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ASSESSMENT OF COMBINING ABILITY OF WATERMELON GERMPLASM DERIVED FROM DIVERSE GEOGRAPHIC ORIGIN FOR YIELD AND QUALITY TRAITS

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A study was conducted to assess the combining ability of diverse genotypes of watermelon in a line x tester mating design at the Vegetable research farm, Department of Vegetable Science, PAU, Ludhiana, Punjab, India. The 40 F_1 hybrids, 10 lines, 4 testers were evaluated in Feb-May, 2019 for yield and component traits. The analysis of variance indicated significant variability among all the genotypes for all the traits. The combining ability analysis revealed that general combining ability effects and specific combining ability effects were significant for all the traits. The ratio of σ^2SCA/ σ^2GCA indicated the predominance of non-additive gene effects for internode length, days to appearance of 1st female flower, fruit length, fruit width, yield/ plant, number of fruits/ plant, average fruit weight, vine length, TSS and vitamin C. Among the parents, lines WM-10, yellow-2 and Barmer; and tester KFF 1-1-2 were good general combiner for fruit yield and component traits. Among the hybrids, W-6-3-3-3-2 × KFF 1-1-2, WM-20 × KFF 1-1-2 and Yellow-2 × KFF 1-1-2 were good specific combiners for higher TSS content and good yield.
Key words: combining ability, line x tester analysis, lycopene and yield, TSS, watermelon

INTRODUCTION

Watermelon is famed for its sweet and juicy fruits which are commercialized in varied shapes (globular to oblong), sizes and flesh colours. The flesh is highly nutritious, and is a good source of water (about 92%), lycopene (2nd after tomato), minerals (magnesium, phosphorus, manganese, iron), and vitamin A (DHALIWAL, 2012). Worldwide annual production of watermelon was more than 118 million tons.

Watermelon improvement entails enhanced fruit quality (TSS, lycopene), yield and disease resistance (KUMAR and WEHNER, 2011). Initially, open pollinated cultivars were released for cultivation by both public and private sectors. However, in the last couple of

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decades, these open pollinated cultivars have been replaced by hybrids because of their higher yield and quality and resistance to biotic and abiotic stresses. The hybrid breeding programme starts with the selection of appropriate parents. Potential parents need to be selected based on their combining ability (GCA) and genetic architecture; as selection based on *per se* performance does not lead to fruitful results. The behavior of F1 hybrids helps to estimate general and specific combining ability. General combining ability is associated with the additive gene action due to additive × additive interaction (RANI and REDDY, 2017). The GCA of a line refers to its behavior with other parental lines to produce progeny with a desirable characteristic (SPRAGUE and TATUM, 1942), *whilst* specific combining ability (SCA) refers to the behavior of a specific combination and generally associated to the non-additive genetic effects which arise from either dominance or epistasis or both interactions. Selection is practiced when the main component of total genetic variation is additive gene action. Whereas, in case of prominent non-additive genetic action, heterosis breeding is proceeded (SOUZA *et al*., 2013).

The line × tester analysis is an alternate hybrid breeding approach to appraise a large number of inbreds at a time as compared to diallel crosses (KEMPTHORNE, 1957) for the detection of appropriate parents and crosses based on their general and specific combining ability effects (IQBAL *et al*., 2018). The studies on GCA and SCA in watermelon were conducted by KUMAR (2005), SINGH *et al.* (2009), BAHARI *et al.* (2012), SOUZA *et al.* (2013) and SAPOVADIYA *et al.* (2014) that brought forth important information about parental lines and the genetics of the inheritance of important characters and revealed the significance of GCA and SCA effects in most yield and quality attributes. Prevalence of non-additive gene action was reported for days before the female flower anthesis, fruit number per plant, fruit yield and weight of dry seeds (SAPOVADIYA *et al.*, 2014; SANTOS *et al*., 2017; NASCIMENTO *et al.*, 2019). However, additive gene action was also found in the case of fruit yield and number of fruits per plant (ZALAPA *et al.,* 2006; FEYZIAN *et al*., 2009; AHMED *et al*., 2012). The preeminence of additive gene action notified for fruit weight, fruit length, fruit width, number of seed per fruit and TSS (FERREIRA *et al*., 2002; SOUZA *et al*., 2002; GUSMINI and WEHNER, 2007; BARROS *et al*., 2011; GVOZDANOVIC-VARGA *et al.*, 2011; AHMED *et al*., 2012; SANTOS *et al*., 2017; NASCIMENTO *et al*., 2019). Therefore, the present investigation was conducted to estimate the combining ability of watermelon genotypes collected from diverse parts of the world to identify promising parents for the development of suitable watermelon hybrids.

MATERIAL AND METHODS

The experiment was conducted at the Vegetable Research Farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana, during Feb-June of the year 2018 and 2019. Ludhiana (30º 54" North latitude and 75º 50" East longitude at an altitude of 247 meters above sea level) falls under the central plain zone of Punjab having a semi-arid climate. The average annual rainfall of this zone is 726 mm. The climate of Ludhiana is humid subtropical. In summer months, the climate is hot and dry while climatic conditions during the period of July to September show slightly low temperature and high humidity. The experimental material comprised of ten lines (Table 1) *viz*. EC-829878, EC-829838, Arka Manik, WM-10, WM-20, W-6-3-3-3-2, Yellow-2, 5419-2011, Barmer and WM-5 and four testers (Table 1) *viz.*

Sugar baby, EC-829870, EC-829828, and KFF 1-1-2. Lines were crossed with testers in line × tester fashion (KEMPTHORNE, 1957) during the summer season February- June 2018. The resulted forty F_1 hybrids and parents were evaluated in summer 2019 in a randomized block design (RBD) replicated thrice for studying combining ability of different characters under study. One-month-old seedlings raised in polythene bags were transplanted on both sides of furrows of 3.0 meter wide beds with a plant to plant distance of 60 cm. All the horticultural practices were followed as per recommendation in the Package of Practice for Vegetable Crops, Punjab Agricultural University, Ludhiana (ANONYMOUS, 2018). During crop growth, data for different characters such as internode length (cm), days to appearance of 1st female flower, fruit length (cm), fruit width (cm), yield/ plant (kg), number of fruits/ plant, average fruit weight (kg), vine length (cm), seed number per fruit, TSS (ºBrix), vitamin C (mg/100ml), total carotenoids (µg/g) and lycopene (µg/g). Data were recorded from five randomly selected plants of each replication excluding the border plants and their average was taken for statistical analysis for all the traits. Dry seeds were counted by using a seed counting waver machine. The total soluble solids were recorded with the help of a handheld refractometer at room temperature. The ascorbic acid content was determined using the method of BAJAJ and KAUR (1981). Total carotenoids and lycopene content were estimated by the methods suggested by SRIVASTAVA and KUMAR (2006).

Table 1. Details of parents (lines and testers) along with source and origin.

