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Heterosis and Correlation of Yield and Yield Components in Tomato (*Lycopersicon esulentum* Mill.)

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Abstract: Heteroisis and character association were estimated in 45 single cross hybrids, obtained by 10 parental lines of tomato for yield and yield component traits : plant height at 60 days after transplantation (PH60D), days to first flowering (DFF), number of flower per cluster (NFPC), number of fruits per plant (NFPP), fruit weight per plant (FWPP), days to first fruit ripening (DFFR). Significant differences among genotypes were obtained for all the traits. Positive high significant heterosis was found for FPP 72.9, 75.53 and 20.74, TFWPP 189, 172 and 187, NFPC 48.65, 44.14 and 37.86 over the mid parent, better parent and standard parent heterosis respectively. The hybrid also showed significantly high percentage of positive heterosis over mid, better and standard parent for NFPP, TFWPP and NFPC. Five hybrids possessed significant positive useful heterobeltiosis for TFWPP. Three single cross hybrids were selected for their high heterotic performance. TFWPP was positively correlated with FPP, NFPC and PH60D.

Key words: Heterosis · components · tomato · *Lycopersicum esculentum*

INTRODUCTION

Now-a-days tomato is grown in most of the countries around the globe except the colder region. As a cash crop, in addition to our country it has a great demand in the international market. Bangladesh could earn foreign exchange by this crop if it could be exported. Unfortunately, the production of this crop in Bangladesh is not enough to meet the internal demand of the country and a large quantity of this crop is to be imported every year. The scope of this new dimension in tomato marketing offers some interesting challenges for breeders, post harvest physiologists and molecular biologists. For high yield potential, recently some hybrid varieties of tomato have been imported in Bangladesh by non-government organizations. Heterosis in tomato was first observed by Hedrick and Booth [1] for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits were extensively studied. Choudhary *et al*. [2] emphasized the extensive utilization of heterosis to step up tomato production. The present study was undertaken to estimate the extent of heterosis and character association in crosses, obtained from ten diverse-tomato parental lines.

MATERIALS AND METHODS

The experimental materials used in the present study consisted of ten tomato genotypes of diverse origin. Seeds were collected from Plant Breeding and Gene Engineering Lab., Department of Botany, University of Rajshahi, Rajshahi-6205. Ten parents were crossed to develop F_1 and backcross populations. The parents were Bari-4 (P_1), Japany (P_2), Dynasagsr (P_3), Pusharubi (P_4), Namdhari (P_5), Epoch (P_6), Dynamo (P_7), Ratan (P_8), Deshy (P_9), Legend (P_{10}),. The experiment was conducted in Botanical garden, Rajshahi University, Rajshahi, during the period from September 2003 to March 2004 and September 2004 to March 2005. Ten varieties and F_1s were grown in randomized block design with three replications. The field size for the experiment was 72.2/20.33 m. The experimental field was divided into three blocks. Each replication comprised one block. There were 100 rows in each replication and in each row 10 plants were grown and plant to plant distance was 60 cm. The genotypes and F_1s were randomly assigned into rows in replication. The borders around the field and between the replication were 121 cm wide. Recommended fertilizers and management practices were followed for raising the crop [3]. Data on

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six quantitative characters were collected on individual plant basis of ten varieties and F_1s generations of tomato. Data were collected on the following characters: plant height at 60 days after transplantation (PH60D), days to first flowering (DFF), number of flowers per cluster (NFPC), number fruits per plant (NFPP), fruits weight per plant (FWPP), days to first fruit ripening (DFFR). Mean data were used to estimate heterosis over standard parents, over mid parents and over better parents following Singh and Narayanan [4]. Correlation coefficient 'r' between yield and yield components in F_1s was also estimated.

RESULTS AND DISCUSSION

Heterosis: Estimates of mean squares for all the characters studied were highly significant indicating wide genetic differences among the genotypes. The heterotic effect in F_1 generation over standard, mid parents and better parents are presented in Tables 1 and 2.

