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Heterosis Studies for Yield and Yield Attributing Characters of Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

A 8x8 full diallel cross of tomato was evaluated with parents and cheks for heterotic manifestation of yield and yield attributing characters. The heterosis over commercial check-2 to the extent of 107.08, 59.79, -13.59, 174.70 and 13.58 per cent was recorded for plant height at 60 DAP, number of branches per plant 60 DAT, days to fifty per cent flowering, number of fruits per plant and average fruit weight respectively. The crosses showing heterosis for yield per plant were not heterotic for all the characters under study. The heterosis for yield was generally accompanied by heterosis for yield components. Promising crosses for yield per plant are Vaibhav x PKM-1, PKM-1 x Anagha and Arka Sourabh x Anagha, for average fruit weight (more than 70 g), Vaibhav x Arka Saurabh and Vaibhav x PKM-1 crosses found promising with high standard heterosis. The yield and yield components indicated the role of both additive and non-additive gene effect in governing these traits.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous vegetable crops grown widely all over the world. It is a very versatile vegetable for culinary purposes ranging from ripe fresh fruit to range of processed products. It is native of Peru Ecuador region. Now, cultivation of tomato has become increasingly popular since mid-nineteenth century. So far efforts of many vegetable breeders from both public and private sector have resulted in spectacular improvement in yield characters. As a result of these efforts, hundreds of new cultivars have been developed since 50 years to meet the diverse needs and varied situations and climates under which tomato grows. Exploitation of heterosis is a quick and convenient way of combining desirable traits from contrasting parents. Keeping aforesaid information in view, a study on tomato was

initiated at College of Horticulture, GKVK, Bengaluru with the objective to estimate the heterosis of crosses for yield and yield attributing characters in tomato.

Materials and Methods

The study on "Heterosis for yield and yield attributing characters in tomato (*Solanum lycopersicum* L.)" was undertaken during the year 2011-2013. Full diallel analysis involving four bacterial wilt resistance genotypes namely Arka Abha, Utkal Pragnya, Anagha and Utkal Raja and four bacterial wilt susceptible genotypes having good horticultural properties *viz.,* Arka Meghali, Arka Saurabha, PKM-1 and Vaibhav were used in the present study. Hand emasculation and pollination technique was followed to develop 56 F_1s.

Results and Discussion

Heterosis is manifested through greater vigour of F_1 over their parents resulting into higher yield through their component characters. Heterosis breeding provides opportunity for improvement in productivity, earliness, uniformity, quality and development for resistance to diseases and pest. The recent trend in tomato breeding has been towards development of hybrids to meet the specific uses (*viz*., earliness, growth habit, disease or pest resistance, fruit quality for processing fresh market *etc*.) coupled with high yield as it may be difficult to develop a hybrid having all the characters.

For plant height at 60 days after transplanting, thirty three crosses exhibited significant positive economic heterosis over check-2. Twenty-four crosses exhibited standard heterosis over the check-1. Seventeen crosses showed significant positive hetrobeltosis. Mid-parent heterosis was observed in majority of crosses. In the earlier studies also, heterosis was reported for plant height by Fageria *et al.,* (2001) and Thakur *et al.,* (2004). At 60 DAT, Utkal Raja x PKM-1 showed maximum positive significant heterois for number of branches per plant.

Days to 50 per cent flowering are one of the important components for earliness. Seven crosses out of fifty six showed negative economic heterosis over check-2 and over check-1.

Twelve crosses exhibited significantly negative heterosis indicating early flowering in hybrids. While fifteen crosses showed negative hetrosis over better and mid-parents. Similar results were observed by Kulkarni, (2003), Mahendrakar, (2004), and Duhan *et al.,* (2005).

Out of 56 hybrids, 42 showed positive heterosis over check-2 and 23 over check-1 exhibited positive heterosis. Three hybrids showed positive significant heterosis over mid-parent.

The magnitude of heterosis over check-1 and check-2 for fruits per plant was as high as 123.90 per cent (PKM-1 x Anagha) and 193.76 per cent (PKM-1 x Anagha). For this character negative and positive heterosis was observed by Thakur *et al.,* (2004).