Sr. No.	Parents	Source	Origin	Fruit Shape	Flesh colour
	LINES				
1	EC-829878	GRIN, USA	Canada	Circular	White
2	EC-829838	GRIN, USA	USA	Narrow elliptic	Red
3	Arka Manik	IIHR, Bangalore	India	Broad elliptic	Red
4	WM-10	PAU, Ludhiana	India	Broad elliptic	Yellow
5	WM-20	PAU, Ludhiana	India	Elliptic	Yellow
6	W-6-3-3-3-2	PAU, Ludhiana	India	Narrow elliptic	Red
7	Yellow-2	PAU, Ludhiana	India	Elliptic	Red
8	5419-2011	PAU, Ludhiana	India	Circular	Red
9	Barmer	PAU, Ludhiana	India	Broad elliptic	Red
10	WM-5	PAU, Ludhiana	India	Broad elliptic	Pinkish Red
	TESTERS				
1	Sugar Baby	IARI, New Dehli	India	Broad elliptic	Red
2	EC-829870	GRIN, USA	China	Narrow elliptic	Orange
3	EC-829828	GRIN, USA	USA	Broad elliptic	Red
4	KFF 1-1-2	PAU, Ludhiana	India	Broad elliptic	Red

RESULTS AND DISCUSSION

The analysis of variance for the experimental design (Table 2a and 2b) showed a highly significant mean square difference due to lines, testers, line vs. testers, parents vs. hybrids and hybrids for almost all of the studied traits, indicating sufficient genetical diversity among genotypes and had good breeding value. Similarly, significant variations among genotypes of watermelon and cucumber also recorded by SOUZA *et al*. (2004); SALEM *et al.* (2009); BARROS *et al.* (2011); GVOZDANOVC-VARGA (2011); SAPOVADIYA (2012); REDDY *et al*. (2014) and NASCIMENTO *et al*. (2018).

Table 2a. Analysis of variance for experimental design for different characters

Source of variation	d.f.	Internode length	Days to appearance of 1st female flower	Fruit length	Fruit width	Yield/ plant	Number of fruits/ plant	Average fruit weight
Replications	2	0.04	41.75**	4.74*	2.20**	0.51**	0.06	0.79**
Parents	13	2.27**	23.09**	27.12**	7.76**	1.18**	0.27**	0.58**
Testers	3	4.15**	2.67	58.46**	11.20**	1.29**	0.28**	0.79**
Lines	9	1.89**	30.32**	15.59**	7.47**	0.97**	0.20**	0.47**
Lines vs. Testers	1	0.00	19.29*	36.85**	0.01	2.72**	0.86**	0.98**
Hybrids	39	0.71**	18.69**	9.48**	3.87**	1.55**	0.17**	0.23**
Parents vs. Hybrids	1	1.61**	103.08**	71.51**	18.28**	13.64**	0.54**	1.35**
Error	106	0.10	4.63	1.03	0.42	0.09	0.02	0.085

*, ** significant at 5 per cent and 1 per cent level, respectively

Table 2b. Analysis of variance for experimental design for different characters

Source of variation	d.f.	Vine length	Seed number per fruit	TSS	Vitamin C	Total carotenoids	Lycopene
Replications	2	2805.13**	2894.00	0.04	1.70**	0.28	0.20
Parents	13	3140.63**	79768.81**	3.48**	12.14**	1,879.63**	1487.09**
Testers	3	1051.66*	128975.42**	1.12**	11.80**	1,741.77**	1421.33**
Lines	9	3568.96**	69237.81**	4.11**	13.59**	1,992.70**	1536.45**
Lines vs. Testers	1	5552.55**	26928.02	4.96**	0.13	1,275.63**	1240.05**
Hybrids	39	4244.98**	64052.31**	1.62**	3.21**	1,039.23**	957.20**
Parents vs. Hybrids	1	113077.19**	254445.91**	13.27**	204.21**	1,439.30**	1025.21**
Error	106	292.92	9530.24	0.01	0.20	0.082	0.37

*, ** significant at 5 per cent and 1 per cent level, respectively

The total genetic variation for combining ability among all genotypes was partitioned into different components (Table 3a and 3b) corresponding to testers in hybrids, lines in hybrids, and lines × testers in hybrids. The mean squares of these components were significant for all yield components and fruit characters, indicated the role of both additive and non-additive gene effects in the inheritance of all traits under study. The results are following the findings of FERREIRA *et al.* (2002); KUMAR (2005); SINGH *et al*. (2009); VASHISHT *et al*. (2010); BAHARI *et al*. (2012); SOUZA *et al*. (2013); SAPOVADIYA *et al*. (2014) in watermelon and muskmelon.

Table 3a. Analysis of Variance for combining ability for different characters

Source of variation	df	Internode length	Days to appearance of 1st female flower	Fruit length	Fruit width	Yield/ plant	Number of fruits/ plant	Average fruit weight
Replication	2	0.19	54.51**	6.52**	2.95**	0.45**	0.14**	1.30**
Testers in hybrids	3	1.30**	25.05**	9.91**	14.33**	1.41**	0.06	0.61**
Lines in hybrids	9	0.78**	36.74**	18.68**	1.87**	4.01**	0.44**	0.29**
Lines x testers	27	0.62**	11.97**	6.36**	3.37**	0.75**	0.09**	0.17**
Error	78	0.08	4.92	1.23	0.52	0.08	0.03	0.08**
Components of genetic variance								
σ^2GCA		0.02	0.90	0.38	0.23	0.09	0.01	0.013
σ^2SCA		0.18	2.35	1.71	0.95	0.22	0.02	0.031
σ^2SCA/ σ^2GCA		9.00	2.61	4.50	4.13	2.44	2.00	2.38

*, ** significant at 5 per cent and 1 per cent level, respectively

Table 3b. Analysis of Variance for combining ability for different characters

Source of variation	d.f.	Vine length	Seed number per fruit	TSS	Vitamin C	Total carotenoids	Lycopene
Replication	2	1329.90*	5827.63	0.08	1.03**	0.25	0.10
Testers in	3	5093.05**	261262.50**	8.66**	0.75*	6,317.42**	5,949.32**
Lines in hybrids	9	5438.53**	99980.46**	1.74**	5.05**	1,553.13**	1,423.73**
Lines x testers	27	3752.90**	30164.01**	0.78**	2.87**	281.46**	247.00**
Error	78	350.48	11297.14	0.05	0.20	0.07	0.28
Components of genetic variance							
σ^2GCA		72.04	7164.64	0.21	0.01	173.99	163.78
σ^2SCA		1134.14	6288.96	0.26	0.89	93.79	82.23
σ^2SCA/ σ^2GCA		15.74	88	1.24	89.00	0.54	0.50

*, ** significant at 5 per cent and 1 per cent level, respectively

The ratio of σ^2SCA/ σ^2GCA was less than unity for seed number per fruit, lycopene and total carotenoids (Table 3a and 3b). This indicated the greater role of additive gene effects in the inheritance of these traits. For internode length, days to appearance of 1st female flower, fruit length, fruit width, yield/ plant, number of fruits/ plant, average fruit weight, vine length, TSS and vitamin C was more than unity (Table 3a and 3b) indicated the predominance of non-additive gene effects. This emphasized the utility of a hybrid breeding approach to exploit existing heterosis for these traits. CHOUDHARY *et al*. (2006); SALEM *et al*. (2009); VASHISHT *et al.* (2010); SANTOS *et al*. (2017); NASCIMENTO *et al*. (2019) in watermelon and muskmelon were also reported the highest effect of non-additive genes for most of the yield and its contributing traits.

