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Heterosis Studies for Yield and its Components in Tomato (*Solanum lycopersicum* L.) Under Valley Conditions of Manipur

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ABSTRACT

Heterosis for yield components and yield per plant was studied using 7x7 half diallel cross between bacterial wilt-resistant/tolerant genotypes and high-yielding varieties. The heterosis over better parent (BP) was up to the extent of -38.14%, 42.04%, 36.14, -5.70%, -5.65%, 26.32%, 63.44%, 4.83%, 16.50%, 38.88%, 62.70% and 45.89% was recorded for plant height, number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, days to maturity, fruit set, fruit length, fruit width, number of locules per fruit, number of fruits per plant, fruit weight and fruit yield per plant, respectively. The extent of heterosis was not so high as we are also looking for resistant to the bacterial wilt disease. The crosses showing heterosis for fruit yield per plant were not heterotic for all the characters under study. The heterosis for yield was generally accompanied by heterosis for yield components. Five promising crosses *viz.*, Arka Ahuti x LO-5973, Arka Vikas x TWC-4, Arka Ahuti x TWC-4, BRH-2 x LO-5973 and CAU-TS-9 x LO-5973 were identified for developing high-yielding F_1 hybrids/varieties of tomato with many desirable traits.

Keywords: *Solanum lycopersicum* L., Heterosis, Yield and yield components

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the major vegetable crops grown in Manipur. Nowadays in Manipur, the cultivation and production of tomato is threatened by the bacterial wilt disease caused by *Ralstonia solanacearum* (Smith). Low yield and bacterial wilt both are the major limiting factors for successful cultivation of tomato in Manipur due to long spell of rainfall every year. Various strategies have been developed for controlling the disease, like application of chemicals, cultural practices and biological control but none of them proved as effective as the cultivation of a resistant variety/ hybrid. Therefore, there is need of high-yielding bacterial wilt-resistant tomato hybrids.

Since the discovery of hybrid vigour by Shull (1908), a tremendous progress has been made in the development of potential hybrids in tomato. Heterosis in tomato was first observed by Hedrick and Booth (1968) for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits were extensively studied. Singh *et al.* (2002) reviewed about heterosis research on tomato. Recent studies on heterosis in tomato were carried out by Ahmad *et al.* (2011), Kumari and Sharma (2011) and Islam *et al*. (2012). The extent of heterosis for yield components and yield of tomato in cross combinations involving wilt-resistant/ tolerant genotypes and improved varieties were studied by several workers (Chadha and Kumar, 2001; Kurian *et al*., 2001; Dharmatti *et al*., 2006, 2009; Singh and Asati, 2011). Tomato hybrids perform differently under different agro-climatic conditions. Hence, the present investigation was undertaken to identify the best parental combination

having high yield with bacterial wilt resistance in this crop under valley conditions of Manipur.

2. MATERIALS AND METHODS

A set of 7x7 diallel crosses of tomato excluding reciprocals were evaluated along with their seven parents (Arka Ahuti, Arka Vikas, BRH-2, CAU-TS-9, CLN-2026-D, LO-5973, TWC-4) in a randomised block design with three replications at the Department of Plant Breeding and Genetics' farm, College of Agriculture, C.A.U., Imphal. Each of the 28 genotypes was accommodated in two lines of 4 m length with a spacing of 60 cm between the rows and 60 cm between the plants. Recommended cultural practices were followed to raise a good crop. Observations were recorded on 10 randomly selected plants of parents and F_1's for the characters *viz*., plant height, number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, days to maturity, fruit set, fruit length, fruit width, number of locules per fruit, number of fruits per plant, fruit weight and fruit yield per plant. Observations for the characters *viz*., days to 50% flowering and days to maturity were recorded on plot basis. Heterosis over better parent and mid-parent for different characters under study were calculated as per standard procedures.

3. RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among genotypes for the various characters studied (Table 1). The magnitude of heterosis for different characters under study among the hybrid combinations are presented in Table 2 to 7.

3.1 Plant Height

Short stature was taken as a positive trait, and in such respect, three crosses, that is, Arka Ahuti x Arka Vikas, CAU-TS-9 x LO-5973 and Arka Ahuti x CLN-2026-D, exhibited negative and significant heterosis over BP of -38.14%, -32.54 % and -32.17%, respectively (Table 2). Negative heterosis was reported by Ahmad *et al*. (2011) and Singh and Asati (2011).

