Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(6): 838-843
Received: 01-09-2018
Accepted: 02-10-2018

Tinku Kumar Sharma
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Jitendra Singh
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Dhananjay Sharma
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Nandan Mehta
Department of Genetics and Plant breeding, COA, IGKV, Raipur, Chhattisgarh, India

Ravi Ratan Saxena
Department of Agricultural Statistics & Social Science, COA, IGKV, Raipur, Chhattisgarh, India

Correspondence
Tinku kumar Sharma
Department of Vegetable Science, COA, IGKV, Raipur, Chhattisgarh, India

Development of F_1 hybrids of tomato (*Solanum lycopersicum* L.) for protected cultivation

Tinku Kumar Sharma, Jitendra Singh, Dhananjay Sharma, Nandan Mehta and Ravi Ratan Saxena

Abstract
The present studies were carried out under Naturally Ventilated Polytunnel at Centre of Excellence on Protected Cultivation and Precision Farming, Department of Vegetable Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experimental material for the present study comprised of a set of 6x6 diallel crosses of tomato excluding reciprocals were evaluated along with their six parents during the year 2017-18. The observations were recorded on days to 50 percent flowering (days), days to marketable maturity (days), number of flowers per cluster, number of fruits per cluster, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant and yield per plant (kg). Experimental outcome revealed that on the basis of heterosis (better parent) F_1 TOINDVAR-1 x TOINDVAR-5 was found best for earliness and hybrid TOINDVAR-2 x TOINDVAR-4 for yield per plant.

Keywords: Tomato, heterosis, protected condition

Introduction
Tomato is one of the major vegetable crops grown under protected condition. Tomato is highly suitable crop for protected cultivation and high yielding indeterminate varieties/ superior F_1 hybrids are preferred for protected cultivation. The cultivars under adoption are from both private and public sector and most of these become obsolete with the passage of time. Hence, there is continuous need to strengthen the crop improvement programmes in tomato and ultimately developing new varieties/hybrids suitable for protected cultivation to fulfill the demand in off-season and satisfying to the present day needs of farmers and consumers as well. So as to meet the ever increasing demand for this vegetable, there is a need for improvement and to develop superior and stable varieties/hybrids having higher yield under protected condition.

Materials and methods
A set of 6x6 diallel crosses of tomato excluding reciprocals were evaluated along with their six parents during the year 2017-18 under the Naturally Ventilated Polytunnel at Centre of Excellence on PCPF, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Six diverse tomato cultivars/lines *viz.*, Toindvar-1 (P1), Toindvar-2 (P2), Toindvar-3 (P3), Toindvar-4 (P4), Toindvar-5 (P5), and Toindvar-6 (P6), were crossed in a diallel fashion (excluding reciprocals) to obtain fifteen cross combinations. The seedlings of parents were raised during November, 2016 and further transplanted in main field to attempt crosses and generate F_1's. The fruit of crosses were harvested during March, 2017. The seedling of F1's along with parents and check variety Yuvraj were raised in July, 2017 and transplanting of each entry in the block was done in August, 2017, on raised bed in polytunnal for their evaluation and generation of data. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were twelve plants of each entry in each replication. The standard cultural practices were followed to raise the healthy crop stand. The observations were recorded on days to 50 percent flowering (days), number of flowers per cluster, number of fruits per cluster, days to marketable maturity (days), fruit diameter (mm), fruit length (mm), fruit weight (g), number of fruits per plant, yield per plant (kg).

Results and discussion
Analysis of variance indicated significant differences among parents for the various horticultural traits (Table 1). The extent of heterosis for different traits under study among the hybrid combinations are presented in Table 2 to 5.