Estimation of combining ability

Earliness

To get higher prices and to avoid market glut farmers prefer to grow early and high yielding hybrids. Therefore earliness is an important trait in vegetables like watermelon. The short internode length and d*ays to appearance of 1st female flower* are indications of earliness and negative combining ability for these traits is desirable.

Short intermodal length enhances earliness in flowering and fruiting which leads to early fruit maturity and harvesting. *Per se* performance of the parents and hybrids varied from 7.27 cm to 9.87 cm and 7.17 cm to 9.27 cm, respectively (Table 4a and 5a). The lines W-6-3-3-3-2 and WM-20 and tester KFF 1-1-2 stood out best *per se* performer for the trait. The line WM-10 (-0.26), W-6-3-3-3-2 (-0.26) and Yellow-2 (-0.18); and tester EC- 829828 (-0.16) and KFF 1-1-2 (-0.13) were good combiners exhibited negative and significant GCA effect (Table 4a). Among forty crosses, WM-10 × Sugar Baby and Yellow-2 × KFF 1-1-2 showed the shortest internode length. Total nine crosses found good SCA combiners out of which WM-10 × Sugar Baby (-0.91), W-6-3-3-3-2 × EC-829870 (-0.67) and Yellow-2 × KFF 1-1-2 (-0.52) showed highest SCA values (Table 5a).

For *d*ays to appearance of 1st female flower, the parental line WM-20 and Yellow-2 and tester EC-829828 exhibited earliness in female flowering. The highest significant and negative GCA effects recorded in line 5419-2011 (-1.44) (Table 4a) therefore best general combiner for improving earliness in female flowering followed by WM-5 (-1.36) and Yellow-2 (-1.28). But line WM-20 noted as a poor combiner. Among testers, EC-829828 (-1.04) found as a good combiner. In crosses, 1st female flower appeared from 53.33 days to 64.00 days (Table 5a). Hybrid, 5419-2011 × EC-829870 (-4.66) exhibited maximum SCA estimates (Table 5a) followed by WM-5 × KFF 1-1-2 (-3.31) and W-6-3-3-3-2 × Sugar Baby (-2.91). BAHARI *et al*. (2012) also reported watermelon genotype BL-14 (-0.64) and cross CS-19 × CH-8 (−1.04) exhibited the highest negative SCA effects. In bitter gourd, SUNDHARAIYA and VENKATESAN (2007) notified line Mithipagal (-3.59) and tester Co 1 (-1.95) as a good general combiner for days to first female flowering.

Fruit characters

Fruit length of the parents recorded from 16.83 to 27.62 cm (Table 4a) and hybrids from 17.66 to 24.67 cm (Table 5a). The line W-6-3-3-3-2 and tester EC-829870 displaced best for fruit length. The highest significant and positive GCA values recorded in line 5419-2011 (2.19) and testers EC-829870 (0.59). But line W-6-3-3-3-2 exhibited positive but nonsignificant GCA values (Table 4a) so noted average combiner. Among hybrids, the highest mean for fruit length was recorded in 5419-2011 × KFF 1-1-2 which also found a good specific combiner. The hybrid Barmer × KFF 1-1-2 found the best SCA with the highest desirable SCA values (2.53)

(Table 5a). Ahmed *et al* (2012) evaluated five watermelon cultivars and noticed Charleston Gray and Giza No.1 x Charleston Gray 133 as good combiner for an increase in fruit length.

For fruit width of parents and hybrids recorded within 14.94 to 19.82 cm (Table 4a and 5a). The line Arka Manik and tester Sugar Baby noted with the highest mean value. The line WM-5 (0.66) and tester Sugar Baby (0.83) constituted the highest significant GCA values (Table 4a); however, Arka Manik noted as average combiner with nonsignificant positive GCA value. The hybrid 5419-2011 × Sugar Baby constituted the highest fruit width 19.82 whereas, Barmer × KFF 1-1-2 (1.62) and 5419-2011 × Sugar Baby (1.56) showed the highest desirable SCA values (Table 5a). NASCIMENTO *et al.* (2018) investigated six watermelon genotypes and reported significant and positive GCA in line ORA (0.94) and ORA × KOD (1.09).

Yield components

The yield components like; the number of fruits per vine and average fruit weight greatly influence the yield potential of the plant. For all these traits positive combining ability is desirable. The fruit yield per plant in parents and hybrids (lines and testers) varied from 1.86 to 4.00 kg (Table 4a) and 2.04 to 4.92 kg (Table 5a), respectively the trait.

Table 4a. General combining ability (GCA) effects and range of mean performance of parents for different characters

S. No.	Parents	Characters						
		Internode length (cm)	Days to appearance of 1st female flower (days)	Fruit length (cm)	Fruit width (cm)	Yield/ plant (kg)	Number of fruits/ plant	Average fruit weight (kg)
	Lines							
1	EC-829878	-0.15*	4.14**	-0.91**	-0.70**	-0.87**	-0.34**	0.10
2	EC-829838	-0.05	0.39	0.27	-0.12	-0.32**	-0.03	-0.19*
3	Arka Manik	0.23**	-0.53	-1.20**	0.26	-0.18*	-0.05	0.002
4	WM-10	-0.26**	-1.28*	-1.98**	-0.15	0.92**	0.24**	0.16*
5	WM-20	-0.11	1.56*	-0.86**	0.20	-0.57**	-0.21**	-0.06
6	W-6-3-3-3-2	-0.26**	0.31	0.58	0.31	0.15	-0.01	0.17*
7	Yellow-2	-0.18*	-1.28*	1.16**	-0.01	0.69**	0.29**	-0.06
8	5419-2011	0.29**	-1.44*	2.19**	0.01	0.07	-0.03	0.10
9	Barmer	0.49**	-0.53	0.08	-0.46*	0.50**	0.16**	0.09
10	WM-5	0.00	-1.36*	0.66*	0.66**	-0.39**	-0.02	-0.30**
	SE±	0.08	0.61	0.30	0.20	0.08	0.04	0.08
	CD@1%	0.20	1.60	0.79	0.53	0.22	0.11	0.21
	CD@5%	0.15	1.21	0.60	0.40	0.17	0.09	0.16
	Range of mean performance	7.27-9.85	53.67-64.67	16.83-23.20	14.94-19.24	2.55- 4.00	0.86-1.59	2.15-3.43
	Testers							
11	Sugar Baby	-0.02	0.49	-0.63**	0.83**	0.12*	-0.01	0.16**
12	EC-829870	0.30**	0.99**	0.59**	-0.56**	0.22**	0.05*	0.07
13	EC-829828	-0.16**	-1.04**	0.37*	0.30*	-0.25**	-0.06*	-0.13**
14	KFF 1-1-2	-0.13**	-0.44	-0.33	-0.57**	-0.09	0.02	-0.10
	SE±	0.04	0.35	0.18	0.12	0.05	0.03	0.05
	CD@1%	0.12	0.93	0.48	0.32	0.13	0.07	0.12
	CD@5%	0.09	0.70	0.36	0.24	0.10	0.05	0.09
	Range of mean performance	7.32-9.87	61.00-63.00	17.71-27.62	14.68-19.13	1.86-3.27	0.60-1.24	2.63-3.70

