

Original Research Article

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Heterosis for Yield and Its Components in Rainy Season Tomato (*Solanum lycopersicum* L.) under Coastal Plain Zone of Odisha, India

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ABSTRACT

Tomato grown during the main season (winter) causes a glut of produce in the market and its sale price is also very low. But the crop grown in rainy season has a better demand and is much remunerative for the farmer. Therefore, the present experiment was undertaken to develop and identify tomato hybrids well adapted to the rainy season. The experiment was conducted at the All India Co-ordinated Research Project on Vegetable Crops, Orissa University of Agriculture and Technology, Bhubaneswar. Forty five F₁ hybrids were developed by crossing 10 divergent parental lines in half diallel fashion during 2016-17 (winter). The 45 F₁ hybrids along with the 10 parents were evaluated in Randomised Block Design with three replications during the rainy season of 2017. Significant differences among genotypes were obtained for all the characters studied. The crosses BT 22-4-1xBT 429-1-1, TOBW-3xBT 215-3-3-1, BT 22-4-1xBT 306-1-2 and BT 317xBT 215-3-3-1 were found to be superior combinations as they exhibited significant heterosis percent for yield per plant over mid parent and better parent. BT 2xBT 305-2-4-2 exhibited highest significant negative heterosis over better parent (-15.58%) for earliness (days to first flowering). For plant height BT 2xBT 215-3-3-1(11.72%) was found to be best. BT 317xBT 215-3-3-1(21.30%) was found to be best for average fruit weight character. The high yielding F₁ hybrids (BT 22-4-1xBT 429-1-1), (TOBW-3xBT 215-3-3-1) and (BT 317xBT 215-3-3-1) which expressed 59.74%, 52.67% and 31.28% heterosis for yield over better parent may be recommended for commercial exploitation.

Keywords

Tomato, Off-season, Rainy season, *kharif*, Heterosis

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Introduction

Tomato (*Solanum lycopersicum*) is considered a nutritional powerhouse among the vegetables grown around the world (Chattopadhyay *et al.*, 2013). Tomatoes are used either as fresh fruits or in the form of various processed products such as paste,

whole peeled tomatoes, tomato powder and various forms of juices and soups (Grandillo *et al.*, 1999). Tomato is universally treated as 'Protective food' since it is a rich source of minerals, vitamins, antioxidants and organic acids. Recent studies indicate that lycopene that gives the ripe tomato its bright red color, is a very effective natural antioxidant and

quencher of free radicals (Simon, 1992). Since the discovery of hybrid vigour by Shul (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 Islam *et al.*, (2012).

The pace at which the F₁ hybrids of tomato are gaining popularity, it is demanding now to obtain such hybrids in public sector also, which have excellent quality and yield stability. Efforts were being made to increase its productivity by developing superior varieties. The improvement in different quantitative and qualitative traits in tomato through heterosis breeding was observed by Tiwari and Lal (2004). Tomato hybrids perform differently under different agro-climatic conditions.

Tomato grown during the main season (winter) causes a glut of produce in the market and its sale price is also very low. But the crop grown in rainy season has a better demand and is much remunerative for the farmer.

Hence, the present investigation was undertaken to identify the best parental combination or hybrid combination having high heterosis in rainy season in this coastal zone of Odisha.

Materials and Methods

A set of 10 x 10 half diallel crosses of tomato excluding reciprocals were evaluated along with their ten parents (BT 2, BT 106, BT 317, BT 22-4-1, BT 306-1-2, BT 413-1-2, BT 429-1-1, BT 305-2-4-2, TOBW-3, BT 215-3-3-1) in a randomized block design with three

replications at the experimental farm of All India Coordinated Research Project on Vegetable Crops (ICAR), OUAT, Bhubaneswar. Seeds were sown in nursery bed on 20.06.2017 and seedlings were transplanted on 20.07.2017. Plant to plant spacing was 40 cm and row to row spacing was 50 cm. Eighteen plants were accommodated in each plot having 1.8m x 2.4m plot size. Recommended cultural practices were followed to raise a good crop.

Observations were recorded on 5 randomly taken plants of parents and F₁s for the characters viz., plant height, days to 1st flowering, number of fruits per plant, fruit length, fruit diameter, average fruit weight, fruit yield per plant. Heterosis over better parent and mid-parent for different characters under study were calculated as per standard procedures (Singh, 1990).

