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Half Diallel Analysis for Biochemical and Morphological Traits in Cultivated Eggplants (*Solanum melongena* L.)

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Abstract: Eleven morphologically diverse cultivated eggplant accessions were used for hybridization following half diallel mating design to obtain 55 hybrids. Evaluation of hybrids along with the parents was conducted over two locations followed by randomised complete block design with three replications to study gene action and combining ability of 15 morphological and biochemical traits. The analysis of variance indicated highly significant differences among the environments and interaction of genotype and environment, except for fruit length to width ratio. Additive gene effects were significant for the inheritance of these traits and expression of these additive genes were greatly affected by environments. The general combining ability (GCA) was greater than their respective specific combining ability (SCA) for all traits except for fruit yield per plant. High values of GCA and SCA effects for characters of interest were dispersed among different genotypes. From this study it was observed that the best parental line was BT15 based on days to first flowering, total number of fruits per plant, total soluble solids and total phenol content. Besides, the parent BM5 showed good general combining ability effects for fruit yield per plant, fruit length and fruit length to width ratio and the parent BB1 performed good general combining ability for fruit diameter, fruit girth and fruit weight. Besides, other parents showed the best performance for only one trait. On the other hand, the hybrid BT6 × BT15 was reported bearing early flowering with high total phenol content and the hybrid BM9 × BB26 has high fruit yield with high soluble solids. Besides, the hybrid BM9 × BB1 has a high fruit diameter and fruit weight. All other hybrids except for these three (BT6 × BT15, BM9 × BB26 and BM9 × BB1) were shown the best performance for only one trait. Hence, based on the desired trait, the hybrid can be selected for future use after large scale evaluation.

Keywords: hybrid development; combining ability; diallel analysis; eggplant

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1. Introduction

Eggplant (*Solanum melongena* L.), also known as brinjal in Asia, aubergine in French, garden egg in Africa, melanzana in Italy, guinea squash in Southern American and patlican in Turkey, is considered an essential vegetable in many parts of the world [1]. It is widely consumed as a vegetable and for medicinal purposes owing to its high antioxidant properties such as anthocyanins, phenolic acids and alkaloids that have favourable health benefits [2]. Eggplant is also considered an interesting vegetable due to its phytochemicals contents. However, it can become toxic depending on the amount consumed [3]. It is an economic crop that provides a great income source for small-scale farmers globally, especially in China, being the highest producer [4]. Eggplant is considered among the top five vegetable crops in Asia and the Mediterranean basin [5]. According to FAOSTAT [4], global eggplant production areas were estimated at 1.84 million hectares with a total production of 55.20 million metric tons in 2019, which is 2.03% higher than in 2018 (54.10 million metric tons). Production of eggplant has increased by 50% in the past decade, likewise the demand due to awareness of its health benefits. Despite its economic importance, eggplant breeding is lagging compared to other Solanaceous crops like pepper or tomato [6]. Due to the rapid increase in human population and the demand for eggplant and decreased cultivated land as a result of urbanization, it is highly required to step up the current yield potential to meet the consumer's demands. Based on this background, several research approaches have been conducted by scientists on pest and disease management, breeding for high fruit yield, physiological method and nutritional method. Among these methods, it is recognised that breeding for high yield traits is the most sustainable method because the traits are highly heritable. Hence, to achieve this breeding objective, the use of heterosis breeding for yield and yield-related traits relevant to hybrid development has made and can continue making significant contributions to improving eggplant new varieties. Parents' selection for getting good hybrids is an important step in any breeding program [6]. Selection of parents with good general combining ability and specific parent combination helps breeder to obtain good hybrid.

The F_1 hybrids have some advantages over non-hybrid varieties such as uniformity, earliness, and increased fruit yield [7]. As eggplant F_1 hybrids' popularity increases, knowledge regarding the combining ability and genetic architecture of different accessions are necessary to develop a useful breeding program in eggplant [8]. Information on SCA (Specific Combining Ability) and GCA (General Combining Ability) helps to select hybrids or parents for effective breeding [9]. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parent and crosses for the exploration of heterosis or to accumulate fixable genes [10]. Parents with good general and specific combining ability will generally result in good hybrids [11,12]. Among the several mating designs adopted for the study of genetic architecture in eggplant, diallel analysis has been widely used for evaluating a high number of genotypes at a time for combining ability. The diallel analysis is a good approach for screening parents to use in hybrid development as compared to other mating designs. There are different types of diallel crosses, but half diallel crosses are more controllable for breeders than full diallel analysis in terms of the number of reciprocal crosses [13]. Different studies have found a different number of parents for half diallel to assess GCA and SCA for fruit yield and other fruit yield-related agronomic traits in eggplant parents and hybrids from Southeast Asia [14], Mediterranean region [15] and Africa [16]. Besides, eggplant flowers are autogamous and have large sizes, making easy emasculation and hand pollination, and each fruit can carry a large number of seeds. This study evaluates fifteen traits consisting of vegetative, yield, yield-related and antioxidant parameters in eleven parents and 55 and their respective 55 hybrids, which is considered a fair number for obtaining effective estimates of genetic parameters. The prime objective of this experiment was to investigate the effects of combining ability as well as a genetic system governing fruit yield, yield-related components and nutritional quality to identify the best general combining parents and specific combining parents for developing productive hybrid varieties of eggplant.

2. Materials and Methods

2.1. Planting Materials

Eleven diverse cultivated eggplant accessions were used as parents for this experiment (Table 1). These accessions were selected based on different morphological and fruit yield performance. These 11 parents were hybridised using the diallel method excluding reciprocals to get 55 F_1 hybrids. Hybridization was performed manually, at first emasculation was performed on the female plant followed by pollination with pollen extracted from male plant flower. Adequate measures were taken to safeguard the genetic identity of each cross before and after crosses.

Table 1. Eggplant materials used in this study including their origin and main characteristics.

Accession Name	Origin	Fruit Colour & Shape	Selection Character
BB1	Bangladesh	Green & round	Fruit girth
BB12	Bangladesh	Purple & semi-long	Fruit yield per plant
BB31	Bangladesh	Purple & long	Fruit length
BB23	Bangladesh	Purple & semi-long	Average fruit weight
BB26	Bangladesh	Purple & very long	Average fruit weight
BT6	Thailand	Green & semi-long	Number of primary branches per plant and number of fruits per plant
BT13	Thailand	Purple & very long	Number of fruits per plant
BT15	Thailand	White & flattened	Number of fruits per plant
BT17	Thailand	Purple & flattened	Average fruit weight
BM5	Malaysia	White & very long	Fruit length & color
BM9	Malaysia	Purple & very long	Fruit length

2.2. Experimental Location

Evaluation of the hybrids and parents was conducted in two locations at the ladang 15 located on latitude 2°59′ north and longitude 101°43′ east at 55 m above from sea level and ladang 10 located on latitude 2°59′ north and longitude 101°42′ east at 45 m above from sea level, Faculty of Agriculture, Universiti Putra Malaysia. The experiments were laid in a randomised complete block design with three replications at a distance of 60 cm from plant to plant and 80 cm from row to row.

2.3. Growing Medium and Cultural Practices

The seeds were sown in germinating trays filled with peat moss soil. After three weeks (21 days), seedlings were transferred to polybags filled with mixed soil and peat moss soil at a ratio of 2:1 for two weeks before transplanting into an. After transplanting, the field was immediately irrigated to settle roots into the soil and subsequently irrigated once a day. After one week of transplanting, NPK (15:15:15) green fertiliser was applied at the rate of 10 g per plant. After four weeks of transplanting, NPK (12:12:17 + Trace element) blue fertiliser was also applied at the same dose. Other cultural practices such as weeding were controlled manually while pests and diseases were controlled using Decis (Bayer, UK) and Confidor (Bayer, UK) according to the recommended dose for maintaining healthy plants.

2.4. Data Collection

Fifteen quantitative traits data were collected from two locations described by IBPGR [17] as present in Table 2. All data were collected from randomly selected five plants of each genotype at each replication.

Table 2. Description of the quantitative traits measured from eggplant genotypes.

Traits	Method of Evaluation
Fruit length (FL, cm)	The average length of 10 marketable fruits per plant from top to bottom was taken
Fruit diameter (FD, cm)	Measured along the middle part of 10 harvestable fruit per plant by Caliper and finally, the average value was converted into cm
Fruit girth (FG, cm)	Measured along the middle part of 10 harvestable fruit per plant by measuring tape and finally, the average value was taken
Fruit length to width ratio (FLWR, ratio)	The value of fruit diameter was divided by the value of fruit length of individual fruit
Average fruit weight (FW, g)	The average weight of 10 harvestable fruit per plant was taken
Average fruit yield per plant (YPP, g)	Total fruits harvested from each selected plant in each replication & each harvest was weighted and summed up
Number of primary branches (PB, no)	Number of branches of an individual plant which produced from the main stem were counted
Days to first flowering (DF, days)	Days from transplanting to the first flowering of every plant of each accession was recorded
Days to fifty percent flowering (DFF, days)	Days from transplanting to the first flowering of fifty percent of plants of every genotype were recorded
Number of fruits per plant (NF, no)	Total number of fruits harvested from individual plant
Plant height (PH, cm)	Length of the main stem from the ground to tip of the stem was measured at 90 Days after Transplanting (DAS)
Stem diameter (SD, cm)	Stem diameter was measured at 5 cm above from the base of the stem by using calliper and the average value was converted into cm
Total soluble solids (TSS, ^{0} Brix)	The average value of five fruits were taken by using a digital refractometer
Total phenol content (TPC, mg/100 g)	TPC was determined by using Folin–Ciocalteau method [18]
Antioxidant activity (DPPH, mg/mL)	DPPH was determined by using the Colourimetric method [19]

2.5. Statistical Analysis

Combined analysis of variance (ANOVA) was performed on all data to assess the amount of variability present among parents and their offspring using SAS (Statistical Analysis Software) version 9.4 (SAS Institute Inc., Cary, NC, USA). Means comparison was conducted using the Tukey test at a 5% level of significance. The general combining ability of parents and specific combining ability of hybrids were determined following Griffing's method 2 model 1 (fixed effects) using SAS software.

