Journal of Medicinal and Aromatic Plant Sciences 38(1-4) (2016) 36-42

Heterosis for Latex Yield and its Attributes in Opium Poppy (*Papaver somniferum L.*)

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Article History

Received: 13th July, 2016
Accepted: 30th December, 2016

Key words
Heterosis
Latex yield
Opium poppy
Papaver somniferum L.
Seed yield

ABSTRACT

Eight parents and their possible crosses (Excluding reciprocals) of opium poppy were grown at experimental farm of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). This experiment was conducted in random block design with three replication and estimate heterosis and yield related traits. Analysis of variances indicated significant variability among parents and their hybrids for all the eleven characters studied. Significant parents v/s hybrids contrast for all the characters except for plant height, peduncle length and diameter of main capsule in pooled over environments indicated the presence of heterosis for these characters. The experimental result for heterosis revealed that out of 28 hybrids, 16 hybrids recorded significant positive heterosis for latex yield per plant, nine and six hybrids recorded significant positive heterobeltiosis and economic heterosis for latex yield per plant, respectively. The crosses UOP-53 X UOP-1185, UOP-80 X UOP-20, UOP-79 X UOP-1185 and UOP-79 X UOP-20 showed the highest magnitude of heterosis and heterobeltiosis for latex yield per plant, seed yield per plant, husk yield per plant, days to 50% flowering and seed harvest index. The crosses UOP-79 X UOP-60 and UOP-80 X UOP-20 showed highest significant positive economic heterosis for latex yield per plant, seed yield per plant, husk yield per plant, effective capsules per plant, days to 50% flowering, morphine content and seed harvest index.

INTRODUCTION

Relative heterosis and heterobeltiosis are important parameters as they provide information about the presence of dominance and over dominance type of gene actions in the expression of various traits. However, in practice not all the characters are governed by additive effects, but non allelic interaction also play a major role and intervenes with the selection process. This paper describes such efforts in opium opppy. Opium

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poppy (*Papaver somniferum* L., 2*n*=22) belongs to family *Papaveraceae.* The genus *Papaver,* which includes some 100 species is affiliated to the section *Mecones* comprising five species, among which *Papaver setigerum* L. (2*n*=44) is a close relative and probably the ancestor of the opium poppy [3]. Opium poppy is considered to be a predominantly self-pollinating species with various rates of out-crossing depending upon variety and environmental factors; large colourful flowers with numerous stamens and large amounts of pollen attract insects, especially bees; the transfer of pollen from one flower to another might also be performed by wind. The scope for exploitation of hybrid vigour largely depends on the direction and magnitude of heterosis and ease with which hybrid seeds can be produced. Further, the extent of heterosis will have direct effect on breeding methodology in the varietal improvement programme. Therefore, an attempt has been made to estimate the heterosis for latex yield and its component traits in diallel mating design using eight genetically diverse parents of opium poppy.

MATERIALS AND METHODS

Eight vigorous and diverse elite parents of opium poppy were crossed using diallel mating design to generate the crosses (Excluding reciprocals). The 38 entries ($28F_{1s}$, 8 parents and two standard checks) were evaluated in randomized block design with three replication. The plot size for parents and hybrids comprised one row each. Each row was 4m long with row to row and plant to plant spacing of 30 and 10 cm, respectively. The agronomic practices followed during the whole crop season were the same as recommended for this crop. Five plants of each parent and hybrid were randomly taken from each replication for recording observations. However days to 50 per cent flowering data were recorded on whole plot basis. A brief description of the procedure adopted for recording the observations for various traits is described below:

1. Days to 50 % flowering: The days to 50 per cent flowering was recorded from the date of sowing to date on which 50 per cent plants of each plot flowered.
2. Peduncle length (cm) was measured in centimeters
3. Plant Height (cm): Height was measured in centimeters from the base (ground level) to the tip of the terminal capsule, with the help of meter scale.
4. Number of leaves per plant: Leaves were counted after the completion of lancing and basal dried leaves were included in the count.
5. Number of effective capsules per plant: The number of effective capsules per plant lance was counted.
6. Diameter of main capsule (mm) : It was measured in centimeters with the help of Vernier Caliiper.
7. Seed yield per plant (g): Capsules per plant were harvested and thrashed to collect seeds. Seed yield per plant was recorded.
8. Husk yield per plant (g): After threshing of capsules husk weight per plant was recorded in grams.
9. Latex yield per plant (g): The latex was obtained by lancing young green capsule per plant and oven dry latex yield was recorded.
10. Harvest index for seed yield (%): It is a ratio of seed yield to biological yield expressed in percentage using this formula:

    Harvest index for seed yield (%) =

$$\frac{\text{Seed yield per plant (g)}}{\text{Biological yield per plant (g)}} \times 100$$

11. Morphine content (%): The morphine content in latex was estimated spectro-photometrically [6].
12. Heterosis was calculated for all the characters as the proportion of deviation of each F_{1s} from the respective best check.

RESULTS AND DISCUSSION

Analysis of variances indicated significant variability among parents and their hybrids for all the eleven characters studied (Table-1). Significant parents v/s hybrids contrast for all the characters except for plant height, peduncle length and diameter of main capsule in pooled over environments indicated the presence of heterosis for these characters. However the magnitude varied with the characters (Table-2) for days to 50% flowering and plant height desirable attributes in opium poppy out of 28 crosses, six crosses UOP-53 X UOP-1185 (-8.76%,-10.47% and -7.66%), UOP-1185 X UOP-60 (-6.99%,-10.66% and -7.85%), UOP-79 X UOP-1185 (-9.41%,-13.43% and -10.71%), UOP-53 X UOP-99 (-5.01%,-6.83% and -7.59%), UOP-69 X UOP-99 (-6.25%,-8.19% and -9.52%) and UOP-79 X UOP-20 (-6.48%,-7.42% and -11.25%) exhibited negative significant relative heterosis, heterobeltiosis and economic heterosis over the best check. Only one cross UOP-53 X UOP-20 (-9.13%)exhibited negative significant heterobeltiosis for plant height. Negative heterosis for days to 50% flowering and plant height has been reported by [1, 2, 7].

The magnitude with the peduncle length, only one cross UOP-1185 X UOP-60 (15.18%) exhibited positive significant economic heterosis over the best check. Only one cross UOP-20 X UOP-60 out of 28 crosses showed positive significant value of 34.00%, 28.50% and 46.40% for relative heterosis, heterobeltiosis and economi heterosis, respectively for effective capsules per plant. Three crosses UOP-53 X UOP-1185 (41.17%, 24.07% and 14.59%), UOP-79 X UOP-60 (42.28%, 35.56% and 14.31%) and UOP-80 X UOP-20 (71.24%,65.20% and 23.68%) exhibited positive significant relative heterosis, heterobeltiosis and economic heterosis for latex yield per plant and eight crosses UOP-53 X UOP-1185 (51.76%, 38.78% and 29.99%), UOP-69 X UOP-80 (58.59%, 38.57% and 42.82%), UOP-79 X UOP-60 (44.29%, 34.69% and 14.60%), UOP-80 X UOP-20 (86.64%, 68.58% and 38.14%), UOP-80 X UOP-1185 (86.86%, 86.58% and 43.71%)

Table-1: Pooled analysis of variance for eleven characters in 8 x 8 diallel set of opium poppy.