3.2 Number of Primary Branches per Plant

Highly significant positive heterosis over BP for this character (Table 2) was exhibited by some of the crosses *viz*., Arka Ahuti x TWC-4 (42.04%) and Arka Ahuti x CLN-2026-D (17.71%).

3.3 Number of Secondary Branches per Plant

For this character, significant positive heterosis over BP (Table 3) was exhibited by some of the crosses *viz*., Arka Ahuti x LO-5973 (36.14%), Arka Ahuti x BRH-2 (30.97%) and Arka Ahuti x TWC-4 (23.86%).

3.4 Maturity Duration

Earliness leads to early supply of the produce in the market and enables it to fetch a remunerative price. Thus, heterosis for days to 50% flowering and days to maturity had been estimated in terms of earliness. For days to 50% flowering, two crosses *viz*., Arka Vikas x CLN-2026-D (-5.70%) and CAU-TS-9 x CLN-2026-D (-4.94%) recorded negative and highly significant heterosis over BP (Table 3 and 4). From the point of view of short duration, the crosses, that is, Arka Vikas x TWC-4 (-5.65%), BRH-2 x LO-5973 (-5.61%) and Arka

Table 1: Analysis of variance for different characters in F_1 generations of tomato

Source	d.f.	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	Days to 50% flowering	Days to maturity	Fruit set (%)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	No. of locules per fruit	No. of fruits per plant	Fruit yield per plant (g)
Replication	2	16.61	1.65	0.18	23.58	34.33	26.66	0.14	0.03	68.02	0.03	9.17	10,830.33
Treatment	27	302.70**	1.24**	1.20**	24.36**	108.85**	120.52**	1.44**	0.60**	469.00**	0.42**	292.87**	237,848.50**
Error	54	27.04	0.42	0.17	8.61	40.12	49.00	0.50	0.22	160.89	0.13	10.98	30,291.19

*P=0.05, **P=0.01

Vikas x BRH-2 (-4.01%), exhibited negative and significant heterosis over the BP were desirable (Table 3). Negative heterosis for earliness has also been reported by Kurian *et al*. (2001), Ahmad *et al.* (2011) and Kumari and Sharma (2011).

3.5 Fruit Set

Positive and significant heterosis over BP (Table 4) were observed in the following crosses Arka Ahuti x CLN-2026-D (26.32%) and Arka Ahuti x TWC-4 (19.63). Higher the fruit set more will be the fruit yield per plant. Similar findings were recorded by Baishya *et al.* (2004) and Dharmatti *et al.* (2006).

3.6 Fruit Length

The following crosses, that is, CLN-2026-D x TWC-4 (63.44%), CAU-TS-9 x TWC-4 (36.84%) and Arka Vikas x CAU-TS-9 (36.13%) exhibited positive and significant heterosis over BP (Table 5). These crosses may be selected for the hybrid breeding of this character.

Table 2: Mean performance and estimates of heterosis over MP and BP for plant height (cm) and number of primary branches per plant

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of plant height (cm)		Mean (P/F_1)	Percent heterosis of number of primary branches per plant	
			MP	BP		MP	BP
1.	Arka Ahuti	75.33			5.23		
2.	Arka Vikas	57.83			5.97		
3.	BRH-2	72.17			5.71		
4.	CAU-TS-9	69.87			7.37		
5.	CLN2026D	62.17			4.85		
6.	LO5973	63.83			5.83		
7.	TWC-4	83.00			4.93		
	1x2	46.60	-30.01**	-38.14**	6.70	19.64*	12.29
	1x3	52.83	-28.36**	-29.87**	6.57	20.17*	15.19
	1x4	53.77	-25.94**	-28.63**	6.50	3.12	-11.84
	1x5	51.10	-25.67**	-32.17**	6.16	22.14*	17.71
	1x6	56.57	-18.71**	-24.91**	6.49	17.23	11.20
	1x7	68.07	-14.02*	-17.99**	7.43	46.23**	42.04**
	2x3	62.00	-4.62	-14.09*	6.11	4.63	2.35
	2x4	58.37	-8.59	-16.46**	5.20	-22.04**	-29.48**
	2x5	55.60	-7.33	-10.56	5.80	7.21	-2.79
	2x6	56.50	-7.12	-11.49	5.77	-2.26	-3.35
	2x7	71.00	0.83	-14.46*	6.13	12.54	2.79
	3x4	56.93	-19.83**	-21.11**	5.43	-16.92*	-26.31**
	3x5	52.13	-22.38**	-27.76**	5.30	0.38	-7.13
	3x6	56.10	-17.50**	-22.26**	5.87	1.68	0.57
	3x7	82.37	6.17	-0.76	6.07	14.04	6.31
	4x5	49.27	-25.37**	-29.48**	5.13	-16.03*	-30.38**
	4x6	47.13	-29.49**	-32.54**	5.56	-15.90*	-24.68**
	4x7	59.33	-22.37**	-28.51**	6.14	-0.22	-16.73*
	5x6	49.43	-21.53**	-22.56**	5.50	2.93	-5.71
	5x7	65.10	-10.31	-21.57**	5.70	16.49	15.54
	6x7	71.10	-3.16	-14.34*	6.17	14.55	5.71

