab Agricultural University, Ludhiana-141001, Punjab
*Corresponding author, E-mail:mampathak@pau.edu;
[1]Presently at Department of Plant Agriculture, University of Guelph, Ontario N1G 2W1, Canada

by Yadav et al. (2009) and Yadav et al. (2013) for most of the traits in bitter gourd. The mean values of various characters are presented in Table 2. A wide range of variation was observed for almost all the traits under studies. Data indicated that for days to first female flower varied from 59 to 83 in genotypes DBG-40 and Punjab Kareli-1, respectively. First female flower appeared at lowest node in PBBG-3, DBG-3, Jaunpuri Long (7.5) and highest in Punjab Kareli-1 (13).The genotype PBIG-56, Hirkani, PBBG-40, PBBG-6 took minimum i.e. 74 days to maturity and genotype PBBG-20 whereas, Coimbatore Long took maximum i.e. 94.5 days. Fruit length was 5 cm in line DBTG-40 and 16.65 cm in variety PBBG-7 with an overall mean of 10.53 cm. Fruit width was maximum in line PBBG-1 (4.5cm), minimum in line Coimbatore Long (1.9 cm) and the grand mean was 3.11 cm. The maximum mean for number of fruits per plant was observed in DBG-41 (102) and minimum in genotype Coimbatore Long (11) with an overall mean of 48.74. Punjab Kareli-1 fruit weight was found maximum (43.5 g) and minimum for Coimbatore Long (19.4 g). Yield varied from 291.5 g/plant in Coimbatore Long to 2072 g/plant in WBBG-48 (Table 3). Vine length was maximum in CO-1 (221cm) and minimum in WBBG-48 (148.5cm) with an overall mean of 185.65cm. The maximum mean for moisture content was observed in line PBBG-31 (96.05) and minimum in genotype WBBG-6 (88.54) with an overall mean of 91.71, whereas, the total soluble sugars was maximum in DBG-3 (4.45) and minimum in PBBG-10 (1.25) with an overall average of 3.19. The treatment mean for reducing sugar ranged from 0.575 in PBBG-10 to 2.4 in PBBG-9 with grand mean of 1.58. The genotype PBBG-1 showed lowest mean of 0.6 for non- reducing sugar and genotype PBBG-7 and PBBG-6 showed highest i.e. 2.35 with grand mean of 1.60. Treatment mean for Vitamin C was highest in PBBG-20 (142mg/100g) and lowest in PBBG-14 (64.88mg/100g) with a grand mean of 103.40mg/100g. However, Singh et al. (2017) also reported the average vitamin C content 86.73 mg/100g in bitter gourd. Cultivar Pusa Do Mausmi and PBBG-11 had highest total carotene content (1.755 mg/100g) and lowest in PBBG-9 (0.067mg/100g) with overall mean of 0.85 mg/ 100 g

The extent of variability was measured in terms of range, mean, GCV, PCV, heritibility (h^2), expected genetic advance and genetic gain. Phenotypic coefficient of variation was lowest for moisture content (3.42%) followed by days to last harvest (7.06%). Carotene content showed highest phenotypic coefficient of variation (60.61%) followed by number of seeds/fruit (40.07%). The lowest genotypic co-efficient of variation was recorded for moisture content (2.37%). It was

