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Combining ability and heterosis for yield and quality characters in bottle gourd

Aastik Jha*, SP Mishra, B Singh[1] and Sudhakar Pandey[1]

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Abstract

Gene action, combining ability and heterosis for quality and yield attributes in bottle gourd was studied by involving 66 cross combination obtained from crossing twelve divers inbred in half- diallel fashion. The studies indicated that the ratio of additive variance to dominance variance revealed the predominance of non-additive gene action for carbohydrate and additive gene action for protein, dry matter, ascorbic acid, total soluble solids and yield per plant. The high *per se* performance along with high *gca* estimates of inbred P-4 was good general combiner for protein and dry matter. P-8 was best general combiner for carbohydrate, ascorbic acid and total soluble solids while, P-11 was best general combiner for yield per plant. Therefore the above inbred utilized in future bottle gourd breeding programmes. The crosses P-3 x P-12 and P-4 x P-7 were best specific combiner for protein, P-1 x P-4 was best specific combiner for carbohydrate, P-11 x P-12, P-3 x P-8 and P-5 x P-6 were found good specific combiner for ascorbic acid, P-5 x P-10 and P-10 x P-11 were found good specific combiner for ascorbic acid and total soluble solids, respectively. P-2 x P-7 and P-2 x P-11 were found good specific combiner for yield per plant. Hence, these combinations could effectively utilize for developing hybrids having high quality and yield purposes. The combination P-4 x P-12 showed maximum heterosis for protein, P-4 x P-8 for dry matter, P-4 x P-10 showed highest heterosis for carbohydrate, P-3 x P-7 was expressed maximum heterosis for ascorbic acid, P-5 x P-9 for total soluble solid, whereas P-1 x P-6 showed maximum heterosis for yield per plant. The study revealed that for improvement of traits like protein, dry matter, ascorbic acid, total soluble solids and yield per plant, selections could be made, while fruit carbohydrate may be improved through hybridization.

Key words: Bottle gourd, combining ability, protein, heterosis, genetics

Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya, Chitrakoot, Satna, MP

*Corresponding author presently at Department of Horticulture, School of Agricultural Sciences & Rural Development, Medziphema Campus, Nagaland University, Nagaland; Email: aastikiivr@gmail.com

[1]ICAR-Indian Institute of Vegetable Research, Varanasi, UP

Introduction

Cucurbits are frost-sensitive, predominantly tendril-bearing vines, which are found in tropical and subtropical regions around the globe (Robinson and Decker-Walters 1999). India is blessed with a rich diversity of cucurbitaceous vegetables and is believed to be the primary and secondary centers of origin of many of them (Choudhari 1996). Among the cucurbits, bottle gourd belongs to the genus *Lagenaria* that is derived from "lagena", meaning bottle. The word *siceraria* means drinking vassals. In the old literature it is often referred as *Lagenaria vulgaris* (common) or *Lagenaria leucantha* (white flowered) but it is now generally agreed that the correct name of bottle gourd is [*Lagenaria siceraria* (Mol.) Standl.] with 2n=2x=22 chromosome number. The centre of origin has been located as the coastal areas of Malabar (North Kerala) and the humid forests of Dehradun (North India). It has spread to western countries from India and Africa. The tender fruits of bottle gourd can be used as a vegetable and sweets (*eg. halva, kheer, petha* and *burfi*) and pickles. A decoction made from the leaf is a very good medicine for jaundice. The fruit has cooling effect; it is a cardio tonic and diuretic. The pulp is good for overcoming constipation, cough, night blindness and as an antidote against of certain poisons. The tender fruit of bottle gourd is good for people suffering from biliousness, indigestion and convalescence. The plant extract is used as a cathartic and seeds are used in dropsy. The fruit is also known to have a good source of essential amino acids *i.e.* leucine, phenyl alanine, threonine, cystine, valine, aspartic acid and proline, along with a good source of vitamin B complex, especially thiamine, riboflavin and niacin. The mineral matter reported to be present in fair amount of calcium, phosphorus, iron, potassium, sodium and iodine. The fruit is rich in pectin which showed good prospects for jelly preparation. The benefit of hybrid breeding for quality traits has not been exploited in bottle gourd. A knowledge of general combining ability (*gca*) and specific combining ability (*sca*) helps to make choice of the parents of hybrid and to know the nature of gene action as a basis of choosing an effective breeding methodology. The present investigation therefore was undertaken to identify potential parental combinations in order to have superior hybrids.