The hybrids in general had lower average fruit weight compared to commercial checks. Hybrid between Vaibhav x Arka Sourabh with 79.16 g is regarded as best. The numbers of hybrids exhibited significant positive heterosis over check-1 were three and two over check-2 while those showing the negative heterosis were higher.

It gives clear indication that the character is governed by additive gene effects. Similar results were reported by Thakur *et al.,* (2004) and Tiwari and Lal (2004) (Table 1 and 2).

Table.1 Estimation of mid parent, better parent and standard heterosis of 8x8 full diallel crosses in tomato for plant height, number of branches and days to 50 per cent flowering

Sl.No.	Hybrids	Plant height (cm) at 60 DAP				Number of branches at 60 DAP				50 per cent flowering			
		MP	BP	Check1	Check2	MP	BP	Check1	Check2	MP	BP	Check1	Check2
1	Vaibhav x PKM-1	45.13**	34.43*	49.09**	70.83**	-7.82	-25.97**	-7.29	-3.87	-2.16	-2.25	0.46	3.33
2	Vaibhav x Arka Meghali	31.62*	26.23	40.00**	60.42**	-3.62	-22.58*	-3.04	0.54	-8.17*	-9.91**	-7.58*	-4.94
3	Vaibhav x Anagha	5.07	-6.56	3.63	18.75	0.86	-11.59	10.73	14.81	-10.86**	-11.26**	-8.96*	-6.37
4	Vaibhav x Utkal Pragnya	1.08	-0.57	10.27	26.35	-16.77	-32.02**	-14.86	-11.72	1.92	0.54	3.14	6.08
5	Vaibhav x Arka Abha	40.83**	39.67**	54.91**	77.50**	-8.09	-31.01**	-13.60	-10.41	-0.27	-0.63	1.94	4.85
6	Vaibhav x Arka Saurabh	-16.33	-18.60	-4.55	9.38	-25.36**	-39.99**	-24.84*	-22.07	4.85	1.35	3.97	6.94
7	Vaibhav x Utkal Raja	0.75	-0.90	9.91	25.94	-30.20**	-35.00**	-18.59	-15.59	-0.73	-1.89	0.65	3.52
8	PKM-1 x Arka Meghali	36.11**	31.25*	33.64*	53.13**	-20.97*	-21.00	-26.39*	-23.68*	-13.03**	-14.75**	-12.38**	-9.89**
9	PKM-1 x Anagha	42.71**	36.54*	29.09	47.92**	-8.44	-16.00	-6.31	-2.86	-16.82**	-17.27**	-14.97**	-12.55**
10	PKM-1 x Utkal Pragnya	44.14**	35.59*	45.45**	66.67**	5.44	3.57	0.00	3.69	-17.52**	-18.71**	-16.45**	-14.07**
11	PKM-1 x Arka Abha	39.29**	30.00*	41.82**	62.50**	11.57	3.70	-3.44	0.12	2.26	1.80	4.62	7.60