Table 1: Analysis of variance for various characters in bitter gourd

Source	Df	Anthesis of 1st male flower	Anthesis of 1st female flower	Node to 1st male flower	Node to 1st female flower	Days to 1st fruit maturity	Days to last harvest	Fruit length (cm)	Fruit width (cm)	No of fruits/ plant	Fruit weight	Yield/ Plant (g)	Vine length (cm)	Fruit cavity (cm)	No of seeds/ fruit	Moisture (g/100g)	Total soluble sugars (g/100g)	Reducing sugars (g/100g)	Non reducing sugars (g/100g)	Vitamin C (mg/100g)	Carotene (mg/100g)
Replication	1	5.7	5.1	7.4	7.4	0.22	9.4	0.4	0.002	75.4	4.01	16306.1	515.7	0.01	36.12	1.31	0.35	0.4	0.05	3.89	0.006
Block (rep)	10	23.7	27.56	0.74	1.92	31.5	20.9	12.1	0.62	91.1	65.8	57670.1	185.3	0.14	5.84	6.58	1.21	0.3	0.32	59.2	0.21
Treatments	35	107.4**	65.4**	1.22*	3.24*	58.2**	133.7**	12.9**	0.6**	768.3**	122.9**	273215.9**	671.2*	0.4*	20.87**	9.2**	1.5**	0.41**	0.43**	980.1**	0.55**
Error	25	4.62	4.72	0.63	1.73	8.4	32.9	2.7	0.14	55.2	6.4	47035.5	417.3	0.2	7.1	0.17	0.02	0.01	0.03	1.16	0.001
CV (%)		10.5	8.4	22.4	18.4	7.1	4.2	24.0	18.2	22.2	23.9	20.1	13.1	24.1	15.0	2.7	18.8	19.9	13.3	18.5	18.1
CD at 5%	-	3.19	3.23	1.18	1.95	4.28	8.42	2.43	0.56	11.03	3.76	322.04	30.33	0.66	3.96	0.61	0.21	0.15	0.26	1.59	0.05
CD at 1%		4.25	4.31	1.57	2.06	5.71	11.23	3.25	0.74	14.71	5.01	429.39	40.44	0.88	5.28	0.82	0.28	0.19	0.34	2.13	0.06