Characters	Source of Variance										
	Env.	Rep/Env	Genotype	Parents	F_1	P vs F_1	G x E	P x E	F_1 x E	PvsF$_1$xE	Pooled Error
DF	[1]	[4]	[35]	[7]	[27]	[1]	[35]	[7]	[27]	[1]	[140]
Plant height	0.91	40.18	53.91**	80.68**	46.32*	71.50	48.95**	33.47	54.20**	15.57	25.50
Peduncle length	100.72**	3.74	5.52**	6.80*	5.03**	9.84	3.19	3.65	3.07	3.41	2.54
Diameter of main capsule	126.50**	9.64	32.98**	20.91*	37.33**	0.06	17.93**	25.83*	15.78*	20.50	9.48
Effective capsules per plant	15.04**	0.07	0.76**	0.36**	0.85**	1.13**	0.56**	0.32**	0.43**	5.89**	0.07
Number of leaves per plant	22.04**	1.31	8.21**	6.37**	7.15**	49.52**	6.27**	5.37**	6.35**	10.36**	1.01
Day to 50% flowering	1467.44**	4.93	36.15**	42.66**	26.27**	257.25**	12.38	21.13	10.52	1.35	11.83
Latex yield (oven dry) per plant	0.05**	0.03	0.04**	0.05**	0.03**	0.01**	0.02**	0.09**	0.02**	0.02**	0.02
Seed yield per plant	115.06**	0.16	5.06**	2.45**	4.40**	41.06**	2.09**	1.22**	2.18**	5.89**	0.12
Husk yield per plant	57.67**	0.01	4.53**	3.24**	4.60**	11.79**	1.60**	0.44**	1.94**	0.70**	0.10
Seed harvest index	341.53**	5.56	34.30**	32.16**	25.24**	294.10**	16.81*	13.73	17.40*	22.29	10.46
Morphine content	0.27**	0.01	1.40**	1.99**	1.30**	0.09*	0.73**	0.63**	0.74**	0.98**	0.02

*,** Significant at 5 and 1 percent level respectively.

Table-2:Extent of relative heterosis(Ha) , heterobeltiosis (Hb) and economic heterosis (Hc) for latex yield and yield related traits in opium poppy crosses.

Crosses	Plant height			Peduncle length			Diameter of main capsule			Effective capsules per plant		
	Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc
UOP-53 x UOP-69	0.76	-0.82	1.73	-7.04	-10.78	-0.72	6.56	-10.71	-12.59*	-9.15	-5.25	2.41
UOP-53 x UOP-79	-2.79	-5.99	-4.70	2.34	-2.22	6.08	-1.51	-5.64	-9.41	-5.99	-14.71	8.66
UOP-53 x UOP-80	0.78	-2.07	-0.42	-7.45	-8.82	0.54	-1.69	-4.40	-11.51*	5.34	1.05	12.98
UOP-53 x UOP-20	-6.46	-9.13*	-7.93	-2.32	-5.94	1.79	-13.89**	-15.32*	-25.01**	-3.34	-3.34	3.13
UOP-53 x UOP-1185	2.71	-0.85	0.46	5.44	-0.03	8.04	6.97	3.69	-6.60	-10.98	-13.85	-3.85
UOP-53 x UOP-60	2.43	1.41	2.76	-5.99	-7.38	0.90	-6.65	-11.07	-18.41**	-0.38	-4.55	12.50
UOP-53 x UOP-99	-0.11	-2.08	2.86	-4.94	-7.41	0.36	-3.90	-9.25	-13.27*	-2.79	-15.22	19.23
UOP-69 x UOP-79	-2.27	-5.08	-4.57	2.85	-2.58	5.18	-0.27	-4.62	-3.39	-16.67**	-25.40**	-
UOP-69 x UOP-80	2.60	0.34	0.95	-0.49	-5.28	8.22	1.09	-3.10	-3.76	-9.79	-9.79	3.85
UOP-69 x UOP-20	1.31	-1.18	-0.66	-3.57	-7.39	-1.07	2.57	-2.80	-4.43	14.86*	10.14	25.48**
UOP-69 x UOP-1185	5.08	1.70	2.29	9.48	5.28	10.72	3.31	-2.31	-4.64	-16.89**	-18.88**	-8.66
UOP-69 x UOP-60	-0.76	-2.18	-0.80	1.16	-1.48	6.97	3.12	-2.56	-5.01	-17.48**	-17.48**	-3.85
UOP-69 x UOP-99	-0.85	-2.79	1.85	4.59	0.80	8.58	-2.01	-4.62	-6.82	-23.51**	-29.71**	-0.72
UOP-79 x UOP-80	1.45	-0.66	-3.20	3.60	-2.53	9.65	7.33	5.62	1.14	-25.00**	-32.89**	-10.10
UOP-79 x UOP-20	2.71	1.74	-2.26	6.53	4.77	5.18	6.27	2.03	-2.62	-13.07*	-21.77**	-
UOP-79 x UOP-1185	5.94	4.07	0.12	13.11*	9.53	10.72	0.78	-3.72	-8.03	11.35	2.94	28.61**
UOP-79 x UOP-60	5.19	2.79	2.07	10.14	6.03	12.86	0.60	-3.85	-8.11	5.84	-5.49	26.20**
UOP-79 x UOP-99	-1.37	-6.08	-1.50	5.20	3.08	5.54	-1.54	-6.14	-7.27	-31.15**	-35.63**	-9.38
UOP-80 x UOP-20	6.48	3.27	2.14	6.63	1.15	12.68	10.57	7.93	0.12	18.10**	13.29	26.93**
UOP-80 x UOP-1185	3.45	2.37	-1.63	2.86	-3.90	7.32	0.49	-2.44	-9.97	6.85	4.02	18.51
UOP-80 x UOP-60	2.00	-0.78	-0.21	-1.69	-3.89	7.15	2.89	-0.74	-7.55	-5.95	-5.95	7.69
UOP-80 x UOP-99	-1.66	-5.68	-1.30	2.42	-1.73	9.47	0.77	-3.74	-6.60	13.41*	3.38	45.68**
UOP-20 x UOP-1185	3.69	0.92	-1.59	12.19*	10.38	10.54	5.79	2.25	-7.41	19.28**	15.39	27.89**
UOP-20 x UOP-60	2.95	1.00	0.28	1.59	-4.52	1.61	1.79	-3.39	-10.51	34.00**	28.50**	46.40**
UOP-20 x UOP-99	-1.93	-6.19	-1.76	0.35	-0.84	1.43	-2.93	-8.62	-12.09*	4.19	-8.70	28.61**
UOP-1185 x UOP-60	7.48*	4.74	4.01	13.38*	8.26	15.18*	-1.64	-3.38	-14.54*	19.05**	15.39	34.14**
UOP-1185 x UOP-99	-0.42	-5.48	-1.23	4.64	1.66	5.00	-4.70	-7.38	-14.54*	-18.44**	-27.54**	2.41
UOP-60 x UOP-99	3.37	0.92	5.31	-1.14	-2.96	3.40	-3.03	-5.88	-13.31*	-15.85**	-22.59**	9.38

