DEVELOPMENT OF SINGLE CROSS HYBRIDS FROM *Momordica charantia* BY FULL DIALLEL CROSSES

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ABSTRACT

A field experiment was carried out in the plastic houses , College of Agricultural Engineering Ssciences , University of Baghdad during the spring season 2018. Six inbred lines of bitter gourd were entered into full diallel crosses, and planted during 2018-2019 season (six inbred lines symbolized as 1,2,3,4,5,6 +15 diallel hybrid + 15 reciprocal hybrid + control hybrid) according to randomized complete block design (RCBD) with three replicates, each experimental unit occupied 6 plants. Results revealed a significant differences among the genotypes in most of studied traits, The reciprocal hybrid 5×4 gave the highest values in leaf chlorophyll content (27.61 mlg mg^{-1}), sex ratio (0.611), fruit setting percent (85.74%), and plant yield (2.005 kg), while the diallel hybrid 1×4 gave the highest values in leaves area (1.172 m2), sex ratio (0.747), fruits number (23.16), and plant yield (2.023 kg plant-1), Also the hybrid 6×4 gave the highest value in plant yield (2.105 kg plant-1), and the hybrid 1×3 gave the highest value in total phenols concentration (5.67 mlg gm-1), and the hybrid 2×3 gave the highest value in fruits weight (105.58 gm), charantin concentration (0.616 gm). Furthermore, many of reversal and reciprocal hybrids showed a positive hybrid abundance in the desired direction among the studied parameters, The reciprocal hybrid 6×4 gave the highest hybrid abundance in fruit weight (59.17%) and plant yield (120.3%), also the hybrid 5×4 gave the highest hybrid abundance in plant yield (69.99%).

Key words: bitter gourd, inbred lines, Heterosis, Charantin
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مجلة العلوم الزراعية العراقية -2021 :52 (1):88-96 **الاسدي و الجبوري**

إستباط هجن فردية من القرع المر *Momordica charantia* بالتضريب التبادلي الكامل

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المستخلص

نفذت التجربة في البيوت البلاستيكية التابعة لكلية علوم الهندسة الزراعية – جامعة بغداد في ربيع 2018 إذ إدخلت ست سلالات نقية من القرع المر في برنامج التضريب التبادلي الكامل وفي الموسم الزراعي 2018–2019 زرعت بذور التراكيب الوراثية (ست سلالات نقية ورمز لها 1 و2 و3 و 4 و5 و6 +15 هجين تبادلي +15 هجين عكسي + هجين القياس) وفق تصميم القطاعات الكاملة المعشاة RCBD وبثلاث مكررات وبمعدل ست نباتات في الوحدة التجريبة .أظهر التحليل الاحصائي وجود فروق معنوية بين التراكيب الوراثية في أغلب مؤشرات الدراسة، إذ اظهر الهجين العكسي 4×5 أفضل القيم لمتوسطات تركيز الكلورفيل الكلي في الاوراق (27.61 ملغم .غم$^{-1}$) والنسبة الجنسية (0.611) والنسبة المئوية للعقد (85.74%) وحاصل النبات الواحد (2.005كغم)، وأظهر الهجين التبادلي 4×1 أفضل القيم لمتوسطات المساحة الورقية (1.172 م^{2}) والنسبة الجنسية (0.747) وعدد الثمار (23.16) وحاصل النبات الواحد (2.032 كغم .نبات$^{-1}$) وأظهر الهجين 4×6 أفضل القيم لمتوسط حاصل النبات الواحد (2.105 كغم .نبات$^{-1}$) وتميز الهجين 3×1 بإعطائه اعلى تركيز للفينولات الكليه (5.67 ملغم .غم$^{-1}$) وأعطى الهجين 3×2 أعلى القيم وزن الثمرة (105.58 غم) وتركيز الكارنتين (524 ملغم .100 غم$^{-1}$) وحاصل النبات من الكارنتين (0.616 غم) .وأظهر عدد من الهجن التبادلية والعكسية غزارة هجينية موجبة ومعنوية بالاتجاة المرغوب في مؤشرات الدراسة إذ أظهر الهجين العكسي 4×6 أفضل غزارة هجينية في وزن الثمره (59.17%) وحاصل النبات (120.3%) كما أعطى الهجين 4×5 أفضل غزارة هجينية في حاصل النبات (69.99%).