Materials and Methods

Twelve divers bottle gourd inbred *viz*, ABG-1 (P-1), Rajendra Chamatakar (P-2), VRBG-7 (P-3), VRBG-136 (P-4), Narendra Rashmi (P-5), NDBG-619 (P-6), Narendra Dharidar (P-7), Kalyanpur Long Green (P-8), Kashi Ganga (P-9), NDBG-132 (P-10), Pant Lauki-1 (P-11) and VRBG-6 (P-12) were selected and crossed with all possible combinations (66 F_1) excluding reciprocals. The F_1^s and parents evaluated under complete randomized block design, which was replicated three times at research form of ICAR-Indian Institute of Vegetable Research, Varanasi during 2013 and 2014. In each row seeds were sown keeping row to row and plant to plant spacing 4m x 70cm, respectively and managed as reported previously (De *et al.* 2004). Observation were recorded on seven competitive plant in each parent and F_1^s for each treatment in each replication selected at random for protein (mg/g), carbohydrate (g/100g), dry matter (g/100g), ascorbic acid (mg/100g), total soluble solids (%) content was estimated with method of (Ranganna 1997), while total carbohydrate content of fruit was estimated with the anthrone method of (Hedge and Hofreiter 1962). The Combining ability variance and effect were worked out according to Griffing (1956) and heterosis was worked out over better and mid parents.

Results and Discussion

The analysis of variance showed significant difference due to treatments for all the characters except yield for parent *vs* F_1^s (Table 1). The t^2 value is non significant for all the characters indicating the validity of hypothesis pertaining to diallel cross analysis except protein. The estimate of H_1 and H_2 were significant and higher than that of D for all the characters. The estimate of F, h_2 and — component was positive and non significant indicating excess of recessive gene. The $(H_1/D)^{0.5}$ showed over dominance for all characters (Pandey *et al*., 2010 and Shaikh *et al*., 2011). The ratio $H_2/4H_1$ indicated asymmetrical distribution of positive and negative gene among the parents. The proportion of KD/KR was more than unity indicating excess of dominant gene. The ratio of h_2/H_2 indicates one gene group controlling characters and exhibiting dominance. The correlation was positive and non significant for all the character except protein, carbohydrate and yield per plant (Table 2).

Highly significant variances were observed for both general and specific combining ability for all the characters indicated that parents and crosses differ significantly with regard to their general and specific combining ability, respectively. The *gca* variance were higher than the *sca* variance for protein, dry matter, ascorbic acid, total soluble solids and yield per plant. This indicated the limited scope of heterosis breeding for these characters and population improvement through recurrent selection should be adopted for exploiting the genetic variations (Kushwaha and Ram 1996 and Yadav and Kumar 2012). The *gca* variances are lower than the *sca* variances for carbohydrate may be improved through hybridization (heterosis) indicating the predominance of non additive gene effects (Table 3). The information regarding *gca* effect of the parent is of prime importance as it helps in successful predication of genetic potentiality of crosses. Estimates of *gca* effect showed that it is difficult to pickup good general combiner for all the characters. Together as the combining ability effect were not consistent for the protein. However, overall evaluation indicates that P-4, P-8, P-11 and P-2 were best general combiner for yield and quality traits on the basis of *per se* performance and significant *gca* effects (Table 4).Similarly on the basis of *per se* performance and significant *gca* effects