Table 1: Analysis of variance for the various characters studied

Source of variation	d. f	1	2	3	4	5	6	7	8	9	10
Replication	2	0.17	0.03	0.01	2.05	10.61	6.97	2.95	0.87	0.03	5.75
Treatments	20	24.91*	2.69*	2.13*	22.98*	176.03*	53.57*	384.59*	68.92*	1.54*	319.41*
Error	40	1.39	0.10	0.11	2.55	9.27	4.54	11.37	4.34	0.10	8.40

*P=0.05 1. Days to first flowering, 2. Days to 50% flowering, 3. Number of flowers per cluster, 4. Number of fruits per cluster, 5. Days to marketable maturity, 6. Fruit diameter (mm), 7.Fruit length (mm), 8. Fruit weight (g), 10. Number of fruits per plant, 11. Yield per plant (kg), 12. Plant height (cm),

Table 2: Better parent heterosis (BP) and standard heterosis (SH)

		Days to 50% flowering		Number of flowers per cluster		
Parents/crosses	**Mean**	**BP**	**SH**	**MEAN**	**BP**	**SH**
Parents						
P1	35.3			8.58		
P2	31.03			9.08		
P3	37.47			10.13		
P4	37.07			7.87		
P5	39.17			9.25		
P6	34.9			11.07		
Crosses						
P1 X P 2	32.1	3.45	-3.69	10.20	12.33*	2.51
P1 x P3	36.07	2.18	8.22*	11.19	10.46*	12.46*
P1 X P4	33	-6.52*	-0.99	9.96	16.08*	0.10
P1 X P5	30.7	-13.03*	-7.89*	10.06	8.76*	1.11
P1 X P6	32.97	-5.53*	-1.08	9.93	-10.30*	-0.20
P2 x P3	32.57	4.96	-2.28	10.15	0.20	2.01
P2 X P4	31.03	0.00	-6.90*	10.28	13.22*	3.32
P2 X P5	29.8	-3.96	-10.59*	10.97	18.59*	10.25*
P2 X P6	29.5	-4.93	-11.49*	12.28	10.93*	23.42*
P3 X P4	37.1	0.08	11.31*	9.63	-4.94	-3.22
P3 X P5	37.67	0.53	13.02*	9.93	-1.97	-0.20
P3 X P6	34.53	-1.06	3.60	10.49	-5.24*	5.43*
P4 X P5	35.87	-3.24	7.62*	10.06	8.76*	1.11
P4 X P6	36	3.15	8.01*	8.77	-20.78*	-11.86*
P5 x P6	36.9	5.73*	10.71*	10.20	-7.86*	2.51
Yuvraj (C)	33.33			9.95		
Mean (P)	34.27			10.00		
SE(m)±	0.59			0.17		
$CD_{(0.05)}$	1.70			0.51		

*Significant at 5% level of significance

Table 3: Better parent heterosis (BP) and standard heterosis (SH)

		Number of fruits per cluster		Days to first marketable maturity		
Parents/crosses	**Mean**	**BP**	**SH**	**MEAN**	**BP**	**SH**
Parents						
P1	4.33			72.73		
P2	4.83			69.53		
P3	6.13			75.13		
P4	3.87			72.93		
P5	5.25			74.27		
P6	6.48			72.43		
Crosses						
P1 X P 2	4.95	2.48	-14.66*	70.33	1.15	-1.29
P1 x P3	5.94	-3.10	2.41	75.33	3.57	5.73*
P1 X P4	4.71	8.78	-18.79*	71.00	-2.38	-0.35
P1 X P5	4.81	-8.38	-17.07*	67.63	-7.01*	-5.08*
P1 X P6	4.68	-27.78*	-19.31*	70.98	-2.00	-0.38
P2 x P3	5.90	-3.75	1.72	70.68	1.65	-0.80
P2 X P4	6.03	24.84*	3.97	64.67	-6.99*	-9.24*
P2 X P5	6.72	28.00*	15.86*	68.60	-1.34	-3.72
P2 X P6	6.95	7.25	19.83*	68.38	-1.65	-4.03*
P3 X P4	5.63	-8.16	-2.93	74.08	1.58	3.97*
P3 X P5	5.93	-3.26	2.24	74.5	0.31	4.56*
P3 X P6	7.50	15.74*	29.31*	72.15	-0.39	1.26
P4 X P5	4.89	-6.86	-15.69*	73.15	0.30	2.67
P4 X P6	4.77	-26.39*	-17.76*	73.25	1.13	2.81
P5 x P6	6.20	-4.32	6.90	73.93	2.07	3.76
Yuvraj (C)	5.80			71.25		

Mean (P)	5.51			71.67		
SE(m)±	0.19			0.92		
$CD_{(0.05)}$	0.54			2.64		

*Significant at 5% level of significance

Table 4: Better parent heterosis (BP) and standard heterosis (SH)