12	PKM-1 x Arka Saurabh	17.81	6.40	24.77	42.97*	7.32	7.19	0.06	3.75	4.28	0.72	3.51	6.46
13	PKM-1 x Utkal Raja	71.89**	68.51**	73.64**	101.88**	-13.56	-24.64**	-5.62	-2.14	-6.01	-7.19	-4.62	-1.90
14	Arka Meghali x Anagha	23.67	14.29	16.36	33.33	-9.70	-17.13	-7.57	-4.16	-3.69	-5.09	-3.51	-0.76
15	Arka Meghali x Utkal Pragnya	22.77	19.64	28.35	47.06**	-0.21	-1.96	-5.34	-1.84	2.79	2.22	2.03	4.94
16	Arka Meghali x Arka Abha	10.11	6.44	16.12	33.05	-3.05	-9.91	-16.06	-12.97	-16.22**	-17.51**	-15.99**	-13.59**
17	Arka Meghali x Arka Saurabh	21.51	13.50	33.11*	52.52**	2.92	2.83	-4.02	-0.48	2.66	1.12	-0.18	2.66
18	Arka Meghali x Utkal Raja	21.30	18.22	26.82	45.31**	-10.69	-22.13*	-2.47	1.13	8.18*	7.38	7.58*	10.65**
19	Anagha x Utkal Pragnya	9.11	-1.53	5.64	21.04	-9.73	-15.79	-6.08	-2.62	1.10	0.18	1.85	4.75
20	Anagha x Arka Abha	28.93*	15.50	26.00	44.38*	0.06	-14.09	-4.19	-0.65	-9.17**	-9.26*	-7.58*	-4.94
21	Anagha x Arka Saurabh	15.63	0.39	17.73	34.90*	-14.48	-21.45*	-12.39	-9.16	-6.37	-9.09*	-7.58*	-4.94
22	Anagha x Utkal Raja	84.69**	64.75**	78.18**	107.08**	-19.41*	-23.82**	-4.59	-1.07	-7.51*	-8.18*	-6.65	-3.99
23	Utkal Pragnya x Arka Abha	22.18	21.17	32.18*	51.46**	4.19	-4.75	-8.03	-4.64	-3.48	-4.45	-2.68	0.10
24	Utkal Pragnya x Arka Saurabh	-32.79**	-35.66**	-24.55	-13.54	-25.68*	-26.92*	-29.43**	-26.83*	-4.73	-6.67	-6.84	-4.18
25	Utkal Pragnya x Utkal Raja	33.47**	33.47*	43.18**	64.06**	-5.85	-16.63	4.42	8.27	2.31	2.12	2.31	5.23
26	Arka Abha x Arka Saurabh	38.88**	34.03**	57.18**	80.10**	10.36	2.46	-4.36	-0.83	-4.68	-7.53*	-5.82	-3.14
27	Arka Abha x Utkal Raja	53.65**	52.37**	66.22**	90.46**	35.87**	11.31	39.41**	44.56**	-4.85	-5.63	-3.88	-1.14
28	Arka Saurabh x Utkal Raja	27.81*	22.36	43.50**	64.43**	-15.49	-26.25**	-7.63	-4.22	4.91	2.58	2.77	5.70
29	PKM-1 x Vaibhav	-5.31	-12.30	-2.73	11.46	-20.59*	-26.08*	-20.14	-17.19	-12.03**	-12.10**	-9.67**	-7.09
30	Arka Meghali x Vaibhav	30.77	25.41	39.09	59.38**	-7.21	-13.60	-6.66	-3.21	-10.84**	-12.52**	-10.26**	-7.70*