Table 2: Mean performance of genotypes for different characters

Source	Anthesis of 1st male flower	Anthesis of 1st female flower	Node to 1st male flower	Node to 1st female flower	Days to 1st fruit maturity	Days to last harvest	Fruit length (cm)	Fruit width (cm)	No of fruits/ plant	Fruit weight	Yield/ plant (g)	Vine length (cm)	Fruit cavity (cm)	No of seeds/ fruit	Moisture (g/100g)	Total soluble sugars (g/100g)	Reducing sugars (g/100g)	Non reducing sugars (g/100g)	Vitamin C (mg/ 100g)	Carotene (mg/ 100g)
Punjab Kareli-1	59*	83**	8**	13**	92**	144	14**	1.9	32.5	43.5**	1441	193**	1.15	11.5**	90.75	3.05**	1.4**	1.65**	113.75*8	1.28**
Arka Harit	54	72	5	11	75	156.5	9.65	3.15	28.5	40.9*	1187	174	2.65	5.5	92.13**	3.7**	1.9**	1.8**	106.6**	1.261**
DBG-35	51	64	6	8.5	76.5	162**	6.85	3.65	70**	19.1	1333	172.5	3*	7.5	90.22	4.35**	2.1**	2.25**	100.58**	0.1315
DBG-3	67**	67	5	7.5	78	151	9.6	2.9	67.5**	25.5	1632.5	172	2.25	10**	92.04**	4.45**	2.2**	2.25**	136.36**	0.824*8
DBG-45	53	60	5.5	8.5	74.5	149.5	5.4	2.65	96**	13.5	1318.5	181*	1.65	8.5	90.27	2.7**	1.5**	1.2	141**	0.1355
Punjab-14	55	71	6	9.5	76	149	8	3.75	43	33.55*	1423	150.5	2.4	5	91.615*	1.7	0.7	1	64.98	0.115
Pant Kareli -2	55	64	6	9.5	78	160.5*	11	3.25	38	35.75*	1409	188.5*	2.25	5.5	89.01	3.1**	1.5**	1.5**	128.06**	0.13
DBG-41	54	60	5.5	8.5	75.5	162*	7.65	3.25	102**	19.3	2001**	170	2.1	11**	93.7	3.2**	1.4**	1.8*8	100.58**	0.8425**
Solan Hara	59**	64	5	9	75	151	13.75**	2.6	28.5	37.35*	1061	170	1.95	8.5	95.715**	1.9	0.7	1.2	93.15**	0.415**
DBG- 44	55	69	4.5	9	77	156	8.1	3.15	85**	29.5	1923.5**	157.5	2.35	8	93.67**	3.7**	1.65**	2.05**	94.68**	0.6295*8
Pusa DoMausmi	52	65	4.5	9	75.5	155	12.8	2.9	42	34.15	1450	198.5**	2.1	7.5	94.62**	1.75	0.8*	0.95	101.08**	1.755**
Pusa Visesh	60**	70	6	9	74.5	162*	10.15	3.4	38	33.35	1257	198.5**	2.45	11**	91.72*	2.9**	1.65**	1.25*	93.715**	0.8425**
WBBG-6	54	64	5.5	10.5	75.5	153	9	3.15	77.5**	24.55	1922.5**	173.5	2.35	10**	88.54	2.95**	1.45**	1.5**	101.38**	0.378**
DBG- 40	55	59	4.5	9	75	145	5	2.95	93**	9.4	885.5	185*	2.1	8	89.93	4.3**	2.1**	2.3**	86.09**	1.207**
WBBG- 48	52	69	6	10.5	78	161.5*	13**	3.65	88**	32.5	2072**	148.5	2.4	13.5**	92.53**	3.3**	1.65**	1.6**	113.87**	0.115
WBBG-5	56	73	5.5	11.5*	85.5*8	151	10.758	3.7	53	34.7	1822**	183.5*	2.35	6.5	89.89	2.9**	1.6**	1.3*	93.21**	0.731**
DBG- 18	63**	71	5.5	9	75.5	158.5	9.4	3.6	51	30.35	1559	182*	2.65	7.5	90.425	1.4	0.75	0.65	141.15**	1.292**