		Fruit Diameter		Fruit length			Fruit weight		
Parents/crosses	**Mean (mm)**	**BP**	**SH**	**Mean (mm)**	**BP**	**SH**	**Mean (g)**	**BP**	**SH**
Parents									
P1	49.73			42.14			116.50		
P2	51.67			44.54			127.90		
P3	47.43			42.67			112.41		
P4	40.17			50.74			113.18		
P5	44.83			47.05			117.25		
P6	46.30			40.71			104.84		
Crosses									
P1 X P 2	53.04	2.65	10.50*	45.56	2.29	7.63	134.36	5.05*	14.29*
P1 x P3	54.95	10.50*	14.48*	45.58	6.82	7.68	139.29	19.56*	18.48*
P1 X P4	50.52	1.59	5.25	55.00	8.40*	29.93*	142.33	22.17*	21.07*
P1 X P5	48.09	-3.30	0.19	43.74	-7.04	3.33	117.08	-0.14	-0.41
P1 X P6	56.17	12.95*	17.02*	43.20	2.52	2.06	134.83	15.73*	14.69*
P2 x P3	49.82	-3.58	3.79	40.05	-10.08*	-5.39	110.93	-13.27*	-5.64
P2 X P4	49.54	-4.12	3.21	56.20	10.76*	32.77*	143.00	11.81*	21.64
P2 X P5	52.90	2.38	10.21*	44.70	-4.99	5.60	131.50	2.81	11.86*
P2 X P6	51.23	-0.85	6.73*	41.48	-6.87	-2.01	121.46	-5.04*	3.32
P3 X P4	49.50	4.36	3.13	43.00	-15.25*	1.58	118.21	4.44	0.55
P3 X P5	49.59	4.55	3.31	45.93	-2.38	8.50	126.86	8.20*	7.91*
P3 X P6	50.64	6.77*	5.50	42.00	-1.57	-0.78	118.27	5.21	0.60
P4 X P5	44.04	-1.76	-8.25*	47.25	-6.88	11.62*	115.52	-1.48	-1.74
P4 X P6	50.06	8.12*	4.29	48.15	-5.10	13.75*	134.29	18.65*	14.23*
P5 x P6	46.57	0.58	-2.98	43.25	-8.08*	2.17	111.91	-4.55	-4.81
Yuvraj (C)	48.00			42.33			117.56		
Mean (P)	47.12			45.23			117.8		
SE(m)±	1.05			1.23			2.15		
$CD_{(0.05)}$	3.02			3.52			6.15		

*Significant at 5% level of significance

Table 5: Better parent heterosis (BP) and standard heterosis (SH)

		Number of fruits per Plant		Yield (kg)			Plant height (cm)		
Parents/crosses	**Mean**	**BP**	**SH**	**MEAN**	**BP**	**SH**	**Mean**	**BP**	**SH**
Parents							170.33		
P1	42.94			5			163.71		
P2	43.40			5.55			155.03		
P3	50.71			5.7			176.47		
P4	39.30			4.45			157.69		
P5	46.97			5.51			161.16		
P6	48.76			5.11			170.33		
Crosses									
P1 X P 2	41.03	-5.46	-12.65*	5.51	-0.72	-0.36	175.43	2.99*	2.76
P1 x P3	45.53	-10.21*	-3.07	6.34	11.23*	14.65*	159.51	-6.35*	-6.57*
P1 X P4	39.75	-7.43	-15.37*	5.66	13.20*	2.35	188.23	6.66*	10.26*
P1 X P5	40.29	-14.22*	-14.22*	4.71	-14.52*	-14.83*	169.67	-0.39	-0.62
P1 X P6	38.10	-21.86*	-18.88*	5.13	0.39	-7.23	185.67	9.01*	8.76*
P2 x P3	45.38	-10.51*	-3.39	5.03	-11.75*	-9.04	177.44	8.39*	3.94*
P2 X P4	48.85	12.56*	4.00	6.99	25.95*	26.40*	172.40	-2.31	0.98
P2 X P5	50.79	8.13*	8.13*	6.68	20.36*	20.80*	157.92	-3.54*	-7.50*
P2 X P6	52.20	7.05	11.13*	6.35	14.41*	14.83*	162.06	-1.01	-5.07*
P3 X P4	48.64	-4.08	3.56	5.75	0.88	3.98	173.33	-1.78	1.53
P3 X P5	49.88	-1.64	6.20	6.33	11.05*	14.47*	164.33	4.21*	-3.74*
P3 X P6	55.71	9.86*	18.61*	6.59	15.61*	19.17*	156.15	-3.11*	-8.53*
P4 X P5	38.88	-17.22*	-17.22*	4.51	-18.15*	-18.44*	180.51	2.29	5.73*
P4 X P6	44.40	-8.94*	-5.47	5.97	16.83*	7.96	188.48	6.81*	10.40*
P5 x P6	50.99	4.57	8.56*	5.71	3.63	3.25	175.00	8.59*	2.51
Yuvraj (C)	46.97			5.53			170.72		
Mean (P)	45.88			5.64			170.04		
SE(m)±	1.20			0.20			1.67		
$CD_{(0.05)}$	3.44			0.58			4.79		