31	Arka Meghali x PKM-1	11.76	7.77	9.73	25.73	8.41	8.37	0.98	4.7	-3.85	-5.76	-3.14	-0.38
32	Anagha x Vaibhav	24.61	10.82	22.91	40.83*	-18.68	-19.96	-10.73	-7.44	-4.43	-4.86	-2.40	0.38
33	Anagha x PKM-1	54.02**	47.36**	39.32*	59.64**	-5.52	-13.32	-3.33	0.24	-12.48**	-12.95**	-10.54**	-7.98*
34	Anagha x Arka Meghali	6.67	-1.43	0.36	15.00	-10.48	-17.85	-8.38	-5.00	-0.37	-1.82	-0.18	2.66
35	Utkal Pragnya x Vaibhav	22.50	20.49	33.64*	53.13**	-12.34	-16.99	-10.33	-7.02	-3.29	-4.59	-2.13	0.67
36	Utkal Pragnya x PKM-1	12.46	5.79	13.48	30.03	6.65	4.75	1.15	4.88	3.01	1.53	4.34	7.32
37	Utkal Pragnya x Arka Meghali	9.22	6.44	14.18	30.83	1.78	0.00	-3.44	0.12	-6.42	-6.94	-7.12	-4.47
38	Utkal Pragnya x Anagha	3.60	-6.50	0.30	14.93	-15.25	-20.94*	-11.82	-8.57	1.93	1.00	2.68	5.61
39	Arka Abha x Vaibhav	2.96	2.11	13.25	29.77	1.50	-11.68	-4.59	-1.07	-6.42*	-6.76	-4.34	-1.62
40	Arka Abha x PKM-1	59.73**	49.08**	62.64**	86.35**	13.56	5.55	-1.72	1.9	-8.58**	-8.99*	-6.47	-3.80
41	Arka Abha x Arka Meghali	62.50**	57.08**	71.36**	96.35**	6.89	-0.68	-7.46	-4.05	-1.94	-3.45	-1.66	1.14
42	Arka Abha x Anagha	34.58*	20.56	31.52*	50.70**	3.12	-11.47	-1.26	2.38	-3.00	-3.09	-1.29	1.52
43	Arka Abha x Utkal Pragnya	3.49	2.63	11.95	28.28	10.24	0.77	-2.70	0.89	2.29	1.27	3.14	6.08
44	Arka Saurabh x Vaibhav	-13.35	-15.70	-1.14	13.28	-21.20*	-26.55*	-20.65	-17.73	1.77	-1.62	0.92	3.80
45	Arka Saurabh x PKM-1	-8.37	-17.25	-2.95	11.20	1.54	1.41	-5.34	-1.84	-5.40	-8.63*	-6.10	-3.42
46	Arka Saurabh x Arka Meghali	-10.79	-16.67	-2.27	11.98	9.69	9.59	2.29	6.07	2.66	1.12	-0.18	2.66
47	Arka Saurabh x Anagha	3.57	-10.08	5.45	20.83	6.80	-1.90	9.41	13.44	-9.64**	-12.27**	-10.81**	-8.27*
48	Arka Saurabh x Utkal Pragnya	-1.38	-5.58	10.73	26.88	5.62	3.86	0.29	3.99	-2.46	-4.44	-4.62	-1.90
49	Arka Saurabh x Arka Abha	17.27	13.18	32.73*	52.08**	2.35	-4.98	-11.30	-8.03	-1.22	-4.17	-2.40	0.38
50	Utkal Raja x Vaibhav	5.00	3.28	14.55	31.25	14.17	11.14	20.14	24.57*	-3.37	-4.50	-2.03	0.76
51	Utkal Raja x PKM-1	68.96**	58.94**	70.50**	95.36**	57.62**	50.56*	54.10**	59.79**	-0.91	-2.16	0.55	3.42
52	Utkal Raja x Arka Meghali	49.85**	46.04**	56.66**	79.51**	-12.79	-16.70	-14.74	-11.60	0.74	0.00	0.18	3.04
53	Utkal Raja x Anagha	49.67**	35.08*	44.91**	66.04**	-6.27	-9.77	0.63	4.34	-5.86	-6.55	-4.99	-2.28
54	Utkal Raja x Utkal Pragnya	-1.69	-1.69	5.45	20.83	-34.00**	-27.46**	-25.76*	-23.02	3.88	3.69	3.88	6.84
55	Utkal Raja x Arka Abha	13.87	12.92	23.18	41.15*	-0.50	-11.43	-9.41	-6.07	-6.50*	-7.26	-5.55	-2.85
56	Utkal Raja x Arka Saurabh	21.46	16.28	36.36*	56.25**	-8.79	-12.78	-11.07	-7.79	0.75	-1.48	-1.29	1.52
	SEm±	7.06	8.15	8.15			0.82	0.94	0.94		0.84	0.97	0.97
	CD@5%	14.49	16.73	16.73			1.68	1.94	1.94		1.73	2.00	2.00
	CD@1%	18.76	21.66	21.66			2.18	2.52	2.52		2.24	2.59	2.59