الكلمات المفتاحية: القرع المر، سلالات نقية، قوة الهجين، كارنتين
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INTRODUCTION

Heterosis is one of the most important genetic phenomenon's that occurs when crossing between genotypes (isogenic strains, pure lines, species and hybrids) in order to combine the desired genes from the parents (F1) which provides better qualities among the parents (1). Recently, it was applied on many of horticultural and field crops to improve the plant growth, yield and active compounds (9,10). Furthermore, the heterosis has been applied on bitter gourd plant (*Momordica charnatia*) which belongs to Cucurbitaceae family (7 and 4), It is widely cultivated as food and medicine in China, Malaysia, India, Africa, Southeast Asia and South America, This plant contains many important medicinal compounds including charantin (a mixture of Stigmastadienol-D-glucoside, and b-stiosterol b-D-glucoside) which is used as a treatment for diabetes (15). It also has a similar properties to insulin (13, 14), a recent pharmacological studies have shown that charantin is more effective than Tolbutamide in reducing diabetes (8). Radha (16) found in a hybridization experiment on bitter gourd an increment in yield, fruit weight, fruit length, fruit diameter, and plant height, and some hybrids showed a negative heterosis in the days until flowering and harvest date. Singh et al (19) studied the full diallel crosses in 8 strains of bitter gourd, some hybrids showed a positive and significant heterosis in plant yield, fruit length, fruit diameter, fruit weight, and plant height as well as a desired negative heterosis in nodes number until flowering. Al-Mashhadani and Al-Jubouri (3) studied the full diallel crosses on watermelon plant and found some hybrids showed a significant variances in plant height, leaves number, leaves area, fruit number and plant yield, as well as a negative heterosis in days number until flowering. Kandasamy (11) found during a study on 20 hybrids resulted by a full daillel crosses from 5 parents of bitter gourd has increased fruits number, fruits length, fruit weight, and plant yield while the desired negative heterosis in nodes number until flowering has not appeared. This research was aimed to develop single cross hybrids characterized by high productivity, growth and fruit concentrations of charantin.

MATERIALS AND METHODS

This experiment was carried out in plastic houses at the Department of Horticulture and Landscape Design, College of Agricultural Engineering Sciences, University of Baghdad . during spring season of 2018 and season of 2018-2019. The field was divided to 5 terraces in 90 cm of width, spaced by 60 cm, with 75 cm on each sides of the house, each terrace contained two planting lines provided with dripping irrigation pipes in 10 cm of each side, the bitter gourd was planted alternately on the terrace and spaced by 50 cm between each plant. All agricultural management were carried out according to the recommendations. In the spring season 2018, the seeds of six pure strains was planted which symbolized as 1, 2, 3, 4, 5 and 6 and involved into full daillel crosses. During flowering, the flowers were covered, and the full diallel crosses between parents were carried out in the next day when all conditions required to ensure the pollination and fertilization were occurred, then the flowers were covered again for three days and tagged with parents names and cross date. Then, the fruits were harvested after maturity stage, and the F1 hybrid seeds were collected and washed by distilled water and dried in the shadow and stored to the next season. In the season of 2018-2019 the seeds were planted directly at 5/9/2018 to evaluate the circular structure of genotypes included 6 pure strains, 15 diallel crosses and 15 reciprocal crosses hybrid and control hybrid. The randomized complete block design (RCBD) with three replicates was applied, each replicate represents a plastic house, and each experiment unit included 6 plants. The studied traits were branches number, leaves area (m^2), total chlorophyll concentration (mlg gm^{-1}), sexual percent (number of feminine flowers/number of masculine flowers), holding percent (number of flower set/number of feminine flowers), fruit weight (gm), charintin concentration (mlg 100 gm^{-1}) According to Reddy and Xavier (22), plant yield of charintin (plant yield (gm) × fruits dry weight(%) × Charintin concentration {(mlg/gm)/1000}, and phenols compounds concentration (mlg gm^{-1}) according to Vernon et al (20). Collected data were by analysis of variance and means of treatments were

compared using L.S.D at 5%. Heterosis for crosses and reciprocal crosses were calculateral for all studied traits according to the best parent, and standard heterosis measured according to control hybrid.

