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RESEARCH ARTICLE

Identification of Potential Bell Pepper Crosses with Improved Nutritional Traits Under Open Cultivation

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Abstract

A half diallel mating design was used to hybridize seven bell pepper inbred parental lines, yielding 21 F_1 hybrids, excluding reciprocals. The generated F_1 hybrids, parental lines, and commercial check hybrid were evaluated to investigate per se performance, combining ability effects, and the magnitude of heterosis over the better-parent and commercial check for quality traits such as ascorbic acid, total carotenoid, and antioxidant traits, using a randomised complete block design with three replications. It was inferred that hybrids that were superior based on per se performance involved good specific combiners, and their crosses were heterotic over commercial check. The present study also concluded the non-additive gene action, governing the nutritional traits in bell pepper.

Keywords: Ascorbic acid, Antioxidants, Bell pepper, Carotenoid, Nutritional trait, Phenols

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Introduction

Bell pepper (*Capsicum annuum* var. grossum) is a preferred vegetable among consumers worldwide owing to its unique flavour profile, which is a combination of six taste sensations, i.e. bitter, sweet, sour, salty, umami and pungent. In general, the purchasing decision of consumers depends on the appearance and attractiveness of fruit, but lately, consumers are also paying attention to flavour and nutritional value. Hence, scientists have started working on nutritional and nutraceutical characteristics as well. Bell pepper is considered as good source of antioxidants, flavonoids, phenolic acids and carotenoids. Depending on the colour of fruit, ascorbic acid ranges from 16.52 to 159.61 mg per 100 g of fresh bell pepper (Nerdy, 2018). Green bell pepper is an excellent source of ascorbic acid and a fair source of provitamin A and carotenoids (Sharma *et al.,* 2013). The red colour of bell pepper is due to the presence of carotenoid pigments that include β-carotene with provitamin A activity and oxygenated carotenoids such as capsanthin, capsorubin and cryptocapsin. It also contains enormous quantities of neutral phenolic compounds or flavonoids called quercetin, luteolin, and capsaicinoids. Bell pepper is believed to have medicinal properties and hence, recommended for the treatment of dropsy, colic, toothache and cholera. Phytochemicals present in bell pepper help in the prevention of oxidation of essential fats within cells of the brain that are considered necessary for its optimal functioning (Aditika *et al.*, 2018).

In India, bell pepper cultivation is very popular in peri-urban production systems because of easy access to urban markets. It is basically a cool-season crop and the day temperature of less than 30°C and night temperature 16-18°C favours its optimum growth and development. The fruit is green when immature and turns red or yellow at maturity. It is a high-value and low-volume crop and is grown mainly under protected structures to avoid crop loss from various biotic and abiotic stresses. However, in places in and around Bangalore, Pune, mid-hills of Himachal Pradesh, where temperature does not go very high or low during the growing season, open cultivation of the crop is also practised. Definitely, the nutritional quality of fruits grown inside a protected structure is better compared to open cultivated one because of less exposure to biotic and abiotic stresses. Small to medium farmers of India cannot afford protected cultivation. Hence, this study was conducted to identify potential crosses that can produce better nutritional quality of fruits compared to their parents under open field conditions. One of the methods to improve nutritional parameters is heterosis breeding. Diallel analysis also allows the breeder to predict the performance of a cross in subsequent generations based on the behaviour of the F_1 itself. The diallel cross approach, being quick and efficient to estimate the combining ability, was adopted to investigate nutritional characters. Keeping these facts in view, the present investigation was planned and conducted to identify the superior crosses with respect to nutritional traits in bell pepper following a half-diallel mating design.

Materials and Methods

Experimental material, design and location

The present investigation was carried out during 2019-2020 for two seasons at farm block number 8 of the Division of Vegetable Crops, ICAR-Indian Institute of Horticulture Research, Bengaluru, India. The geographical location of the experimental farm is having a latitude of 13° 7' N and 77 ° 29' E. The 21 F_1 hybrids were developed by crossing seven diverse parents in a half diallel mating design from April to September 2019. Crossing was done by manual hand emasculation and pollination. Ripened cross-fertilised fruits were collected, and seed extraction was carried out. Evaluation of those hybrids was undertaken from October 2019 to March 2020. The experimental material consists of seven parents, namely, Arka Mohini (AM), Arka Basant (AB), Arka Gaurav (AG), Yolo Wonder (YW), Californina Wonder (CW), UHF-BP-4 and CW308. Twenty-one F_1 crosses and a check Indra (Syngenta Pvt. Ltd) were sown in pro-trays during October 2019, and healthy seedlings were transplanted in the field in November 2019 at a spacing of 60 cm x 30 cm in a randomized complete block design with three replications. Each replication had 25 plants in a row. Five randomly selected plants were tagged for observation in each replication. Mature green fruits were harvested from tagged plants and were analysed for ascorbic acid, total phenols, antioxidant activity (FRAP and DPPH method) and total carotenoid content. Fresh samples were extracted for all quality estimation.