*Significant at 5% level of significance

Days to fifty percent flowering

The range of heterobeltiosis for this trait was -13.03 (Toindvar-1 x Toindvar-5) to 5.73 percent (Toindvar-5 x Toindvar-6). Three cross combinations *viz.,* Toindvar-1 x Toindvar-5 (-13.03%), Toindvar-1 x Toindvar-4 (- 6.52%) and Toindvar-1 x Toindvar-6 (-5.53%), exhibited significant negative heterosis over better parent. The relative heterosis for same trait were ranged from -17.89 (Toindvar-2 x Toindvar-6) to 4.25 percent (Toindvar-1 x Toindvar-3). The standard heterosis varied from -11.49 (Toindvar-2 x Toindvar-6) to 13.02 percent (Toindvar-3 x Toindvar-5). These results are in conformity with the findings of following researcher's viz., Duhan *et al*. (2005) [9]. And Shende *et al*. (2012) [17].

Number of flowers per cluster

The extent of heterobeltiosis ranged from -20.78 (Toindvar-4 x Toindvar-6) to 18.59 percent (Toindvar-2 x Toindvar-5) for this trait and among all crosses, eight crosses showed significant positive heterobeltiosis and top three crosses were *viz.,* Toindvar-2 x Toindvar-5 (18.59%), Toindvar-1 x Toindvar-4 (16.08%) and Toindvar-2 x Toindvar-4 (13.22%). The heterosis over check variety ranged from -11.86 percent (Toindvar-4 X Toindvar-6) To 23.42 Percent (Toindvar-2 x Toindvar-6). The significant positive standard heterosis was observed in four crosses out of fifteen crosses and only one cross (Toindvar-4 x Toindvar-6) exhibited significant negative standard heterosis for this trait. Highest positive standard heterosis was observed in cross Toindvar-2 x Toindvar-6 (23.42%) followed by Toindvar-1 x Toindvar-3 (12.46%), Toindvar-2 x Toindvar-5 (10.25%) and Toindvar-3 x Toindvar-6 (5.43%).These results are in accord with the interpretation of Hannan *et al.* (2007), Gul *et al.* (2010) [10]. and Shankar *et al*. (2013) [16].

Number of fruits per cluster

Heterobeltiosis and standard heterosis for number of fruits per cluster is ranged from -27.78 (Toindvar-1 x Toindvar-6) to 28 percent (Toindvar-2 x Toindvar-5) and -19.31 (Toindvar-1 x Toindvar-6) to 29.31 percent (Toindvar-3 x Toindvar-6), respectively. Among fifteen cross combinations, three crosses *viz.,* Toindvar-2 x Toindvar-4 (24.84%), Toindvar-2 x Toindvar-5 (28.00%) and Toindvar-3 x Toindvar-6 (15.74%) over better parent and following crosses *viz.,* Toindvar-2 x Toindvar-5 (15.86%), Toindvar-2 x Toindvar-6 (19.83%) and Toindvar-3 x Toindvar-6 (29.31%), exhibited positively significant heterosis over standard check (Yuvraj) for this trait in desirable direction. Variable results of the current study for number of fruits per cluster are in line with the past findings of Harer *et al*., (2006), Islam *et al* (2012) [12]. And Amaefula *et al.* (2014) [3].