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference
SE for heterosis over MP and BP = 3.68 4.25 0.46 0.53
*C.D. (0.05) = 7.67 8.86 0.96 1.10; **C.D. (0.01) = 9.82 11.34 1.22 1.41

3.7 Fruit Width

For fruit width, the following crosses exhibiting positive heterosis over BP *viz*., CAU-TS-9 x LO-5973 (4.83%) and Arka Vikas x CLN-2026-D (3.59%) may be selected (Table 5).

3.8 Numbers of Locules per Fruit

From the point of view of hybrid seed production, number of locules per fruit is considered as desirable character in tomato. For number of locules per fruit (Table 6), highest positive and significant heterosis over BP was observed to the extent of 16.50% in BRH-2 x CLN-2026-D followed by BRH-2 x LO-5973 (14.56%).

3.9 Number of Fruits per Plant

For the character, three crosses *viz*., BRH-2 x LO-5973 (38.88%), Arka Ahuti x TWC-4 (36.30%) and Arka Vikas x TWC-4 (27.12%) showing significant heterosis over BP may be selected (Table 6). Heterosis for number of

Table 3: Mean performance and estimates of heterosis over MP and BP for number of secondary branches per plant and days to 50% flowering

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of number of secondary branches per plant		Mean (P/F_1)	Percent heterosis of days to 50% flowering	
			MP	BP		MP	BP
1.	Arka Ahuti	2.77			83.67		
2.	Arka Vikas	3.97			76.33		
3.	BRH-2	3.77			84.33		
4.	CAU-TS-9	4.30			79.00		
5.	CLN2026D	3.70			87.67		
6.	LO5973	2.47			87.33		
7.	TWC-4	2.93			86.67		
	1x2	3.80	12.87	-4.20	86.33	7.92	3.19
	1x3	4.93	51.02**	30.97**	87.00	3.57	3.16
	1x4	4.77	34.91**	10.85	85.33	4.92	1.99
	1x5	3.73	15.46	0.90	86.00	0.39	-1.90
	1x6	3.77	43.95**	36.14**	88.67	3.70	1.53
	1x7	3.63	27.49*	23.86*	86.67	1.76	0.00
	2x3	4.13	6.90	4.20	84.00	4.56	-0.40
	2x4	4.97	20.16*	15.50	86.00	10.73	8.86**
	2x5	4.80	25.22**	21.01*	82.67	0.81	-5.70
	2x6	3.67	13.99	-7.56	87.00	6.31	-0.38
	2x7	3.60	4.35	-9.24	84.00	3.07	-3.08
	3x4	4.67	15.70*	8.53	85.00	4.08	0.79
	3x5	3.47	-7.14	-7.96	85.33	-0.78	-2.66
	3x6	3.77	20.86*	0.00	85.00	-0.97	-2.67
	3x7	3.67	9.45	-2.65	86.33	0.97	-0.38
	4x5	4.30	7.50	0.00	83.33	0.00	-4.94
	4x6	3.47	2.46	-19.38*	91.67	10.22	4.96
	4x7	3.47	-4.15	-19.38*	87.33	5.43	0.77
	5x6	3.13	1.62	-15.32	85.00	-2.86	-3.04
	5x7	3.30	-0.50	-10.81	86.33	-0.96	-1.52
	6x7	3.47	28.40*	18.18	86.67	-0.38	-0.76

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference
SE for heterosis over MP and BP = 0.29 0.33 2.07 2.40
C.D. (0.05) = 0.60 0.69 4.33 5.00; **C.D. (0.01) = 0.77 0.89 5.54 6.40

fruits per plant in tomato has earlier been reported by majority of workers (Dharmatti *et al*., 2006; Kumari and Sharma, 2011).