Heterosis over better parent (heterobeltiosis) and mid parent (relative heterosis) were estimated by the formulae

$$\text{Relative Heterosis (\%)} = \frac{(F_1 - MP)}{MP} \times 100$$

$$\text{Heterobeltiosis (\%)} = \frac{(F_1 - BP)}{BP} \times 100$$

Where, F₁ = Mean performance of cross.
BP = Mean performance of better parent
MP = Mean performance of mid parent.

Significance of heterosis was tested with the help of standard error using 't' test.

Results and Discussion

There were significant differences among the parental lines with respect to different characters studied including yield per plant.

Plant height

With respect to plant height, range of heterosis varied from -11.68% to 26.70% over mid parent and -21.64% to 11.72% over better parent. Out of 45 F₁ hybrids, 24 crosses showed positive heterosis over mid parent and 4 over better parent for plant height. The F₁ hybrids BT 2xBT 215-3-3-1 showed maximum heterosis over mid parent (26.70%), and F₁ hybrid BT 2xBT 215-3-3-1 over better parent (11.72%). Positive heterosis for this trait has also been reported by Singh and Asati (2011), Kumari and Sharma (2011) and Ahmed *et al.*, (2011) (Table 1).

Days to first flowering

For days to first flowering, range of heterosis varied from -14.60% to -5.11% over mid parent and -15.58% to -6.17% over better parent. Out of all 45 F₁ hybrids, 17 hybrids showed negative heterosis over mid parent, out of which BT 2xBT 306-1-2 exhibited highest significant negative heterosis over mid parent (-14.60%) and 24 hybrids showed significant negative heterosis over better parent, out of which BT 2xBT 305-2-4-2 exhibited highest significant negative heterosis over better parent (-15.58%). In accordance with the present finding, Singh and Singh (1993), Joshi & Thakur (2003) also observed earliness in heterotic combinations of tomato.

Number of fruits / plant

The extent of heterosis for number of fruits per plant varied from 38.78% to -22.61% over mid parent, and 18.99% to -43.10% over better parent. Ten hybrids showed positive heterosis over mid parent, out of which BT 413-1-2xBT 215-3-3-1 expressed highest heterosis over mid parent (38.78%); five hybrids showed positive heterosis over better parent, out of which TOBW-3xBT 215-3-3-1 exhibited highest heterosis over better parent

(18.99%). Similar observations were also made by Joshi & Thakur (2003) and Kumar *et al.*, (2012) with a different set of material in tomato.

Average fruit weight

With respect to average fruit weight, range of heterosis varied from 36.96% to -28.61% over mid parent and 31.34% to -36.55% over better parent. Out of 45 F₁ hybrids, 21 crosses showed positive heterosis over mid parent, and 14 crosses over better parent. The F₁ hybrid BT 2xBt 106 showed maximum heterosis over mid parent (36.96%) and BT 2 x BT 106 over better parent (31.34%), followed by BT 317xBT 215-3-3-1 for both cases respectively with values of 24.85% and 21.30%. these results are in consonance with Sundaram *et al.*, (1994), and Dharmatti *et al.*, (2006) and Kumari and Sharma (2011).

Fruit length

For fruit length, range of heterosis varied from 45.73% to -23.27% over mid parent and 38.75% to -30.14% over better parent. The highest significant positive heterosis was noted in 26 and 18 hybrids over mid parent and better parent respectively. The F₁ hybrid BT 22-4-1xBT 429-1-1 expressed maximum heterosis over mid parent (45.73%) and better parent (38.75%). Dev *et al.*, (1994) and Chattopadhyay and Paul (2012) also reported significant positive heterosis for fruit length in tomato.

Fruit girth

The extent of heterosis for fruit diameter varied from 54.49% to -16.86% over mid parent and 49.35% to -27.28% over better parent. 21 hybrids showed positive heterosis over mid parent, out of which BT 317xBt 215-3-3-1 expressed highest heterosis over mid parent (54.49%) (Table 2).