3. Result

3.1. Variation among All Genotypes for Quantitative Traits in Pooled Environments

The pooled analysis of variance for the 15 quantitative traits among the 11 parents and 55 crosses over the two locations is presented in Table 3. Highly significant differences ($p \leq 0.01$) were observed among the genotypes (parents and offspring) and genotype by environment (G $\times$ E) for all the evaluated traits except for the fruit length to width ratio. Similarly, highly significant differences ($p \leq 0.01$) were recorded for the environment except for fruit yield per plant and the number of primary branches per plant. For replication within the environment, highly significant differences ($p \leq 0.01$) were recorded in fruit length, fruit diameter, fruit length to width ratio, and total phenol content, while significant differences ($p \leq 0.05$) was recorded in fruit width and days to fifty percent flowering.

Table 3. Mean squares of analysis of variance for 15 traits of parents and crosses.

Trait	ENV	REP (ENV)	Genotype	G × E	CV (%)	Error
	(df = 1)	(df = 4)	(df = 65)	(df = 65)		(df = 260)
FL	34.02 **	1.85 **	150.66 **	8.78 **	5.18	0.53
FD	10.87 **	0.22 **	10.04 **	1.27 **	5.45	0.05
FG	68.22 **	1.69 ns	101.02 **	6.74 **	6.05	0.77
FLWR	660.32 **	828.63 **	7.31 ns	6.77 ns	6.74	6.95
FW	5219.36 **	123.67 *	25,352.66 **	2372.43 **	5.3	38.43
YPP	1319 ns	838 ns	452,798.96 **	224,492.26 **	8.37	1696.94
PB	0.002 ns	0.70 **	8.64 **	0.008 **	4.81	0.04
DF	185.45 **	23.83 ns	10,904.40 **	3184.04 **	4.96	834.17
DFF	225.76 **	16.70 *	172.63 **	51.02 **	5.74	5.3
NF	297.30 **	0.04 ns	502.94 **	28.34 **	7.73	0.28
PH	4192.18 **	18.00 ns	437.48 **	264.84 **	6.16	14.83
SD	0.37 **	0.001 ns	0.19 **	0.15 **	4.15	0.002
TSS	0.58 **	0.07 ns	1.71 **	0.29 **	3.96	0.07
TPC	1416.59 **	42.62 **	2865.13 **	263.97 **	4.74	7.74
AA (DPPH)	2782.45 **	16.62 ns	351.29 **	132.77 **	4.46	7.6

Note: * Significant at 0.05 probability level, ** highly significant at 0.01 probability level, ns = non-significant, df: Degrees of freedom, ENV: Environment, REP (ENV): Replication within environment, G × E: Genotype and environment interaction, CV: Coefficient of variation, FL: Fruit length, FD: Fruit diameter, FG: Fruit girth, FLWR: Fruit length to width ratio, FW: Average fruit weight, YPP: Fruit yield per plant, PB: Number of primary branches per plant, DF: Days to first flowering, DFF: Days to fifty percent flowering, NF: Total number of fruits per plant, PH: Plant height, SD: Stem diameter, TSS: Total soluble solid, TPC: Total phenol content, AA (DPPH): Antioxidant activity (Diphenylpicryl hydrazyl).

3.2. Variation among All Genotypes Due to Combining Ability Effects in Pooled Environments

The mean squares analysis of variance due to combining ability effects were shown in Table 4. Highly significant genetic variation was observed for all studied traits for general and specific combining ability effects. The interaction between GCA and environment, and SCA and environment showed highly significant interaction except for the number of primary branches per plant, which showed no significant interaction. The value of the GCA and SCA ratio ranged from 0.97 to 32.52. The trait fruit length showed the highest value (32.52), whereas the lowest value was recorded for fruit yield per plant at 0.97 (Table 4). All of the traits showed higher than unity for GCA/SCA ratio except for fruit yield per plant.

Table 4. Mean squares of Analysis of variance for combining ability of the studied traits in pooled environments.

Trait	GCA	SCA	GCA × ENV	SCA × ENV	Error	CV (%)	GCA/SCA
FL	837.64 **	25.76 **	7.15 **	9.08 **	0.53	5.17	32.52
FD	47.52 **	3.23 **	1.23 **	1.28 **	0.05	5.45	14.73
FG	500.65 **	28.36 **	5.78 **	6.92 **	0.77	6.05	17.65
FLWR	79.73 **	4.01 **	2.30 **	1.84 **	0.06	6.74	19.87
FW	117,130.88 **	8665.71 **	1487.77 **	2533.27 **	38.43	5.3	13.52
YPP	439,657.52 **	455,188.31 **	398,851.74 **	192,790.54 **	1696.94	8.37	0.97
PB	23.24 **	5.96 **	0.02 ns	0.02 ns	0.04	4.81	3.9
DF	212.40 **	159.64 **	82.54 **	42.88 **	3.21	4.96	1.33
DFF	218.37 **	164.32 **	69.85 **	47.60 **	5.3	5.74	1.33
NF	1683.09 **	288.37 **	86.00 **	17.86 **	0.28 **	7.73	5.84
PH	764.52 **	378.01 **	493.75 **	223.21 **	14.83	6.16	2.02
SD	0.30 **	0.17 **	0.17 **	0.15 **	0	4.15	1.81
TSS	7.40 **	0.67 **	0.25 **	0.30 **	0.07	3.96	10.98
TPC	8723.06 **	1800.05 **	140.58 **	286.41 **	7.74	4.74	4.85
AA(DPPH)	358.26 **	351.48 **	124.69 **	132.78 **	7.61	4.47	1.02

Note: ** highly significant at 0.01 probability level, ns = non-significant, GCA = General combining ability, SCA = Specific combining ability, GCA × ENV = Interaction of GCA and environment, SCA × ENV = Interaction of SCA and environment, FL: Fruit length, FD: Fruit diameter, FG: Fruit girth, FLWR: Fruit length to width ratio, FW: Average fruit weight, YPP: Fruit yield per plant, PB: Number of primary branches per plant, DF: Days to first flowering, DFF: Days to fifty percent flowering, NF: Total number of fruits per plant, PH: Plant height, SD: Stem diameter, TSS: Total soluble solid, TPC: Total phenol content, AA(DPPH): Antioxidant activity (Diphenylpicryl hydrazyl).

3.3. Mean Performance of Genotypes over Two Locations

The mean comparison for all genotypes (parents and offspring) was presented in Table 5. The fruit length ranged from 3.84 to 25.62 cm as observed in BT15 × BT15 and BB31 × BT13, respectively with an average value of 14.09 cm. The trait fruit diameter varied from 2.56 to 7.58 cm as recorded by BB12 × BT6 and BT17 × BT17, respectively with an average value of 4.23 cm. The least value of fruit girth was recorded at 8.63 cm (BT15 × BT15) whereas the highest value of fruit girth's 25.38 cm was observed in BT17 × BT17. The average value of fruit girth was 14.52 cm. Fruit length to width ratio ranged from 1.43 to 7.74 (ratio) with an average value of 3.61 (ratio). The maximum value of fruit length to width ratio was observed in cross BM9 × BB31 whereas, the minimum value was found from the cross BT17 × BT6. The cross performance value for average fruit weight ranged from 9.57 g (BT15 × BT15) to 334.06 g (BM9 × BB1) with an overall mean of 116.83 g.

Table 5. Means for quantitative characters studied in 66 eggplants in two environments.