Plant height at 60 days after transplantation: The hybrid P_4 x P_5 exhibited the highest performance (65.36%) for plant height at 60 days after transplantation. Heterosis for Plant height at 60 days after transplantation varied from -47.6 to 56.9 over standard parent, 40.8 to 63.9 over mid parents and 44.29 to 78.19 over better parents. Among the crosses, only the hybrid P_4 x P_5 was significantly superior to standard parent. The cross P_4 x P_5 also exhibited the highest percentage of heterosis over mid parent and P_4 x P_9 over better parent. Among the 45 crosses, seven and ten crosses were significantly superior to their mid parents and better parents respectively (Table 1).

Days to first flowering: The longest days to first flowering (58.66) was observed in P_2 x P_7 followed by P_1 x P_2 (55.66). The heterosis varied from -31.43 to 4.39 over standard parent, -26.32 to 36.12 over mid parents and -20.95 to 40.05 over better parents. The heterotic performance for this trait was the highest in P_2 x P_7 cross over standard parent, P_6 x P_9 over mid parent and P_2 x P_6

Table 1: F_1 means and heterosis over standard, mid and better parents for PH60D, DEF and NFPC

	PH60D				DFF				NFPC			
Crosses	Mean (cm)	Mid Parent	Better Parent	Standard Parent	Mean	Mid Parent	Better Parent	Standard Parent	Mean	Mid Parent	Better Parent	Standard Parent
$P_1 \times P_2$	53.79	22.5**	1.16	29.1**	55.66	6.16**	3.726**	-0.949	9.16	31.958**	21.24**	6.30**
$P_1 \times P_3$	49.15	3.65**	-7.57**	17.9**	48.16	-12.31	-10.24**	-14.29	10.89	48.65**	44.14**	26.36**
$P_1 \times P_4$	62.18	40.4**	16.93**	49.2**	42.83	-16.55***	-20.18**	-23.78**	7.50	-6.619	0.79**	-13.02
$P_1 \times P_5$	49.77	1.65	-6.40**	19. 7**	49.5	6.07***	-7.76**	-11.92**	10.83	34.91**	43.29**	25.63**
$P_1 \times P_6$	41.12	-12.8**	-22.6**	-1.28	52.5	14.08***	-2.173	-6.58**	8.21	11.59	8.67**	-4.71**
$P_1 \times P_7$	46.31	-5.03**	4.40*	11.1**	54.36	2.90**	4.55**	-3.26	9.03	13.76*	19.52**	4.76**
$P_1 \times P_8$	44.12	-4.41**	-17.02**	5.92	50.33	0.365	-6.21	-10.43**	6.34	-15.88**	-16.06	-26.40
$P_1 \times P_9$	33.05	-30.6**	-37.84**	-20.6**	49.33	3.13**	-8.07**	-12.21*	7.24	-10.48	-4.19	-16.00
$P_1 \times P_{10}$	59.25	7.48*	11.42**	42.2**	53.66	4.98*	0	-4.51	9.83	32.89**	30.10**	14.07**
$P_2 \times P_3$	42.68	11.9**	2.45**	2.45	54	0.56	-3.91	-3.91	7.61	34.67**	0.701**	26.118**
$P_2 \times P_4$	37.18	6.28**	5.16**	-10.74*	46.66	-6.85**	-4.76	-16.96	6.85	7.841	-9.351	-7.885*
$P_2 \times P_5$	26.01	-34.4**	-41.88**	-37.5**	39.33	-13.42**	-0.84	-30.01**	6.46	1.783	-14.470*	-13.043*
$P_2 \times P_6$	47.86	26.2**	16.12**	14.8**	53.73	19.98**	40.05**	-4.39	6.72	18.171*	-11.111	10.103
$P_2 \times P_7$	24.61	-7.68*	-17.83	-12.49*	58.66	13.69**	12.82**	4.39**	7.55	20.479*	-0.132*	3.946
$P_2 \times P_8$	21.81	-40.8**	-44.29**	-47.6**	44.33	-9.37	-4.93**	-21.11**	5.27	-10.139	-30.24**	-18.453**
$P_2 \times P_9$	23.50	-38.73	-44.21**	-43.5**	49.83	6.94**	18.6**	-11.33**	8.05	25.539*	6.521*	6.525
$P_2 \times P_{10}$	34.52	-24.69*	-39.5**	-17.12*	44.33	-11.16**	-8.71*	-21.11**	7.86	37.293**	3.968	27.184**
$P_3 \times P_4$	54.39	41.2**	53.86**	30.6*	38.73	-26.32**	-20.95**	-31.07**	5.61	-12.61*	-25.76**	-12.64**
$P_3 \times P_5$	60.48	40.0**	35.16**	45.2*	40.66	-15.1**	2.52*	-27.64**	7.14	6.08	-5.47	-3.89
$P_3 \times P_6$	52.86	27.8**	28.26**	26.9**	46	-2.71	19.89**	-18.15	6.28	3.57	-16.85*	3.003
$P_3 \times P_7$	53.50	30.2**	26.23**	34.4**	45.33	-16.25**	-12.8**	-19.34**	9.24	39.05**	22.30**	27.31**
$P_3 \times P_8$	41.59	2.93**	6.22**	-0.16*	44.16	-14.1**	-5.29	-21.41*	8.11	30.63**	7.35	26.28*
$P_3 \times P_9$	52.99	26.5*	25.76 **	27.2**	48.9	-0.40	16.42**	-12.99	7.11	25.88**	17.89*	17.89*
$P_3 \times P_{10}$	59.63	20.8*	43.14**	43.1**	52	-0.73*	-7.47*	-7.47	7.02	14.98	-7.10	13.64
$P_4 \times P_5$	48.67	21.5**	37.67**	16.84*	43.53	-1.81	-11.16**	-22.54**	7.82	5.17	3.47**	5.15
$P_4 \times P_6$	49.06	28.1**	38.77**	17.78*	45.5	4.15**	-7.14	-19.04*	6.08	-10.11	-19.49	-18.18
$P_4 \times P_7$	65.36	63.9**	47.34**	56.9**	48	-4.95	-7.69	-14.59**	6.02	-18.11**	-20.37**	-19.08*
$P_4 \times P_8$	51.34	37.8**	45.23**	23.2**	43	-10.07*	-12.24	-23.48**	5.514	-20.70**	-27.07	-25.89**
$P_4 \times P_9$	62.99	62.6**	78.19**	51.2**	42.53	-6.52	-13.19**	-24.31**	5.63	-24.92**	-25.53**	25.53**
$P_4 \times P_{10}$	48.42	-9.53**	18.25*	0.36	46.83	-3.99	-4.42**	-16.66*	7.45	9.39*	-1.45*	0.13*
$P_5 \times P_6$	47.76	11.1**	15.90*	14.6**	46.66	19.60**	21.63**	-16.963	6.02	30.47**	-20.33**	26.80
$P_5 \times P_7$	56.58	26.9**	27.54**	35.8**	39.83	-13.09**	-23.3**	-29.12**	7.09	23.29	-6.13	13.44
$P_5 \times P_8$	49.13	17.1**	25.48**	17.9**	47.5	10.08**	1.858**	-15.48	9.06	6.69**	19.92**	-2.86**
$P_5 \times P_9$	42.94	-1.13	1.93	3.09*	51.16	25.30**	21.82**	-8.95	7.61	21.73	0.66*	10.01