*,** Significant at 5 and 1 percent level respectively.

UOP-20 X UOP-60 (44.54%, 30.89% and 13.02%), UOP-80 X UOP-99 (28.73%, 13.37% and 15.43%) and UOP-53 X UOP-20 (44.53%,25.05% and 17.26%) exhibited positive significant relative heterosis, heterobeltiosis and economic heterosis for seed yield per plant (Table-3). Whereas eight crosses UOP-53 X UOP-1185 (51.63%,44.80% and 37.17%), UOP-69 X UOP-80 (40.88%,17.56% and 52.89%), UOP-79 X UOP-60 (47.88%,43.60% and 28.01%), UOP-80 X UOP-20 (45.50%,39.41% and 24.02%), UOP-80 X UOP-1185 (59.39%, 55.04% and 38.68%), UOP-20 X UOP-60 (39.92%,36.65% and 16.98%), UOP-79 X UOP-80 (29.86%,21.67% and 13.57%) and UOP-79 X UOP-20 (48.11%,41.38% and 25.48%) exhibited positive significant relative heterosis, heterobeltiosis and economic heterosis for husk yield per plant. Three crosses UOP-80 X UOP-20 (16.14%,12.08% and 15.16%), UOP-79 X UOP-1185 (17.19%,13.94% and 12.99%) and UOP-20 X UOP-1185 (17.03%,

Table-3:Extent of relative heterosis(Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for latex yield and yield related traits in opium poppy crosses.