Table.1 Estimates of heterosis over MP and BP for plant height, days to 1st flowering, number of fruits/plant and average fruit weight

Sl no	Crosses	Percent heterosis of plant height		Percent heterosis of days to 1st flowering		Percent heterosis of number of fruits/plant		Percent heterosis of average fruit weight(g)	
		MP	BP	MP	BP	MP	BP	MP	BP
1	P1 XP 2	11.09 **	4.71	-6.49 *	-9.52 **	-0.25	-11.34 *	36.96 **	31.34 **
2	P1 XP 3	16.87 **	0.73	-7.52 **	-7.52 **	-5.79	-23.73**	21.77 **	5.9
3	P1 X P4	9.22 **	3.31	-5.52 *	-7.36 *	8.26	-8.86	7.13 *	7.09
4	P1 XP 5	16.64 **	2.83	-14.60 **	-15.15 **	-5.06	-9.72	-18.96**	-22.93**
5	P1 XP 6	1.99	-1.5	-5.49 *	-7.82 **	0.72	-15	1.16	-6.43
6	P1 X P7	17.01 **	5.47	-10.04 **	-10.82 **	-6.03	-17.42 **	23.77 **	20.19 **
7	P1 X P8	22.66 **	9.54 **	-13.72 **	-15.58 **	-0.5	-12.11*	20.86**	12.64**
8	P1 X P9	10.04 **	3.87	-10.78 **	-12.81 **	23.87 **	13.74 *	-28.61 **	-36.55 **
9	P1X P10	26.70 **	11.72 **	-6.43 *	-8.66 **	9.48	0.94	-1.4	-12.05 **
10	P2 X P3	1.02	-8.19 **	-9.43 **	-11.11 **	-3.37	-13.21 **	-13.68 **	-22.08 **
11	P2 X P4	3.01	3.01	-4.57	-5.86	-1.56	-7.5	14.71**	10.04*
12	P2 X P5	9.41 **	1.88	-3.15	-5.7	-22.08**	-27.44 **	13.11**	12.13**
13	P2 X P6	15.14 **	5.03	-7.63 **	-12.76 **	-13.83 *	-33.87 **	0.3	-10.72 **
14	P2 XP 7	9.15 **	4.06	-3.84	-6.17 *	-4.05	-5.28	9.28 **	7.87 *
15	P2 X P8	5.17 *	-0.71	2.52	1.36	4.44	3.7	-4.74	-7.54
16	P2 X P9	3.6	3.44	-0.87	-6.20 *	6.31	2.57	24.46**	14.94**
17	P2X P10	1.67	-5.31 *	4.59	3.64	-13.71 **	-17.10 **	20.75**	11.94**
18	P3 X P4	11.65 **	1.12	-5.58 *	-8.56 **	-20.72**	-24.47**	12.31**	-2.3
19	P3 X P5	4.41 *	1.71	-5.05	-9.21 **	0.69	-16.26**	-3.78	-12.46 **
20	P3 X P6	12.69 **	-5.67 *	-9.09 **	-15.64 **	-10.66	-36.31**	-12.51 **	-28.77 **
21	P3 X P7	9.00 **	3.64	0.69	-3.52	-6.55	-15.09**	-6.55 *	-16.61 **
22	P3 X P8	5.63 *	1.44	-0.7	-3.62	-2.82	-12.16*	6.60*	-1.09
23	P3 X P9	4.47	-5.18 *	3.11	-4.13	4.35	-9.20 *	-19.55 **	-21.53 **
24	P3 X P10	2.62	-0.06	2.34	-0.45	21.86**	5.63	24.85**	21.30**
25	P4 X P5	-6.51 **	-13.25 **	-8.00 **	-9.21 **	11.05*	-2.37	22.59**	16.63**
26	P4 X P6	-11.28 **	-18.79 **	0.22	-4.12	-22.61 **	-43.10 **	3.91	-3.91
27	P4 X P7	17.08 **	11.22 **	-3.79	-4.85	17.89**	12.15*	20.43**	16.99**
28	P4X P8	5.71 *	-0.56	-2.93	-3.15	3.29	-2.29	-6.3	-12.64**
29	P4 X P9	1.84	1.6	-0.43	-4.55	5.3	-4.31	-3.48	-14.18 **
30	P4 X P10	2.16	-5.19	4.52	4.05	7.55	-2.65	2.96	-8.13 *
31	P5 X P6	14.89 **	-1.72	-9.98 **	-12.76 **	-6.68	-24.40**	0.27	-11.43**
32	P5 X P7	-1.12	-3.55	-5.05	-5.26	-20.30**	-26.68**	-0.95	-3.07
33	P5 X P8	2.88	1.39	-4.23	-5.7	16.88**	8.12	3.72	1.53
34	P5 X P9	14.36 **	6.34 *	2.13	-0.83	3.95	0.17	15.56**	7.59*
35	P5 X P10	3.56	3.54	-0.45	-2.19	9.3	5.79	19.65**	11.82**
36	P6 X P7	5.08	-8.19 **	-5.11 *	-8.23 **	-11.64 *	-32.79 **	8.89 *	-1.95
37	P6 X P8	-6.21 *	-18.77 **	-3.88	-8.23 **	5.53	-19.41**	10.46**	-4.21
38	P6 X P9	5.44	-3.69	1.86	1.65	38.78**	9.68	-0.62	-17.47 **
39	P6 X P10	-8.41 **	-21.64 **	-2.38	-7.00 *	38.78**	9.68	-5.35	-21.15 **
40	P7 X P8	1.6	0.55	-8.93 **	-10.13 **	-7.92	-8.46	-4.86	-8.81*
41	P7 X P9	5.97 *	0.9	1.49	-1.65	12.19*	6.91	13.41**	3.51
42	P7 X P10	3.59	1.06	-4.7	-6.17 *	9.08	3.5	-1.08	-9.39 **
43	P8 X P9	7.19 **	1.05	-2.81	-7.02 *	16.99**	12.11*	1.15	-3.91
44	P8 X P10	-1.67	-3.08	-3.85	-4.07	18.25**	12.83*	20.29**	14.72**
45	P9 X P10	7.79 **	0.25	-1.73	-6.20 *	19.52**	18.99**	21.87**	21.38**