Parental Crosses and Hybrids	FL	FD	FG	FLWR	FW	YPP	PB	DF	DFF	NF	PH	SD	TSS	TPC	AA (DPPH)
BB12 × BB12	10.68l–u	3.32f–l	11.1m–t	3.18c–k	45.5m–q	216.4b	5.67fg	35.33b–f	37.83b–e	4.78de	55.0ab	1.04a	6.27cde	59.40c–o	72.02ab
BT17 × BT17	12.39i–t	7.58a	25.38a	1.63i–k	207.16b–f	732.6ab	6.83b	39.17a–f	41.67b–e	4.11de	61.95ab	1.53a	7.12b–e	48.96f–p	63.70a–d
BM9 × BM9	15.50d–p	5.48a–k	17.74c–l	2.86d–k	158.05b–n	171.7b	4.89j	41.67a–f	45.17a–e	1.05e	62.11ab	1.45a	6.22cde	66.46c–o	62.10a–d
BB1 × BB1	12.89h–t	6.15a–f	23.25abc	2.24g–k	207.92b–f	258b	3.11qr	37.67a–f	42.67b–e	1.16e	57.58ab	1.25a	6.75b–e	41.42h–p	54.61a–d
BB23 × BB23	13.81h–s	3.75d–l	15.07f–t	3.77b–k	114.19b–q	251b	2.89r	39a–f	42.83a–e	2.33de	42.61ab	1.39a	6.43cde	57.63c–o	64.37a–d
BB26 × BB26	12.13j–t	5.95a–h	19.11a–h	2.06h–k	127.37b–q	369.1ab	3.22pq	42b–f	46.17a–d	2.67de	73.75ab	1.29a	5.9e	61.42c–o	70.72abc
BB31 × BB31	22.42a–f	4.49c–l	15.08f–t	5.00a–h	225.14abc	580.5ab	3.22pq	34.33b–f	37.67b–e	2.47de	71.11ab	1.66a	6.53cde	43.59h–p	68.83a–d
BM5 × BM5	22.91a–d	3.72d–l	12.56i–t	6.26a–d	190.46b–i	440.6ab	3.89n	43.17a–f	45.5a–e	2.78de	58.86ab	1.15a	6.08de	48.42f–p	55.39a–d
BT13 × BT13	17.71b–n	2.94i–l	9.44rst	5.96a–e	63.42k–q	664.7ab	5.22hi	33.83b–f	38.17b–e	11.69b–e	61.03ab	1.3a	6.87b–e	73.54b–m	66.25a–d
BT6 × BT6	7.39stu	2.98i–l	9.86rst	2.49f–k	36.6n–q	304.4b	4.89j	26.5def	31.33de	11.05b–e	61.36ab	1.19a	6.92b–e	81.21b–h	73.39a
BT15 × BT15	3.84u	2.63kl	8.63t	1.44k	9.57q	611.7ab	3.50o	40a–f	45.17a–e	69.83a	38.75b	0.73a	9.58a	81.88b–h	40.87d
Parental mean	**13.79**	**4.45**	**15.2**	**3.35**	**125.94**	**418.24**	**4.3**	**37.51**	**41.29**	**10.35**	**58.55**	**1.27**	**6.79**	**60.35**	**62.93**
BB12 × BT17	10.66m–u	3.27g–l	11.72j–t	3.36c–k	57.04l–q	479.9ab	5.11ij	35b–f	37.17b–e	6.61cde	51.33ab	1.02a	6.85b–e	47.10f–p	70.03abc
BB12 × BM9	11.79j–t	3.49f–l	11.26l–t	3.46c–k	58.97l–q	586.5ab	4.22lm	34.83b–f	36.33b–e	10.89b–e	57.67ab	0.92a	6.78b–e	59.75c–o	70.33abc
BB12 × BB1	11.11k–u	4.70b–l	15.73d–r	2.33g–k	82.78g–q	950.3ab	3.22pq	29c–f	33.5cde	11.72b–e	68.63ab	1.45a	6.55cde	38.38j–p	55.98a–d
BB12 × BB23	12.03j–t	3.61e–l	14.38g–t	3.31c–k	92.44e–q	456.8ab	4.89j	34.67b–f	37b–e	5.41cde	57.80ab	1.26a	6.5cde	75.25b–l	62.71a–d
BB12 × BB26	13.87h–s	4.44c–l	15.52e–s	3.11c–k	86.8f–q	266.4b	2.57s	35.83b–f	38.33b–e	3.05de	63.3ab	1.12a	6.45cde	71.21b–m	68.35a–d
BB12 × BB31	16.64c–n	3.79d–l	12.25i–t	4.38a–k	102.18d–q	496.8ab	4.22lm	35.5b–f	38.33b–e	5.36cde	64.34ab	1.24a	6.43cde	51.00e–p	71.49abc
BB12 × BM5	16.41c–n	3.47f–l	12.52i–t	4.77a–k	87.25f–q	489.3ab	4.11mn	36.67b–f	38b–e	6.42cde	72.98ab	1.27a	6.55cde	46.46f–p	62.81a–d
BB12 × BT13	17.20b–n	3.14h–l	11.06m–t	5.56a–g	76.51h–q	194.2b	4.22lm	32.5b–f	35.33b–e	2.39de	59.15ab	1.61a	6.67b–e	42.17h–p	60.84a–d
BB12 × BT6	7.72r–u	2.56l	10.53p–t	2.95d–k	34.67opq	731ab	7.45a	33b–f	36.33b–e	18.61bc	59.31ab	1.31a	7.28bcd	76.54b–k	59.68a–d
BB12 × BT15	6.09tu	2.89i–l	10.71o–t	2.09h–k	24.55pq	526.9ab	7b	31.5b–f	36.17b–e	22.05b	65.73ab	1.64a	7.53bc	71.79b–m	69.15a–d
BT17 × BM9	12.93h–t	5.02a–l	17.38c–n	2.53e–k	117.75b–q	354.5ab	6.44c	41a–f	43.83a–e	3.64de	64.69ab	1.30a	6.73b–e	38.17j–p	64.89a–d
BT17 × BB1	15.31e–q	6.63abc	22.21a–d	2.29g–k	196.98b–h	1103.7ab	4.89j	36.17b–f	39.17b–e	5.64cde	72.00ab	1.64a	6.86b–e	42.59h–p	58.37a–d
BT17 × BB23	15.17f–q	4.83a–l	17.94c–k	3.23c–k	173.68b–l	571.9ab	4.56k	43.5a–e	44.5a–e	4.33de	65.44ab	1.55a	6.5cde	69.46b–n	58.86a–d
BT17 × BB26	13.18h–t	6.63abc	21.67a–e	1.96i–k	212.87a–e	377.5ab	3.11qr	35.5b–f	36.83b–e	1.78de	67.0ab	1.49a	6.92b–e	78.25b–j	61.29a–d
BT17 × BB31	18.00b–m	4.95a–l	16.93c–p	3.70b–k	203.5b–g	708.4ab	4.44kl	38.17a–f	40.5b–e	3.44de	63.11ab	1.40a	6.42cde	43.42h–p	53.16a–d
BT17 × BM5	18.08b–l	3.65d–l	12.39i–t	5.08a–g	114.2b–q	513.8ab	3.89n	43.67a–d	45.17a–e	5.72cde	62.69ab	1.47a	6.45cde	55.96d–o	68.31a–d
BT17 × BT13	16.41c–n	4.33c–l	13.79g–t	3.80b–k	105.59c–q	561.6ab	3.56o	33.83b–f	37.17b–e	6.69cde	64.08ab	1.42a	7.1b–e	37.71j–p	56.16a–d
BT17 × BT6	8.70o–u	6.08a–g	20.14a–g	1.43k	152.53b–o	556.5ab	4.11mn	36.33b–f	39.17b–e	3.69de	67.11ab	1.48a	6.6cde	52.45e–p	59.94a–d
BT17 × BT15	8.17p–u	5.18a–l	17.55c–m	1.56jk	74.25i–q	265.8b	4.17m	35.83b–f	39.83b–e	3.64de	63.94ab	1.24a	7.1b–e	72.38b–m	57.99a–d
BM9 × BB1	17.25b–n	7.43ab	24.62ab	2.35g–k	334.06a	457ab	3.89n	39.83a–f	43a–e	1.55de	74.5ab	1.32a	6.45cde	58.34c–o	61.60a–d
BM9 × BB23	13.07h–t	2.70kl	9.15st	4.99a–j	70.15i–q	124.5b	5.11ij	36.83b–f	40.83b–e	1.61de	54.83ab	1.14a	7.01b–e	67.75b–o	76.47a
BM9 × BB26	15.89c–o	6.47a–d	22.01a–e	2.52e–k	232.71ab	1532a	4.89j	37b–f	40.5b–e	7.72cde	82.94a	1.48a	7.03b–e	53.04d–p	62.45a–d
BM9 × BB31	21.80a–g	3.01i–l	11.74j–t	7.74a	160.76b–m	225.7b	4mn	38.33a–f	40b–e	1.61de	53.72ab	1.32a	6.43cde	44.84g–p	54.24a–d
BM9 × BM5	19.91a–h	3.7d–l	12.70i–t	5.43a–h	143.11b–p	663.9ab	5ij	32.67b–f	37.5b–e	5.11de	65.69ab	1.50a	6.52cde	50.88e–p	60.22a–d
BM9 × BT13	21.89a–g	3.40f–l	11.55k–t	6.49a–c	137.33b–p	506.6ab	3.89n	28.33c–f	31.67de	3.78de	59.55ab	1.43a	7.13b–e	79.17b–i	71.68abc
BM9 × BT6	13.45h–t	3.02i–l	10.3q–t	4.40a–k	70.08i–q	151.8b	6de	39.5a–f	41.67b–e	1.83de	60ab	1.19a	6.78b–e	29.71nop	62.84a–d
BM9 × BT15	7.09stu	2.98i–l	10.99n–t	2.6e–k	34.6opq	270.2b	4.92j	33.33b–f	38.83b–e	6cde	61.33ab	1.26a	6.72b–e	93.61bcd	67.40a–d
BB1 × BB23	11.26k–u	5.53a–j	17.98c–j	2h–k	119.81b–q	177.5b	2.56s	43.17a–f	46a–d	1.61de	48.55ab	1.18a	6.48cde	29.88nop	60.48a–d