Crosses	Number of leaves per plant			Day to 50% flowering			Latex yield (oven dry) per plant			Seed yield per plant		
	Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc
UOP-53 x UOP-69	-14.16**	-20.42**	-10.44*	-3.79	-1.96	-1.61	-11.82	-20.50**	-9.02	-9.84	-14.34*	-10.82
UOP-53 x UOP-79	-14.54**	-18.42**	-15.66**	-2.15	-4.73	-5.53	-9.79	-17.85*	-23.02**	-1.93	-11.24	-16.60**
UOP-53 x UOP-80	-8.93*	-15.47**	-9.61*	0.34	-1.35	-2.19	3.25	-8.85	-14.59*	2.48	-6.79	-12.45*
UOP-53 x UOP-20	-9.27*	-12.13**	-12.13**	-1.26	-2.89	-3.69	4.39	-5.52	-11.54	44.53**	25.05**	17.26**
UOP-53 x UOP-1185	1.82	-1.70	0.90	-8.76**	-10.47**	-7.66*	41.17**	24.07**	14.59*	51.76**	38.78**	29.99**
UOP-53 x UOP-60	0.06	-4.31	-0.80	-1.93	-4.04	-4.82	-5.91	-10.24	-16.41*	10.10	4.66	-1.45
UOP-53 x UOP-99	-5.12	-10.06*	-3.48	-5.01*	-6.83*	-7.59*	-8.24	-15.24*	-5.88	4.09	0.29	1.18
UOP-69 x UOP-79	-15.13**	-19.35**	-8.62*	-0.78	-3.91	-4.80	27.59**	5.84	21.20**	9.54	-5.72	-2.49
UOP-69 x UOP-80	-14.88**	-18.38**	-6.79	-3.53	-5.03	-6.69*	33.31**	8.00	23.90**	58.59**	38.57**	42.82**
UOP-69 x UOP-20	0.61	-5.70	6.08	-1.74	-4.28	-4.83	15.42*	-3.84	10.47	31.15**	11.78	14.54*
UOP-69 x UOP-1185	-4.69	-8.89*	2.62	-3.60	-6.09*	-3.14	16.79*	-6.00	7.62	4.05	-9.12	-5.47
UOP-69 x UOP-60	-9.31*	-13.33**	-2.63	-1.85	-4.84	-5.39	-12.32	-23.84**	-12.79	-13.70	-19.55**	-17.84**
UOP-69 x UOP-99	-9.88*	-11.98**	-0.86	-6.25*	-8.19*	-9.52**	-19.78**	-22.88**	-9.44	-5.61	-7.00	-3.88
UOP-79 x UOP-80	-7.55	-10.47*	-6.13	-2.07	-3.68	-7.06*	44.45**	39.30**	4.79	39.24**	26.69**	5.91
UOP-79 x UOP-20	-9.55*	-11.02**	-9.55*	-6.48*	-7.42*	-11.25**	42.57**	35.87**	7.70	55.17**	49.28**	10.34
UOP-79 x UOP-1185	2.94	1.64	5.27	-9.41**	-13.43**	-10.71**	41.69**	36.64**	3.12	45.92**	32.67**	10.07
UOP-79 x UOP-60	-8.15*	-8.55*	-6.04	-1.58	-2.07	-7.04*	42.28**	35.56**	14.31*	44.29**	34.69**	14.60*
UOP-79 x UOP-99	1.97	-0.86	7.04	-2.06	-3.12	-7.25*	22.56**	3.18	15.54*	25.46**	9.97	10.75
UOP-80 x UOP-20	3.83	-0.98	4.36	-1.80	-2.83	-5.89	71.24**	65.20**	23.68**	86.64**	68.58**	38.14**
UOP-80 x UOP-1185	-1.61	-5.96	0.86	-4.10	-7.52*	-4.62	55.57**	47.58**	11.06	86.86**	86.58**	43.71**
UOP-80 x UOP-60	-1.85	-5.42	0.91	-0.99	-2.51	-5.58	34.27**	25.28**	5.47	22.69**	15.59**	-0.17
UOP-80 x UOP-99	-7.56	-9.62*	-2.56	0.02	-0.57	-4.42	11.22	-9.05	1.96	28.73**	13.37*	15.43**
UOP-20 x UOP-1185	-0.43	-2.53	0.02	-5.69*	-8.99*	-6.14	3.52	-4.92	-25.06**	18.76**	6.91	-12.67*
UOP-20 x UOP-60	0.44	-1.64	0.90	4.01	3.49	-0.76	16.21*	5.90	-7.04	44.54**	30.89**	13.02*
UOP-20 x UOP-99	-7.66	-11.37**	-5.27	-1.29	-1.76	-5.59	1.05	-13.02	-4.35	6.84	-8.85	-8.40
UOP-1185 x UOP-60	-3.20	-4.02	-0.91	-6.99*	-10.66**	-7.85*	18.55*	8.34	-8.65	-1.10	-6.98	-19.24**
UOP-1185 x UOP-99	-8.67*	-10.51*	-4.41	-5.47*	-9.03**	-6.17	-16.34*	-31.91**	-24.11**	25.25**	10.38	12.52*
UOP-60 x UOP-99	-7.13	-9.20*	-2.62	1.46	0.47	-3.48	11.11	-2.38	8.93	18.50**	9.00	10.88