PBBG-1	53	67	5.5	10	78	155	10.68	4.5*	50.5	30	1522	192.5**	3.1*	9.5*	91.86*	1.7	1.1**	0.6	100.78**	1.3635**
PBBG-2	64**	69	5.5	11	75	174.5**	15.7**	2.9	48.5	39.1	1879**	198**	1.75	4.5	93.56**	2.9**	1.3**	1.6**	100.58**	1.166**
Janupuri Long	59**	63	4.5	7.5	78	151	12.5**	3.15	32	43.45**	1456	173.5	2.45	17.5**	91.48*	3.8**	1.8**	2**	127.6**	0.579**
PBBG-3	55	68	4.5	7.5	78	150	12.5**	3.5	17	33.7	588	212.5	2.6	7.5	91.32*	3.4*8	1.9**	1.5**	141.75**	1.505**
PBBG-7	57	65	6.5	9	85.5**	154.5	16.65**	2.9	28	35.2	1027	161.5	1.65	6.5	89.07	4.1**	1.75**	2.35**	101.08**	1.0215**
PBBG-6	53	63.5	5	9	74	154	8.75	3.55	48.5	32	1567	187*	2.35	14**	95.22**	4.4**	2.05**	2.35**	86.09**	0.3095**
PBBG-9	50	69	4.5	11	77	161.5*	9.7	2.75	44	35	1714	215**	1.95	5.5	95.76**	4.3*8	2.4**	1.9**	101.08**	0.067
PBBG-8	56.5	62	5.5	9	77.5	159	9.75	3.4	67.5**	28.5	1858*8	202**	2.4	12**	93.08**	3.9**	1.95**	1.95**	64.88	0.204**
PBBG-10	54	64.5	4.5	9	77	160*	11.5*	3.75	40	37*	1530	167.5	2.6	13**	91.16*	1.25	0.575	0.675	93.21**	1.2665**
PBBG-11	71**	77**	5.5	11	79	162*	11.35*	2.5	44	37.5*	1685	190**	1.65	7	89.32	2.15*	1.2**	0.95	86.14**	1.755**
PBBG-14	52.5	66	5.5	8.5	76.5	160*	13.3**	3.4	80**	38.5*	2007.5**	207.5**	2.5	6.5	89.5	2.9*8	1.5**	1.4**	64.88	1.2395**
PBBG-13	73.5**	67.5	5.5	9	78	153	12.1**	2.4	50.5	33.5	1762.5*	205**	1.4	5	91.81*	3.65**	1.9**	1.75**	92.91**	1.298**
PBBG-40	71**	73.5*	4.5	9.5	74	157.5	8.75	3.55	88**	19	1658	168.5	2.35	9.5*	90.43	3.75**	1.75**	2**	106.35**	1.299**
PBBG-20	74**	69	4.5	8	94.5**	136	9.8	2.9	27	24.4	634	219.5**	2.1	6	89.89	3.25**	1.4**	1.65**	142.8**	0.31**
PBBG-31	76**	77**	4.5	10.5	78	136	11.65*	2.15	46	23.55	1283	166.5	1.85	9*	96.05**	2.9**	1.6**	1.5**	65.38	1.238**
CO-1	73.5**	77.5**	6	8.5	78.5	146	11.35*	2.65	24.5	33.65	820.5	221**	1.75	8.5	88.55	3.4**	1.4**	1.75**	127.56**	1.146**
Hirkani	69**	76.5**	3.5	9	74	155	12.35**	3.25	29	34.8	928	180*	2.35	12.5**	92.06**	4.15**	2.05**	1.75**	129.9**	1.216**
PBIG-56	55.5	64.5	4.5	11	74	151	10	3.3	36.5	31.1	1362	212.5**	2.65	13.5**	95.43**	3.95**	2.2**	1.75**	93.21**	0.43**
Coimbatore Long	46	60	5.5	9	94.5**	114.5	6.5	1.9	11	27.5	291.5	205**	2.05	9	89.37	3.8**	2*8	1.8**	86.15*8	1.005**
CD at 5%	3.19	3.23	1.18	1.95	4.28	8.42	2.43	0.56	11.03	3.76	322.04	30.33	0.66	3.96	0.61	0.21	0.15	0.26	1.59	0.05
CD at 1%	4.25	4.31	1.57	2.06	5.71	11.23	3.25	0.74	14.71	5.01	429.39	40.44	0.88	5.28	0.82	0.28	0.19	0.34	2.13	0.06