RESULTS AND DISCUSSION

Results in Table 1 reveal Significant differences among the genotypes in floral and vegetative traits, the parent 4 had the highest number of branches (5.25), and the parent 6 in leaves area (1.106 m^2) and total chlorophyll concentration (21.84 mlg gm-1), and the parent 5 superiored in sexual ratio (0.42), setting percent (79.79%), these variances between parents leaded to variances between their hybrids, the hybrid 4×5 gave the highest branches number (6.75), and 6×5 in leaves area (1.327 m2), while the hybrid 5×4 gave the highest values in total chlorophyll concentration (27.61 mlg gm-1), sexual ratio (0.611), setting percent (85.74%), and the diallel hybrid 4×1 in leaves area (1.172 m2), sexual ratio (0.747). these results are in agreement with the result of singh et al (18).

Results in Table 2 show that the parent 2 gave the highest value in fruits weight (97.44 gm), plant yield (1.466 kg), and the parent 4 in charintin concentration (163.6 mg 100 g^{-1}), and plant yield of charantin (0.234 gm), while the parent 5 gave the highest values in phenols compounds concentration (4.71 mlg. gm^{-1}). The diallel hybrids 1×4, 1×3 and 5×6 had the lowest period to maturty date reached 53.66, 54.88 and 55.83 (days) respectively, while the reciprocal cross hybrids 6×4, 5×4 and 6×5 had 54.33, 54.33 and 54.44 (days) respectively. The reciprocal cross hybrid 6×4 gave the highest value in fruits weight reached 115.66 gm followed by diallel hybrid 2×3 (105.58 gm). The hybrids 6×4, 1×4 and 4×6 gave the highest values in plants yield reached 2.102, 2.032 and 2.005 kg respectively followed by the hybrids 3×5 and 1×3.

Table1. Floral and vegetative traits for pure strains and their diallel, cross, and control hybrids of bitter gourd

characters					
genotype	branches number	total leaf area	total chlorophyll)concentration (mg. g^{-1}	sexual ratio	holding percentage
1	3.750	0.887	18.80	0.299	69.89
2	5.000	1.092	21.64	0.343	73.86
3	2.500	0.668	18.41	0.230	77.65
4	5.250	0.723	14.40	0.250	77.24
5	2.330	0.771	18.67	0.412	79.79
6	4.720	1.106	21.84	0.400	61.63
1×2	3.750	1.080	17.06	0.289	79.92
1×3	3.330	0.894	23.98	0.553	68.57
1×4	4.750	1.172	17.72	0.747	63.00
1×5	4.750	1.066	23.80	0.523	55.35
1×6	6.330	1.063	18.87	0.540	61.93
2×1	5.660	0.961	16.33	0.376	74.39
2×3	3.330	1.011	19.51	0.281	67.48
2×4	2.000	0.901	20.25	0.311	58.00
2×5	2.500	1.091	24.89	0.310	55.97
2×6	2.330	1.151	19.86	0.342	62.11
3×1	2.660	0.889	23.40	0.289	57.25
3×2	2.663	1.178	21.87	0.265	62.09
3×4	3.500	0.831	18.09	0.336	58.93
3×5	2.250	1.008	17.23	0.401	74.19
3×6	2.000	0.724	18.55	0.370	63.79
4×1	2.500	1.056	15.99	0.335	74.33
4×2	2.500	0.920	18.81	0.390	55.42
4×3	3.500	0.675	20.70	0.290	65.46
4×5	6.750	0.731	14.08	0.580	65.13
4×6	2.660	0.914	17.23	0.431	62.55
5×1	4.660	0.716	16.80	0.507	61.46
5×2	5.500	0.901	17.20	0.404	62.75
5×3	3.000	0.827	15.22	0.476	68.20
5×4	3.500	1.191	27.61	0.611	85.74
5×6	4.200	1.045	20.20	0.547	72.26
6×1	6.500	1.267	17.11	0.484	53.22
6×2	4.500	1.292	17.17	0.339	62.34
6×3	2.663	1.238	24.62	0.436	68.54
6×4	5.250	1.251	25.73	0.483	78.02
6×5	4.500	1.327	26.60	0.439	78.92
CONTROL	3.330	0.852	16.66	0.297	61.49
Mean	3.810	0.990	19.65	0.403	67.00
L .S.D 5%	0.526	0.094	1.365	0.043	4.631