BP, better parent; MP, mid parent; SE, Standard error of mean

SE for heterosis over MP and BP = 2.3238, 2.6833, 1.987, 2.2944, 1.0903, 1.259, 0.8944, 1.0328

Table.2 Estimates of heterosis over MP and BP for fruit length (cm), fruit girth (cm) and yield/plant (g)

Sl no	Entries	Percent heterosis of fruit length(cm)		Percent heterosis of fruit girth (cm)		Percent heterosis of yield/plant (g)	
		MP	BP	MP	BP	MP	BP
1	P1 XP 2	26.46**	26.04**	12.42 **	11.12 *	38.31**	29.95**
2	P1 XP 3	-0.79	-14.70 **	5.98	-8.45 *	-20.11 **	-43.60 **
3	P1 X P4	-8.50 *	-9.48 *	4.65	1.7	9.68	-2.69
4	P1 XP 5	18.92 **	12.88 **	12.14**	5.46	30.30 **	20.05 *
5	P1 XP 6	25.86 **	18.80 **	44.50 **	37.09 **	1.84	-28.99 **
6	P1 X P7	-0.3	-4.08	3.69	2.89	7	4.98
7	P1 X P8	-17.92 **	-22.98 **	0.69	-10.86 **	24.05 **	17.77 *
8	P1 X P9	-2.49	-13.47 **	3.93	-9.59	5.31	-10.78
9	P1X P10	-2.54	-16.34 **	0.62	-7.47	13.04	1.69
10	P2 X P3	31.19**	13.12**	18.48**	3.36	-18.28 **	-39.99 **
11	P2 X P4	-1.5	-2.23	-1.52	-3.19	13.94 *	7.17
12	P2 X P5	2.96	-1.96	8.93*	3.57	24.58 **	8.43
13	P2 X P6	23.11 **	15.85 **	35.21 **	26.87 **	36.08 **	-8.36
14	P2 XP 7	17.95 **	13.11 **	24.71 **	24.23 **	28.14**	22.60**
15	P2 X P8	7.83 *	1.5	11.51 **	-0.26	18.62**	17.32**
16	P2 X P9	36.75**	21.71**	23.87**	8.84*	40.66**	25.88**
17	P2X P10	19.65 **	3	20.71**	12.20**	23.67**	18.04**
18	P3 X P4	-13.90 **	-25.29 **	-8.29 *	-18.79 **	-30.37 **	-46.66 **
19	P3 X P5	-20.15 **	-28.09 **	-14.11**	-21.58 **	-24.92 **	-49.43 **
20	P3 X P6	-12.59 **	-28.37 **	20.50 **	-0.41	-45.05 **	-68.06 **
21	P3 X P7	-5.09	-20.98 **	-6.32	-18.54 **	-21.19 **	-43.73 **
22	P3 X P8	-23.27 **	-30.14 **	1.86	-0.98	-19.94 **	-41.61 **
23	P3 X P9	16.16**	12.03**	5.05	4.18	-24.71 **	-40.02 **
24	P3 X P10	22.03**	21.78**	54.48**	44.22**	73.24**	31.28**
25	P4 X P5	31.67**	26.28**	54.49**	49.35**	64.15**	35.63**
26	P4 X P6	28.29**	19.89**	-21.20**	11.91 *	15.86 ns	-24.37 **
27	P4 X P7	45.73**	38.75**	51.11**	47.98**	77.02**	59.74**
28	P4X P8	12.17 **	6.33	48.25 **	34.67 **	26.67**	17.91**
29	P4 X P9	5.63	-5.37	0.42	-10.43*	-2.20 ns	-7.26
30	P4 X P10	-8.13 *	-20.42 **	-13.57**	-18.35**	4.04 ns	2.44
31	P5 X P6	1.95	-8.36 *	-9.60*	-19.07**	28.96 *	-5.33
32	P5 X P7	29.04**	18.09**	-9.12*	-13.90**	29.60**	17.34*
33	P5 X P8	-9.65 **	-10.74 **	-10.29**	-15.90 **	42.85**	25.51 **
34	P5 X P9	8.10 *	0.66	7.16	-1.42	18.19 **	-6.33
35	P5 X P10	5.04	-5.58	15.50**	12.77**	30.66 **	9.31
36	P6 X P7	34.91**	32.27**	2.77	-3.22	43.12 **	-1.27
37	P6 X P8	24.72 **	10.91 **	-14.02 **	-27.28 **	74.92**	18.47**
38	P6 X P9	8.81 *	-8.17 *	12.08**	-6.76	44.23 **	-8.13
39	P6 X P10	5.66	-13.55 **	6.31	-6.81	63.16 **	7.3
40	P7 X P8	29.25 **	16.99 **	-16.86 **	-25.89 **	27.81 **	23.59 **
41	P7 X P9	39.11**	19.35**	3.81	-9.09*	35.56**	16.68**
42	P7 X P10	12.37 **	-6.60 *	10.01*	1.89	31.91**	20.72**
43	P8 X P9	7.34 *	1.1	-22.55**	-24.10**	10.3	-2.25
44	P8 X P10	9.81 **	-0.2	25.00**	19.90**	37.98**	30.33**
45	P9 X P10	29.35**	24.51**	51.68**	42.70**	63.39**	52.67**