Table.2 Estimation of mid parent, better parent and standard heterosis of 8x8 full diallel crosses in tomato for number of fruits per plant, average fruit weight and yield per plant

Sl. No.	Hybrids	Number of fruits per plant				Average fruit weight (g)				Yield (kg/plant)			
		MP	BP	Check1	Check2	MP	BP	Check1	Check2	MP	BP	Check1	Check2
1	Vaibhav x PKM-1	18.08	-13.04	19.86	57.26	-8.62	-24.18*	15.53	4.53	98.97**	61.00*	57.49*	112.50**
2	Vaibhav x Arka Meghali	35.44	12.90	10.32	44.74	-39.70**	-53.18**	-28.65	-5.44**	8.55	5.86	-35.97	-13.60
3	Vaibhav x Anagha	127.31*	80.99	99.14	161.28*	-20.75	-41.57**	-10.96	-19.43	33.64	29.73	-21.53	5.88
4	Vaibhav x Utkal Pragnya	32.01	12.49	4.11	36.60	-36.12**	-53.09**	-28.51	-35.32**	-6.02	-15.22	-36.24	-13.97
5	Vaibhav x Arka Abha	8.74	-2.61	-19.77	5.26	-35.45**	-44.01**	-14.68	-22.80	35.20	15.24	-1.09	33.46
6	Vaibhav x Arka Saurabh	-58.37	-67.49	-62.28	-50.51	-3.73	-17.62	25.53	13.58	-36.43	-45.89	-53.41*	-37.13
7	Vaibhav x Utkal Raja	-12.40	-39.19	-60.36	-47.99	-19.93	-46.59**	-18.61	-26.36	11.19	-32.88	-59.40*	-45.22
8	PKM-1 x Arka Meghali	-28.83	-39.19	-16.19	9.96	-60.16**	-63.37**	-63.19**	-66.70**	-51.23	-61.28*	-62.13*	-48.90
9	PKM-1 x Anagha	-80.67*	62.45	123.90*	193.76**	-36.83*	-45.68**	-45.42**	-50.61**	109.86**	66.02**	62.40*	119.12**
10	PKM-1 x Utkal Pragnya	81.77*	51.91	109.37*	174.70**	-35.47*	-44.80**	-44.54**	-49.82**	34.80	19.22	16.62	57.35
11	PKM-1 x Arka Abha	23.81	-1.09	36.32	78.85	-25.42*	-29.25*	-20.77	-28.31*	41.54	32.87	29.97	75.37*
12	PKM-1 x Arka Saurabh	3.84	-4.37	31.81	72.93	-32.61**	-35.08*	-29.61*	-36.32**	6.96	0.56	-1.63	32.72
13	PKM-1 x Utkal Raja	10.65	-34.51	-9.74	18.42	8.57	-18.21	-17.82	-25.64	37.78	-22.28	-23.98	2.57
14	Arka Meghali x Anagha	24.97	17.97	29.80	70.30	-27.23	-32.39	-43.01**	-48.44**	52.38	51.66	-12.81	17.65
15	Arka Meghali x Utkal Pragnya	66.91	62.51	58.78	108.33	-16.33	-22.72	-34.86*	-41.06**	67.15*	47.46	10.90	49.63
16	Arka Meghali x Arka Abha	75.02	61.29	57.59	106.77	-32.09*	-40.49**	-33.36*	-39.70**	38.78	15.87	-0.54	34.19
17	Arka Meghali x Arka Saurabh	0.00	-7.90	6.88	40.23	-17.89	-27.02	-20.88	-28.42*	21.82	1.58	-12.53	18.01
18	Arka Meghali x Utkal Raja	155.27*	60.70	57.02	106.02	-6.22	-24.79	-36.61*	-42.64**	105.84**	86.26*	7.08	44.49
19	Anagha x Utkal Pragnya	72.80	59.08	75.03	129.64	-33.84	-34.26	-52.45**	-56.98**	20.82	6.16	-20.16	7.72
20	Anagha x Arka Abha	67.00	46.02	60.66	110.79	-35.22*	-46.69**	-40.30**	-45.99**	63.74*	36.19	16.89	57.72
21	Anagha x Arka Saurabh	17.62	14.57	32.95	74.44	-24.98	-37.47**	-32.21*	-38.66**	29.52	7.59	-7.36	25.00
22	Anagha x Utkal Raja	35.49	-16.67	-8.31	20.30	-2.47	-16.92	-39.91**	-45.63**	30.98	-20.10	-54.50*	-38.60
23	Utkal Pragnya x Arka Abha	23.54	16.75	8.05	41.77	-56.96**	-64.76**	-60.53**	-64.29**	-49.24	-52.38	-59.13*	-44.85
24	Utkal Pragnya x Arka Saurabh	-7.28	-16.67	-3.30	26.88	-45.80**	-55.05**	-51.27**	-55.91**	-46.62	-50.00	-56.95*	-41.91
25	Utkal Pragnya x Utkal Raja	69.20	7.74	-0.29	30.83	-21.73	-32.97	-52.13**	-56.69**	-5.59	-44.93	-58.58*	-44.12
26	Arka Abha x Arka Saurabh	-26.56	-37.21	-27.13	-4.40	-15.13	-16.48	-6.47	-15.37	29.64	29.43	11.44	50.37
27	Arka Abha x Utkal Raja	80.92	18.26	-2.58	27.82	7.32	-21.95	-12.59	-20.91	111.63*	21.27	4.09	40.44