*, ** significant at 5 per cent and 1 per cent level, respectively

Table 4b. General combining ability (GCA) effects and range of mean performance of parents for different characters

S. No.	Parents	Vine length (cm)	Seed number per fruit	TSS (°Brix)	Vitamin C (mg/100ml)	Total carotenoids (µg/g)	Lycopene (µg/g)
	Lines						
1	EC-829878	26.04**	-45.40	-0.69**	-0.25*	-28.85**	-26.98**
2	EC-829838	30.89**	32.60	-0.16**	0.13	10.33**	9.60**
3		9.79	40.60	0.14**	-0.55**	2.82**	2.37**
4	WM-10	-22.06**	-49.40	-0.26**	-1.01**	-4.98**	-4.90**
5	WM-20	-12.53*	-12.65	0.41**	0.29*	-0.71**	-1.09**
6	W-6-3-3-3-2	-36.70**	-104.73**	0.29**	-0.89**	1.53**	0.88**
7	Yellow-2	-12.81*	25.77	0.62**	0.27*	9.97**	11.10**
8	5419-2011	2.40	-145.82**	-0.21**	0.59**	9.50**	9.64**
9	Barmer	1.24	153.68**	-0.19**	0.55**	0.70**	-0.22
10	WM-5	13.73**	105.35**	0.05**	0.86**	-0.30**	-0.41**
	SE±	5.13	29.11	0.02	0.12	0.08	0.15
	CD@1%	13.54	76.85	0.05	0.32	0.20	0.39
	CD@5%	10.20	57.92	0.04	0.24	0.15	0.29
	Range of mean performance	200.18-308.16	267.33-740.00	7.54-10.75	5.70-7.25	16.54-81.53	11.34-68.54
	Testers						
11	Sugar Baby	2.46	50.62**	0.07**	-0.01	3.69**	3.73**
12	EC-829870	-9.42**	100.32**	-0.65**	-0.15*	-20.48**	-19.93**
13	EC-829828	17.45**	-42.98*	-0.08**	-0.05	3.01**	2.98**
14	KFF 1-1-2	-10.49**	-107.95**	0.66**	0.21**	13.78**	13.22**
	SE±	2.96	16.81	0.01	0.07	0.04	0.09
	CD@1%	7.81	44.37	0.03	0.18	0.11	0.22
	CD@5%	5.89	33.44	0.02	0.14	0.09	0.17
	Range of mean performance	265.92-306.68	353.67-813.20	9.50-10.82	6.26-6.82	34.50-84.37	25.70- 69.53

*, ** significant at 5 per cent and 1 per cent level, respectively

The line EC-829838 and tester Sugar Baby had a higher mean yield. The highest significant GCA effects were recorded in lines WM-10 (0.92), Yellow-2 (0.69) and Barmer (0.50); and tester EC-829870 (0.22) (Table 4a). However, tester Sugar baby also found good combiner for the trait although line EC-829838 showed a negative GCA effect. Among forty crosses, the highest positive SCA effects observed in Barmer × Sugar Baby (0.63) followed by Yellow-2 × EC-829828 (0.61) and W-6-3-3-3-2 × EC-829828 (0.59) (Table 5a). All three hybrids also possessed higher yield (4.92 kg, 4.69 kg and 4.14 kg respectively). AHMED *et al.* (2012) studied five watermelon cultivars and noted Charleston Gray 133 and Peacock WK 60 as best combiners for total fruit yield/plant. MULE *et al.* (2012) reported three hybrids *viz*; Pilibhit Local × K-90, Sheetal × SPP-44 and Sheetal × CC-9 produced the highest SCA effects for the fruit yield per vine. SINGH *et al.* (2009) also found promising parents Asahi Yamato and Durgapura Selection and; crosses-7 × RW 117-3, RW 187-2 × AHW-19 and Durgapura selection × Sugar Baby based on combining ability effects for the trait.

Table 5a. Specific combining ability (SCA) effects and range of mean performance of the hybrids for different characters