Estimation of ascorbic acid

Ascorbic acid estimation was done at the marketable green fruit stage by the 2,6-dichlorophenol-indophenol titration method (Harris and Olliver, 1942). A sample weighing 5 g was extracted in 4% oxalic acid, and the volume was made up to 100 ml after centrifugation. 5 ml of working standard solution was pipetted into a 100 ml conical flask to which 10 ml of 4% oxalic acid was added and titrated against the dye (V_1 ml). 5 ml of supernatant was pipetted from the sample extracted, and 10 ml of 4% oxalic acid was added and titrated against the dye (V_2 ml). The ascorbic acid (mg/100g) was calculated as:

$$\text{Ascorbic acid (mg/100g)} = \frac{0.5\text{mg}}{V_1\,\text{ml}} \times \frac{V_2\,\text{ml}}{5\text{ ml}} \times \frac{100\text{ ml}}{\text{Wt. of the sample}} \times 100$$

Estimation of total phenols

Total phenols were estimated as per the procedure given by Singleton and Rossi (1965). Diluted sample 0.8 ml was taken in a test tube to which 7.7 ml of distilled water and 0.4 ml of Folin-Ciocalteau reagent was added, and were kept in B.O.D. at 40°C for 10 minutes. 1 ml of 20% sodium carbonate solution was added to all the test tubes and kept in the dark for incubation for one hour. The blue colour developed was read in a spectrophoto-meter at 660 nm.

Estimation of antioxidant contents

2.3.1. FRAP (Ferric reducing antioxidant power) method: 0.1 ml of the sample was taken into test tubes. 160 ml acetate + 16 ml $FeCl_3$ + 16 ml TPTZ was mixed, and the solution was prepared and poured them at 6ml to each test tube, including a blank containing 0.1 ml 80% alcohol. Then incubated for 1 hour, and readings were taken in a spectrophotometer at 593 nm.

2.3.2. DPPH (2,2-diphenyl-1-picrylhydrazyl) method:200 ml of DPPH was prepared by adding 8 mg DPPH to 200 ml of methanol. 6 ml of DPPH solution was added to test tubes containing 0.1 ml of the sample and incubated for an hour, and readings were taken at 517 nm using methanol as a blank.

Estimation of total carotenoid

3 g of the sample was extracted using acetone, and the volume was made up to 50 ml. Supernatant was taken from the sample, and readings were taken at wavelengths 450 nm, 470 nm, 644.8 nm, 661.6 and 503 nm in a spectrophotometer. Total carotenoids were measured as mg/100g fresh weight.

Statistical analysis

The method of analysis for combining ability estimation was carried out using Griffing (1956), and for estimation of heterosis in terms of increase or decrease in performance, measured as the proportion of deviation of F_1 from better parent and standard check (Indra) and expressed in percentage. All the statistical analysis was carried out using Indostat software.

I) Better parent heterosis (BPH): F1-BP/BP x 100
ii) Standard parent heterosis (SPH): F1- SP/SP x 100

Results and Discussion

Mean performance of hybrids with their parental lines

The mean performance of all parents and their F_1 hybrids revealed that the parents in this study were genetically different and had potential breeding values. The mean performance of 21 F_1 hybrids with their parental lines and commercial check hybrid is presented in Table 1. Among the parental genotypes,

Table 1: Mean performance of crosses and parents (FRAP, DPPH, total phenols antioxidant activity, ascorbic acid and carotenoid)