highest for carotene content (50.57%) followed by number of fruits/plant (43.78%) as revealed from Table 4. Higher phenotypic coefficient of variation for all traits was higher than their corresponding genotypic coefficient of variation signifying the role of environment in the expression of genotypes and this finding is in agreement with Thakur (1994) and Bhave (2003). Characters such as anthesis of first male flower, anthesis of first female flower, and moisture content had nearly equal GCV and PCV (Table 4) indicating least influence of environment on their expression. In such a situation, phenotypic selection may lead to equal probability of success. Kadam and Kale (1987) reported similar results in ridge gourd. With the help of genotypic coefficient of variation alone, it is not possible to determine the extent of heritable variation. Heritable variation can be understood when heritability in conjunction with genetic advance is studied (Dudley and Moll, 1969). Hence, both heritability and genetic advance were determined to generate a clear picture of the scope of improvement of various characters thorough selection. The heritability estimates ranged from 10 % for vine length to 99 % for

Table 3: Top five genotypes based on mean value for different characters

Trait	Variety				
Anthesis of 1st male flower	Coimbatore Long 46	PBBG-9 50	DBG-35 51	WBBG-48 51.5	Pusa Do Mausmi 51.5
Anthesis of 1st female flower	DBG- 40 59	DBG-45 59.5	Coimbatore long 60	DBG-41 60	PBBG-8 62
Node to 1st male flower	Hirkani 3.5	PBBG-31 4.5	PBIG-56 4.5	PBBG-20 4.5	PBBG-40 4.5
Node to 1st female flower	DBG-3 7.5	Janupuri Long 7.5	PBBG-3 7.5	PBBG-20 8	CO-1 8.5
Days to 1st fruit maturity	PBBG-40 74	Hirkani 74	PBIG-56 74	PBBG-6 74	Pusa Visesh 74.5
Days to last harvest	PBBG-2 174.5	DBG-35 162	DBG-41 162	Pusa Visesh 162	DBG-11 162
Fruit length (cm)	PBBG-7 16.65	PBBG-2 15.7	Punjab Kareli-1 14	Solan Hara 13.75	PBBG-14 13.3
Fruit width (cm)	PBBG-1 4.5	Punjab-14 3.75	PBBG-10 3.75	WBBG-5 3.7	DBG-35 3.65
No of fruits/plant	DBG-41 102	DBG-45 96	DBG-40 93	WBBG- 48 88	PBBG-40 88
Average fruit weight	Punjab Kareli-1 43.5	Jaunpuri long 43.4	Arka Harit 40.9	PBBG-2 39.1	PBBG-14 38.5
Yield/plant (g)	WBBG- 48 2072	PBBG-14 2007.5	DBG-41 2001	DBG-44 1923.5	WBBG-6 1922.5
Vine length (cm)	CO-1 221	PBBG-20 219.5	PBBG-9 215	PBBG-3 212.5	PBIG-56 212.5
Fruit cavity (cm)	PBBG-1 3.1	DBG-35 3	Arka Harit 2.65	DBG-18 2.65	PBIG-56 2.65
No of seeds/fruit	PBBG-2 4.5	Punjab-14 5	PBBG-13 5	PBBG-9 5.5	Pant Kareli-2 5.5
Moisture (g/100g)	WBBG-6 88.54	CO-1 88.55	Pant Kareli-2 89.01	PBBG-7 89.07	PBBG-11 89.32
Total soluble sugars (g/100g)	DBG-3 4.45	PBBG-6 4.4	DBG-35 4.35	DBG-40 4.3	PBBG-9 4.3
Reducing sugars (g/100g)	PBBG-9 2.4	DBG-3 2.2	PBIG-56 2.2	DBG-35 2.1	DBG-40 2.1
Non-reducing sugars (g/100g)	PBBG-7, 2.4	PBBG-6 2.4	DBG-40 2.3	DBG-35 2.3	DBG-3 2.3
Vitamin C (mg/100g)	PBBG-20 142.8	PBBG-3 141.75	DBG- 18 141.15	DBG-45 141	DBG-3 136.4
Carotene (mg/100g)	Pusa Do Mausmi 1.755	PBBG-11 1.755	PBBG-3 1.505	PBBG-1 1.365	PBBG-40 1.299

Table 4: Range, variances, genotypic and phenotypic coefficient of variation, heritability and genetic advance for different traits

Characters	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic advance as percentage of mean
Anthesis of 1st male flower	58.68	46-76	13.33	15.81	93	15.01
Anthesis of 1st female flower	67.79	59-83	7.98	9.59	86	9.61
Node at which 1st male flower appears	5.21	3.5-8	10.31	18.14	32	10.36
Node no at which 1st female flower appears	9.43	7.5-13	7.81	16.73	21	10.33
Days to first fruit maturity	78.28	74-94.5	6.36	9.34	75	7.72
Days to last harvest	153.28	114.5-174.5	5.96	7.06	71	13.45
Fruit length (cm)	10.53	5-16.65	22.32	27.57	66	3.17
Fruit width (cm)	3.11	1.9-4.5	15.24	19.83	59	8.58
No of fruits/plant	48.74	11-102	43.78	45.93	91	40.84
Average fruit weight (g)	30.38	9.4-43.5	24.83	26.00	91	14.44
Total yield/plant (g)	1403.54	291.5-2072	29.33	32.57	81	105.25
Vine length (cm)	185.65	148.5-221	10.21	15.29	10	8.01
Fruit cavity (cm)	2.21	1.5-3	15.95	21.69	54	10.39
No of seeds/fruit	8.93	4.5-17.5	26.75	40.07	44	2.20
Moisture content (g/100g)	91.71	88.54-96.05	2.37	3.42	95	4.29
Total soluble sugars (g/100g)	3.19	1.25-4.45	28.06	38.48	97	1.79
Reducing sugar (g/100g)	1.58	0.575-2.4	29.08	40.06	94	12.89
Non reducing sugar (g/100g)	1.60	0.6-2.35	28.87	40.92	87	13.83
Vitamin C (mg/100g)	103.40	64.88-142.8	21.60	31.63	99	45.93
Carotene (mg/100)	0.85	0.067-1.755	50.57	60.61	99	11.06