3.10 Fruit Weight

Average fruit weight has a key role in acceptance of produce by the consumer. Three crosses *viz*., CLN-2026-D x LO-5973 (62.70%), Arka Ahuti x LO-5973 (62.51%) and Arka Ahuti x CAU-TS-9 (24.12%) showed highest significant heterosis over BP (Table 7). Positive heterosis has been reported for this trait by Chadha and Kumar (2001), Dharmatti *et al*. (2006) and Kumari and Sharma (2011).

3.11 Fruit Yield per Plant

The two crosses (Table7) that exhibited highest heterosis over BP were Arka Ahuti x LO-5973 (45.89%) and Arka Ahuti x C AU-TS-9 (21.63). Earlier heterosis of varying degree for yield has been reported by Dharmatti *et al*. (2006), Kumari and Sharma (2011) and Singh and Asati (2011).

Negative heterosis over BP is a desirable attribute for some of the characters especially concerning with crop maturity period and plant height. In the present investigation, negative heterosis over superior parent was exhibited in many of the cross combinations. Negative

Table 4: Mean performance and estimates of heterosis over MP and BP for days to maturity and fruit set

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of days to maturity		Mean (P/F_1)	Percent heterosis of fruit set	
			MP	BP		MP	BP
1.	Arka Ahuti	135.00					
2.	Arka Vikas	110.67			61.67		
3.	BRH-2	133.00			57.67		
4.	CAU-TS-9	121.33			64.33		
5.	CLN2026D	132.67			57.00		
6.	LO5973	136.67			48.00		
7.	TWC-4	135.67			52.67		
	1x2	135.67	10.45*	0.49	54.00	-6.90	-12.43*
	1x3	134.33	0.25	-0.49	62.33	11.31*	8.09
	1x4	135.67	5.85	0.49	62.00	4.49	-3.63
	1x5	135.00	0.87	0.00	72.00	29.34*	26.32**
	1x6	137.00	0.86	0.24	60.33	17.92*	11.04
	1x7	136.33	0.74	0.49	65.00	21.50*	19.63**
	2x3	127.67	4.79	-4.01**	60.33	1.12	-2.16
	2x4	132.00	13.79*	8.79**	54.00	-14.29*	-16.06**
	2x5	133.00	9.32	0.25	59.33	0.00	-3.78
	2x6	139.67	12.94*	2.20	56.00	2.13	-9.19
	2x7	128.00	3.92	-5.65**	56.00	-2.04	-9.19
	3x4	139.00	9.31	4.51**	62.00	1.64	-3.63
	3x5	134.00	0.88	0.75	56.67	-1.16	-1.73
	3x6	129.00	-4.33	-5.61**	53.67	1.58	-6.94
	3x7	135.00	0.50	-0.49	56.33	2.11	-2.31
	4x5	127.67	0.52	-3.77*	67.00	10.44*	4.15
	4x6	136.33	5.68	-0.24	48.67	-13.35*	-24.35**
	4x7	135.00	5.06	-0.49	48.33	-17.38*	-24.87**
	5x6	136.33	1.24	-0.24	55.33	5.40	-2.92
	5x7	139.67	4.10	2.95	46.67	-14.89*	-18.13**
	6x7	137.33	0.86	0.49	46.00	-8.61	-12.66

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference
SE for heterosis over MP and BP = 1.73 1.99 2.65 3.06
*C.D. (0.05) = 3.60 4.16 5.53 6.39; **C.D. (0.01) = 4.61 5.32 7.08 8.17

and moderate heterosis for such traits has also been observed by Kurian *et al*. (2001), Ahmad *et al.* (2011) and Kumari and Sharma (2011).