Table 1. Analysis of variance for quality and yield in bottle gourd

Source of Variation	d.f.	Protein	Carbohydrate	Dry matter	Ascorbic acid	Total soluble solids	Yield per plant
Replications	2	0.02	0.00	0.01	0.41	0.07	0.32
Treatments	77	14.64**	0.37 **	0.60 **	12.34**	2.43 **	1.27 **
Parents	11	17.30**	0.43 **	0.74 **	6.57 **	3.77 **	1.60 **
F_1^s	65	13.92**	0.37 **	0.51 **	13.44 **	2.23 **	1.23 **
P v F_1	1	32.45**	0.06 *	4.58 **	4.21 **	0.64 **	0.31
Error	154	0.07	0.01	0.01	0.08	0.04	0.274

*, ** Significant at 5 and 1% probability levels, respectively.

Table 2. Genetic parameters and their related statistics for quality and yield.

Gentic Parameters & Related Statistics	Protein	Carbohydrate	Dry matter	Ascorbic acid	Total soluble solids	Yield per plant
	1	2	3	4	5	6
$\hat{D}$	5.746*	0.140**	0.242**	2.163*	1.242**	0.441
	±1.918	±0.043	±0.053	±0.755	±0.247	±0.203
$\hat{F}$	6.648	0.248*	0.408**	2.369	1.655**	0.763
	±4.347	±0.097	±0.120	±1.711	±0.559	±0.460
$?_1$	19.769**	0.607**	0.896**	15.871**	3.346**	1.755
	±3.837	±0.085	±0.106	±1.510	±0.494	±0.406
$?_2$	17.236**	0.479**	0.660**	12.969**	2.550**	1.289**
	±3.192	±0.071	±0.088	±1.256	±0.411	±0.337
$?^2$	3.573	0.005	0.504**	0.456	0.067	0.006
	±2.134	±0.048	±0.059	±0.840	±0.275	±0.226
Ê	0.022	0.004	0.003	0.027	0.015	0.092
	±0.532	±0.012	±0.015	±±0.209	0.068	±0.056
$H_1/D^{0.05}=F_1$	1.86	2.08	1.92	2.71	1.64	2.00
$?_2/4?_1$	0.22	0.20	0.18	0.20	0.19	0.18
KD/KR	1.91	2.48	2.56	1.51	2.37	2.53
h 2/H2	0.21	0.01	0.76	0.04	0.03	0.01
R	-0.012	-0.020	0.187	0.615	0.423	-0.155
t_2	6.013**	1.747	1.132	1.338	2.061	0.216

*,**: Significant at 5 and 1% probability levels, respectively.

Table 3. Analysis of variance for combining ability for quality and yield

Source of Variance	df	Protein	Carbohydrate	Dry matter	Ascorbic acid	Total soluble	Yield per plant
gca	11	6.70 **	0.08 **	0.23**	7.94 **	1.44 **	0.51 **
sca	66	4.58 **	0.13 **	0.19**	3.47 **	0.70 **	0.417 **
Error	154	0.02	0.00	0.003	0.03	0.02	0.09

*,** Significant at 5 and 1% probability levels, respectively.

P-4 was good general combiner for protein and dry matter. P-8 was best general combiner for carbohydrate, ascorbic acid and total soluble solids while, P-11 was best general combiner for yield per plant (Thangamani *et al* 2011 and Rana *et al*. 2015). Among 66 crosses, the P-3 x P-12 and P-4 x P-7 were best specific combiner for protein, P-1 x P-4 was best specific combiner for carbohydrate, P-11 x P-12, P-3 x P-8 and P-5 x P-6

Table 4. Estimate of general combining ability effect of parents for quality and yield.