Days to first marketable maturity

The heterobeltiosis for days to marketable maturity ranged from -7.01 percent (Toindvar-1 x Toindvar-5) to 3.57 percent (Toindvar-1 x Toindvar-3). Two cross combination *viz.,* Toindvar-2 x Toindvar-4 (-6.99%) and Toindvar-1 x Toindvar-5 (-7.01%) revealed significant negative heterosis over better parent. The standard heterosis varied from -9.24 percent to 5.73 percent in crosses Toindvar-2 x Toindvar-4 and Toindvar-1 x Toindvar-3, respectively. Significant negative standard heterosis were registered in crosses *viz.,* Toindvar-2 x Toindvar-4 (-9.24%), Toindvar-1 x Toindvar-5 (-5.08%) and Toindvar-2 x Toindvar-6 (-4.03%). Similar results of heterobeltiosis and standard heterosis in both positive and negative directions have been reported by Asati *et al.* (2007) [4], Singh *et al.* (2008) [18], in tomato, Leena *et al.* (2013) [14]. In brinjal and Chauhan *et al.* (2014) [7]. In tomato under field condition.

Fruit diameter (mm)

Heterobeltiosis for fruit diameter ranged from -4.12 to 12.95 percent in the crosses Toindvar-2 x Toindvar-4 and Toindvar-1 x Toindvar-6, respectively. Four cross combinations *viz.,* Toindvar-3 x Toindvar-6 (6.77%), Toindvar-4 x Toindvar-6 (8.12%), Toindvar-1 x Toindvar-3 (10.50%) and Toindvar-1 x Toindvar-6 (12.95%), showed significant positive heterosis over better parent. At the same time, the standard heterosis varied from -8.25 percent (Toindvar-4 x Toindvar-5) to 17.02 percent (Toindvar-1 x Toindvar-6). Significant positive heterosis over the check was shown by five cross combinations *viz.,* Toindvar-1 x Toindvar-6 (17.02%), Toindvar-1 x Toindvar-3 (14.48%), Toindvar-1 x Toindvar-2 (10.50%), Toindvar-2 x Toindvar-5 (10.21%) and Toindvar-2 x Toindvar-6 (6.73%). Similar results have been reported by Shende *et al.* (2012) [17]. And Chauhan *et al.* (2014) [7].

Fruit length (mm)

Heterobeltiosis for fruit length ranged from -15.25 percent (Toindvar-3 x Toindvar-4) to 10.76 percent (Toindvar-2 x Toindvar-4). The following crosses *viz.,* Toindvar-1 x Toindvar-4 and Toindvar-2 x Toindvar-4 registered significant positive heterosis over better parent (8.40% and 10.76%, respectively). On other hand, standard heterosis varied from -5.39 percent (Toindvar-2 x Toindvar-3) to 32.77 percent (Toindvar-2 x Toindvar-4). The following crosses; Toindvar-2 x Toindvar-4 (32.77%), Toindvar-1 x Toindvar-4 (29.93%), Toindvar-4 x Toindvar-6 (13.75%) and Toindvar-4 x Toindvar-5 (11.62%) were showed significant positive heterosis over the check (Yuvraj). Fruit length positively contributed to yield per plant. In the present study, significant heterobeltiosis and standard heterosis for fruit length was exhibited by some crosses. Similar outcome were confirmed by Chattopadhyay and Paul (2012) [17]. And Dagade *et al.* (2015) [8].

Fruit weight (g)

For this trait, heterobeltiosis and standard heterosis ranged from -13.27 (toindvar-2 x Toindvar-3) to 22.17 percent (Toindvar-1 x Toindvar-4) and -5.64 (Toindvar-2 x Toindvar-3) to 21.64 percent (Toindvar-2 x Toindvar-4), respectively. The significant positive heterosis over better parent (heterobeltiosis) for this trait exhibited by seven crosses and highest heterosis was recorded in Toindvar-1 x Toindvar-4 (22.17%) followed by Toindvar-1 x Toindvar-3 (19.56%) and Toindvar-4 x Toindvar-6 (18.65%) etc. In desirable direction. Similarly eight crosses showed significant positive heterosis over check variety and the cross Toindvar-2 x Toindvar-4 (21.64%) registered highest heterotic hybrid over standard variety for said character in desirable direction. Average fruit weight is one of the important trait which is directly associated with fruit yield per plant. These results are in consonance with the result of Agarwal *et al.* (2014) [1], Chauhan *et al.* (2014) [7] and Amaefula *et al.* (2014) [3]. In tomato, while, analogous results exhibiting positive heterosis for improved average fruit weight was explained by Kumari and Sharma (2011) [13].