Sl. No.	Genotypes	Ascorbic acid	Carotenoids	Total phenols	FRAP	DPPH
Parents						
1.	AM	135.59	1.59	100	70.07	50.88
2.	AG	153.67	2.36	128.37	146.09	123.55
3.	AB	85.88	0.51	121.12	130.74	133.64
4.	YW	140.11	2.09	121.62	82.81	73.20
5.	CW	131.07	2.31	117.87	103.10	94.19
6.	UHFBP4	126.55	2.20	125.87	101.89	91.76
7.	CW308	140.11	1.46	131.12	106.07	91.76
Crosses						
8.	AM x AG	180.94	2.29	119.12	183.66	161.69
9.	AM x AB	144.63	0.94	124.37	100.08	100.13
10.	AM x YW	167.23	2.14	110.62	115.61	109.69
11.	AM x CW	117.51	1.32	111.24	98.50	90.43
12.	AM x UHFBP4	167.23	1.29	106.87	75.95	66.005
13.	AM x CW308	122.03	0.95	115.62	136.38	125.22
14.	AG x AB	171.75	1.53	152.50	183.99	157.16
15.	AG x YW	149.15	1.68	111.87	113.34	112.80
16.	AG x CW	203.29	1.66	139.37	94.12	157.92
17.	AG x UHFBP4	162.71	2.25	142.50	126.37	121.06
18.	AG x Cw308	216.95	1.52	107.47	108.33	71.25
19.	AB x YW	171.75	0.88	116.75	149.84	156.12
20.	AB x CW	198.87	1.06	161.04	94.12	89.99
21.	AB x UHFBP4	189.83	0.59	118.12	104.14	94.35
22.	AB x CW308	144.63	1.45	127.50	156.60	152.36
23.	YW x CW	149.15	3.07	119.37	111.32	102.89
24.	YW x UHFBP4	140.11	1.62	125.21	98.28	157.80
25.	YW x CW308	135.58	1.59	120.00	124.03	127.32
26.	CW x UHFBP4	126.55	1.57	130.21	97.06	105.26
27.	CW x CW308	162.71	1.03	117.71	106.11	111.27
28.	UHFBP4 x CW308	167.33	1.95	120.00	115.49	94.45

Commercial check						
29.	Indra	153.67	2.09	109.3	107.6	99.695
	SEm±	4.95	0.06	2.6898	2.5506	4.8676
	CD @ 5%	14.31	0.18	7.7799	7.3774	14.0789
	CD@ 1%	19.29	0.25	10.485	9.9426	18.9742

AM: Arka Mohini, AG: Arka Gaurav, AB: Arka Basant, YW: Yolo Wonder, CW: California Wonder.

the mean value ranged from 85.88 mg/100g (AB) to 153.67 mg/100g (AG) for ascorbic acid content, whereas it ranged from 117.51mg/100g (AM x CW) to 216.95 mg/100g (AG x CW308) in hybrids. On the other hand, carotenoid content varied from 0.51 (AB) mg/100g to 2.36 (AG) mg/100g in parents and 0.95 mg/100g (AM x CW308) to 3.07 mg/100g (YW x CW) in hybrids. Total phenol content ranged from 100 mg/100g (AM) to 131.12 mg/100g (CW308) in parents, and it varied from 106.87 mg/100g (AM x UHFBP4) to 161.04 mg/100g (AB x CW) in hybrids. Range of FRAP activity among parents was 70.07 mg/100g (AM) to 146.09 mg/100g (AG), whereas it ranged from 94.12 mg/100g (AG x CW). For DPPH antioxidant activity, values ranged from 50.88 mg/100g (AM) to 133.64 mg/100g (AB) among parents and 71.05 mg/ 100g (AG x CW308) to 161.69 mg/100g (AM x AG) among hybrids.

Analysis of general combining ability among parents and specific combining ability among crosses

A parent is said to be a good general combiner if it has a significant GCA effect. In this experiment, the parents and crosses were scored based on their GCA and SCA status. Significantly negative GCA and SCA were scored as "-1" and non-significant GCA and SCA were scored as "0", whereas "+1" score was given to significantly positive GCA and SCA effects. By taking these scores into consideration, parents and hybrids were classified as poor, average and good combiners (Supplementary Table 1, 2). For ascorbic acid content, AG (18.08) had a significant positive GCA effect. UHFBP-4 (0.34), AM (0.18) and YW (0.11) exhibited significant GCA effect for carotenoid content. For FRAP antioxidant activity, three parents had exhibited significant positive GCA effects, which were highest in AG (19.77) followed by AB (14.03). For DPPH antioxidant activity, AB (13.86) exhibited highest significant positive GCA effects followed by AG (15.15). The highest significant GCA was exhibited by AB (6.52), followed by AG (5.08), for total phenols (Table 2). These results suggest that, out of seven parents, Arka Gaurav and Arka Basant were considered to be good general combiners and can be used as the best source to improve the quality traits in bell pepper. With respect to SCA effects AM x CW308, AB x YW, AG x AB, BP4 x CW308 exhibited good SCA effects for most of the quality traits studied (Table 3). Out of 21 crosses, ten