Table 1: Continued

$P_5 \times P_{10}$	45.5	18.6*	34.92**	44.9**	40	-9.33**	0.840	-28.82**	6.46	-5.02	-17.47*	-13.04
$P_6 \times P_7$	63.96	49.5*	44.19**	53.5**	56.93	26.01**	9.48**	1.30**	8.24	23.29**	8.99	13.44*
$P_6 \times P_8$	45.42	13.0**	10.20	9.03**	40.73	-4.156**	6.16**	-27.52**	8.20	30.47**	8.46**	26.80**
$P_6 \times P_9$	30.81	-26.0**	-26.87*	-26.0**	54.7	36.12**	30.23**	-2.66	8.31	21.73**	10.00*	10.01*
$P_6 \times P_{10}$	49.64	1.00	20.44**	19.1**	38.53	-11.35**	0.434	-31.43**	8.52	38.42**	12.61**	37.86**
$P_7 \times P_8$	52.37	25.4**	18.05**	25.7**	44	-10.78	-15.38**	-21.70	6.83	-11.10	-9.61	-16.9
$P_7 \times P_9$	61.52	42.2**	38.68**	47.7*	47.66	1.418*	-8.33**	-15.18*	6.57	-7.32**	-13.05**	-14.02**
$P_7 \times P_{10}$	34.92	-31.1**	-21.27**	-16.1	54.16	7.72*	4.16	-3.61	6.67	8.75	-11.73	6.34
$P_8 \times P_9$	36.99	-8.98*	-12.21**	-11.2**	46.66	5.30**	11.11**	-16.96**	6.50	-7.32	-14.02	-14.02
$P_8 \times P_{10}$	59.31	17.44*	44.3**	35.6**	49.5	3.99*	6.15*	-11.92*	6.87	8.75	-9.05	6.34
$P_9 \times P_{10}$	58.36	17.64*	38.51**	40.1*	41	-9.46	-2.38	-27.04**	5.68	-17.23*	-24.86**	-24.87
SEm	0.77	-	-	-	2.49	-	-	-	0.06	-	-	-

** and * indicate significant at 01% and 5% level respectively.

Table 2: F_1 means and heterosis over standard, mid and better parents for NFPP, FWPP and DFFR