The major components of yield on tomato are fruit set, number of fruits per plant, fruit weight, fruit length and fruit width. In the present study, heterosis over BP was to the extent of 26.32% in Arka Ahuti x CLN-2026-D for fruit set, 38.88% in BRH-2 x LO-5973 for number of fruits per plant, 62.70% in CLN-2026-D x LO-5973 for fruit weight, 63.44% in CLN-2026-D x TWC-4 for fruit length, 4.83% in CAU-TS-9 x LO-5973 for fruit width and 45.89% in Arka Ahuti x LO-5973 for fruit yield per plant. Thus, the observed high heterosis for yield per plant might be due to increase in fruit size and fruit weight rather than increase in number of fruits per plant. The wide range of heterosis observed for yield in the present study may be attributed to genetic diversity of parents used in hybrid combinations and such findings were supported by those of Thakur *et al*. (2004), Hannan *et al*. (2007), Kumari and Sharma (2011) and Islam *et al*. (2012). High heterosis in both positive and negative directions for yield and its components in tomato genotypes with bacterial wilt-resistant lines/genotypes were also observed by Vidyasagar *et al*. (1997), Kurian *et al*. (2001), Dharmatti *et al*. (2006, 2009) and Singh and Asati (2011).

Table 5: Mean performance and estimates of heterosis over MP and BP for fruit length (cm) and fruit width (cm)

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of fruit length (cm)		Mean (P/F_1)	Percent heterosis of fruit width (cm)	
			MP	BP		MP	BP
1.	Arka Ahuti	3.70			3.90		
2.	Arka Vikas	3.97			3.86		
3.	BRH-2	3.33			3.96		
4.	CAU-TS-9	3.17			4.13		
5.	CLN2026D	3.10			3.99		
6.	LO5973	3.60			4.21		
7.	TWC-4	2.60			2.54		
	1x2	4.43	15.65*	11.76**	3.80	-2.11	-2.57
	1x3	4.23	20.38*	14.41**	3.93	-0.04	-0.84
	1x4	4.47	30.10*	20.72**	4.13	2.82	-0.08
	1x5	3.37	-0.98	-9.01*	4.11	4.23	3.01
	1x6	3.97	8.68	7.21	4.16	2.67	-1.11
	1x7	4.33	37.57*	17.12**	3.38	5.18	-13.17**
	2x3	3.60	-1.37	-9.24*	4.07	4.01	2.69
	2x4	5.40	51.40**	36.13**	4.16	4.21	0.81
	2x5	3.03	-14.15*	-23.53**	4.13	5.31	3.59
	2x6	3.73	-1.32	-5.88	4.19	3.88	-0.40
	2x7	5.07	54.31**	27.73**	3.39	6.10	-12.09**
	3x4	3.97	22.05*	19.00**	4.03	-0.45	-2.50
	3x5	3.10	-3.63	-7.00	4.12	3.73	3.34
	3x6	3.50	0.96	-2.78	4.18	2.45	-0.55
	3x7	3.13	5.62	-6.00	3.10	-4.57	-21.72**
	4x5	3.40	8.51	7.37	4.02	-0.99	-2.66
	4x6	2.90	-14.29*	-19.44**	4.41	5.80	4.83
	4x7	4.33	50.29**	36.84**	3.16	-5.20	-23.49**
	5x6	3.73	11.44*	3.70	4.19	2.24	-0.40
	5x7	5.07	77.78**	63.44**	3.23	-1.02	-19.05**
	6x7	4.13	33.33*	14.81**	3.28	-2.72	-22.03**

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference
SEfor heterosis over MP and BP= 0.13 0.15 0.14 0.17
*C.D. (0.05) = 0.28 0.32 0.30 0.35; **C.D. (0.01) = 0.36 0.42 0.38 0.44

By considering the magnitude of heterosis expressed in the present study, it can be suggested that in the heterosis breeding programme, parents Arka Vikas and TWC-4 would be good as parents for early hybrids, CAU-TS-9 and LO-5973 for compact plant stature and fruit width, Arka Ahuti and LO5973 for number of secondary branches per plant, fruit weight, fruit set and fruit yield per plant (Table 8). On the other hand, CLN-2026-D and TWC-4 for fruit length, BRH-2 and LO-5973 for number of fruits per plant, and BRH-2 and CLN-2026-D for number of locules per fruit could be used as parents for heterosis breeding in tomato.

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REFERENCES

[1] Ahmad S, Quarmruzzaman AKM and Islam MR (2011). Estimate of heterosis in tomato (*Solanum lycopersicum* L.). *Bangladesh J. Agric. Res.* **36**(3): 521-527.

[2] Baishya KC, Shyamal MM and Singh KP (2004). Heterosis studies in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci.* **28**: 168-169.