*,** Significant at 5 and 1 percent level respectively.

10.84% and 15.65%) depicted positive significant relative heterosis, heterobeltiosis and economic heterosis for seed harvest index and five crosses UOP-69 X UOP-99 (10.03%,9.39% and 12.16%), UOP-1185 X UOP-99 (5.86%,3.93% and 5.86%), UOP-53 X UOP-69 (9.77%,4.34% and 18.42%), UOP-69 X UOP-79 (8.30%,4.77% and 14.92%) and UOP-69 X UOP-1185 (7.99%,5.55% and 8.24%), exhibited positive significant relative heterosis, heterobeltiosis and economic heterosis for morphine content (Table-4). Out of 28 crosses, none of crosses for diameter of main capsule and number of leaves per plant exhibited positive significant relative heterosis, heterobeltiosis and economic heterosis. Similar results on economic heterosis, heterobeltiosis and relative heterosis in opium poppy for latex yield and yield contributing traits were reported by [2,4,5,7,8].

Table-4:Extent of relative heterosis(Ha), heterobeltiosis (Hb) and economic heterosis (Hc) for latex yield and yield related traits in opium poppy crosses.

Crosses	Husk yield per plant			Seed harvest index			Morphine content		
	Ha	Hb	Hc	Ha	Hb	Hc	Ha	Hb	Hc
UOP-53 x UOP-69	-12.69*	-24.41**	-1.88	2.51	-4.06	1.51	9.77**	4.34**	18.42**
UOP-53 x UOP-79	-17.18**	-20.13**	-22.88**	11.59	5.21	11.19	0.70	-1.20	12.81**
UOP-53 x UOP-80	-6.37	-11.01	-13.75*	5.66	2.45	8.35	-1.55	-3.52**	9.61**
UOP-53 x UOP-20	13.63*	4.51	-	15.01*	9.44	17.16*	-4.20**	-5.39**	7.31**
UOP-53 x UOP-1185	51.63**	44.80**	37.17**	0.65	-2.43	3.18	4.97**	-1.98*	11.39**
UOP-53 x UOP-60	0.62	-5.11	-8.81	7.02	3.64	13.99*	-7.38**	-9.51**	2.96*
UOP-53 x UOP-99	-3.70	-7.56	-4.42	4.44	3.13	11.82	3.52**	-1.94*	10.84**
UOP-69 x UOP-79	-0.51	-16.72**	8.08	9.59	7.40	1.78	8.30**	4.77**	14.92**
UOP-69 x UOP-80	40.88**	17.56**	52.89**	8.10	4.19	3.47	2.41*	-0.94	8.62**
UOP-69 x UOP-20	14.95*	-6.43	22.19**	13.72*	8.68	8.19	3.29**	-0.71	10.51**
UOP-69 x UOP-1185	-11.58*	-26.47**	-4.70	9.91	6.02	5.22	7.99**	5.55**	8.24**
UOP-69 x UOP-60	-3.83	-20.09**	4.81	-4.95	-11.45*	-5.20	-5.45**	-8.25**	-0.39
UOP-69 x UOP-99	-13.06*	-22.62**	0.95	4.71	-3.15	5.12	10.03**	9.39**	12.16**
UOP-79 x UOP-80	29.86**	21.67**	13.57*	7.57	4.50	3.79	-1.79*	-3.02**	7.74**
UOP-79 x UOP-20	48.11**	41.38**	25.48**	4.67	1.94	0.17	-5.96**	-7.65**	3.38**
UOP-79 x UOP-1185	12.89*	8.75	-2.62	17.19**	13.94*	12.99*	2.16*	-3.06**	6.43**
UOP-79 x UOP-60	47.88**	43.60**	28.01**	1.90	-4.61	2.36	-4.99**	-6.44**	3.81**
UOP-79 x UOP-99	15.48*	7.90	10.04	7.09	-0.17	8.16	4.74**	0.89	10.40**
UOP-80 x UOP-20	48.50**	39.41**	24.02**	16.18**	12.08*	15.16*	-5.77**	-8.65**	4.13**
UOP-80 x UOP-1185	59.39**	55.04**	38.68**	10.27	8.23	9.37	3.87**	-1.46	8.07**
UOP-80 x UOP-60	15.07*	11.03	-1.00	4.61	0.85	8.00	-3.88**	-4.26**	5.03**
UOP-80 x UOP-99	11.11*	2.98	4.87	9.73	5.18	13.95*	0.13	-3.62**	5.49**
UOP-20 x UOP-1185	-6.40	-9.90	-22.00**	17.03**	10.84*	15.65*	-2.23*	-7.52**	2.41
UOP-20 x UOP-60	39.92**	36.65**	16.98**	3.45	-1.06	6.12	-2.91*	-6.07**	6.55**
UOP-20 x UOP-99	-1.85	-11.98	-10.42	5.90	0.81	9.51	-1.06	-5.27**	5.26**
UOP-1185 x UOP-60	-7.63	-8.49	-19.71**	6.26	2.76	9.75	-2.48*	-7.09**	0.92
UOP-1185 x UOP-99	6.02	-2.10	-0.32	10.59	5.89	14.83*	5.86**	3.93**	5.86**
UOP-60 x UOP-99	20.51**	10.72	12.64*	-1.25	-4.70	6.57	-2.11*	-5.40**	2.90*