Table2. Fruit traits of bitter guard pure strains and their diallel, cross, and control hybrids

characters					
genotype	fruit weight	plant yield	phenols compounds concentration	charintin concentration	plant yield of chrintain
1	90.11	1.012	3.910	28.93	0.021
2	97.44	1.466	4.310	163.6	0.171
3	83.77	0.802	2.340	11.40	0.006
4	72.66	0.686	4.34	463.1	0.234
5	52.75	0.924	4.71	44.01	0.024
6	63.16	0.954	4.26	42.43	0.033
1×2	95.33	1.242	4.61	296.8	0.308
1×3	81.26	1.652	5.67	48.33	0.058
1×4	87.66	2.032	4.120	158.8	0.266
1×5	48.94	0.748	4.610	162.1	0.076
1×6	81.00	1.415	5.010	153.5	0.144
2×1	91.66	1.320	5.010	477.3	0.483
2×3	105.5	1.317	5.110	524.0	0.616
2×4	84.07	0.699	4.260	231.6	0.108
2×5	73.49	0.839	5.120	202.9	0.108
2×6	89.00	1.268	4.090	354.9	0.332
3×1	87.16	0.818	4.910	34.19	0.018
3×2	89.66	0.973	5.160	13.29	0.009
3×4	87.94	1.090	5.260	5.333	0.004
3×5	87.55	1.697	4.310	46.18	0.064
3×6	86.50	1.061	4.380	314.6	0.256
4×1	80.30	1.151	3.910	466.0	0.398
4×2	86.16	0.980	5.210	392.6	0.280
4×3	89.66	0.930	4.760	272.3	0.193
4×5	62.00	1.143	4.110	216.3	0.162
4×6	89.50	1.194	3.720	343.9	0.256
5×1	65.33	0.874	4.160	130.3	0.081
5×2	46.33	0.577	4.810	253.6	0.091
5×3	89.66	1.571	5.010	49.27	0.058
5×4	68.77	2.005	3.910	121.0	0.184
5×6	68.33	1.413	3.910	24.50	0.026
6×1	53.16	0.768	5.010	120.30	0.065
6×2	99.33	1.246	4.910	411.8	0.445
6×3	97.99	1.420	4.910	136.2	0.157
6×4	115.66	2.102	5.010	108.2	0.262
6×5	89.83	1.710	5.110	98.21	0.150
CONTROL	73.66	0.768	4.370	240.0	0.124
Mean	81.42	1.190	4.550	193.5	0.169
L .S.D 5%	4.771	0.125	0.298	13.32	0.036

The diallel hybrid 1×3 gave the highest values in phenols reached 5.670 mlg gm^{-1}, while the diallel hybrid 2×3 gave the highest charantin concentration 524.0 mlg 100 gm^{-1} and charantin yield (0.616 gm.) Results in Table 3 reveal positive hybrid abundance for the diallel and reciprocal crosses among the floral and vegetative traits, the diallel hybrid 1×6 and the reciprocal cross hybrid 6×1 gave the highest value in branches number (37.71%, 34.11% respectively). The daillel hybrid gave the highest value in leaves number and sexual ratio (32.10, 149.62 respectively) while the reciprocal cross hybrid 5×4 gave the highest values in leaves area (54.4%), total chlorophyll concentration (47.92%), holding percent (7.47%). Also the diallel hybrid 1×3 gave a positive and significant value in total chlorophyll content reached 27.56% followed by 1×5 and 2×5. As for the holding percent, the diallel hybrid 1×2 had the highest value reached 8.21%. these results are in agreement with Askandar et al (5) on pea plant. Results in Table 4 show hybrid abundance for yield and chemical compounds. In the harvest date, the diallel hybrid 5×6 and the reciprocal cross hybrids 6×4, 6×5 gave the highest negative heterosis reached -6.25%, -8.77% and 8.58% respectively, while the reciprocal cross hybrids 6×4, 6×5 and the diallel hybrid 4×6 gave the highest values in fruits weight reached 59.17%, 42.22% and 23.17% respectively, also the cross hybrids 6×4, 5×4 and the diallel hybrid 1×4 produced the highest plant yield reached 120.30%, 116% and 100.8% respectively. The diallel hybrid 1×3 and cross

hybrid 3×1 gave the highest phenols concentration reached 45.05% and 25.60 respectively . As for charantin concentration, the diallel hybrids 3×6, 1×5, 2×3 and reciprocal cross hybrid 6×3 gave the highest hybrid abundance reached 641.5, 268.27, 220.22 and 221.19% respectively. The positive heterosis could be due to the over dominance genes action of the parents, while the negative values of heterosis occurred under the influence of the partial dominance genes of the lowest parents, which led to a lower value to the highest parents, the equal heterosis indicates the influence of over dominance genes of the highest parents, which led to an equal value to the highest parents.