Table 5. *Cont.*

Parental Crosses and Hybrids	FL	FD	FG	FLWR	FW	YPP	PB	DF	DFF	NF	PH	SD	TSS	TPC	AA (DPPH)
BB1 × BB26	13.13h–t	6.32a–e	21.29a–f	2.1g–k	189.27b–j	183.9b	2.44s	34.17b–f	39.17b–e	1e	49.30ab	1.06a	6.67b–e	54.29d–p	56.04a–d
BB1 × BB31	14.99g–r	6.86abc	21.88a–e	2.16g–k	218.31a–d	393.4ab	1.89t	42.33a–f	46.83a–d	1.5de	59.56ab	1.34a	6.67b–e	52.63e–p	58.16a–d
BB1 × BM5	14.87g–r	5.66a–i	18.66b–i	2.71e–k	172.59b–l	592.6ab	2.89r	30.17b–f	32.17cde	3.86de	65.31ab	1.19a	6.7b–e	44.00g–p	58.77a–d
BB1 × BT13	12.05j–t	3.73d–l	13.71g–t	3.4c–k	98.05d–q	279.4b	3.5o	37.33c–f	44.67a–e	3.5de	47.89ab	1.14a	6.53cde	40.00i–p	64.07a–d
BB1 × BT6	11.96j–t	5.37a–l	16.64d–q	2.20g–k	121.6b–q	283.4b	1.89t	55a	60.67a	1.94de	48.72ab	1.16a	6.58cde	34.34m–p	53.02a–d
BB1 × BT15	7.26stu	4.2c–l	14.54g–t	1.74i–k	49.66m–q	589.6ab	3.56o	26ef	31.5de	10.61b–e	66.5	1.17a	7.98b	76.04b–k	65.56a–d
BB23 × BB26	15.52d–p	4.9a–l	14.42g–t	3.21c–k	111.71b–q	161.6b	3.11qr	43.83a–d	47.67a–d	1.39de	59.00ab	1.45a	6.57cde	46.79f–p	57.20a–d
BB23 × BB31	17.19b–n	4.34c–l	13.61h–t	4.05b–k	130.42b–q	783.9ab	3.44op	33.5b–f	37.67b–e	6.42cde	64.72ab	1.36a	6.35cde	54.00d–p	57.13a–d
BB23 × BM5	19.66a–i	3.48f–l	12.57i–t	5.87a–f	143.58b–p	969.5ab	4.89j	30.33b–f	36.67b–e	7.33cde	63.25ab	1.34a	6.63b–e	84.67b–g	55.94a–d
BB23 × BT13	18.22a–k	4.09c–l	13.45h–t	4.49a–k	133.74b–p	459.2ab	5.45gh	42.67a–f	45a–e	4.39de	60.11ab	1.36a	6.7b–e	51.17e–p	52.45a–d
BB23 × BT6	12.03j–t	3.25h–l	12.25i–t	4.09b–k	67.39j–q	308.8b	5ij	32.83b–f	43.67a–e	4.89de	55.64ab	1.18a	7.03b–e	87.00b–f	60.86a–d
BB23 × BT15	6.23tu	2.76jkl	11.31l–t	2.26g–k	26.43pq	294.4b	4.56k	32.5b–f	35.83b–e	11.78b–e	65.72ab	1.17a	7.97b	90.00b–e	74.67a
BB26 × BB31	18.76a–j	5.3a–l	16.70d–q	3.55c–k	183.71b–k	387.8ab	4.56k	37b–f	46.17a–d	2.17de	78.33ab	1.41a	6.31cde	35.09l–p	58.45a–d
BB26 × BM5	23.02abc	3.76d–l	14.61g–t	6.55a–c	196.94b–h	1153.4ab	2.56s	37.67a–f	43.33a–e	6.94cde	71.80ab	1.3a	6.92b–e	28.42op	50.57a–d
BB26 × BT13	13.25h–t	2.96i–l	14.35g–t	4.46a–k	105.35c–q	141b	2.44s	44.17abc	52.33ab	1.33de	54.5ab	1.03a	6.25cde	37.13k–p	43.13cd
BB26 × BT6	10.33n–u	3.62e–l	13.34h–t	2.87d–k	67.39j–q	538.2ab	4.56k	34b–f	37.17b–e	8.89b–e	82.33a	1.28a	7.28bcd	60.13c–o	63.17a–d
BB26 × BT15	7.30stu	4.13c–l	13.99g–t	1.75i–k	43.63m–q	255.3b	4.56k	35b–f	38.17b–e	6.5cde	76.06ab	1.28a	7.17b–e	48.09f–p	55.12a–d
BB31 × BM5	22.71a–e	3.59e–l	11.47k–t	6.31a–d	125.71b–q	987.4ab	4.56k	32.67b–f	41.5b–e	8.53cde	68.50ab	1.39a	6.38cde	28.13op	64.62a–d
BB31 × BT13	25.62a	3.61e–l	11.83j–t	7.03ab	138.22b–p	683.6ab	3.44op	37b–f	42.17b–e	4.75de	59.53ab	1.42a	6.48cde	13.75p	43.89bcd
BB31 × BT6	15.41e–p	4.64b–l	17.12c–o	3.43c–k	150.66b–o	687.3ab	4.11nm	32.67b–f	39.33b–e	5.53cde	63.2ab	1.36a	7b–e	48.96f–p	54.52a–d
BB31 × BT15	8.70o–u	4.05c–l	12.78h–t	2.16g–k	54.43l–q	704.4ab	3.22pq	29.83b–f	33.5cde	14.14b–e	74.28ab	1.28a	7.27bcd	107.75ab	73.84a
BM5 × BT13	24.13ab	3.41f–l	11.14m–t	7.15ab	127.6b–q	640.3ab	5.89ef	32b–f	38.33b–e	6.14cde	60.22ab	1.44a	6.7b–e	45.71g–p	63.17a–d
BM5 × BT6	17.73b–n	3.09i–l	9.81rst	5.83a–f	80.04h–q	295b	4.56k	47ab	49.67abc	5.14de	54.11ab	1.54a	6.8b–e	66.75c–o	75.11a
BM5 × BT15	8.25p–u	3.36f–l	10.65o–t	2.44f–k	39.85m–q	537.5ab	3.89n	25.83f	27.83e	14.53bcd	68.61ab	1.45a	7.52bc	69.67b–n	73.85a
BT13 × BT6	13.27h–t	2.94i–l	10.96n–t	4.65a–k	126.68b–q	532.1ab	3.44op	35b–f	38b–e	8.06cde	68.22ab	1.45a	7.1b–e	98.13bc	63.51a–d
BT13 × BT15	7.96q–s	2.80jkl	10.63o–t	2.9d–k	33.32opq	632.2ab	6.22cd	30.67b–f	35.83b–e	22.22b	67.22ab	1.31a	7.12b–e	90.34b–e	56.68a–d
BT6 × BT15	7.65r–u	3.15h–l	10.75o–t	2.44f–k	32.33opq	115.3b	3.11qr	29.5b–f	36.17b–e	3.72de	56.39ab	1.09a	7.53bc	140.25a	63.96a–d
Hybrid mean value	**14.15**	**4.19**	**14.38**	**3.66**	**115.01**	**507.12**	**4.18**	**35.86**	**40.04**	**6.16**	**63.28**	**1.32**	**6.82**	**58.37**	**61.55**
Mean	14.09	4.23	14.52	3.61	116.83	492.3	4.2	36.13	40.12	6.86	62.49	1.31	6.81	58.7	61.78
EMS	8.78	1.27	6.74	1.91	2372.43	224492.3	0.01	48.98	51.02	28.34	264.84	0.15	0.29	263.98	132.77
HSD (0.05)	7.42	2.83	6.51	3.46	122.04	1187.1	0.23	17.54	17.9	13.34	40.77	0.98	1.35	40.71	28.87

Note: FL: Fruit length, FD: Fruit diameter, FG: Fruit girth, FLWR: Fruit length to width ratio, FW: Average fruit weight, YPP: Fruit yield per plant, PB: Number of primary branches per plant, DF: Days to first flowering of the plant, DFF: Days to fifty percent flowering, NF: Total number of fruits per plant, PH: Plant height, SD: Stem diameter, TSS: Total soluble solid, TPC: Total phenol content, AA (DPPH): Antioxidant activity (Diphenylpicryl hydrazyl), HSD: Honest significance difference, EMS: Error mean square. Means within each column with the same letter are not significantly different with Tukey's range (HSD) test at $p > 0.05$.

Mean values for total fruit yield per plant among the genotypes varied from 124.50 g (BM9 × BB23) to 1153.40 g (BB26 × BM5) with an average value of 492.30 g. Number of primary branches per plant varied from 1.89 (BB1 × BB31 & BB1 × BT6) to 7.45 (BB12 × BT6), with an average value of 4.20. The lowest value for days to first flowering was recorded for the cross BM5 × BT15 at 25.83 days, while the highest value of 55 days was recorded BB1 × BT6. The range of variation for days to fifty percent flowering was recorded from 27.83 days (BM5 × BT15) to 60.67 days (BB1 × BT6) with an overall mean value of 40.12 days. The lowest number of fruits per plant was recorded for BB1 × BB26 (1.00), and the highest number of fruits per plant was 69.83 (BT15 × BT15). The average value of this trait was 6.86. The performance of genotypes for plant height ranged from 38.75 cm (BT15 × BT15) to 82.94 cm (BM9 × BB26) with an average value of 62.49 cm. Among the genotypes, the trait stem diameter varied from 0.73 cm (BT15 × BT15) to 1.64 cm (BB12 × BT15 & BT17 × BB1). Total soluble solid (TSS) values ranged from 5.90 (^{0} Brix) to 9.58 (^{0} Brix), with an overall mean of 6.81(^{0} Brix). The highest value of TSS was observed in genotype BT15 × BT15, and the lowest value was found from BB26 × BB26. A wide variation was found for total phenol content (TPC) which varied from 13.75 mg/100 g (BB31 × BT13) to 140.25 mg/100 g (BT6 × BT15) with an average value of 58.70 mg/100 g. Antioxidant activity (DPPH) ranged from 40.87 mg/mL to 76.47 mg/mL with an overall mean 61.78 mg/mL. The maximum value of antioxidant activity (DPPH) was observed in the genotype (BM9 × BB23), and the minimum value was 40.87 mg/mL (BT15 × BT15). The hybrid mean is greater than the parental mean for fruit length, fruit yield per plant, plant height, stem diameter and total soluble solids. In contrast, days to first flowering and days to fifty percent of flowering higher in parental mean which indicated that the hybrids are early flowering than parents. Similarly, fruit diameter, fruit girth, fruit length to width ratio, average fruit weight, number of primary branches per plant, number of fruits per plant, total phenol content and antioxidant activity (DPPH) were higher in parental mean compared to the hybrid mean.