	PH60D				DFF				NFPC			
Crosses	Mean (cm)	Mid Parent	Better Parent	Standard Parent	Mean	Mid Parent	Better Parent	Standard Parent	Mean	Mid Parent	Better Parent	Standard Parent
$P_1 \times P_2$	33.5	41.6**	24.53**	-5.278	3.76	76.9**	29.3**	181**	96.13	2.57**	4.08*	1.94
$P_1 \times P_3$	30.5	-2.034*	13.38**	-13.7**	1.84	-10.8**	-34.9**	41.4**	94.73	1.49	2.56**	0.456**
$P_1 \times P_4$	42.7	72.9**	58.73**	20.74**	4.33	20.6**	32.2**	187**	91.43	-2.263	-1.01	-3.04**
$P_1 \times P_5$	23.53	-0.282	-12.51**	-33.5**	3.14	41**	-6.27*	104**	92.8	0.943	0.49*	-1.59
$P_1 \times P_6$	33.78	10.26*	25.58**	-4.47*	2.2	-13.4**	-33.1**	45.3**	96.7	3.77**	4.69**	2.54
$P_1 \times P_7$	32.93	21.4**	20.44**	-6.88	2.85	24.8**	121**	89**	94.4	2.49**	2.79**	0.10
$P_1 \times P_8$	33.23	22.8**	23.54**	-6.03**	3.05	23.1**	-6.73*	103**	95.23	3.96**	3.10**	0.98
$P_1 \times P_9$	17.1	-24.8**	-36.43**	-51.6**	1.393	-15.9	-12.15	-19.78	95.13	3.46**	2.99**	0.88**
$P_1 \times P_{10}$	18.9	-14.0**	-29.74**	-46.5**	2.16	-27.7**	-35.1**	41**	87.67	-4.01**	-5.09*	-7.04**
$P_2 \times P_3$	24	-13.9**	-32.14**	-32.1**	2.57	70.2**	70.5**	70.5**	95.13	0.47	0.88*	0.88*
$P_2 \times P_4$	31.2	45.6**	38.87**	-11.78	1.64	-39.5**	-58**	8.71**	93.67	-1.3	-1.13*	-0.67**
$P_2 \times P_5$	30.23	48.6**	48.93**	-14.51	1.06	-18.3**	-1.98*	-30**	94.37	1.16**	3.13**	0.07
$P_2 \times P_6$	24.37	-11.0**	-29.12**	-31.1**	1.78	7.84*	-0.47	18*	94.73	0.21	0.78**	0.45**
$P_2 \times P_7$	20.5	-14.1**	-25.03**	-42.0**	1.03	-26.2**	-19.8**	-31**	97.43	4.26**	6.09**	3.32**
$P_2 \times P_8$	26.3	10.4**	-3.47**	-25.6**	1.42	19.3**	13**	26.6**	91.29	-1.78	0.50*	-3.19**
$P_2 \times P_9$	18.4	-5.69	-1.18*	-47.9**	1.81	11.9**	-0.27**	27.7	95.24	2.08**	4.05**	0.99*
$P_2 \times P_{10}$	27.7	47.8**	62.30**	-21.7**	2.26	9.42**	-13.6	49.6**	93.00	0.34	2.99**	-1.38
$P_3 \times P_4$	28.17	-2.594	25.37**	-20.36	2.71	-0.06	-30.7**	79.4**	92.2	-2.45**	-2.67**	-2.23**
$P_3 \times P_5$	35.63	28.0**	75.53**	0.75**	2.11	8.97**	30.6**	-6.5	91.3	-1.72**	-0.22	-3.185
$P_3 \times P_6$	34.1	-2.218	-0.8144	-3.582	4.21	155**	136**	179**	93.07	-1.15**	-0.99	-1.31
$P_3 \times P_7$	33.1	5.565	21.05**	-6.41	1.38	-1.78*	6.45**	-8.8	97.78	5.06***	6.47**	3.68**
$P_3 \times P_8$	34.5	10.22*	26.68**	-2.451	3.11	94.7**	84.2**	106**	90.3	-2.45**	-0.59	-4.25**