Table3. Hybrid abundance (%) of diallel and cross hybrids in floral and vegetative traits of bitter guard

characters					
genotype	**branches number**	**total leaf area**	**total chlorophyll concentration (mg. g^{-1})**	**sexual ratio**	**holding %percentage**
1×2	**-25.00**	**-1.08**	**-21.15**	**-15.85**	**8.21**
1×3	**-11.20**	**0.76**	**27.56**	**84.80**	**-11.69**
1×4	**-9.52**	**32.10**	**-5.74**	**149.6**	**-18.44**
1×5	**26.67**	**20.14**	**26.62**	**27.09**	**-30.63**
1×6	**34.11**	**-3.84**	**-13.60**	**35.00**	**-11.38**
2×1	**13.20**	**-12.03**	**-24.53**	**9.72**	**0.73**
2×3	**-33.40**	**-7.45**	**-9.86**	**-18.14**	**-13.09**
2×4	**-61.90**	**-17.52**	**-6.46**	**-9.43**	**-24.91**
2×5	**-50.00**	**-0.05**	**14.98**	**-24.78**	**-29.85**
2×6	**-53.40**	**4.11**	**-9.10**	**-14.48**	**-15.91**
3×1	**-29.07**	**0.16**	**24.47**	**-3.50**	**-27.27**
3×2	**-46.73**	**7.91**	**2.31**	**-22.60**	**-20.04**
3×4	**-33.33**	**15.04**	**-1.71**	**34.61**	**-24.11**
3×5	**-10.00**	**30.74**	**-7.68**	**-2.60**	**-7.01**
3×6	**-57.63**	**-34.48**	**-15.10**	**-7.69**	**-17.85**
4×1	**-52.38**	**18.96**	**-14.91**	**12.00**	**-3.77**
4×2	**-52.38**	**-15.77**	**-14.61**	**13.62**	**-28.25**
4×3	**-33.33**	**-6.56**	**12.48**	**16.21**	**-15.70**
4×5	**28.57**	**-5.19**	**-24.59**	**40.86**	**-18.36**
4×6	**-49.33**	**-17.35**	**-21.12**	**7.73**	**-19.02**
5×1	**24.27**	**-19.33**	**-10.64**	**23.16**	**-22.96**
5×2	**10.00**	**-17.47**	**-20.54**	**-1.78**	**-21.35**
5×3	**20.00**	**7.32**	**-18.47**	**15.51**	**-14.52**
5×4	**-33.33**	**54.44**	**47.92**	**48.51**	**7.47**
5×6	**-11.02**	**-5.45**	**-7.51**	**32.77**	**-9.43**
6×1	**37.71**	**14.61**	**-21.68**	**20.97**	**-23.84**
6×2	**-10.00**	**16.86**	**-21.40**	**-15.38**	**-15.59**
6×3	**-43.57**	**11.94**	**12.68**	**8.85**	**-11.72**
6×4	**0.00**	**13.17**	**17.80**	**20.70**	**1.01**
6×5	**-4.66**	**20.02**	**21.76**	**6.58**	**-1.08**
S.E	**5.62**	**3.38**	**3.49**	**6.36**	**1.92**

Table4. Heterosis (%) of diallel and reciprocal cross hybrids in yield and chemical compounds of bitter guard.