3.4. Combing Ability Effects on Genotypes (Parents and Offspring)

3.4.1. General Combining Ability Effects on Genotypes (Parents and Offspring) in Pooled Environment

Genotype BM5 showed the highest positively significant GCA effect for the trait fruit length, fruit length to width ratio and fruit yield per plant with the value of 4.73, 1.64 and 139.71, respectively (Table 6). Whereas, BB1 recorded the highest positively significant GCA effect for the traits fruit diameter, fruit girth and average fruit weight with the values of 1.38, 4.58 and 45.92, respectively. The parent BB26 showed the highest GCA effect for days to the first flowering of plant (1.89), days to 50% flowering of plant (2.35) and plant height (6.32). The parent with the maximum value for the total number of primary branches per plant and stem diameter was found from BT17 with the value of 0.60 and 0.10 respectively. The highest value of the total number of fruits per plant, total soluble solids and total phenol content was recorded from the parent BT15 with GCA values of 13.27, 0.87 and 24.56, respectively. Conversely, BT15 showed the lowest GCA effect for fruit length, fruit girth, average fruit weight, fruit length to width ratio, stem diameter and days to first flowering of plants with the values of −6.67, −2.55, −74.60, −0.11 and −3.35, respectively. The parent BB1 had the lowest negative GCA values for the number of primary branches per plant (−1.04), total number of fruits per plant (−2.85) and antioxidant activity (DPPH) (−3.08). The line BB12 had the highest positive GCA value for antioxidant activity (DPPH) and the lowest negative GCA value for days to fifty percent flowering.

Table 6. Estimation of general combining ability (GCA) effects on parents for 15 traits of eggplant.

Trait	BB12	BT17	BM9	BB1	BB23	BB26	BB31	BM5	BT13	BT6	BT15
FL	−1.86 **	−0.59 **	1.31 **	−1.09 **	−0.08 ns	−0.04 ns	4.27 **	4.73 **	2.80 **	−2.77 **	−6.67 **
FD	−0.66 **	1.14 **	0.11 **	1.38 **	−0.29 **	0.74 **	0.18 **	−0.48 **	−0.81 **	−0.54 **	−0.77 **
FG	−2.03 **	3.71 **	0.23 *	4.58 **	−0.54 **	2.45 **	0.17 ns	−1.74 **	−2.53 **	−1.75 **	−2.55 **
FLWR	−0.12 **	−0.85 **	0.38 **	−1.20 **	0.13 **	−0.55 **	0.86 **	1.64 **	1.43 **	−0.31 **	−1.42 **
FW	−46.76 **	32.36 **	21.05 **	45.92 **	−8.02 **	21.78 **	39.70 **	16.14 **	−14.83 **	−32.73 **	−74.60 **
YPP	−22.83 **	80.86 **	−53.19 **	−29.29 **	−84.44 **	−13.26 **	100.94 **	139.71 **	3.99 ns	−84.59 **	−37.90 **
PB	0.58 **	0.60 **	0.59 **	−1.04 **	−0.09 **	−0.71 **	−0.47 **	−0.03 ns	0.16 **	0.27 **	0.13 **
DF	−1.88 **	1.83 **	0.88 **	1.15 **	1.40 **	1.89 **	−0.61 **	0.11 ns	−0.96 **	−0.44*	−3.35 **
DFF	−3.02 **	0.40 ns	0.24 ns	1.58 **	1.47 **	2.35 **	−0.01 ns	−0.02 ns	−0.35 ns	0.24 ns	−2.88 **
NF	1.52 **	−2.23 **	−2.81 **	−2.85 **	−2.20 **	−2.79 **	−1.85 **	−0.55 **	0.33 **	0.16 **	13.27 **
PH	−1.52 **	1.18 **	0.71 ns	−2.60 **	−5.36 **	6.32 **	3.20 **	1.61 **	−2.11 **	−0.93 *	−0.51 ns
SD	−0.06 **	0.10 **	0.00 ns	−0.05 **	0.00 ns	−0.02 **	0.08 **	0.03 **	0.04 **	−0.02 **	−0.11 **
TSS	−0.12 **	0.00 ns	−0.13 **	−0.06 *	−0.09 **	−0.18 **	−0.23 **	−0.19 **	−0.02 ns	0.16 **	0.87 **
TPC	−0.46 ns	−5.31 **	0.29 ns	−11.62 **	5.14 **	−5.32 **	−10.59 **	−6.69 **	−1.70 **	11.71 **	24.56 **
AA (DPPH)	3.87 **	−0.09 ns	2.69 **	−3.08 **	0.32 ns	−1.86 **	−1.09 **	0.22 ns	−2.56 **	1.69 **	−0.11 ns

Note: *, **, ns: Significant at $p \leq 0.05$, $p \leq 0.01$ and non-significant respectively, FL: Fruit length, FD: Fruit diameter, FG: Fruit girth, FLWR: Fruit length to width ratio, FW: Average fruit weight, YPP: Fruit yield per plant, PB: Number of primary branches per plant, DF: Days to first flowering of the plant, DFF: Days to fifty percent flowering, NF: Total number of fruits per plant, PH: Plant height, SD: Stem diameter, TSS: Total soluble solid, TPC: Total phenol content, AA (DPPH): Antioxidant activity (Diphenylpicryl hydrazyl).

3.4.2. Specific Combing Ability Effects on Hybrids across the Environment

The specific combining ability effects on hybrids over the environments were presented in Table 7. Out of 55 hybrids evaluated, 20 were negatively significant for fruit length. Hybrid BM5 × BT15 showed the lowest and negative significant SCA effect (−4.55). On the other hand, 21 hybrids showed a positively significant SCA effect for fruit length whereas hybrid BB31 × BT13 registered the highest and positive significant SCA effect with the value of 4.46. For fruit diameter, 22 hybrids showed a positively significant SCA effect among 55 hybrids. The hybrid BM9 × BB1 showed the highest and positively significant SCA effect with the value of 1.71, and hybrid BB12 × BT17 showed the least and negatively significant SCA effect with the value of −1.58. For the trait fruit girth, 19 hybrids showed a negatively significant SCA effect, while another 19 crosses showed a positively significant SCA effect indicating their good specific combining ability. The maximum and positively significant SCA effect was recorded from the cross BT17 × BT15 with the value of 5.31. The lowest and negative significant SCA effect was recorded from the cross BM9 × BB23 (−5.05) among 18 negatively significant SCA values. For the trait fruit length to width ratio, 18 crosses showed a positively significant SCA effect with the highest value of 2.89 (BM9 × BB31). The lowest and negative significant SCA effect was recorded from the cross BM5 × BT15 (−2.03) among 24 negatively significant SCA values.

Table 7. Estimation of specific combining ability (SCA) effects on hybrids for 15 traits of eggplant.