28	Arka Saurabh x Utkal Raja	-35.42	-60.67	-54.36	-40.11	7.55	-20.98	-14.33	-22.48	3.87	-40.51	-48.77	-30.88
29	PKM-1 x Vaibhav	-26.14	-45.60	-25.03	-1.64	-40.86**	-50.93**	-25.23	-32.35*	-25.65	-39.83	-41.14	-20.59
30	Arka Meghali x Vaibhav	-6.19	-21.80	-23.60	0.24	-29.25**	-45.06**	-16.28	-24.25	32.10	28.83	-22.07	5.15
31	Arka Meghali x PKM-1	-23.18	-34.36	-9.53	18.70	-11.20	-18.35	-17.96	-25.77	7.02	-15.04	-16.89	12.13
32	Anagha x Vaibhav	119.46*	74.74	92.26	152.26*	-2.94	-28.44**	9.05	-1.33	112.53**	106.60**	24.80	68.38*
33	Anagha x PKM-1	32.17	18.85	63.80	114.91	15.23	-0.92	-0.44	-9.91	44.01	13.93	11.44	50.37
34	Anagha x Arka Meghali	47.35	39.10	53.05	100.81	-44.15**	-48.11**	-56.26**	-60.43**	20.00	19.43	-31.34	-7.35
35	Utkal Pragnya x Vaibhav	23.40	5.15	-2.68	27.69	-25.64*	-45.40**	-16.79	-24.71	58.23	42.75	7.36	44.85
36	Utkal Pragnya x PKM-1	36.19	13.83	56.88	105.83	-36.08*	-45.32**	-45.06**	-50.29**	20.94	6.96	4.63	41.18
37	Utkal Pragnya x Arka Meghali	34.53	30.98	27.98	67.91	-32.66	-37.80*	-47.57**	-52.56**	3.90	-8.33	-31.06	-6.99
38	Utkal Pragnya x Anagha	-21.50	-27.73	-20.49	4.32	-38.44*	-38.83	-55.76**	-59.97**	-49.69	-55.80	-66.76**	-55.15
39	Arka Abha x Vaibhav	16.21	4.09	-14.26	12.50	-39.27**	-47.32**	-19.73	-27.37*	11.73	-4.76	-18.26	10.29
40	Arka Abha x PKM-1	-2.77	-22.33	7.05	40.45	-11.13	-15.70	-5.59	-14.58	28.49	20.61	17.98	59.19
41	Arka Abha x Arka Meghali	-23.85	-29.82	-31.43	-10.04	-14.86	-25.39	-16.44	-24.40	-13.31	-27.62	-37.87	-16.18
42	Arka Abha x Anagha	68.52	47.34	62.12	112.71	-40.89**	-51.36**	-45.53**	-50.71**	32.82	10.48	-5.18	27.94
43	Arka Abha x Utkal Pragnya	12.20	6.04	-1.86	28.76	-37.35**	-48.70**	-42.55**	-48.02**	-24.87	-29.52	39.51	-18.38
44	Arka Saurabh x Vaibhav	-47.83	-59.26	-52.72	-37.97	-43.11**	-51.32**	-25.82	-32.88*	-53.16	-60.13*	-65.67**	-53.68
45	Arka Saurabh x PKM-1	-32.28	-37.63	-14.04	12.78	-19.15	-22.11	-15.56	-23.60	20.00	12.81	10.35	48.90
46	Arka Saurabh x Arka Meghali	-55.98	-59.46	-52.95	-38.27	-41.15**	-47.70**	-43.30**	-48.70**	-69.64*	-74.68**	-78.20**	-70.59*
47	Arka Saurabh x Anagha	49.24	45.37	68.70	121.33	-38.62**	-48.83**	-44.53**	-49.81**	117.90**	81.01**	55.86*	110.29**
48	Arka Saurabh x Utkal Pragnya	-20.33	-28.40	-16.91	9.02	-29.37*	-41.42**	-36.50*	-42.54**	-15.20	-20.57	-31.6	-7.72
49	Arka Saurabh x Arka Abha	-32.95	-42.68	-33.48	-12.73	-34.68**	-35.73**	-28.02	-34.87**	7.45	7.28	-7.63	24.63
50	Utkal Raja x Vaibhav	15.56	-19.78	-47.71	-31.39	-50.75**	-67.15**	-49.94**	-54.71**	28.36	-22.52	-53.13*	-36.76
51	Utkal Raja x PKM-1	-9.25	-46.29	-25.97	-2.88	16.64	-12.14	-11.71	-20.12	26.91	-28.41	-29.97	-5.51
52	Utkal Raja x Arka Meghali	-7.81	-41.96	-43.30	-25.60	11.28	-10.75	-24.78	-31.94*	108.56	27.01	-26.98	-1.47
53	Utkal Raja x Anagha	17.94	-27.46	-20.19	4.72	-27.28	-38.05	-55.19**	-59.46**	33.33	-18.66	-53.68*	-37.50
54	Utkal Raja x Utkal Pragnya	-11.27	-43.50	-47.71	-31.39	-48.40*	-55.81**	-68.44**	-71.45**	-61.49	-77.54*	-83.11**	-77.21*
55	Utkal Raja x Arka Abha	77.20	15.83	-4.58	25.19	-18.67	-40.85**	-33.76*	-40.07**	19.11	-31.75	-41.42	-20.96
56	Utkal Raja x Arka Saurabh	-17.91	-50.00	-41.98	-23.87	11.47	-18.09	-11.20	-19.66	28.18	-26.58	-36.78	-14.71
	SEm±	15.03	17.36	17.36		7.87	9.09	9.09		0.37	0.43	0.43	
	CD@5%	30.85	35.62	35.62		16.16	18.66	18.66		0.77	0.89	0.89	
	CD@1%	39.94	46.12	46.12		20.92	24.16	24.16		1.00	1.16	1.16	