characters					
genotype	fruit weight	plant yield	phenols compounds concentration	charintin concentration	plant yield of chrintain
1×2	**-2.17**	**-15.29**	**6.97**	**81.41**	**79.92**
1×3	**-9.81**	**63.26**	**45.05**	**67.06**	**178.70**
1×4	**-2.71**	**100.8**	**-5.07**	**-65.71**	**14.51**
1×5	**-45.68**	**-26.07**	**-2.12**	**268.27**	**208.8**
1×6	**-10.11**	**39.91**	**17.62**	**261.85**	**332.5**
2×1	**-5.93**	**-9.96**	**17.65**	**191.68**	182.17
2×3	**8.35**	**-10.16**	**17.88**	**220.22**	260.16
2×4	**-13.72**	**-52.31**	**-1.84**	**-49.99**	-53.20
2×5	**-24.57**	**-42.74**	**8.71**	**24.03**	-36.40
2×6	**-8.66**	**-13.46**	**-5.11**	**116.91**	94.33
3×1	**-3.27**	**-19.19**	**25.60**	**18.17**	-13.78
3×2	**-7.98**	**-33.61**	**19.74**	**-91.88**	-94.53
3×4	**4.97**	**35.94**	**21.21**	**-98.85**	-98.08
3×5	**4.51**	**83.55**	**-8.50**	**4.92**	160.66
3×6	**3.25**	**11.23**	**2.82**	**641.5**	10.47
4×1	**-10.89**	**13.78**	**-9.92**	**0.64**	71.31
4×2	**-11.57**	**-33.11**	**20.06**	**-15.21**	20.50
4×3	**7.03**	**15.96**	**9.68**	**-41.19**	-16.89
4×5	**-14.68**	**23.61**	**-12.75**	**-53.28**	-29.96
4×6	**23.17**	**25.07**	**-14.30**	**-25.74**	10.33
5×1	**-27.50**	**-13.64**	**-11.69**	**196.08**	230.05
5×2	**-52.45**	**-60.62**	**2.12**	**55.01**	-46.62
5×3	**7.03**	**69.99**	**6.37**	**11.95**	137.19
5×4	**-5.35**	**116.87**	**-17.00**	**-73.87**	-20.75
5×6	**8.18**	**48.04**	**-16.78**	**-44.33**	-20.66
6×1	**-41.0**	**-24.12**	**17.62**	**183.50**	95.64
6×2	**1.94**	**-14.97**	**13.93**	**151.67**	160.04
6×3	**16.97**	**48.79**	**15.27**	**221.19**	371.8
6×4	**59.17**	**120.3**	**15.45**	**-76.63**	12.98
6×5	**42.22**	**79.22**	**8.50**	**123.14**	351.1
S.E	**4.15**	**9.20**	**2.70**	**28.52**	**57.40**

Results in Table5 show that the diallel hybrid 4×5 and the reciprocal cross hybrid 6×1 had the highest standard heterosis in branches number reached 102.70% and 95.20% respectively. As for the leaves area, the reciprocal cross hybrids 6×5, 6×2, 6×1, 6×4, 6×3, 5×4, 3×2 and diallel hybrids 1×4, 2×6, and 2×5 had the highest values. As for the total chlorophyll concentration, the diallel hybrid 2×5 gave the highest standard heterosis reached 49.32%, while the reciprocal cross hybrid 5×4 gave the highest heterosis for chlorophyll concentration, sexual ratio, and holding percent reached 65.68, 106.19, and 39.45% respectively, these results are in agreement with Al-Mashhadani and Al-Jubouri (3) on watermelon and Wuhaib et al (2016) on maize. The diallel hybrid 1×4 gave the highest heterosis in sexual ratio reached 152.10%, while the diallel hybrid 1×2 gave the highest value in holding percent reached 29.97%. Results in Table 6 reveal that the diallel hybrid 1×4 had a significant heterosis in harvest date and plant yield reached -16.72% and 165.01% respectively, the diallel hybrid 2×3 gave the highest positive heterosis in fruits weight, plant yield, and negative heterosis in harvest date reached 57.01, 174.25, and -15.69% respectively, these results are in agreement with Radha (16) and Singh et al (19) and Kandasamy (11) and Bhatt et al (6) on bitter gourd plant and Al-Karagholi and Alwan(2) on Okra . As for the phenols concentration, the diallel hybrid 1×3 and the cross hybrid 4×1 gave the highest values reached 19.13 and 17.87 respectively.