Hybrid	FL	FD	FG	FLWR	FW	YPP	PB	DF	DFF	NF	PH	SD	TSS	TPC	AA(DPPH)
BB12 × BT17	−0.98 **	−1.58 **	−4.48 **	0.73 **	−45.40 **	−70.42 **	0.00 ns	−1.08 ns	−0.34 ns	0.46 *	−10.83 **	−0.33 **	0.16 ns	−5.83 **	8.24 **
BB12 × BM9	−1.75 **	−0.19 *	−1.46 **	−0.40 **	−32.15 **	170.23 **	−1.16 **	−0.30 ns	−1.00 ns	5.32 **	−4.02 **	−0.32 **	0.23 *	1.22 ns	1.99 ns
BB12 × BB1	−0.03 ns	−0.25 **	−1.34 **	0.04 ns	−33.22 **	510.15 **	−0.53 **	−6.40 **	−5.18 **	6.20 **	10.25 **	0.25 **	−0.08 ns	−8.24 **	−6.58 **
BB12 × BB23	−0.12 ns	0.33 **	2.43 **	−0.31 **	30.39 **	71.74 **	0.19 *	−0.99 ns	−1.57 ns	−0.77 **	2.18 ns	0.01 ns	−0.10 ns	11.87 **	−3.26 **
BB12 × BB26	1.69 **	0.13 ns	0.58 ns	0.18 ns	−5.06 *	−189.85 **	−1.52 **	−0.31 ns	−1.12 ns	−2.54 **	−4.00 **	−0.11 **	−0.05 ns	18.29 **	4.56 **
BB12 × BB31	0.13 ns	0.04 ns	−0.41 ns	0.03 ns	−7.60 **	−73.63 **	−0.09 ns	1.86 **	1.24 ns	−1.17 **	0.16 ns	−0.09 **	−0.03 ns	3.35 **	6.93 **
BB12 × BM5	−0.55 *	0.37 **	1.76 **	−0.36 **	1.03 ns	−119.90 **	−0.65 **	2.31 **	0.92 ns	−1.42 **	10.39 **	−0.01 ns	0.05 ns	−5.10 **	−3.06 **
BB12 × BT13	2.18 **	0.38 **	1.10 **	0.65 **	21.26 **	−279.29 **	−0.73 **	−0.80 ns	−1.41 ns	−6.32 **	0.28 ns	0.32 **	0.00 ns	−14.38 **	−2.24 *
BB12 × BT6	−1.73 **	−0.46 **	−0.22 ns	−0.22 *	−2.68 ns	346.08 **	2.38 **	−0.81 ns	−1.00 ns	10.07 **	−0.74 ns	0.08 **	0.44 **	6.59 **	−7.66 **
BB12 × BT15	0.84 *	0.66 **	1.40 **	−0.15 ns	51.25 **	−134.88 **	2.09 **	3.56 **	5.70 **	−4.71 **	0.80 ns	0.35 **	−0.32 *	−9.39 **	2.34 ns
BT17 × BM9	−1.87 **	−0.46 **	−1.07 **	−0.60 **	−52.49 **	−165.45 **	1.05 **	2.16 **	3.07 **	1.81 **	0.30 ns	−0.11 **	0.06 ns	−15.51 **	0.51 ns
BT17 × BB1	2.89 **	−0.13 ns	−0.60 ns	0.73 **	1.87 ns	559.87 **	1.13 **	−2.94 **	−2.94 **	3.86 **	10.93 **	0.27 **	0.11 ns	0.82 ns	−0.24 ns
BT17 × BB23	1.76 **	−0.25 **	0.26 ns	0.34 **	32.51 **	83.17 **	−0.16 *	4.14 **	2.51 **	1.89 **	7.13 **	0.13 **	−0.22*	10.93 **	−3.14 **
BT17 × BB26	−0.27 ns	0.52 **	0.98 **	−0.25 **	41.90 **	−182.38 **	−0.98 **	−4.35 **	−6.04 **	−0.07 ns	−3.00 *	0.10 **	0.29 **	30.18 **	1.46 ns
BT17 × BB31	0.23 ns	−0.60 **	−1.47 **	0.08 ns	14.60 **	34.29*	0.11 ns	0.82 ns	−0.01 ns	0.65 **	−3.77 *	−0.10 **	−0.17 **	0.62 ns	−7.44 **
BT17 × BM5	−0.15 ns	−1.24 **	−4.10 **	0.68 **	−51.13 **	−199.08 **	−0.88 **	5.60 **	4.66 **	1.63 **	−2.59 ns	0.02 ns	−0.18 ns	9.26 **	6.40 **
BT17 × BT13	0.12 ns	−0.23 **	−1.91 **	−0.39 **	−28.78 **	−15.56 ns	−1.40 **	−3.17 **	−3.00 **	1.73 **	2.52 ns	−0.03 ns	0.28 **	−13.98 **	−2.97 **
BT17 × BT6	−2.02 **	1.26 **	3.65 **	−1.02 **	36.06 **	67.89 **	−0.97 **	−1.18 ns	−1.59 ns	−1.10 **	4.37 **	0.09 **	−0.37 **	−12.66 **	−3.44 **
BT17 × BT15	0.82 *	1.65 **	5.31 **	−0.04 ns	25.25 **	−190.92 **	0.66 **	0.61 ns	2.93 **	−12.56 **	−2.13 ns	−0.05 *	−0.27 *	−4.69 **	−1.49 ns
BM9 × BB1	2.93 **	1.71 **	5.30 **	−0.45 **	150.26 **	47.16 **	0.13 ns	1.68 *	1.06 ns	0.35 ns	13.90 **	0.05*	−0.17 ns	10.97 **	0.22 ns
BM9 × BB23	−2.25 **	−1.35 **	−5.05 **	0.87 **	−59.71 **	−230.22 **	0.40 **	−1.58 *	−0.99 ns	−0.25 ns	−3.01 *	−0.17 **	0.42 **	3.62 **	11.68 **
BM9 × BB26	0.53 ns	1.39 **	4.82 **	−0.92 **	73.06 **	1106.16 **	0.80 **	−1.90 **	−2.21 *	6.46 **	13.42 **	0.19 **	0.54 **	−0.63 ns	−0.16 ns
BM9 × BB31	2.13 **	−1.51 **	−3.17 **	2.89 **	−16.83 **	−314.37 **	−0.32 **	1.93 **	−0.35 ns	−0.60 **	−12.68 **	−0.08 **	−0.02 ns	−3.56 **	−9.13 **
BM9 × BM5	−0.22 ns	−0.16 ns	−0.31 ns	−0.20 *	−10.91 **	85.11 **	0.24 **	−4.45 **	−2.84 **	1.60 **	0.88 ns	0.15 **	0.02 ns	−1.42 ns	−4.47 **
BM9 × BT13	3.70 **	−0.13 ns	−0.66 *	1.07 **	14.28 **	63.48 **	−1.06 **	−7.72 **	−8.34 **	−0.61 **	−1.54 ns	0.08 **	0.47 **	21.88 **	9.77 **
BM9 × BT6	0.82 **	−0.77 **	−2.70 **	0.72 **	−35.07 **	−202.70 **	0.93 **	2.93 **	1.07 ns	−2.38 **	−2.27 ns	−0.10 **	−0.06 ns	−40.99 **	−3.32 **
BM9 × BT15	−2.84 **	0.44 **	1.55 **	−1.47 **	−29.56 **	−345.24 **	−0.51 **	3.46 **	5.93 **	−11.52 **	−3.16 ns	0.19 **	−1.16 **	17.25 **	−2.02 ns
BB1 × BB23	−1.66 **	0.21 *	−0.58 ns	−0.55 **	−34.92 **	−201.10 **	−0.52 **	4.49 **	2.83 **	−0.20 ns	−5.98 **	−0.09 **	−0.18 ns	−22.34 **	1.46 ns
BB1 × BB26	0.17 ns	−0.03 ns	−0.26 ns	0.23 *	4.74 *	−265.86 **	−0.01 ns	−5.00 **	−4.89 **	−0.22 ns	−16.91 **	−0.19 **	0.10 ns	12.54 **	−0.80 ns
BB1 × BB31	−2.29 **	1.07 **	2.61 **	−1.12 **	15.85 **	−170.53 **	−0.80 **	5.66 **	5.14 **	−0.67 **	−3.54 *	−0.01 ns	0.14 ns	16.14 **	0.56 ns
BB1 × BM5	−2.87 **	0.52 **	1.30 **	−1.35 **	−6.30 **	−10.13 ns	−0.24 **	−7.22 **	−9.51 **	0.40 *	3.80 **	−0.10 **	0.13 ns	3.61 **	−0.14 ns
BB1 × BT13	−3.75 **	−1.08 **	−2.86 **	−0.44 **	−49.87 **	−187.56 **	0.18 *	1.01 ns	3.32 **	−0.84 **	−9.90 **	−0.16 **	−0.20 ns	−5.38 **	7.93 **
BB1 × BT6	1.73 **	0.31 **	−0.71 *	0.10 ns	−8.42 **	−95.04 **	−1.55 **	18.16 **	18.73 **	−2.22 **	−10.24 **	−0.08 **	−0.33 **	−24.45 **	−7.37 **
BB1 × BT15	1.90 **	−1.49 **	−2.44 **	1.76 **	−39.24 **	−11.26 ns	1.24 **	−8.68 **	−7.94 **	−6.66 **	7.41 **	0.04 ns	0.42 **	10.37 **	5.97 **
BB23 × BB26	1.56 **	0.22 *	−2.01 **	0.01 ns	−18.88 **	−233.02 **	−0.30 **	4.41 **	3.73 **	−0.49 *	−4.46 **	0.15 **	0.03 ns	−11.73 **	−3.04 **
BB23 × BB31	−1.09 **	0.22 *	−0.54 ns	−0.55 **	−18.10 **	275.15 **	−0.20 **	−3.43 **	−3.91 **	3.59 **	4.38 **	−0.04 *	−0.15 ns	0.75 ns	−3.88 **
BB23 × BM5	0.93 **	0.02 ns	0.33 ns	0.49 **	18.63 **	421.92 **	0.81 **	−7.31 **	−4.90 **	3.21 **	4.50 **	0.00 ns	0.09 ns	27.52 **	−6.37 **
BB23 × BT13	1.42 **	0.96 **	2.00 **	−0.68 **	39.76 **	47.36 **	1.17 **	6.09 **	3.77 **	−0.61 **	5.08 **	0.01 ns	0.00 ns	−10.97 **	−7.09 **
BB23 × BT6	0.80 **	−0.15 ns	0.02 ns	0.65 **	−8.69 **	−14.53 ns	0.61 **	−4.26 **	1.84 *	0.06 ns	−0.57 ns	−0.11 **	0.15 ns	11.45 **	−2.94 **
BB23 × BT15	−1.23 **	−0.31 **	1.51 **	−0.17 ns	5.62 ns	−148.01 **	−0.84 **	−1.62 *	−3.09 **	−6.30 **	−0.07 ns	0.04 ns	0.17 ns	−9.75 **	14.63 **