S. No.	Hybrids	Characters						
		Internode length (cm)	Days to appearance of 1st female flower (days)	Fruit length (cm)	Fruit width (cm)	Yield/ plant (kg)	Number of fruits/ plant	Average fruit weight (kg)
1	EC-829878 × Sugar Baby	0.13	0.59	-0.42	-0.08	0.19	0.05	0.06
2	EC-829878 × EC-829870	-0.21	0.43	-1.13*	-1.06**	0.15	-0.01	0.16
3	EC-829878 × EC-829828	-0.04	-1.21	1.97**	1.35**	-0.36*	-0.02	-0.32
4	EC-829878 × KFF 1-1-2	0.12	0.19	-0.40	-0.20	0.02	-0.02	0.09
5	EC-829838 × Sugar Baby	-0.16	-0.66	1.00	0.37	-0.23	-0.09	-0.03
6	EC-829838 × EC-829870	-0.13	-0.49	-1.20*	-0.74*	-0.17	0.04	-0.24
7	EC-829838 × EC-829828	0.05	-0.46	0.73	0.03	0.45**	0.19*	0.01
8	EC-829838 × KFF 1-1-2	0.24	1.61	-0.52	0.33	-0.04	-0.14	0.25
9	Arka Manik × Sugar Baby	0.67**	-1.74	0.91	0.76*	-0.08	-0.08	0.08
10	Arka Manik × EC-829870	0.22	3.43**	1.04	0.94**	-0.05	-0.11	0.18
11	Arka Manik × EC-829828	-0.49**	0.13	0.07	-0.08	0.53**	0.03	0.38**
12	Arka Manik × KFF 1-1-2	-0.40**	-1.81	-2.02**	-1.62**	-0.38**	0.16*	-0.66**
13	WM-10 × Sugar Baby	-0.91**	2.01	0.42	-0.93**	-0.28*	-0.08	-0.05
14	WM-10 ×EC-829870	0.87**	-1.49	-1.96**	0.15	-0.48**	0.00	-0.34*
15	WM-10 ×EC-829828	-0.22	-0.13	0.41	0.92**	0.39**	0.08	0.14
16	WM-10 × KFF 1-1-2	0.26*	-0.39	1.12*	-0.15	0.37**	0.00	0.25
17	WM-20 × Sugar Baby	0.32*	-0.16	-0.38	-1.48**	-0.19	-0.08	-0.03
18	WM-20 × EC-829870	-0.07	0.01	0.09	0.11	0.53**	0.11	0.16
19	WM-20 × EC-829828	0.23	-1.96	1.48**	1.15**	-0.48**	-0.09	-0.15
20	WM-20 × KFF 1-1-2	-0.48**	2.11*	-1.18*	0.22	0.14	0.06	0.02
21	W-6-3-3-3-2 × Sugar Baby	-0.37**	-2.91**	-0.108	0.41	-0.36*	-0.12	0.10
22	W-6-3-3-3-2 × EC-829870	-0.67**	0.26	1.32*	0.28	-0.02	-0.03	-0.01
23	W-6-3-3-3-2 × EC-829828	0.68**	1.63	0.40	-0.41	0.59**	0.21**	-0.003
24	W-6-3-3-3-2 × KFF 1-1-2	0.36**	1.03	-1.62**	-0.28	-0.20	-0.06	-0.08
25	Yellow-2 × Sugar Baby	0.25	1.34	-0.75	-0.10	-0.42**	-0.19*	0.15
26	Yellow-2 × EC-829870	-0.11	-0.83	0.41	1.31**	0.23	0.07	-0.06
27	Yellow-2 × EC-829828	0.38**	-0.13	-0.16	-1.91**	0.61**	0.14	0.15
28	Yellow-2 × KFF 1-1-2	-0.52**	-0.39	0.50	0.69*	-0.41**	-0.03	-0.24
29	5419-2011 × Sugar Baby	-0.27*	0.84	0.28	1.56**	0.26	0.02	0.11
30	5419-2011 × EC-829870	0.21	-4.66**	0.43	-0.82*	-0.30*	-0.09	-0.06
31	5419-2011 × EC-829828	-0.33*	1.04	-2.26**	0.10	0.27	0.18*	-0.20
32	5419-2011 × KFF 1-1-2	0.39**	2.78*	1.57**	-0.85*	-0.23	-0.12	0.16
33	Barmer × Sugar Baby	0.34*	0.26	-1.70**	-1.31**	0.63**	0.29**	-0.22
34	Barmer × EC-829870	0.10	2.09	1.70**	0.57	-0.04	-0.06	0.24
35	Barmer × EC-829828	-0.15	-0.54	-2.52**	-0.87*	-1.06**	-0.37**	0.01

S. No.	Hybrids	Internode length (cm)	Days to appearance of 1st female flower (days)	Fruit length (cm)	Fruit width (cm)	Yield/ plant (kg)	Number of fruits/ plant	Average fruit weight (kg)
		Characters						
36	Barmer × KFF 1-1-2	-0.29	-1.81	2.53**	1.62**	0.47**	0.15*	-0.03
37	WM-5 × Sugar Baby	0.02	0.43	0.78	0.79*	0.50**	0.28**	-0.17
38	WM-5 × EC-829870	-0.22	1.26	-0.70	-0.74*	0.17	0.08	-0.02
39	WM-5 × EC-829828	-0.10	1.63	-0.12	-0.29	-0.95**	-0.35**	-0.02
40	WM-5 × KFF 1-1-2	0.31*	-3.31**	0.03	0.24	0.28*	-0.01	0.22
	SE±	0.13	1.05	0.53	0.34	0.14	0.08	0.14
	CD@1%	0.35	2.78	1.40	0.90	0.37	0.20	0.36
	CD@5%	0.26	2.09	1.05	0.68	0.28	0.15	0.27
	Range of mean performance	7.17 - 9.27	53.33 - 64.00	17.66 - 24.67	15.07 - 19.82	2.04 - 4.92	0.84 - 1.71	2.13 - 3.34

*, ** significant at 5 per cent and 1 per cent level, respectively

Table 5b. Specific combining ability (SCA) effects and range of mean performance of the hybrids for different characters

S. No.	**Hybrids**	**Vine length (cm)**	**Seed number per fruit**	**TSS (°Brix)**	**Vitamin C (mg/100ml)**	**Total carotenoids (µg/g)**	**Lycopene (µg/g)**
		Characters					
1	EC-829878 × Sugar Baby	-7.58	168.97**	-0.78**	-0.50*	-17.98**	-17.44**
2	EC-829878 × EC-829870	-14.06	-144.40**	0.44**	1.26**	12.26**	9.76**
3	EC-829878 × EC-829828	-43.94**	124.90*	-0.01	-0.73**	-8.19**	-5.91**
4	EC-829878 × KFF 1-1-2	65.58**	-149.47**	0.35**	-0.02	13.90**	13.58**
5	EC-829838 × Sugar Baby	-19.82*	-0.03	-0.10**	0.85**	-5.11**	-3.72**
6	EC-829838 × EC-829870	33.48**	-96.07	-0.41**	-0.25	7.91**	8.62**
7	EC-829838 × EC-829828	-37.57**	50.90	0.01	0.83**	-4.62**	-4.56**
8	EC-829838 × KFF 1-1-2	23.91**	45.20	0.50**	-1.43**	1.82**	-0.34
9	Arka Manik × Sugar Baby	3.64	-15.70	-0.01	-0.66**	4.15**	5.08**
10	Arka Manik × EC-829870	15.42	16.60	-0.27**	-0.43*	-7.66**	-6.69**
11	Arka Manik × EC-829828	29.65**	10.90	-0.21**	-0.59**	1.15**	1.10**
12	Arka Manik × KFF 1-1-2	-48.71**	-11.80	0.49**	1.68**	2.36**	0.51*
13	WM-10 × Sugar Baby	9.11	-116.70*	0.66**	2.08**	6.28**	5.34**
14	WM-10 ×EC-829870	-25.87**	57.60	-0.17**	-0.42*	-0.35**	0.21
15	WM-10 ×EC-829828	46.10**	109.57*	0.19**	-0.26	0.79**	1.12**
16	WM-10 × KFF 1-1-2	-29.33**	-50.47	-0.68**	-1.39**	-6.72**	-6.67**
17	WM-20 × Sugar Baby	-17.29	-72.12	0.16**	0.52*	3.95**	3.86**
18	WM-20 × EC-829870	11.91	45.85	-0.55**	-0.01	-15.65**	-14.71**