*,** Significant at 5 and 1 percent level respectively.

Relative heterosis and heterobeltiosis are important parameters as they provide information about the presence of dominance and over dominance type of gene actions in the expression of various traits. The present investigations on all three types of heterosis were under taken for all the characters studied. However, in practice not all the characters are governed by additive effects, but non allelic interaction also play a major role and intervenes with the selection process [4]. However such crosses viz., UOP-53 X UOP-1185, UOP-79 X UOP-60 and UOP-80 X UOP-20 were identified and shall be handled by suitable breeding method.

REFERENCES

1. Dodiya NS, Jain SK, Dubey RB. 2005. Heterosis and combining ability in Opium poppy *(Papaver somniferum* L.). *J Med Arom Pl Sci* **27**: 431-434.

2. Dubey RB, Jain SK, Maloo SR. 2007. Combining ability and heterosis for latex yield,

seed yield and other agronomic traits in Opium poppy *(Papaver somniferum* L.). *Ind J Gen* **67**: 392-395.

3. Hammer K, Fritsch R. 1977. The question of ancestral species of cultivated Opium poppy (*Papaver somniferum* L.). *Kulturpflanze* **25**: 113–124.

4. Kumar B, Singh HP, Verma AK, Misra HO, Patra NK. 2008. Combining ability analysis in relation to heterosis in Opium poppy (*Papaver somniferum* L.). *J Med Arom Pl Sci* **30**:83–87.

5. Patidar H. 1994. Hybrid vigour in Opium poppy. *Ind Gen* **54**: 395-397.

6. Pride RP, Stern ES. 1954. A specific method for the determination of Morphine. *Ind J Pharm Pharmacol* **6**: 590-606.

7. Singh R, Pandey RM. 2011. Combining ability and heterosis in Opium poppy (*Papaver somniferum* L.). *Curr Adv Agri Sci* **3**: 130-134.

8. Yadav HK, Shukla S, Singh SP. 2007.Genetic divergence in parental genotypes and its relation with heterosis, F1 performance and general combining ability (GCA) in Opium poppy (*Papaver somniferum* L.). *Euphytica* **157**:123–130.