Table 7. *Cont.*

Hybrid	FL	FD	FG	FLWR	FW	YPP	PB	DF	DFF	NF	PH	SD	TSS	TPC	AA(DPPH)
BB26 × BB31	0.44 ns	0.15 ns	−0.45 ns	−0.37 **	5.40 *	−192.13 **	1.53 **	−0.41 ns	3.70 **	−0.06 ns	6.32 **	0.03 ns	−0.09 ns	−7.71 **	−0.38 ns
BB26 × BM5	4.24 **	−0.74 **	−0.63 ns	1.85 **	42.20 **	534.64 **	−0.90 **	−0.46 ns	0.88 ns	3.42 **	1.38 ns	−0.03 ns	0.47 **	−18.28 **	−9.57 **
BB26 × BT13	−3.59 **	−1.21 **	−0.09 ns	−0.03 ns	−18.44 **	−342.05 **	−1.21 **	7.10 **	10.22 **	−3.07 **	−12.21 **	−0.30 **	−0.36 **	−14.56 **	−14.23 **
BB26 × BT6	−0.95 **	−0.81 **	−1.89 **	0.12 ns	−38.50 **	143.71 **	0.79 **	−3.58 **	−5.54 **	4.66 **	14.45 **	0.01 ns	0.50 **	−4.97 **	1.55 ns
BB26 × BT15	−1.95 **	0.16 ns	−0.75 ns	−0.35 **	−53.40 **	−282.53 **	1.36 **	2.42 **	−0.08 ns	−9.46 **	6.37 **	0.12 **	−0.88 **	−16.50 **	7.96 **
BB31 × BM5	−0.39 ns	−0.35 **	−1.48 **	0.20*	−46.97 **	254.43 **	0.86 **	−2.96 **	1.41 ns	4.05 **	1.19 ns	−0.04 ns	−0.02 ns	−13.29 **	3.72 **
BB31 × BT13	4.46 **	0.01 ns	−0.33 ns	1.13 **	−3.49 ns	86.42 **	−0.45 **	2.43 **	2.41 **	−0.60 **	−4.06 **	−0.01 ns	−0.08 ns	−32.66 **	−14.24 **
BB31 × BT6	−0.18 ns	0.77 **	4.18 **	−0.73 **	26.84 **	178.64 **	0.10 ns	−2.41 **	−1.01 ns	0.35 ns	−1.50 ns	−0.01 ns	0.25 *	−10.86 **	−7.86 **
BB31 × BT15	−3.22 **	0.31 **	0.85 *	−1.22 **	1.39 ns	35.42 ns	−0.69 **	−2.91 **	−6.17 **	−4.85 **	11.30 **	0.17 **	−0.02 ns	41.15 **	22.49 **
BM5 × BT13	2.51 **	0.46 **	0.89 **	0.47 **	9.47 **	4.26 ns	1.56 **	−3.28 **	−1.41 ns	−0.51 *	−1.78 ns	0.06 **	0.09 ns	−4.61 **	3.74 **
BM5 × BT6	1.68 **	−0.12 ns	−1.22 **	0.89 **	−20.21 **	−252.47 **	0.11 ns	11.20 **	9.33 **	−1.34 **	−9.06 **	0.22 **	0.01 ns	3.03 **	11.42 **
BM5 × BT15	−4.55 **	0.81 **	1.94 **	−2.03 **	22.83 **	−387.68 **	−0.66 **	−0.24 ns	−3.97 **	−8.05 **	−1.84 ns	−0.03 ns	−0.33 **	−3.81 **	5.14 **
BT13 × BT6	−0.85 **	0.05 ns	0.72 *	−0.08 ns	57.40 **	120.40 **	−1.19 **	0.27 ns	−2.00 *	0.71 **	8.77 **	0.12 **	0.15 ns	29.41 **	2.59 *
BT13 × BT15	−4.23 **	0.47 **	1.16 **	−1.21 **	−17.83 **	338.16 **	2.43 **	−1.54 ns	−2.30 *	5.94 **	10.10 **	−0.02 ns	−0.45 **	27.01 **	7.16 **
BT6 × BT15	1.85 **	0.08 ns	−0.65 ns	0.07 ns	8.05 **	−273.26 **	−1.36 **	−11.58 **	−10.57 **	−12.69 **	−3.93 *	−0.15 **	−0.53 **	44.37 **	8.81 **

Note: *, **, ns: Significant at $p \leq 0.05$, $p \leq 0.01$ and non-significant respectively, FL: Fruit length, FD: Fruit diameter, FG: Fruit girth, FLWR: Fruit length to width ratio, FW: Average fruit weight, YPP: Fruit yield per plant, PB: Number of primary branches per plant, DF: Days to first flowering of the plant, DFF: Days to fifty percent flowering, NF: Total number of fruits per plant, PH: Plant height, SD: Stem diameter, TSS: Total soluble solid, TPC: Total phenol content, AA (DPPH): Antioxidant activity (Diphenylpicryl hydrazyl).

Positively significant SCA effects were recorded from 22 crosses for average fruit weight. The highest and positive significant effect of SCA (150.26) was found from the cross BM9 × BB1. On the other hand, negative significant SCA effects were recorded from 27 crosses. The least and negative significant SCA value (−59.71) was recorded from the cross BM9 × BB23. Positively significant SCA effects were observed in 22 crosses for fruit yield per plant. The highest and positive significant value (1106.16) of SCA for this trait was recorded from the cross BM9 × BB26. On the other hand, a negatively significant value of SCA effects was recorded from 27 crosses with the least value of −387.68 (BM5 × BT15). For the trait total number of primary branches per plant, 21 crosses showed positively significant SCA effects, whereas another 21 crosses showed negatively significant SCA effects. The highest and positive significant value of SCA was 2.43, recorded from the cross BT13 × BT15. The lowest and negative significant SCA value was −1.55 found from the cross BB1 × BT6. Out of 55 hybrids, 19 hybrids showed positively significant SCA effects, whereas 21 hybrids showed negatively significant SCA effect for the trait days to first flowering of plants. The highest and positive significant value of SCA was 18.16 recorded from the cross BB1 × BT6. The lowest and negative significant SCA value was −11.58 found from the cross BT6 × BT15. Positively significant SCA effects were observed in 17 hybrids out of 55 crosses for the trait days to fifty percent flowering. The highest and positive significant value (18.73) of SCA for this trait was recorded from the cross BB1 × BT6. On the other hand, negatively significant value of SCA effects was recorded from 19 hybrids with the least value of −10.57 (BT6 × BT15). A total of 27 crosses showed a negatively significant effect on the total number of fruits per plant. The hybrid BT6 × BT15 showed the lowest and negative significant SCA effect with the value of −12.69. On the other hand, 20 hybrids showed a positively significant SCA effect for this trait whereas; the hybrid BB12 × BT6 registered the highest and positive significant SCA effect with the value of 10.07. Positively significant SCA effects were recorded from 17 hybrids and negatively significant SCA effects were also recorded from 17 hybrids out of 55 for the trait plant height. The hybrid BB26 × BT6 revealed the highest value of SCA and the hybrid BB1 × BB26 showed the lowest negative value of SCA with the value of 14.45 and −16.91 respectively. Among 55 hybrids, 19 hybrids showed a positively significant SCA effect for stem diameter. The hybrid BB12 × BT15 showed the highest and positively significant SCA effect with the value of 0.35 and the hybrid BB12 × BT17 showed the least and negatively significant SCA effect with the value of −0.33. Total 19 hybrids, among 55 showed negatively significant SCA effect for this trait.

Positively significant SCA effects were observed in 11 crosses for total soluble solids. The highest and positive significant value (0.54) of SCA for this trait was recorded from the cross BM9 × BB26. On the other hand, a negatively significant value of SCA effects was recorded from 12 crosses with the least value of −1.16 (BM9 × BT15). Positively significant SCA effects were observed in 22 crosses for total phenol content. The highest and positive significant value (44.37) of SCA for this trait was recorded from the cross BT6 × BT15. On the other hand, a negatively significant value of SCA effects was recorded from 27 crosses with the least value of −40.99 (BM9 × BT6). For the trait DPPH, 18 hybrids showed positively significant SCA effects, whereas 22 hybrids showed negatively significant SCA effects. The highest and positive significant value of SCA was 22.49, recorded from the cross BB31 × BT15. The lowest and negative significant SCA value was −14.24 found from the cross BB31 × BT13. The top general and specific combiner based on the performance of different traits are presented in Table 8.

Table 8. The best general and specific combiner for 15 traits.

Sl No.	Traits	General Combiner	Specific Combiner
1	Fruit length	BM5	BB31 × BT13
2	Fruit diameter, Average fruit weight	BB1	BM9 × BB1
3	Fruit girth	BB1	BT17 × BT15
4	Fruit length to width ratio	BM5	BM9 × BB31
5	Total fruit yield per plant	BM5	BM9 × BB26
6	Number of primary branches per plant	BT17	BT13 × BT15
7	Days to first flowering of plants	BT15	BT6 × BT15
8	Days to fifty percent flowering	BB12	BT6 × BT15
9	Number of fruits per plant	BT15	BB12 × BT6
10	Plant height	BB26	BB26 × BT6
11	Stem diameter	BT17	BB12 × BT15
12	Total soluble solids	BT15	BM9 × BB26
13	Total phenol content	BT15	BT6 × BT15
14	Antioxidant activity (Diphenylpicryl hydrazyl)	BB12	BB31 × BT15

4. Discussions

The result showed that environmental factors influenced the expression of the characters of eggplant genotypes. The mean of hybrids for fruit length, fruit yield per plant, plant height, stem diameter and total soluble solid is higher than the parental mean. It indicated that hybrids had long fruit sizes with high soluble solids compared to parents. However, days to first flowering and days to fifty percent of flowering of hybrids had less mean value than parental mean indicated that early flowering among the hybrids, which ultimately increased fruit yield per plant. On the other hand, fruit diameter, fruit girth, fruit length to width ratio, average fruit weight, number of primary branches per plant, number of fruits per plant, total phenol content and antioxidant activity (DPPH) were higher among the parents compared to hybrid mean indicating that the parents had thick fruit with a high number of primary branches which ultimately increased number of fruits with high total phenol content and antioxidant activity (DPPH).