Table 2: General combining ability (GCA) effects of parents for quality traits

Parent	Ascorbic acid	Carotenoids	FRAP	DPPH	Total phenols
Arka Mohini	-6.52 **	0.18 **	-8.19 **	-15.29 **	-10.66 **
Arka Gaurav	18.08**	-0.02	19.77 **	15.15 **	5.08**
Arka Basant	-4.02 *	-0.45 **	14.03 **	13.86 **	6.52 **
Yolo Wonder	-4.02 *	0.11 **	-5.11 **	2.27	-4.09 **
California Wonder	-1.02	0.04	-12.96 **	-5.16*	3.43 **
UHF-BP-4	-2.50	0.34 **	-11.44 **	-7.79**	1.20
CW308	0.005	-0.21 **	3.89 **	-3.03	-1.48
SEm±	1.48	0.03	0.78	1.51	0.83
CD at 5%	3.61	0.07	1.92	3.68	2.03
CD at 1%	5.47	0.11	2.90	5.58	3.08

Table 3: Specific combining ability (SCA) effects of crosses for quality traits

Crosses	Ascorbic acid	Carotenoids	FRAP	DPPH	Total phenols
AM x AG	15.70 **	0.03	56.57 **	50.26 **	1.73
AM x AB	1.49	0.56 **	-21.26 **	-10.02 *	5.54 *
AM x YW	24.09 **	-0.25 *	13.41 **	11.14 **	2.39
AM x CW	-28.63 **	0.69**	4.14*	-0.68	4.49*

AM x UHFBP4	22.58 **	0.15*	-19.93 **	-22.48 **	-6.64 *
AM x CW308	-25.13 **	0.57 **	25.17 **	31.97 **	4.79*
AG x AB	4.01	-0.09	34.68 **	16.57 **	17.91 **
AG x YW	-18.58**	-0.51 **	-16.82 **	-16.19 **	-12.10 **
AG x CW	32.55 **	-0.46 **	-28.19 **	36.36 **	7.88 **
AG x UHFBP4	-6.54	-0.16*	2.53	2.13	13.23 **
AG x CW308	45.18 **	0.58 **	-30.84 **	-52.46 **	-19.11 **
AB x YW	26.12 **	0.89 **	25.42 **	28.46 **	-8.67 **
AB x CW	50.24 **	-0.62 **	-22.45 **	-30.29 **	28.11 **
AB x UHFBP4	42.68 **	0.58 **	-13.95 **	-23.29 **	-12.58 **
AB x CW308	-5.03	0.03	23.17 **	29.95 **	-0.52
YW x CW	0.518	0.82 **	13.89 **	-5.79	-2.95
YW x UHFBP4	-7.038	-0.09	-0.67	51.75 **	5.11 *
YW x CW308	-14.08**	-0.40 **	9.74 **	16.50 **	2.58
CW x UHFBP4	-23.59**	0.17	5.95 *	6.64	2.59
CW x CW308	10.05 *	-0.89 **	-0.34	7.88*	-7.22**
UHFBP4 x CW308	16.153 **	0.51 **	7.53 **	-6.30	-2.71
SEm±	3.65	0.07	1.94	3.73	2.05
CD at 5%	7.62	0.15	4.04	7.77	4.29
CD at 1%	10.39	0.21	5.51	10.60	5.85

*and**: Significance at p= 0.05 and p= 0.01, respectively. AM: Arka Mohini, AG: Arka Gaurav, AB: Arka Basant, YW: Yolo Wonder, CW: California Wonder.

crosses were good specific combiners for ascorbic acid content and the maximum significant positive SCA effect was exhibited by the cross AB x CW (50.54), followed by AG x CW308 (45.18). Likewise, eight crosses exhibited positive significant SCA effects, out of which the highest significant SCA effect was shown by cross AB x YW (0.89) followed by YW x CW (0.82) for total carotenoid. Similarly, AM x AG (56.57) followed by AG x AB (34.68) for FRAP antioxidant activity. For DPPH antioxidant activity ten crosses had exhibited positive significant SCA effects and the highest was exhibited by the cross YW x UHFBP4 (51.75) followed by AM x AG (50.26). likewise for total phenols eight crosses exhibited significant positive SCA effects, and the cross AB x CW (28.11) followed by AG x AB (17.91) had the highest SCA effects. For all the quality traits estimated, it was found that the traits are governed by non-additive genes, hence, it is highly amenable for exploitation through heterosis. Similarly, Khalil and Hatem (2014), Hegde (2016), Praveen *et al*., (2017) and Aditika (2018) have reported the same for ascorbic acid content. The obtained results are supported by the studies of Navazio and Simon (2001) in cucumber, Tamilselvi *et al.,* (2015) in pumpkin for total carotenoids.