Table 6: Mean performance and estimates of heterosis over MP and BP for number of locules per fruit and number of fruits per plant

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of No. of locules/fruit		Mean (P/F_1)	Percent heterosis of No. of fruits/plant	
			MP	BP		MP	BP
1.	Arka Ahuti	3.17			38.55		
2.	Arka Vikas	3.90			39.46		
3.	BRH-2	3.43			28.79		
4.	CAU-TS-9	4.07			55.81		
5.	CLN2026D	3.30			33.95		
6.	LO5973	3.07			28.85		
7.	TWC- 4	3.40			43.90		
	1x2	3.00	-15.09*	-23.08**	42.77	9.64	8.39
	1x3	3.57	8.08	3.88	41.07	21.97*	6.52
	1x4	4.03	11.52	-0.82	40.18	-14.84*	-28.00**
	1x5	3.47	7.22	5.05	40.62	12.04	5.35
	1x6	3.53	13.37	11.58	40.46	20.07*	4.95
	1x7	3.70	12.69	8.82	59.84	45.14**	36.30**
	2x3	3.40	-7.27	-12.82	41.10	20.44*	4.16
	2x4	3.53	-11.30	-13.11	55.81	17.16*	0.00
	2x5	3.30	-8.33	-15.38	35.16	-4.21	-10.89
	2x6	3.30	-5.26	-15.38	45.21	32.37*	14.57*
	2x7	3.20	-12.33	-17.95*	55.81	33.90*	27.12**
	3x4	4.27	13.78	4.92	38.38	-9.27	-31.23**
	3x5	4.00	18.81	16.50	37.32	18.97*	9.92
	3x6	3.93	21.03*	14.56	40.06	39.03*	38.88**
	3x7	3.80	11.22	10.68	29.80	-18.01*	-32.13**
	4x5	4.23	14.93*	4.10	57.47	28.05*	2.97
	4x6	4.10	14.95*	0.82	32.19	-23.95*	-42.32**
	4x7	3.30	-11.61	-18.85*	54.65	9.62	-2.07
	5x6	3.67	15.18*	11.11	30.53	-2.76	-10.07
	5x7	3.13	-6.47	-7.84	56.71	45.68**	29.17**
	6x7	3.23	0.00	-4.90	57.41	57.84**	30.77**

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference

SE for heterosis over MP and BP = 0.25 0.29 2.34 2.71

*C.D. (0.05) = 0.53 0.61 4.89 5.64; **C.D. (0.01) = 0.68 0.78 6.26 7.22

Table 7: Mean performance and estimates of heterosis over MP and BP for fruit weight (g) and fruit yield per plant (g)

Sl.No.	Entries	Mean (P/F_1)	Percent heterosis of fruit weight (g)		Mean (P/F_1)	Percent heterosis of fruit yield/plant (g)	
			MP	BP		MP	BP
1.	Arka Ahuti	36.72			1,369.04		
2.	Arka Vikas	56.33			1,887.86		
3.	BRH-2	39.47			1,384.75		
4.	CAU-TS-9	43.50			1,285.87		
5.	CLN2026D	27.33			1,143.51		
6.	LO5973	20.31			831.80		
7.	TWC-4	31.25			1,287.65		
	1x2	53.99	16.05*	-4.15	1,910.28	17.31*	1.19
	1x3	44.14	15.89*	11.85	1,371.23	-0.41	-0.98
	1x4	53.99	34.62*	24.12**	1,665.11	25.44*	21.63*
	1x5	38.40	19.90*	4.58	1,315.68	4.73	-3.90
	1x6	59.67	109.26**	62.51**	1,997.23	81.50**	45.89**
	1x7	21.49	-36.76*	-41.47**	1,162.08	-12.52	-15.12
	2x3	42.31	-11.68*	-24.90**	1,309.71	-19.96*	-30.62**
	2x4	52.50	5.18	-6.80	1,413.40	-10.93	-25.13**
	2x5	32.39	-22.57*	-42.50**	1,287.94	-15.03*	-31.78**
	2x6	54.88	43.20*	-2.59	1,575.69	15.87*	-16.54*
	2x7	18.91	-56.83**	-66.44**	1,036.21	-34.74*	-45.11**
	3x4	51.45	24.02*	18.27**	1,336.11	0.06	-3.51
	3x5	35.45	6.13	-10.19	1,177.02	-6.89	-15.00
	3x6	52.21	74.67**	32.28**	1,454.32	31.22*	5.02
	3x7	21.89	-38.10*	-44.54**	1,027.04	-23.14*	-25.83*
	4x5	40.50	14.35*	-6.90	1,213.35	-0.11	-5.64
	4x6	34.79	9.03	-20.03**	1,507.46	42.37*	17.23
	4x7	23.63	-36.78*	-45.68**	1,017.13	-20.95*	-21.01
	5x6	44.47	86.68**	62.70**	1,323.89	34.04*	15.77
	5x7	26.69	-8.88	-14.59	916.67	-24.59*	-28.81*
	6x7	25.73	-0.18	-17.65*	1,209.05	14.09	-6.10