$P_3 \times P_9$	24.4	-9.60	31.04**	-31.0**	2.66	54.1**	37.2**	75.7**	93.33	0.45	1.96**	-1.03
$P_3 \times P_{10}$	25.43	-2.98	-28.08*	-28.1**	2.11	2.55	40.1**	40.1**	85.93	-6.89**	-8.88**	-8.87**
$P_4 \times P_5$	26.43	23.6**	17.656**	-25.26	1.89	-24.5**	-51.8**	24.8**	94.4	1.37**	-0.35*	0.10
$P_4 \times P_6$	27.73	-2.428	23.44**	-21.6**	2.9	1.57	-26**	91.7**	93.63	-0.77	-1.16**	-0.71
$P_4 \times P_7$	33	32.5**	20.68**	-6.69	2.26	-12.7	75.6**	50.4**	92.33	-1.02	0.54**	-2.09**
$P_4 \times P_8$	25.17	1.27	12.02**	-28.8**	2.16	-22.8**	-44.7**	43.2**	91.45	-1.44**	-3.47	-3.03
$P_4 \times P_9$	14.3	-30.4**	-36.35***	-59.6**	1.37	-53.4**	-65.2**	-9.8*	93.33	0.21	-1.48	-1.03
$P_4 \times P_{10}$	23.33	18.0**	3.85*	-34.0**	3.16	-35.7**	-46.4**	38.8**	89.2	-3.58**	-5.84**	-5.41**
$P_5 \times P_6$	28.13	2.902	-18.17**	-20.45	1.56	189**	132**	175**	96.75	4.31**	2.92**	2.59**
$P_5 \times P_7$	35.54	49.2**	29.97**	0.49***	2.30	94**	78.1**	52.5**	100	9.13**	8.92**	6.07**
$P_5 \times P_8$	32.8	38.0**	20.44**	-7.25	2.34	96.9**	61.4**	80.8**	91.3	0.16	0.54*	-3.19**
$P_5 \times P_9$	20.47	5.173*	9.917**	-42.1**	2.93	94.8**	51.8**	94.4**	93.53	2.20**	2.18**	-0.82
$P_5 \times P_{10}$	25.32	35.5**	24.71**	-28.4**	2.81	59**	172**	94.6**	88.07	-3.17**	-3.75	-6.61**
$P_6 \times P_7$	17.5	-43.3**	-35.99**	-50.5**	1.29	-15.9	0.25	-14**	94.09	1.26	2.45**	-0.22
$P_6 \times P_8$	34.9	13.3**	1.51**	-1.32	1.65	-5.12**	-7.72**	9.39*	94.2	1.93**	0.21**	-0.11**
$P_6 \times P_9$	22.37	-15.6*	20.12**	-36.7**	1.89	2	-1.79*	25.8**	97.27	4.85**	6.26**	3.14**
$P_6 \times P_{10}$	21.5	-16.42*	-37.46**	-39.2**	1.94	-8.9**	12.1**	32.9*	92.33	0.19	-1.77	-2.09
$P_7 \times P_8$	18.5	-32.2**	-32.34**	-47.7**	2.13	39.5**	61**	37.9**	91.23	-0.11**	-0.65*	-3.25**
$P_7 \times P_9$	17	-26.0**	-37.82**	-51.9**	2.57	91.1**	138**	104**	88.83	-3.11**	-3.27	-5.8**
$P_7 \times P_{10}$	20.53	-7.52*	-24.90**	-41.9**	1.63	-16.7**	25.9**	7.84*	84.7	-6.99**	-7.77**	-10.2**
$P_8 \times P_9$	23.93	4.39	28.5**	-32.3**	3.14	73.3**	62.5**	108**	92.43	1.37*	0.98*	-1.98
$P_8 \times P_{10}$	15.1	-31.8**	-44.55**	-57.3**	3.88	84.6**	135**	163**	93.27	2.98*	2.68*	-1.09
$P_9 \times P_{10}$	17.8	-0.24	-4.40	-49.7**	3.05	34**	57.6**	102**	87.43	-3.83**	-4.48**	-7.28
SEm	0.24	-	-	-	0.028	-	-	-	0.27	-	-	-