Number of fruits per plant

Percent increase or decrease of heterosis revealed that heterobeltiosis and standard heterosis for number of fruit ranged from -21.86 to 12.56 percent and -18.88 to 18.61 percent, respectively. Among fifteen cross combinations, three crosses *viz.*, Toindvar-2 x Toindvar-4 (12.56%), toindvar-3 x Toindvar-6 (9.86%) and Toindvar-2 x Toindvar-5 (8.13%), showed significant positive heterosis over better parent. For standard heterosis four cross combinations out of fifteen showed significant values in desirable direction and cross combination Toindvar-3 x Toindvar-6 (18.61%), showed highest value for standard heterosis followed by Toindvar-2 x Toindvar-6 (11.13%), Toindvar-5 x Toindvar-6 (8.56%) and Toindvar-2 x Toindvar-5 (8.13%). Various researchers observed significant heterosis for higher number of fruits per plant in tomato, suggesting good scope for yield improvement through its components Asati *et al.* (2007) [4], Kumari and Sharma (2011) [13], Singh and Sastry (2011) [19], Saleem *et al.* (2013) [15]. And Chauhan *et al.* (2014) [7].

Yield per plant (kg)

Heterobeltiosis for fruit yield ranged from -18.15 percent (Toindvar-4 x Toindvar-5) to 25.95 percent (Toindvar-2 x Toindvar-4). Eight crosses exhibited significant positive heterosis over better parent and three crosses showed significant negative heterobeltiosis. The top three crosses showed significant positive heterobeltiosis were Toindvar-2 x Toindvar-4 (25.95%), Toindvar-2 x Toindvar-5 (20.36%) and Toindvar-4 x Toindvar-6 (16.83%). The standard heterosis ranged from -18.44 (Toindvar-4 x Toindvar-5) to 26.40 percent (Toindvar-2 x Toindvar-4) for fruit yield. Six crosses out of fifteen crosses recorded significant positive standard heterosis, while two cross exhibited significant negative standard heterosis. Fruit yield is the resultant manifestation of its component traits and heterosis observed for those traits, ultimately contributes towards this complex character**.** The results of this study find close agreement with the reports of several former researchers viz., Singh *et al.* (2008) 18, Gul *et al*. (2010) [10], Ahmad *et al*. (2011) [2], Agarwal *et al.* (2014) [1], who also reported significant heterosis for improved fruit yield in tomato.

Plant height (cm)

The heterobeltiosis for plant height (cm) ranged from -6.35 to 9.01 percent, in crosses Toindvar-1 x Toindvar-3 and Toindvar-1 × Toindvar-6, respectively. The seven cross combinations resulted in significant positive heterosis over better parent and out of these, the top three crosses were Toindvar-1 x Toindvar-6 (9.01%), Toindvar-5 x Toindvar-6 (8.59%) and Toindvar-2 x Toindvar-3 (8.39%). The standard heterosis varied from -8.53 (Toindvar-3 x Toindvar-6) to 10.40 percent (Toindvar-4 x Toindvar-6). Significant positive heterosis over the check (Yuvraj) was registered in the five cross combinations and out of these, best three crosses were; Toindvar-4 x Toindvar-6 (10.40%), Toindvar-1 x Toindvar-4 (10.26%) and Toindvar-1 x Toindvar-6 (8.76%). The present investigation agreed well to some earlier reports by Harer *et al.* (2006) Singh and Asati (2011) [20]. And Amin *et al.* (2017) [5].

Conclusion

It can be concluded that cross Toindvar-1 x Toindvar-5 best for earliness, Toindvar-2 x Toindvar-5 best for number of flowers per cluster and number of fruits per cluster, cross Toindvar-1 x Toindvar-6 best for fruit diameter and plant height, Toindvar-1 x Toindvar-4 best for fruit weight, Toindvar-2 x Toindvar-4 best for fruit length, number of fruits per plant and yield per plant over better parent. In overall hybrid Toindvar-2 x Toindvar-4 was exhibited highest significant heterosis over better parent and standard check in desirable direction for fruit yield under protected condition.