The best combinations for economic characters

Sl. No.	Character	Cross combination
1	Yield per plant (More than 2500 g)	Vaibhav x PKM-1
		PKM-1 x Anagha
		Arka Sourabh x Anagha
2	Number of fruits per plant (More than 60 fruits per plant)	PKM-1 x Anagha
		PKM-1 x Utkal Pragnya
		Vaibhav x Anagha
3	Average fruit weight (More than 70 g)	Vaibhav x Arka Saurabh
		Vaibhav x PKM-1

Yield is a composite character, evidences suggest that heterosis of such a complex character is much regulated by the vigour expressed by its component character, such as average fruit weight and number of fruits per plant. In the present investigation, the yield per plant increased mainly due to increase in average fruit weight and number of fruits per plant.

Except fourteen crosses out of fifty six hybrids manifested positive heterosis over mid-parent. Twenty five crosses showed negative heterosis over better parent. The highest mean value for this trait is shown by the hybrid PKM-1 x Anagha (2.98) is higher than that of best parent PKM-1 (1.79). Only three hybrids exhibited significant positive heterosis over check-1 and over check-2, five hybrids showed significantly positive heterosis. All these crosses except one have high yielding PKM-1 as one of their parent.

The foregoing discussion on yield and yield components indicated the role of non-additive and additive gene effect in governing these traits.

Heterosis never concerns directly to the whole plant organization, but occurs in the development of individual traits. Therefore, the sources of heterosis are essentially formed and located in separate systems, enclosed in the cell apparatus of the hybrid progenies. These sources represent on altered genetic system brought about by the interaction of heterogeneous genetic background.

The interaction does so through complementation and mutual intensification of structural genes (such as changes in gene dose, position effect, production of extra DNA copies *etc*.) and through improvement of the balance of genetic factors controlling the regulatory mechanisms of the cell.

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