** and * indicate significant at 01% and 5% level respectively.

Table 3: Genotypes means for yield and yield components in tomato

Genotypes	PH60D	DFF	NFPC	FPP	TFWPP	DFFR
Bari-4	44.33±0.93	44.20±0.64	6.66±0.21	33.86±1.81	1.58±0.05	89.83±0.94
Japany	43.67±1.13	53.90±0.72	5.10±0.25	36.00±0.99	1.76±0.06	80.10±0.61
Dynasagor	53.87±1.30	48.03±0.69	8.50±0.22	69.53±1.69	1.73±0.07	87.46±1.04
pusharubi	53.20±1.04	42.13±0.49	6.46±0.18	63.23±2.59	1.74±0.04	83.03±0.17
Namdhary	46.47±1.17	54.96±0.57	6.60±0.28	31.46±2.13	1.47±0.04	88.26±0.91
Epoch	47.33±1.29	54.06±0.55	7.66±0.34	38.50±2.04	1.27±0.03	87.00±0.92
Dynamo	59.00±1.74	44.43±4.93	5.53±0.26	42.53±1.80	1.17±0.04	83.16±0.26
Ratan	54.87±0.90	43.93±0.37	5.67±0.25	40.50±1.48	1.42±0.07	81.26±0.63
Deshy	46.96±0.89	24.83±0.50	3.33±0.17	22.76±1.41	1.73±0.05	83.40±0.49
Legend	46.63±1.30	54.30±0.57	3.46±0.20	21.60±0.91	1.57±0.09	89.06±0.80

over better parent. Six crossing were significantly superior to their mid parent and of them seven were superior to their respective better parent (Table 1).

No. of flowers per cluster: Maximum no. of flower per cluster was observed in P_1 x P_3 (10.89) followed by P_1 x P_5 (10.83) and P_1 x P_{10} (9.83). The estimates of heterosis varied from -25.89 to 37.86 over standard parent, -24.92 to 48.65 over mid parents and -30.24 to 44.14 over better parents. P_6 x P_{10} was the only hybrid that showed significant positive useful heterosis 37.86. Significant positive estimate of mid parent heterosis was recorded in eleven crosses for no. of flower per cluster and four of the hybrids showed significant positive heterobeltiosis (Table 1).