Genotypes and environment interaction were highly significant for the entire studied trait except for the fruit length to width ratio. These results indicated that both parents and offspring were highly influenced by the environment for all traits except for the fruit length to width ratio. [20]. Eggplants are mostly self-pollinated crops that have fixed alleles, and genetic variation is also limited among cultivated varieties. Under this situation, different underexploited variabilities in different gene pools can contribute useful genes to improve existing cultivars [21]. In our study, 11 cultivated eggplant accessions with different sizes and shapes were used in which mean squares value of GCA were greater than the mean squares of SCA for all of the traits (except for fruit yield per plant). It indicated the preponderance of additive gene action over non-additive gene action [22,23] and this result usually favours the selection method of breeding due to the presence of high additive gene effects [23]. This result is similar to the finding of Kaushik et al. [6]. Fruit yield per plant, mean square of GCA is smaller than the respective mean square of SCA. It indicated the role of non-additive gene action for the expression of this trait. This result is similar to the result reported by [24]. The mean square values of GCA were highly significant for all the studied traits, indicating the ample amount of genetic variability present among the studied parental materials. The highly significant effect of GCA × ENV was found for all the studied traits meaning that the additive gene action was affected by the environmental variation. Moreover, the variation of these characters was greatly affected by environments [20]. The additive genetic variance is mostly responsible for the GCA component. The GCA variance with each parent has a substantial impact on the parent's selections. A good general combiner is a parent with higher positive significant GCA effects [25]. Here, GCA's high value for characters of interest was dispersed among different genotypes, meaning that none of the genotypes used had the best combiner of GCA values for different characters of interest. For example, BM5 had high GCA values for the trait fruit length, fruit length to width ratio, and fruit yield per plant which are favourable traits, which contributed positively to the hybrid for these traits in which it was involved. This breeding program's main objective is to develop high yielding hybrid, which has a high potential fruit yield comparatively existing cultivar or equal to existing cultivar [21]. Hence, BM5 could be recorded well combiner for fruit yield per plant. The parent BB1 showed the best combiner for the traits fruit diameter, fruit girth and average fruit weight. Although favourable fruit shapes depend on the market's consumer demand [6]. The parent BB26 was a good combiner for late flowering and a tall plant. The least GCA value of plant height contributed by BB23 meaning that it was the most favourable combiner to shorten plant height. That means this parent is useful to develop the dwarf plant. A similar result was reported by [26]. The parent BT15 gave the highest positively significant GCA value across the environments for the total number of fruits per plant, total phenol content and total soluble solids. This result indicated that this parent contributed to attaining more fruits with more sweetness and more phenol content [27]. On the other hand, this parent produces early flowering and small size fruits as it had the least value for first flowering and fruit size contributing traits. Days to fifty percent flowering of the plant are another important trait for consideration of earliness. The parent BB12 showed the least value for this trait and the highest positive value for antioxidant activity (DPPH). This result indicated that parent BB12 could be selected for developing early and rich in free radical scavenging activity variety. The studied parents with high GCA value (strong GCA effects) could be used to further varietal improvement of the eggplant population in Malaysia depending on desirable traits.

Specific combining ability (SCA) is the deviation from the assumed performance depending on general combining ability [28]. Specific combining ability is regulated by non-additive gene action [29]. It is considered an important criterion to evaluate hybrids. Positive and significant SCA values were usually related with hybrids in which leastwise one parent was well combined. For fruit length, hybrid BB31 × BT13 showed a desirable significant value while hybrid BM5 × BT15 showed an unwanted performance due to the highest negative performance of this hybrid. It was clear that hybrid BM9 × BB1 was the intended hybrid for high fruit diameter as it performed the highest value of SCA for these traits across the environment. Additionally, a hybrid with positive and the highest value of SCA was revealed from the cross BT17 × BT15 followed by other crosses for the trait fruit girth. On the contrary, the least significant negative SCA effect was performed by the hybrid BM9 × BB23. This result was in conformity with the finding of Bhushan et al. [30]. The most important hybrid for fruit length to width ratio was BM9 × BB31 as it recorded the highest positive value of SCA. The cross BM9 × BB1 was recorded to be the best specific combiner for average fruit weight, followed by other crosses. They [30] also found the significant and positive result of SCA for this trait. The most hopeful hybrid, for the traits fruit yield per plant and the total soluble solid was BM9 × BB26, as this hybrid showed a high value of SCA effects for both the traits (poor × poor combiner). Although the performance of GCA for both parents was poor, they were the outstanding parent, which attributed to total fruit yield per plant and total soluble solid by additive gene action. These results conformed to the results of Sarker et al. [31]. Quamruzzaman et al. [25] reported that the parents having poor GCA effects for specific traits when crossed with another parent of poor performance of GCA showed highly significant positive SCA effects. The result of this study for these two traits was similar to the previous study of Quamruzzaman et al. [25]. The number of branches per plant is a significant trait to enhance the productivity of eggplant. The higher number of branches per plant leads to a higher number of fruits per plant. The hybrid BT13 × BT15 had a superior performance for the trait number of primary branches per plant. The early flowering of plants is a highly intended character. Days to first flowering and days to fifty percent flowering are important characters for considering earliness. The hybrid BB1 × BT6 showed the highest and positively significant value of SCA for both traits (DF and DFF), indicating that this hybrid needs more time for flowering across the environment. On the other hand, the hybrid BT6 × BT15 performed the least negative SCA effects for days to first flowering and days to fifty percent flowering. It indicated that this hybrid was a good specific combiner for the early flowering of plants. Similar results were also reported by Sao and Mehta [7] and Sharma et al. [32]. The highest and significant positive value of the SCA effect for plant height was recorded from the hybrid BB26 × BT6 and the lowest negatively significant SCA value was recorded from the hybrid BB1 × BB26. It indicated that if we want to select the short type of plant, this hybrid (BB1 × BB26) will perform well. A similar type of result was also reported for this trait by the reporter Sharma et al. [32]. The hybrid BB12 × BT15 had the highest and positively significant SCA value, indicating a strong stem from this hybrid. The strong stem is less susceptible to lodging, which ultimately influences an increased fruit yield. A similar type of finding was reported by earlier reporter Sharma et al. [32].

Among the cultivated crops of the Solanaceae family, eggplant is supposed to be the best source for total phenol content. Chlorogenic acid which is the important part of the phenolic compound (70% to 90% of all the polyphenol) present in fruit flesh has antioxidant, anti-obesity, cardio-protective, anti-diabetic and anti-carcinogenic effects in many cancer cells (leukaemia and lung cancer) of the human body by inducing apoptosis [33]. Hence, high total phenol content is a desirable character of eggplant. The highest value of SCA was recorded from the cross BT6 × BT15 for total phenol content. It indicated that this hybrid was the best as a high value of phenol content is desirable for human health.

Antioxidant enzymes are produced inside the human body. However, these enzymes level are insufficient to neutralise or recycle the ROS (Reactive oxygen species) produced by metabolic processes inside the cells. Hence, antioxidants through dietary sources are needed [33,34]. Plants can produce different non-enzymatic and enzymatic antioxidants [35]. Hence, vegetables are the rich source of both enzymatic antioxidants, such as SOD, POD, CAT, POX, etc. [36,37] and non-enzymatic antioxidants, such as pigments, betalain, carotenoids, tocopherols, ascorbic acids, different phenolic and flavonoid compounds such as simple phenols, different hydroxybenzoic acids and hydroxycinnamic acids, flavanols, flavonols, flavones, flavanones, etc. [38,39] having high ROS quenching capacity. The antioxidant capacity of eggplant is considered as the top ten among 120 different vegetables [33,40]. The antioxidant activity of eggplant fruits can be determined by different assays [41]. One of the important testing methods was the antioxidant activity (DPPH) free radical scavenging assay [42]. The literature of vegetables has shown that the non-enzymatic antioxidants had strongly correlated with antioxidant activity (DPPH) in *A. blitum* [43], *A. spinosus* and *A. viridis* [44], red amaranth [45], green amaranth [31] and stem amaranth [46]. For antioxidant activity (DPPH), the hybrids BT6 × BT15 and BB31 × BT15 showed the highest positively significant performance. So these two hybrids can be considered as new hybrid varieties due to their high antioxidant potentiality.

5. Conclusions

Both additive and non-additive variances were important in the genetic control of all traits such as yield, yield related, and fruit characters in this study. Using a diallel selective mating or mass selection with concurrent random mating could result in both in the release of new eggplant high yielding hybrid varieties. From this study, it was found that the best parental lines are BT15 (based on DF, NF, TSS and TPC) followed by BM5 (based on YPP, FL, FLWR) and BB1 (based on FD, FG, FW) and could be exploited for future breeding by adopting proper strategies. Besides, other parents showed the best performance for only one trait. On the other hand, the hybrid BT6 × BT15 was reported early flowering with high total phenol content and the hybrid BM9 × BB26 has a high yield with high soluble solids. Besides, the hybrid BM9 × BB1 has a high fruit diameter and fruit weight. All other hybrids, except these three (BT6 × BT15, BM9 × BB26 and BM9 × BB1), showed the best performance for only one trait. Hence, based on the desired trait, the hybrid can be selected for future use.

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