Parents	Protein (mg/g)	Carbohydrate (g/100g)	Dry matter (g/100g)	Ascorbic acid(mg/100g)	Total soluble solids (%)	Yield per plant (kg)
	1	2	3	4	5	6
P-$_{1}$	0.01	-0.10 **	-1.30 **	-0.12 **	-4.71	0.79 **
P-$_{2}$	-0.04 **	-0.16 **	0.15 **	-0.04	38.28 **	0.54 **
P-$_{3}$	0.11 **	-0.06 **	-0.35 **	-0.12 **	-36.64 **	0.99 **
P-$_{4}$	0.02	-0.03 *	1.42 **	0.02	-13.13 **	-0.23 **
P-$_{5}$	0.04 *	0.04 **	-0.56 **	-0.25 **	17.88 **	-0.35 **
P-$_{6}$	0.02	0.06 **	0.62 **	-0.34 **	-13.29 **	-0.65 **
P-$_{7}$	-0.12 **	0.11 **	0.40 **	0.43 **	-13.51 **	0.09 *
P-$_{8}$	-0.03	0.15 **	-1.15**	0.69 **	43.51 **	-0.25 **
P-$_{9}$	0.08 **	-0.25 **	0.38 **	-0.05	-7.99	-0.74 **
P-$_{10}$	-0.14 **	0.19 **	0.09 *	-0.07 *	-20.39**	-1.24 **
P-$_{11}$	0.05 **	-0.03 *	0.17 **	0.28 **	2.28	0.67 **
P-$_{12}$	0.004	0.065 **	0.13 **	-0.42 **	7.72	0.37 **
SE(Gi)	0.038	0.016	0.013	0.041	0.031	0.077
SE(GIGJ)	0.056	0.023	0.019	0.061	0.046	0.114
Best parents based on *per se* performance and *gca* effects	P-4	P-8	P-4	P-8	P-8	P-11

*,** Significant at 5 and 1% probability levels, respectively.

were found good specific combiner for ascorbic acid, P-5 x P-10 and P-10 x P-11 were found good specific combiner for ascorbic acid and total soluble solids, respectively. P-2 x P-7 and P-2 x P-11 were found good specific combiner for yield per plant, when considered on the basis of *per se* performance and positive *sca* effects (Table 5). Similar finding were reported by Thangamani *et al.* (2011) and Pandey *et al.* (2010). The range of heterosis over better parent varied between -74.26 to 145.05% for protein, -32.43-19.35% for carbohydrate, -38.00 to 16.28% for dry matter, -44.44 to 42.86% for ascorbic acid, -58.33 to 79.31% for total soluble solids and -35.61 to 23.25% for yield per plant.

Table 5. Ranking of three desirable specific combiner on the basis of *per se* performance and *sca* effect for quality and yield.

Characters	Best crosses based on *per se* performance	Best crosses based on *gca* effects	Best crosses based on *per se* performance and *gca* effects
Protein	P-3 x P-12, P-2 x P-3, P-4 x P-7	P-3 x P-12, P-4 x P-7, P-1 x P-8	P-3 x P-12, P-4 x P-7
Carbohydrate	P-10 x P-12, P-1 x P-4, P-3 x P-9	P-1 x P-10, P-1 x P-4, P-4 x P-7	P-1 x P-4
Dry matter	P-11 x P-12, P-3 x P-8, P-5 x P-6	P-11 x P-12, P-5 x P-6, P-3 x P-8	P-11 x P-12, P-3 x P-8, P-5 x P-6
Ascorbic acid	P-3 x P-7, P-5 x P-10, P-3 x P-9	P-5 x P-10, P-2 x P-12, P-3 x P-11	P-5 x P-10
Total soluble solids	P-10 x P-11, P-7 x P-8, P-7 x P-12	P-4 x P-9, P-10 x P-11, P-3 x P-6	P-10 x P-11
Yield per plant	P-2 x P-7, P-2 x P-10, P-2 x P-11	P-2 x P-7, P-2 x P-11, P-11 x P-12	P-2 x P-7, P-2 x P-11