Estimation of the magnitude of heterosis for quality traits

By observing the mean values of parents and hybrids, it can be inferred that hybrids have performed good for the quality traits studied. Significant positive heterosis is desirable for all the quality traits studied. The better parent heterosis percentage ranged from 16.13 to 51.73, of which cross AB x CW (51.73) showed the highest heterobeltiosis followed by AB x UHFBP4 (50.00) for ascorbic acid content. Similarly, commercial heterosis percentage ranged from -17.64 to 41.18, of which the cross AG x CW308 (41.18) recorded the highest, followed by AG x CW (32.29) (Table 4). The results are similar in comparison with the studies by Sharma *et al*., (2013), Hegde (2016), Praveen *et al*., (2017) and Aditika (2018) in capsicum, where they have reported positive heterosis for ascorbic acid content. For carotenoid content, better parent heterosis ranged from -55.31 to 67.08, the cross AM x CW308 (67.08) showed the highest positive heterobeltiosis, followed by AM x AB (50.67) and commercial heterosis ranged from -50.49 to 46.76, of which the highest was reported by the cross YW x CW (46.76) followed by AM x CW (44.27) (Table 4). Similar results were obtained by Bhutia *et al*., (2015) in chilli and Roy *et al.,* (2018) in capsicum. Significant differences among genotypes for total phenols were observed, ranging from 106.87 (AM x UHFBP4) to 152.50 (AG x AB) among crosses. The heterobeltiosis ranged from -15.09 to 32.95 and the cross AB x CW (32.95) showed highest significant positive heterobeltiosis followed by AG x AB (18.79). Commercial heterosis ranged from -8.07 to 47.34 of which the highest positive commercial heterosis was

Table 4: Better parent and commercial heterosis for quality traits

Crosses	Ascorbic acid		Carotenoids		Total phenols		FRAP		DPPH	
	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC
AM x AG	17.75 *	17.75 *	-3.19**	9.42**	-7.21	8.99 *	25.72 **	70.69 **	30.87 **	62.19 **
AM x AB	6.67	-5.88	50.67 **	13.67 **	2.68	13.79 **	-23.45 **	-6.98	-25.08 **	0.44
AM x YW	19.36 **	8.82	2.51**	2.51**	-9.04 *	1.21	39.61 **	7.44 *	49.85 **	10.03
AM x CW	-13.33	-23.53 **	30.23 **	44.27 **	-5.62	1.78	-4.46	-8.46 *	-3.99	-9.29
AM x UHFBP4	23.34 **	8.82	25.68 **	32.23 **	-15.09 **	-2.22	-25.46 **	-29.41 **	-28.07 **	-33.79 **
AM x CW308	-12.90	-20.59 **	67.08 **	26.06 **	-11.82 **	5.79	28.57 **	26.75 **	36.47 **	25.61 **
AG x AB	11.77 *	11.77	-35.38 **	-26.97 **	18.79 **	39.52 **	25.95 **	71.00 **	17.60**	57.65 **
AG x YW	-2.94	-2.94	-28.98 **	-19.72 **	-12.85 **	2.36	-22.41 **	5.34	-8.7	13.15
AG x CW	32.29 **	32.29 **	-29.80 **	-20.66 **	8.57 *	27.52 **	-35.57 **	-12.52 **	27.82 **	58.41 **
AG x UHFBP4	5.89	5.89	-4.61**	7.82**	11.00 **	30.38 **	-13.50 **	17.44 **	-2.01	21.44 **
AG x CW308	41.18**	41.18**	3.72**	17.24**	-18.04**	-1.67	-25.84**	0.68	-42.33**	-28.53**
AB x YW	22.58**	11.77	26.39**	26.39**	-4.01	6.82	14.60**	39.26**	16.82*	56.60**
AB x CW	51.73**	29.41**	-54.06**	-49.10**	32.95**	47.34**	-28.01**	-12.52**	-32.66**	-9.73
AB x UHFBP4	50.00**	23.53**	16.45**	22.52**	-6.16	8.07*	-20.34**	-3.21	-29.40**	-5.36
AB x CW308	3.23	-5.88	-0.51**	-30.43**	-2.76	16.65**	19.78**	45.54**	14.01	52.83**
YW x CW	6.45	-2.94	32.48**	46.76**	-1.85	9.22*	7.98*	3.46	9.23	3.2
YW x UHFBP4	0	-8.82	11.34**	17.14**	-0.53	14.56**	-3.55	-8.66*	71.97**	58.28**
YW x CW308	-3.23	-11.77	-24.00**	-24.00**	-8.48*	9.79*	16.93**	15.27**	38.75**	27.71**
CW x UHFBP4	-3.44	-17.64*	14.42**	26.75**	3.44	19.13**	-5.86	-9.80*	11.75	5.59
CW x CW308	16.13*	5.88	-55.31**	-50.49**	-10.23*	7.69	0.03	-1.38	18.13*	11.62
UHFBP4 x CW308	19.43**	8.89	23.95**	30.41**	-8.48*	9.79*	8.88*	7.33	2.93	-5.26
Sem±	4.95	4.95	0.06	0.06	2.69	2.69	2.55	2.55	4.87	4.87
CD@ 5%	14.31	14.31	0.18	0.18	7.78	7.78	7.38	7.38	14.08	14.08
CD@ 1%	19.29	19.29	0.25	0.25	10.49	10.49	9.94	9.94	18.97	18.97