Number of fruits per plant: The hybrid P_1 x P_4 exhibited the highest number (42.7) of fruits per plant. Only significant positive useful heterosis was observed in P_1 x P_4 (20.74). Six crosses gave significantly positive mid parent heterosis and four of them exhibited significant positive heterobeltiosis (Table 2).

Fruit weight per plant: The hybrid P_1 x P_4 had the highest fruit weight (4.33) per plant. Heterosis varied from -31.00 to 187.00 over standard parent, -39.5 to 189.0 over mid parents and -65.2 to 172.0 over better parents. Significant positive heterosis over standard parent was observed in P_1 x P_4 (187) followed by P_1 x P_2 (181). Among the 45 crosses, ten crosses showed significantly positive heterosis over mid parents and nine of them over better parents (Table 2).

Days to first fruit ripening: Maximum days (97.78) to first fruit ripening was observed in P_5 x P_7 followed by P_3 x P_7 (97.78) and P_2 x P_7 (97.43). Heterosis ranged from -10.2 to 6.07, -6.89 to 9.13 and -7.77 to 8.92 over standard parent, mid parents and better parents respectively. Significant positive useful heterosis was observed in hybrids P_5 x P_7 (6.07). Five crosses showed significant positive heterosis over mid parents. Of these hybrids, three showed significant positive heterobeltiosis (Table 2).

The magnitude of useful heterosis, mid parent heterosis and heterobeltosis varied considerably for yield and all other yield contributing traits. Useful significant positive mid parent heterosis for total fruit weight per plant was observed in P_5 x P_6 (189), P_3 x P_8 (94.7), P_5 x P_8 (96.9) respectively. The increased fruit weight observed in the hybrids was in agreement with Lrson and Currence [5] who reported larger fruit size from those inbred lines having larger fruits. Also agreed with the intermediate fruit size between parents [6, 7]. P_5 x P_6 was the best hybrid which showed the height performance. Similar result was reported by Alice Kurian [8].

Some of the hybrids were late to ripening as indicated by the positive estimates of heterosis and some were early ripening as indicated by the negative estimates of heterosis. Kurganskya and Agentova [9] found that heterosis for earliness occurred most often when both the parents were early. Therefore, the observed lateness can be attributed to the strong influence of male parents which were late. Hewitt and Stevens [10] also reported delayed maturity in tomato hybrids.

The hybrid P_1 x P_4 showed mean value of FPP (42.7) and observed positive significant mid parent heterosis (72.9), better parent heterosis (58.73) and standard parent heterosis (20.74) followed by TFWPP and NFPC. The increased yield in these hybrids may be due to the high yielding parents selected for hybridization as suggested by Courtney and Peirce [11] and Alice Kurian *et al*. [8]. The hybrid P_4 x P_7 showed the highest mean of PH60D and positive significant of standard parent heterosis, mid parent heterosis and better parent heterosis. The highest FPP and TFWPP were obtained from P_3 and P_4 (Table 3). In case of hybrids, the highest yield was exhibited by P_1 x P_4 followed by P_3 x P_6, P_1 x P_2 and P_1 x P_5. This

Table 4: Correlation coefficients between various yield components

Characters	DFF	NFPC	NFPP	TFWPP	DFFR
PH60D	-0.742**	0.181	0.685*	0.494	-0.324
DFF		1.263***	0.127	-1.013***	1.069***
NFPC			0.695*	0.316	0.332
NFPP				0.039	0.136
TFWPP					-0.023

*, **, *** indicate significant at 5%, 1% and 0.1% level respectively

indicated that *per se* performance of parents did not reflect the *per se* performance of their respective crosses. Debnath [12, 13] also reported that crossing between two superior inbreeds did not result in good specific combination.