S. No.	Hybrids	Characters					
		Vine length (cm)	Seed number per fruit	TSS (°Brix)	Vitamin C (mg/100ml)	Total carotenoids (µg/g)	Lycopene (µg/g)
19	WM-20 × EC-829828	-10.72	-73.85	0.12**	-0.23	9.62**	9.87**
20	WM-20 × KFF 1-1-2	16.10	100.12	0.27**	-0.27	2.07**	0.98**
21	W-6-3-3-3-2 × Sugar Baby	10.82	-17.37	-0.34**	-1.19**	5.73**	5.67**
22	W-6-3-3-3-2 × EC-829870	-8.28	140.27**	0.30**	-1.21**	-13.08**	-12.06**
23	W-6-3-3-3-2 × EC-829828	34.27**	-118.43*	-0.49**	1.29**	0.38**	0.51*
24	W-6-3-3-3-2 × KFF 1-1-2	-36.81**	-4.47	0.53**	1.11**	6.96**	5.88**
25	Yellow-2 × Sugar Baby	0.71	8.13	0.42**	-1.20**	3.18**	0.36
26	Yellow-2 × EC-829870	-7.34	117.10*	-0.65**	0.24	9.50**	7.96**
27	Yellow-2 × EC-829828	-32.59**	-101.60*	0.27**	-0.01	-4.95**	-7.14**
28	Yellow-2 × KFF 1-1-2	39.23**	-23.63	-0.04	0.96**	-7.73**	-1.18**
29	5419-2011 × Sugar Baby	20.72*	45.72	-0.09*	0.17	-4.53**	-4.30**
30	5419-2011 × EC-829870	-35.69**	-77.65	0.70**	0.01	19.71**	19.14**
31	5419-2011 × EC-829828	-29.74**	-17.02	-0.11**	-0.21	-1.63**	-1.74**
32	5419-2011 × KFF 1-1-2	44.72**	48.95	-0.50**	0.02	-13.55**	-13.10**
33	Barmer × Sugar Baby	-9.92	-70.78	0.64**	0.18	2.57**	3.32**
34	Barmer × EC-829870	15.38	39.18	0.41**	0.27	-8.34**	-8.88**
35	Barmer × EC-829828	9.39	-68.52	-0.26**	-0.24	4.29**	4.24**
36	Barmer × KFF 1-1-2	-14.85	100.12	-0.80**	-0.21	1.48**	1.32**
37	WM-5 × Sugar Baby	9.62	69.88	-0.55**	-0.25	1.74**	1.84**
38	WM-5 × EC-829870	15.06	-98.48	0.19**	0.53*	-4.30**	-3.35**
39	WM-5 × EC-829828	35.16**	83.15	0.48**	0.16	3.16**	2.50**
40	WM-5 × KFF 1-1-2	-59.84**	-54.55	-0.12**	-0.44*	-0.60**	-0.98**
	SE±	8.88	50.42	0.03	0.21	0.13	0.25
	CD@1%	23.44	133.10	0.09	0.55	0.34	0.67
	CD@5%	17.67	100.33	0.07	0.42	0.26	0.51
	Range of mean performance	243.61- 408.74	330.67 - 926.67	8.70 - 11.57	8.37 - 12.10	25.45 -94.51	14.80 - 78.63

*, ** significant at 5 per cent and 1 per cent level, respectively

The number of fruits per plant has a major influence on higher yield per plant. For the increasing number of fruits per plant lines Yellow-2 (0.29), WM-10 (0.24) and Barmer (0.16); and tester EC-829870 (0.05) showed positive and significant GCA effects (Table 4a). *Per se* performance was the highest of parents WM-10 and Sugar Baby; and of hybrids Barmer × Sugar Baby, Yellow-2 × EC-829870 and Yellow-2 × EC-829828. The cross Barmer × Sugar Baby observed the highest positive SCA effect (0.29) (Table 5a). But Yellow-2 × EC-829870 and Yellow-2 × EC-829828 recorded poor SCA combiners. BAHARI *et al.* (2012) reported watermelon line CS-19-S7 as good general combiner with the highest mean (2.94) and cross BL-14-S7 × 6372-4-S7 (0.17) as a good specific combiner. In muskmelon, CHOUDHARY *et al.* (2003) and BARROS *et al.* (2011) also declared parents DMDR-1 and Hy Mark, as a good combiner for number of fruits per plant, respectively.

In the case of average fruit weight, mean performance of parents and hybrids ranged between 2.15 to 3.70 kg and 2.13 to 3.34 kg (Table 4a and 5a), respectively. The GCA estimates showed lines W-6-3-3-3-2 (0.17) and WM-10 (0.16); and tester Sugar Baby (0.16) exhibited the highest significant and positive GCA effects (Table 4a) as a good general combiner for an increase in fruit weight. However, their *per se* performance showed lower average fruit weight. Parental line Arka Manik and tester EC-829870 exhibited the highest fruit weight but recorded poor combiners. Among hybrids, twenty one reported positive SCA effects. Out of these, only one cross combination (Arka Manik × EC-829828) showed a significant positive SCA effect (Table 6). The hybrid 5419-2011 × Sugar Baby produced maximum fruit weight but not a good combiner due to non-significant positive SCA effects. GVOZDENOVIC-VARGA *et al.* (2011), AHMED *et al.* (2012), SINGH *et al.* (2009) and CHOUDHARY *et al.* (2003) also found positive and significant GCA and SCA effects in watermelon and muskmelon
for average fruit weight.

Short vine length is also a well-known trait for higher yield per unit area as more number of plants can be possible to grow in per unit area. The data observed for vine length of parents (lines and testers) was ranged from 200.81 cm to 308.16 cm. Similarly, vine length for hybrids varied from 243.61 to 408.74 cm. The line WM-20 and W-6-3-3-3-2 possessed shortest vines. The line W-6-3-3-3-2 (-36.70) was adjudged good general combiner for small vine length as it exhibited significant and highly negative GCA effects (Table 4b) but WM-20 found poor general combiner. Among the testers, KFF 1-1-2 (-10.49) recorded as the best combiner although KFF 1-1-2 had long vine length. In the case of hybrids, WM-5 × KFF 1-1-2 recorded the best SCA combiner with the highest significant negative SCA value (-59.84) (Table 5b). The hybrids (W-6-3-3-3-2 × KFF 1-1-2 and WM-10 × KFF 1-1-2) with the shortest mean vine length were also found good SCA combiners. BAHARI *et al.* (2012) investigated four watermelon lines and noticed that line CH-8 (-0.25) and cross CS-19 × CH-8 (-0.12) showed the highest significant negative GCA and SCA values in cucumber.

Seed traits

Consumer's preference for watermelon fruits highly depends upon the seed traits. The absence of seeds improves eating quality of fruit flesh (TANAKA *et al.* 1995) which results in more acceptances by consumers. Therefore negative combining ability effects are desirable for the seed traits.