The heterosis over mid parent ranged between -65.47 to 178.97% for protein, -30.23-32.14 % for carbohydrate, -32.92 to 20.48% for dry matter, -41.18 to 45.75% for ascorbic acid, 43.66 to 92.59% for total soluble solids and -33.55 to 28.76% for yield per plant (Table 6). The highest magnitude of heterosis over better parent was recorded in cross combination P-4 x P-12 (145.05%) followed by P-6 x P-7 (52.00%) and P-6 x P-10 (27.38%) for protein. Whereas cross combination P-4 x P-12 (178.97%) followed by P-6 x P-7 (105.41%) and P-1 x P-6 (51.23%) was found better over mid parent. The maximum heterosis over better parent was found in cross combination P-2 x P-10 (19.35%) followed by P-2 x P-9 (12.31%) and P-2 x P-12 (12.12%) for carbohydrate, whereas cross P-2 x P-10 (32.14%) followed by P-2 x P-12 (27.59%) and P-2 x P-9 (26.96%) was found over mid parent. The maximum heterosis recorded for dry matter in the cross combination P-4 x P-8 (16.28%) followed by P-2 x P-5 (11.90%) and P-1 x P-4 (7.91%) over better parent and P-4 x P-8 (20.48%) followed by P-3 x P-11 (13.89%) and P-8 x P-11 (13.64%) for over mid parent. The highest heterosis over better parent was recorded in P-3 x P-7 (42.86%) followed by P-7 x P-8 (41.71%) and P-3 x P-12 (34.17%) for ascorbic acid. Whereas over mid parent cross combination P-6 x P-10 (45.75%), P-3 x P-12 (43.62%) and P-3 x P-7 (43.40%) exhibited maximum heterosis. The maximum heterosis recorded for total soluble solid in the cross combination P-5 x P-9 (79.31%) followed by P-4 x P-6 (66.67%) and P-9 x P-10 (66.67%) over better parent and P-5 x P-9 (42.86%) followed by P-4 x P-6 (41.80%) and P-9 x P-10 (38.46%) for over mid parent. The highest magnitude of heterosis over better parent was recorded

Table 6: Best three crosses selected on the basis of heterosis for quality and yield.

Character	Heterosis over BP		Heterosis over MP		Range over	
	Crosses	% Heterosis	Crosses	% Heterosis	BP	MP
Protein	P-4 x P-12, P-6 x P-7, P-6 x P-10	145.05, 52.00, 27.38	P-4 x P-12, P-6 x P-7, P-1 x P-6	178.97, 105.41, 51.23	-74.26 to 145.05	-65.47 to 178.97
Carbo-ydrate	P-2 x P-10, P-2 x P-9, P-2 x P-12	19.35, 12.31, 12.12	P-2 x P-10, P-2 x P-12, P-2 x P-9	32.14, 27.59, 26.96	-32.43 to 19.35	-30.23 to 32.14
Dry matter	P-4 x P-8, P-2 x P-5, P-1 x P-4	16.28, 11.90, 7.91	P-4 x P-8, P-3 x P-11, P-8 x P-11	20.48, 13.89, 13.64	-38.00 to 16.28	-32.92 to 20.48
Ascorbic acid	P-3 x P-7, P-7 x P-8, P-3 x P-12	42.86, 41.71, 34.17	P-6 x P-10, P-3 x P-12, P-3 x P-7	45.75, 43.62, 43.40	-44.44 to 2.86	-41.18 to 45.75
Total soluble solids	P-5 x P-9, P-4 x P-6, P-9 x P-10	79.31, 66.67, 66.67	P-5 x P-9, P-4 x P-6, P-9 x P-10	42.86, 41.80, 38.46	-58.33 to 79.31	-43.66 to 92.59
Yield per plant	P-1 x P-6, P-3 x P-7, P-1 x P-4	23.25, 16.39, 14.67	P-3 x P-7, P-1 x P-6, P-3 x P-11	28.76, 28.65, 26.80	-35.61 to 23.25	-33.55 to 28.76

in cross combination P-1 x P-6 (23.25%) followed by P-3 x P-7 (16.39%) and P-1 x P-4 (14.67%) for yield per plant. Whereas cross combination P-3 x P-7 (28.76%) followed by P-1 x P-6 (28.65%) and P-3 x P-11 (26.80%) was found better over mid parent.