Table5. Standard heterosis (%) of diallel, and reciprocal cross hybrids in floral and vegetative traits of bitter guard

characters					
genotype	branches number	total leaf area	total chlorophyll concentration (mg. g^{-1})	sexual ratio	holding percentage %
1×2	12.61	26.79	2.39	-2.65	29.97
1×3	0.00	4.96	43.87	86.63	11.52
1×4	42.64	37.60	6.31	152.1	2.46
1×5	42.64	25.14	42.82	76.45	-9.98
1×6	90.09	24.78	13.25	82.28	0.72
2×1	69.97	12.75	-1.98	26.92	20.99
2×3	0.00	18.62	17.06	-5.30	9.75
2×4	-39.94	5.72	21.48	4.77	-5.66
2×5	-24.92	28.10	49.32	4.44	-8.98
2×6	-30.03	35.10	19.15	15.47	1.01
3×1	-20.12	4.33	40.39	-2.54	-6.90
3×2	-20.02	38.31	32.86	-10.47	0.98
3×4	5.110	-2.43	8.56	13.35	-4.16
3×5	-32.43	18.32	3.40	35.23	20.66
3×6	-39.94	-14.97	11.29	24.63	3.75
4×1	-24.92	23.91	-4.03	13.12	20.88
4×2	-24.92	7.96	10.89	31.44	-9.87
4×3	5.11	-20.75	24.23	-2.15	6.46
4×5	102.7	-14.19	-15.53	95.57	5.93
4×6	-20.12	7.25	3.39	45.45	1.73
5×1	39.94	-15.97	0.790	70.99	-0.04
5×2	65.17	5.78	3.200	36.37	2.06
5×3	-9.91	-2.87	-8.68	60.38	10.92
5×4	5.11	39.77	65.68	106.19	39.45
5×6	26.13	22.69	21.23	84.33	17.52
6×1	95.20	48.73	2.65	63.33	-13.44
6×2	35.14	51.65	3.02	14.25	1.39
6×3	-20.02	45.26	47.70	46.96	11.48
6×4	57.66	46.87	54.40	62.96	26.89
6×5	35.14	55.75	59.60	47.98	28.36
S.E	7.70	1.58	4.00	7.22	2.44

Table 6. Standard heterosis (%) of diallel and reciprocal cross hybrids in yield and chemical compounds of bitter guard

parameters					
genotype	fruit weight	plant yield	phenols compounds concentration	charintin concentration	plant yield of chrintain
1×2	29.41	61.97	-3.15	23.68	138.43
1×3	10.32	115.4	19.13	-79.86	-54.65
1×4	19.00	165.01	-13.45	-33.84	106.02
1×5	-33.56	-2.440	-3.15	-32.47	-41.00
1×6	9.95	84.64	5.26	-36.03	11.63
2×1	24.43	72.15	6.52	98.86	273.9
2×3	43.33	71.77	6.73	118.32	377.2
2×4	14.13	-8.810	-10.51	-3.51	-15.80
2×5	-0.23	9.47	7.57	-15.44	-15.71
2×6	20.81	65.46	-14.09	47.88	157.5
3×1	18.33	6.64	3.15	-85.76	-85.97
3×2	21.17	26.93	8.41	-94.46	-92.76
3×4	19.38	42.17	10.51	-97.78	-96.54
3×5	18.85	121.3	-9.46	-80.76	-50.20
3×6	17.42	38.46	-7.99	31.08	98.77
4×1	9.00	50.15	17.87	94.16	208.22
4×2	16.97	27.89	9.46	63.59	116.81
4×3	21.72	21.28	0.00	13.45	49.51
4×5	-15.84	49.06	-13.67	-9.87	26.015
4×6	21.49	55.70	-21.86	43.27	98.52
5×1	-11.31	13.96	-12.61	-45.71	-36.94
5×2	-37.10	-24.70	1.05	5.68	-29.27
5×3	21.71	104.98	5.26	-79.47	-54.68
5×4	-6.64	161.52	-17.87	-49.59	42.58
5×6	-7.24	84.29	-17.66	-89.79	-79.52
6×1	-27.83	0.14	5.26	-49.88	-49.51
6×2	34.84	62.58	3.15	71.58	244.61
6×3	33.03	85.22	3.15	-43.22	21.75
6×4	57.01	174.25	5.26	-54.91	103.27
6×5	21.95	123.1	7.36	-59.08	16.42
S.E	3.94	9.64	1.95	11.44	21.65

There are a significant variances among bitter gourd genotypes in all studied traits. The variances among the heterosis of diallel and cross hybrids confirms the genetic variances between the parents in this study, which indicate the possibility to produce a high quality and productivity hybrids, as well as production of medical compounds, the parents 4, 6 and 2 has the most familiarity in many desired traits, This indicates the possibility to involve them in breeding programs in order to improve plant growth and production of medicinal compounds.

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