The seed number of fruits in parents and hybrids varied from 267.33 to 813.33 (Table 4b) and 330.67 to 926.67 (Table 5b), respectively. The lowest number of seeds noted in lines W-6-3-3-3-2 and tester Sugar Baby. Maximum desirable combining ability recorded in line 5419-2011 (-145.82) and tester KFF 1-1-2 (-107.95); however, W-6-3-3-3-2 also found to be good general combiner with GCA value -104.73 (Table 4b). In hybrids, lower seed number per fruit observed in EC-829878 × KFF 1-1-2, W-6-3-3-3-2 × EC-829828 and W-6-3-3-3-2 × KFF 1-1-2. On other side, the highest SCA value recorded in EC-829878 × KFF 1-1-2 (-149.47) followed by EC-829878 × EC-829870 (-144.40) to W-6-3-3-3-2 × EC-829828 (-118.43). But cross W-6-3-3-3-2 × KFF 1-1-2 (-4.47) found with non-significant negative SCA effect for the trait (Table 5b). SAPOVADIYA (2012) also reported lines GP-42 (-39.07) and GP-10 (-29.33) exhibiting the highest negative and significant GCA effects for the number of seed per fruit. SANTOS *et al.*

(2017) observed BGCIA 997 (-72.51) and BGCIA 996 × BGCIA 998 (-120.49) and BGCIA 997 × BGCIA 228 (-91.09) as a good combiner for the trait.

Flesh quality traits

Total soluble solid directly relate to sugar content is one of the most important traits, which deserve the highest consideration in any breeding program for watermelon. From a consumer point of view, more than 10^0Brix TSS content is necessary for watermelon fruits. The spectrum of variation for TSS content in parents (lines and testers) was from 7.54 to 10.82 ^{0}Brix (Table 4b) and in hybrids, it was from 8.70 to 11.59 ^{0}Brix (Table 5b). *Per se* performance recorded high in line W-6-3-3-3-2, 5419-2011 and Aaka Manik; in tester KFF 1-1-2 and Sugar Baby. The GCA estimates found significant and positive for all mentioned parents except 5419-2011 (Table 4b). Highest GCA value recorded in Yellow-2 (0.62). Among hybrids, SCA effects were significant and positive in nineteen crosses (Table 6). The best specific combiners were; 5419-2011 × EC-829870 (0.70), WM-10 × Sugar Baby (0.66) and Barmer × Sugar Baby (0.64) (Table 5b and 6). The best ones on the mean value basis were W-6-3-3-3-2 × KFF 1-1-2, WM-20 × KFF 1-1-2 and Arka Manik × KFF 1-1-2 which also noted good combiners. AHMED *et al.* (2012) observed Sugar Baby with highly significant and positive GCA value for TSS. SAPOVADIYA *et al.* (2014) preferred line GP-42 and crosses GP-10 x RW-187-2, GP-10 x GP-42 and GP-10 x Durgapura Lal as good combiner for the trait. In muskmelon, VARINDER and VASHISHT (2018) investigated ten inbred lines and noticed MM-304 as the best combiner for TSS content with the highest significant positive GCA effects (0.86).

For vitamin C content, among parents, W-6-3-3-3-2 and hybrids, Yellow-2 × KFF 1-1-2 possessed the highest vitamin C content. The lines WM-5 (0.86) exhibited the highest positive and significant GCA effect (Table 4b) but W-6-3-3-3-2 was adjudged as a poor combiner. Among testers, KFF 1-1-2 (0.21) stood out good combiner. Out of forty crosses, ten crossed showed positive and significant SCA effects (Table 6) which were ranked as good specific combiners. The hybrids WM-10 × Sugar Baby (2.08) recorded best with the highest desirable SCA effects (Table 5b). The hybrid Yellow-2 × KFF 1-1-2 also displayed good combining ability. VARINDER and VASHISHT (2018) reported muskmelon cross combinations; MM 2008-8 × Punjab Sunehri, MM 2008-8 × MM-303 and IC-267375 × MM-304 as a good specific combiner for ascorbic acid content on the basis of highest SCA effects. In bottle gourd, PARMAR (2016) noticed Gutka Long and PSPL as a good general combiner for ascorbic acid content.

Total carotenoids recorded from 16.54 µg to 84.37 µg in parents (lines and testers) (Table 4b). In hybrids, it ranged from 25.45 µg to 94.60 µg (Table 5b). The Lines W-6-3-3-3-2, Arka Manik and EC-829838 and tester KFF 1-1-2 recorded the highest mean performer; and all of these found good combiners in the term of GCA effects. The line EC-829838 (10.33) and tester KFF 1-1-2 (13.78) recorded the highest positive and significant GCA estimates (Table 4b). Twenty four crosses exhibited significant and positive SCA effects (Table 6). Best hybrids noted with the highest SCA effects in desirable direction were; 5419-2011 × EC-829870 (19.71), 5419-2011 × EC-829870 (13.90) and EC-829878 × EC-829870 (12.26). Cross combinations EC-829838 × KFF 1-1-2, W-6-3-3-3-2 × KFF 1-1-2 and Arka Manik × KFF 1-1-2 stood out best based on *per se* performance and also noted good combiner for the trait.

Table 6. Best 5 specific combiners for different traits

Characters	Number of significant hybrids in desirable direction	Best SCA Combiners
Internode length	9	WM-10 × Sugar Baby, W-6-3-3-3-2 × EC-829870 Yellow-2 × KFF 1-1-2, Arka Manik × EC-829828 WM-20 × KFF 1-1-2
Days to appearance of 1st female flower	3	5419-2011 × EC-829870, WM-5 × KFF 1-1-2 W-6-3-3-3-2 × Sugar Baby
Fruit length	7	Barmer × KFF 1-1-2, EC-829878 × EC-829828 Barmer × EC-829870, 5419-2011 × KFF 1-1-2 WM-20 × EC-829828
Fruit width	10	Barmer × KFF 1-1-2, 5419-2011 × Sugar Baby EC-829878 × EC-829828, Yellow-2 × EC-829870 WM-20 × EC-829828
Yield/ plant	11	Barmer × Sugar Baby, Yellow-2 × EC-829828 W-6-3-3-3-2 × EC-829828, Arka Manik × EC-829828 WM-20 × EC-829870
Number of fruits/ plant	7	Barmer × Sugar Baby, WM-5 × Sugar Baby W-6-3-3-3-2 × EC-829828, EC-829838 × EC-829828 5419-2011 × EC-829828
Average fruit weight	1	Arka Manik × EC-829828
Vine length	11	WM-5 × KFF 1-1-2, Arka Manik × KFF 1-1-2 EC-829878 × EC-82982, EC-829838 × EC-829828 W-6-3-3-3-2 × KFF 1-1-2
Seed number per fruit	5	EC-829878 × KFF 1-1-2, EC-829878 × EC-829870 W-6-3-3-3-2 × EC-829828, WM-10 × Sugar Baby Yellow-2 × EC-829828
TSS	19	5419-2011 × EC-829870, WM-10 × Sugar Baby Barmer × Sugar Baby, W-6-3-3-3-2 × KFF 1-1-2 Yellow-2 × KFF 1-1-2
Vitamin C	10	WM-10 × Sugar Baby, Arka Manik × KFF 1-1-2, W-6-3-3-3-2 × EC-829828, EC-829878 × EC-829870 W-6-3-3-3-2 × KFF 1-1-2
Total carotenoids	24	5419-2011 × EC-829870, EC-829878 × KFF 1-1-2 EC-829878 × EC-829870, WM-20 × EC-829828 Yellow-2 × EC-829870
Lycopene	22	5419-2011 × EC-829870, EC-829878 × KFF 1-1-2 WM-20 × EC-829828, EC-829878 × EC-829870 EC-829838 × EC-829870