BP, better parent; MP, mid parent; SE, Standard error of mean

SE for heterosis over MP and BP = 0.1451, 0.1676, 0.1411, 0.1629, 21.2794, 24.5714

Again 10 hybrids showed positive heterosis over better parent, out of which BT 22-4-1xBT 429-1-1 exhibited highest heterosis over better parent (49.35%). Dev *et al.*, (1994) also observed significant positive heterosis for fruit girth in different cross combination of tomato.

Yield / plant

Heterosis for yield per plant varied from 77.02% to -45.05% over mid parent and 59.74% to -68.06% over better parent respectively. Significant positive heterosis was recorded in 29 crosses over mid parent. However, 19 crosses expressed significant heterosis in desirable direction over better parent. Maximum heterosis over mid parent was recorded in BT 22-4-1xBT 429-1-1 (77.02%) followed by BT 317xBT 215-3-3-1 (73.24%), BT 22-4-1xBT 306-1-2 (64.15%) and TOBW-3xBT 215-3-3-1 (63.39%). Whereas highest heterosis over better parent was exhibited by BT 22-4-1xBT 429-1-1 (59.74%) which was followed by TOBW-3xBT215-3-3-1 (52.67%), BT 22-4-1xBT 306-1-2 (35.63%) and Bt 317xBT 215-3-3-1 (31.28%).

High positive heterosis for yield/plant was also reported by Wang *et al.*, (1998), Dudi & Sanwal (2004), Gul *et al.*, (2011) and Ahmad *et al.*, (2011).

The crosses BT 22-4-1xBT 429-1-1, TOBW-3xBT 215-3-3-1, BT 22-4-1xBT 306-1-2 and BT 317xBT 215-3-3-1 were found to be best heterosis combinations as they exhibited significant heterosis percent for yield per plant over mid parent and better parent. The high yielding F1 hybrid (BT 22-4-1xBT 429-1-1), (TOBW-3xBT 215-3-3-1) and (BT 317xBT 215-3-3-1) were expressed 59.74%, 52.67% and 31.28% heterosis for yield over better parent may be recommended for commercial exploitation.

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