The results also conformity with those obtained by Tamilselvi *et al*. (2015), Kumar *et al.* (2014) and Pandey *et al.* (2010). On the basis of results, P-4, P-8, P-11, P-2, P-7 and P-3 may be used for hybridization. The crosses P-3 x P-11, P-4 x P-12, P-2 x P-10 P-5 x P-9 and P-3 x P-7 may be tasted further for yield and quality traits for performance under different agro climatic conditions for commercial exploitation of hybrid vigour. On the basis of above findings, it can be concluded that improvement in bottle gourd for protein, carbohydrate, dry matter, ascorbic acid, total soluble solids and yield per plant may be brought out through hybridization followed by recurrent selection and significant specific hybrid for yield would be useful to researchers and needs confirmation.

सारांश

लौकी में गुणवत्ता एवं उपज घटकों की जीन क्रियाकर, संयोजन क्षमता तथा ओज का निर्धारण हाफ डायएलील विधि से 66 संकरण संयोजनों जो 12 विभिन्न जन्मजातों को समाहितकर अध्ययन से स्पष्ट हुआ था। योज्य प्रसरण वे प्रभावी प्रसरण अनुपात के अध्ययन से स्पष्ट हुआ कि प्रोटीन, शुष्क पदार्थ, एस्कार्विक एसीड कुल विलेय ठोस एवं उपज प्रति पौध के लिये अयोज्य जीन प्रक्रिया पाया गया। उच्च प्रति प्रदर्शन के साथ उच्च सामान्य संयोजन क्षमता पी–4 जन्मजात में प्रोटीन व शुष्क पदार्थ के लिये अच्छा सामान्य संयोजक है। पी–8 उत्तम सामान्य संयोजक कार्बोहाइड्रेट, एस्कार्बिक एसीड, कुल विलेय ठोस के लिये था जबकि पी–11 उत्तम सामान्य संयोजक उपज प्रति पौध के लिये पाया गया। इसलिये उपरोक्त जन्मजात को भविष्य में लौकी प्रजनन कार्यक्रम के लिये उपयोग किया जा सकता है। संकरण पी–3xपी–12 तथा पी–4xपी–7 प्रोटीन के लिये, पी–1xपी–4 कार्बोहाइड्रेट के लिए, पी–11x पी–12, पी–3x पी–8 एवं पी–5x पी–6 एस्कार्विक एसीड, पी–5xपी–10 तथा पी–10xपी–11 एस्कार्विक एसीड व कुल विलेय ठोस के लिए उत्तम विशिष्ट संयोजक थे। पी–2xपी–7 तथा पी–2xपी–11 उपज/पौध के लिए अच्छे विशिष्ट संयोजक पाये गये। अतः इन संयोजो को उच्च गुणवत्ता तथा अधिक उपज के उद्देश्य से संकर प्रजनन में उपयोग किया जा सकता है। अधिकतम ओज संयोजन पी–4xपी–12 प्रोटीन, पी–4xपी–10 काबोहाइड्रेट, पी–3xपी–7 एस्कार्विक एसीड एवं पी–5xपी–9 कुल विलेय ठोस के लिये पाया गया जबकि पी–1x पी–6 प्रति पौध उपज के लिए अधिकतम ओज प्रदर्शित किये। अध्ययन से स्पष्ट होता है कि प्रोटीन, शुष्क पदार्थ, एस्कार्विक एसीड, कुल विलेय ठोस एवं प्रति पौध जैसे गुणों हेतु चयन पद्धति को अपनाया जाना चाहिए जबकि कार्बोहाइड्रेट में उन्नयन संकरण द्वारा लाया जा सकता है।

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