Lycopene is an important trait in watermelon that gives a red colour to the flesh. The range of lycopene content in the parents varied from 11.34 µg to 69.53 µg (Table 4b) and in hybrids, it was from 14.80 µg to 78.63 µg (Table 5b). Lines W-6-3-3-3-2, Arka Manik and EC-829838; and tester Sugar Baby exhibited the highest lycopene content and also recorded good combiners. Line Yellow-2 and tester KFF 1-1-2 displayed the highest significant GCA estimates (Table 4b). In the case of hybrids highest SCA effect was recorded in 5419-2011 × EC-829870 (19.14) (Table 5b). The hybrids Yellow-2 × KFF 1-1-2, EC-829838 × KFF 1-1-2, W-6-3-3-3-2 × KFF 1-1-2 showed higher lycopene content out of which only W-6-3-3-3-2 × KFF 1-1-2 found good combiner.

Good and desirable general combining ability effects observed for different characters help sort out outstanding parents with favorable alleles for different components of yield which are reliable for hybridization programs for the improvement of the respective traits (SINGH *et al.* 2009). The resulted general combining ability estimates revealed that none of the parents exhibited good combining ability effects for all the characters, which shows that the genes for different desirable characters would have to be combined from different sources (NEHE *et al.* 2007). So it was difficult to pick good combiners for all the characters together. Among the ten parental lines, WM-10, Yellow-2 and Barmer were good general combiner for fruit yield per plant. These parents also showed significant GCA effects in desirable direction for another various trait, WM-10 for vine length, internode length, days to appearance of 1st female flower, average fruit weight and number of fruits/ plant, while Yellow-2 for vine length, internode length, days to appearance of 1st female flower, fruit length, number of fruits/ plant, TSS, vitamin C, total carotenoids and lycopene and Barmer for number of fruits/ plant, vitamin C and total carotenoids. Whereas among the four testers, KFF 1-1-2 was good general combiner for of most characters *viz*. vine length, internode length, seed number per fruit, TSS, vitamin C, total carotenoids and lycopene while Sugar Baby noted good combiner for fruit width, average fruit weight, yield/ plant, total carotenoids and lycopene. These parents were superior for most of the traits and crossing among them will be expected to offer the maximum promise in watermelon breeding for yield and quality attributes.

Table 7. Top five cross combinations on the basis of per se performance, their respective SCA ranking and GCA performance of their respective parents

S. No.	Cross	TSS (ºBrix)	Yield/ plant (kg)	SCA for TSS	SCA Ranking	GCA of Parents (P1 x P2)
1	W-6-3-3-3-2 × KFF 1-1-2	11.59	3.50	0.53**	4	High x High
2	WM-20 × KFF 1-1-2	11.44	3.12	0.27**	13	High x High
3	Yellow-2 × KFF 1-1-2	11.39	3.83	0.53**	4	High x High
4	Arka Manik × KFF 1-1-2	11.34	2.98	0.49**	6	Medium x High
5	Yellow-2 × Sugar Baby	11.21	4.05	0.42**	9	High x Medium

P1 Female Parent

P2 Male Parent

*, ** significant at 5 per cent and 1 per cent level, respectively

The hybrids that exhibited highest fruit yield/ plant were Barmer × Sugar Baby (4.92 kg), WM-10 × KFF 1-1-2 (4.85 kg) and Yellow-2 × EC-829870 (4.80 kg), WM-10 × EC-829828 (4.71 kg), and Yellow-2 × EC-829828 (4.69 kg) were low in total soluble content (10.63, 9.83, 9.43, 9.95 and 10.91, respectively) (Table 7) which can't be preferred by consumers. While, among the hybrids which possessed the highest TSS content, were also good yielder except (Arka Manik × KFF 1-1-2) (Table 7).

It was observed that, the five crosses recorded with the highest TSS mean also exhibited significant and positive SCA values (Table 7) indicating a significant role of nonadditive effects for the inheritance of the trait. Out of these, three crosses had high x high and two from medium x high or high x medium combining parents (Table 7).

CONCLUSIONS

From the above study, it is concluded that all the genotypes (parents and hybrids) were genetically diverse. The resulted general combining ability estimates revealed that none of the parents and hybrids exhibited good combining ability effects for all the characters. Therefore, among the parents, lines WM-10, yellow-2 and Barmer; and tester KFF 1-1-2 were good general combiner for fruit yield and component traits. Among the hybrids, W-6-3-3-3-2 × KFF 1-1-2, WM-20 × KFF 1-1-2 and Yellow-2 × KFF 1-1-2 were recorded good specific combiners for higher TSS content and good yield.

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PROCENA KOMBINACIONE SPOSOBNOSTI GERMPLAZME LUBENICA RAZLIČITOG GEOGRAFSKOG POREKLA ZA PRINOS I SVOJSTVA KVALITETA

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Izvod

Sprovedena je studija kako bi se procenila kombinaciona sposobnost različitih genotipova lubenice u dizajnu linija x tester na farmi za istraživanje povrća, Departman za nauku o povrću, Pendžab, Indija. 40 F_1 hibrida, 10 linija, 4 testera procenjeno je u februaru-maju 2019. za osobine prinosa i komponenti. Analiza varijanse je pokazala značajnu varijabilnost među svim genotipovima za sve osobine. Analiza kombinacionih sposobnosti je otkrila da su opšti efekti kombinacione sposobnosti i efekti specifičnih kombinacionih sposobnosti značajni za sve osobine. Odnos of σ^2SCA/ σ^2GCA ukazuje na preovlađivanje neaditivnih efekata gena na dužinu internodija, dane do pojave 1. ženskog cveta, dužinu ploda, širinu ploda, prinos/biljci, broj plodova po biljci, prosečnu težinu ploda, dužinu loze, TSS i vitamin C. Među roditeljima, linije VM-10, žuta-2 i Barmer; i tester KFF 1-1-2 su bili dobar opšti kombinator za prinos ploda i svojstva komponenti. Među hibridima, V-6-3-3-3-2 × KFF 1-1-2, VM-20 × KFF 1-1-2 i Yellow-2 × KFF 1-1-2 bili su dobri specifični kombinatori za viši sadržaj TSS i dobar prinos.

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