carotene content and vitamin C (Table 4). High heritability was observed for vitamin C (99%), carotene content (99%), total soluble sugars (97%) moisture content (95%), reducing sugars (94%) and anthesis of first male flower (93%). A comparatively low heritability was found for node at which first male flower appears (32), node at which first female flower appears (21) and vine length (10). This is in consonance with the findings of Srivastava and Srivastava (1976) and Thakur (1994) in bitter gourd.

It is fact that heritability alone is not sufficient to determine the amount of heritable variation, it can be realized with greater accuracy when heritability along with genetic advance is studied. According to Johnson (1955) genetic advance as percent of mean depends upon selection differential, genetic coefficient of variation and heritability ratio. It is obvious that a character with high GCV and high heritability will have high genetic gain. In the present study, higher genetic gain was observed for yield, number of fruits, vitamin C content, whereas, high heritability coupled with high genetic advance for characters like vitamin C content, number of fruits and anthesis of first male flower may be attributed to additive gene effects and could be improved through simple mass selection and can also be selected as donors for traits specifying to use in the hybridization programme.

Thirty six diverse genotypes of bitter gourd were evaluated for genetic variability for twenty traits including both agronomic and quality characters. The differences observed between genotypes were highly significant for all the characters studied. Coefficient of variation is lowest (2.7) for moisture content followed by anthesis of first female flower (8.4) and anthesis of first male flower (10.5) and highest (24.1) in fruit cavity. Total carotene content followed by yield showed maximum genotypic and phenotypic co-efficient of variation. Moisture content and days to last harvest exhibited lowest value for both genotypic coefficient of variation and phenotypic coefficient of variation. In almost all the characters genotypic coefficient of variation values were lower than phenotypic coefficient of variation indicating considerable influence of environment in the expression of all the traits. The heritability estimates of different characters ranged from 10% for vine length to 99% for total carotene content and vitamin C each. Very high heritability estimates observed for total sugars, moisture content, reducing sugars indicating the preponderance of additive gene action. However, heritable variation can be realized with greater accuracy when heritability along with genetic advance studied. It is obvious that a character with high genotypic coefficient of variation and high heritability will have high genetic gain. Higher genetic gain was observed in respect of yield, number of fruits, vitamin C content. In the present investigation, high heritability coupled with high genetic advance traits like vitamin C content, number of fruits and anthesis of first male flower may be attributed to additive gene effects and could be improved through simple mass selection.

सारांश

वर्तमान अध्ययन में करेले के 36 विविध प्रभेदों में अनुवांशिक विविधता निर्धारण, वृहद् वंशागतित्व एवं अनुवांशिक उन्नयन के लिये किया गया। प्रभेदों के बीच प्राप्त अन्तर सभी गुणों के लिये सार्थक पाये गये। नमी की मात्रा का निम्न गुणांक विविधता (2.7) में पाया गया तथा इसके उपरान्त प्रथम मादा पुष्पन (8.4) एवं नर पुष्पन का स्थान रहा जबकि सबसे अधिक फल गुहिका (24.1) के लिये पाया गया। उच्च लक्षण रूपी प्रसरण गुणांक व अनुवांशिक प्रसरण रूपी गुणांक कुल कैरोटिन की मात्रा तथा इसके बाद उपज के प्रति रहा। उच्च अनुवांशिक उन्नयन के साथ वंशागतित्व फल संख्या, प्रथम नर पुष्पन व विटामिन सी का योज्य योगदान प्रभाव पाया गया तथा इन्हे चयन के माध्यम से सुधारा जा सकता है।

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