Correlation coefficient: The Correlation coefficients between various yield components are given in Table 4. The significant positive correlation of fruit per plant with PH60D (r=0.685*) and NFPC (r=0.695*) was obtained which was in conformity with the findings of Patil and Bajappa [14] and Neetu Bhardwaj [15] suggesting that these traits could be improved simultaneously. The positive correlation of fruit per plant with DFF (r=0.127), TFWPP (r=0.039) and DFFR (r=0.136) suggested their simultaneous improvement to some extent. This confirms the findings of Younis *et al*. [16] and Neetu Bhardwaj *et al*. [15]. There was significant association between PH60D and DFF (r= -0.742**), FPP (r= 0.685*) and DFF with NFPC (r= 1.263***), TFWPP (r=-1.013***) and DFFR (r=1.069***). It is also noted that traits, such as fruit per plant, number of fruits per cluster, plant height at 60 days and days of first fruit ripening exhibiting positive association with yield have also shown positive association among them.

Based on the high percent of heterosis for yield and its components F_1s P_1 x P_4, P_5 x P_6, P_5 x P_7 were selected. The positive association of yield with its components offered advantage for selection.

REFERENCES

1. Hedrick, U.P. and N.O. Booth, 1968. Mendelian characters in tomato. Proc. Am. Soc. Hort. Sci., 5: 19-24.
2. Choudhary, B., R.S. Punia and H.S. Sangha, 1965. Manifestation of hybrid vigour in F_1 and its correlation in F_2 generation of tomato (*Lcopersicon esculentum* Mill.) Indian J. Hort., 22: 52-59.
3. Quayyum, M.A., 1993. Methods of maize cultivation. *In*: Production and uses of maize (in Bengali). M.K. Chowdhury and M.A. Islam Eds.). On-Farm Research Division, BARI, Gazipur, pp: 43-48.
4. Singh and S.S. Narayanan, 1993. Biochemical techniques in plant breeding. Kalayani Publishers, New Delhi, pp: 208-220.
5. Lrson, R.E. and T.M. Currence, 1944. The extent of hybrid vigour in F_1 and F_2 generation of tomato crosses with prticular reference to early yield, total yield and fruit size. *Tech*. Bull. Univ. Min. Agric. Exp. Stn., 164: 1-32.
6. Tesi, R., A. Graitenberg and M. Greatini, 1970. Heterosis and quality in F_1 hybrid of *Lycopersicon esculentum* Mill. grown under glass. Riv. Ortoflorofrutic, 54: 69-292.
7. Conti, S., 1974. Research on heterosisand component of phenotypic variance in long fruited tomato hybrids. Rivista de Agronomica, 8: 383-391.
8. Alice, K., K.V. Peter and S. Rajan, 2001. Heterosis for yield components and fruit characters in tomato. Journal of Tropical Agriculture, 39: 5-8.
9. Kurganskaya, N.V. and M.V. Agentova, 1974. Earliness of heterotic hybrids of tomato. *Genetika i. Seleksiya rast i. Zhivotnykh v Kazakhstane.* Alma - Ata kazakah SSR, Kainar, 40-43 (In) Referalivnyi Zhurnal, 9-55: 243.
10. Hewitt, J.D. and M.A. Stevens, 1979. Physiological basis of genotypic variation for solid content of tomato fruits. Hort Science, 14: 458.
11. Courtney, W.H. and L.C. Peirce, 1979. Parent selection in tomato based on morpho-physiological traits. Hort Science, 14: 458.
12. Debnath, S.C., 1984. Heterosis in maize: 1.Grain yield and some of its attributes. Bangladesh J. Asri. Res., 9 (2): 78-83.
13. Debnath, S.C., 1987. Heterosis in maize: Bangladesh J. Asri. Res., 12 (3): 161-168.
14. Patil, A. and K.M. Bajappa, 1987. Correlation and path analysis for fruit quality traitsand yield intomato. South Indian Horticulture, 35: 199-202.
15. Neetu Bhardwaj, Vinay Bhardwaj and Manish K. Sharma, 2005. Genetic parameters and character association in tomato. Bangladesh J. Agril. Res., 30(1): 49-56.
16. Younis, S.E.A., M.K. Omara and M.Y. Hussein, 1988. A genetic analysis of fruit characteristics and their interrelationships in tomato (*Lycopersicon esculentum* Mill.) Assicit. Journal Agriculture Science, 19: 312-324.