References

1. Agarwal A, Arya DN, Ranjan R, Ahmed Z. Heterosis, combining ability and gene action for yield and quality traits in tomato (*Solanum lycopersicum* L.). Helix. 2014; 2:511-515.
2. Ahmad SK, Quamruzzaman M, Islam MR. Estimate of heterosis in tomato (*Solanum lycopersicum* L.). Bangladesh J Agri. Res. 2011; 36(3):521-527.
3. Amaefula C, Agbo CU, Nwofia GE. Hybrid vigour and genetic control of some quantitative traits of tomato (*Solanum lycopersicum* L.). Open J of Genet. 2014; 4:30-39.
4. Asati BS, Singh G, Rai N, Chaturvedi AK. Hetrosis and combining ability studies for yield and quality traits in tomato. Veg. Sci. 2007; 34(1):92-94.
5. Amin A, Wani KP, Dar ZA, Jabeen N, Mushtaq F. Heterosis studies in Tomato (*Solanum lycopersicum* L.). J Pharmacognosy and Phyto. 2017; 6(6):2487-2490.
6. Chattopadhyay A, Paul A. Studies on heterosis for different fruit quality parameters in tomato. Intl. J of Agri., Env. And Biotech. 2012; 5 (4):405-410.
7. Chauhan VBS, Kumar R, Behera TK, Yadav RK. Studies on heterosis for yield and its attributing traits in tomato (*Solanum lycopersicum* L.). Intl. J Agri., Env& Biotech. 2014; 7(1):95-100.
8. Dagade SB, Barad AV, Dhaduk LK. Studies on hybrid vigour in F1 and its retention in F2 for fruit firmness and related traits in tomato. Intl. J Applied Bio. and Pharmaceutical Tech. 2015; 6(1):193-198.
9. Duhan D, Partap PS, Rana MK, Baswana KS. Study on heterosis for growth and yield characters in tomato. Haryana J Horti. Sci. 2005; 34(3-4):366-370.
10. Gul R, Rahman HU, Khalil IH, Shah SMA, Ghafoor A. Heterosis for flower and fruit traits in tomato (*Lycopersicon esculentum* M.). African J Biotech. 2010; 9(27):4144-4151.
11. Harer PN, Kulkarni RV, Deeptashri B. Heterosis for yield components, TSS and ascorbic acid contents in tomato (*Lycopersicon esculentum* Mill). Res. on Crops. 2007: (1):270-274.
12. Islam MR, Ahmad S, Rahman MM. Heterosis and qualitative attributes in winter tomato (*Solanum lycopersicum* L.) hybrids. Bangladesh J Agril. Res. 2012; 37(1):39-48.
13. Kumari LS, Sharma MK. Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). Intl. J Farm Sci. 2011; 1(2):45-55.
14. Leena B, Mehta N, Sabeena FA. Hybrid vigour studies in brinjal (*Solanum melongena* L.). Global J of Sci. Frontier Res. 2013; 13(9):9-11.
15. Saleem MY, Asghar M, Iqbal Q, Rahman A, Akram M. Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum* L.). Pak. J Bot. 2013; 45(4):1247-1250.
16. Shankar A, Reddy VSKR, Sujatha M, Pratap M. Combining ability and gene action studies for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.). Helix. 2013; 6:431-435.

17. Shende VD, Seth T, Mukherjee S, Chattopadhyay A. Breeding tomato (*Solanum lycopersicum* L.) for higher productivity and better processing qualities. SABRAO J Breed. Genet. 2012; 44(2):302-321.
18. Singh CB, Rai N, Singh RK, Singh MC, Singh AK, Chaturvedi AK. Heterosis, combining ability and gene action studies in tomato (*Solanum lycopersicum* L.). Veg. Sci. 2008; 35:132-135.
19. Singh J, Sastry EVD. Heterosis and stress susceptibility index for fruit yield and contributing traits in tomato (*Lycopersicon esculentum*). Indian J Agric. Sci. 2011; 81(10):957-966.
20. Singh AK, Asati BS. Combining ability and heterosis studies in Tomato under bacterial wilt condition. Bangladesh J Agril. Res. 2011; 36(2):313-318.