*and**: Significance at P= 0.05, P= 0.01 respectively. BP: Heterosis percent over better parent. CC: heterosis over commercial check (Indra). AM: Arka Mohini, AG: Arka Gaurav, AB: Arka Basant, YW: Yolo Wonder, CW: California Wonder.

observed in AB x CW (47.34) followed by AG x AB (39.52) (Table 4). Positive heterosis for total phenols was also reported by Patel *et al*., (2017) in brinjal. For FRAP antioxidant activity, the heterobeltiosis ranged from -35.57 to 39.61and AM x CW308 (28.57) showed highest positive heterobeltiosis followed by AG x AB (25.95). Commercial heterosis ranged from -29.41 to 71.00 and highest commercial heterosis for this trait was observed in AG x AB (71.00) followed by AM x AG (70.69) (Table 4). The range of heterobeltiosis was -42.33 to 71.97 for DPPH activity. The cross YW UHFBP4 (71.97) showed highest significant positive heterobeltiosis, followed by AM x YW (49.85). Commercial heterosis for the same ranged from -33.79 to 62.19 and highest was observed in AM x AG (62.19) followed by AG x CW (58.41) (Table 4).

General and specific combining ability variances

General combining ability (GCA) variance, variance of specific combining ability (SCA) and GCA/SCA ratio are furnished in Table 5. All the studied traits showed a

Table 5: General and specific combining ability variance for quality parameters

Character	GCA	SCA	GCA: SCA
Ascorbic acid content	65.64	860.28	0.08
Carotenoids	0.07	0.34	0.20
Total phenols	34.89	130.31	0.27
DPPH antioxidant activity	123.62	860.04	0.14
FRAP antioxidant activity	165.09	590.72	0.28

GCA: General combining ability variance; SCA: Specific combining ability variance.

higher magnitude of SCA variance. The relatively lower GCA/SCA ratio for all the traits showed the preponderance of non-additive gene effects. Khalil and Hatem (2014), Tamilselvi *et al.,* (2015) in pumpkin, Hegde (2016), Praveen *et al*., (2017) and Aditika (2018) have reported the same.

Conclusion

The overall objective of this study was to improve the nutritional traits of F_1 hybrids in bell pepper developed through a half-diallel mating design. From the above results, the promising hybrids based on combining ability and heterosis for quality traits were Arka Gaurav x CW308, Arka Basant x California Wonder for ascorbic acid, Yolo Wonder x California Wonder for carotenoid, Yolo Wonder x UHFBP4 and Arka Mohini x Arka Gaurav for DPPH activity, Arka Gaurav x Arka Basant and Arka Mohini x Arka Gaurav for FRAP, Arka Basant x California Wonder and Arka Gaurav x Arka Basant for total phenols. Thus, the best performing crosses have potential to be exploited. The present study has also inferred a preponderance of non-additive gene action for quality traits where heterosis breeding could be more useful for improvement of quality traits in bell pepper.

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