BP, better parent; MP, mid parent; SE, Standard error of mean; C.D., Critical difference
SE for heterosis over MP and BP = 2.27 2.62 123.07 142.11
*C.D. (0.05) = 4.73 5.46 256.72 296.43; **C.D. (0.01) = 6.05 6.99 328.59 379.42

Table 8: Superior crosses and characters exhibiting significant heterosis

S.No.	Best crosses	Yield per plant (g)	Heterosis over better parent (BP) for
1.	Arka Ahuti x LO-5973	1,997.23	Fruit set, fruit yield per plant, number of secondary branches per plant, number of locules per fruit and fruit weight
2.	CAU-TS-9 x LO-5973	1,507.46	Fruit width, plant height and fruit yield per plant
3.	Arka Ahuti x TWC-4	1,162.08	Number of primary branches per plant, number of secondary branches per plant, fruit set and number of fruits per plant.
4.	Arka Vikas x TWC-4	1,036.21	Days to maturity, days to 50% flowering and number of fruits per plant
5.	BRH-2 x LO-5973	976.08	Number of fruits per plant and number of locules per fruit

[3] Chadha S and Kumar J (2001). Heterosis for marketable fruit yield and some quality attributing in bacterial wilt resistant tomato lines. *Karnataka J. Agric. Sci.* **114**: 1134-1136.

[4] Dharmatti PR, Kulkarni GP and Patil RV (2006). Heterosis for yield and bacterial wilt incidence in tomato. *J. Asian Hort.* **8**: 151-154.

[5] Hannan MM, Ahmed MB, Razvy MA, Karim R, Khatun M, Haydar A, Hossain M and Roy UK (2007). Heterosis and Correlation of Yield and Yield Components in Tomato (*Lycopersicon esulentum* Mill.). *American-Eurasian J. Sci. Res.* **2**(2): 146-150.

[6] Hedrick UP and Booth NO (1968). Mendelian characters in tomato. *Proc. Am. Soc. Hort. Sci.* **5**: 19-24.

[7] Islam MR, Ahmad S and Rahman MM (2012). Heterosis and qualitative attributes in winter tomato (*Solanum lycopersicum* L.) hybrids. *Bangladesh J. Agric. Res.* **37**(1): 39-48.

[8] Kumari S and Sharma MK (2011). Exploitation for yield and its contributing traits in tomato, *Solanum Lycopersicum* L. *Int. J. Farm Sci.* **1**(2): 45-55.

[9] Kurian A, Peter KV and Rajan S (2001). Heterosis for yield components and fruit characters in tomato. *J. Tropical Agric.* **39**: 5-8.

[10] Shull GH (1908). The composition of field maize. *Rep. Am. Breeders' Assoc.* **4**: 296-301.

[11] Singh AK and Asati BS (2011). Combining ability and heterosis studies in tomato under bacterial wilt condition. *Bangladesh J. Agril. Res.* **36**(2): 313-318.

[12] Singh JP, Joshi A and Singh VP (2002). Heterosis breeding in tomato: a review. *Progressive Hort.* **34**(2): 161-167.

[13] Smith EF (1908). A bacterial disease of the tomato, eggplant, and potato (*Bacillus solanacearum* n.sp.). *USDA, Div. Veg. Phys. and Path. Bull.* **12**: 1-28.

[14] Thakur AK, Kholi UK and Joshi A (2004). Evaluation of diallel progeny and heterosis for yield and yield components in tomato (*Lycopersicon esculentum* Mill.). *Haryana J. Hort. Sci.* **33**: 106-109.

[15] Vidyasagar, Chadha S and Kumar J (1997). Heterosis in bacterial wilt resistant tomato lines. *Him. J. Agric. Res.* **23**(1&2): 40-44.