Plant Archives Vol. 21, No. 2, 2021 pp. 583-589 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.089

STUDY OF HETEROSIS AND COMBINING ABILITY FOR YIELD AND ITS COMPONENT TRAITS IN BARLEY (*HORDEUM VULGARE* L.)

Akashdeep. Kamboj, Madakemohekar, A.H., Gaurav Thakur and Sumant Bindal

Department of Genetics and Plant Breeding,

School of Agriculture, Lovely professional University, Phagwara- 144411(Punjab), India

*Correspondent author e-mail: anant.madke@gmail.com

(Date of Receiving : 14-12-2020; Date of Acceptance : 04-08-2021)

ABSTRACT

Combining ability and heterosis were determined in a population obtained from crosses between 3 tester and 7 lines and grown during 2018-19. Analysis of variance (ANOVA) revealed the presence of significant variance due to general combining ability (GCA) as well as for specific combining ability (SCA) among the parents for all the traits. Among Testers, only a single tester *i.e.* BH 902 was observed to be best general combiner for number of effective tillers, spike length,1000 grain weight, harvest index and grain yield per plant. K745 found to be good combiner for awn length, where as K603 found to be good combiner for number of effective tillers. SCA effects of crosses showed significant results for many characters. Crosses, KR 521 x K 603, Azad x K745, HUB 113 x BH 902, RD 2508 x K 603 were recorded as outstanding specific combiners for grain yield per plant. For grain yield, the maximum per cent heterosis over standard check were observed in HUB 113 x BH 902, Azad x K745, Azad x BH902, Dolma 6 x K745, RD 2508 x K745 revealed greatest value of positive significant heterosis over standard check, while the crosses Azad x K 603 followed by Dolma 6 x K745, RD 2508 x K745, Azad x BH 902 and Azad x K745 showed positive and significant heterosis over better parent.

***Keywords* :** Barley, heterosis, diversity, combining ability, grain yield.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the world's most ancient food crops. It has been an important cereal crop since the early stages of agricultural innovations 8,000-10,000 years ago (Giles and von Bothmer, 1985). It is an economically important cereal crop, ranking fourth after wheat, rice and maize in the world, both in terms of quantity produced and in area of cultivation (FAO, 2014). Barley originates from the Eastern Mediterranean region where plants experience many abiotic stresses in the field. It is grown in many areas where climatic conditions are unfavorable. Though its commercial value is less than that of wheat but it replaces the later in the dry regions in areas of too low and erratic rainfall, because of low input requirement and better adaptation, it survives easily under rainfed condition and known as poor men's crop (Verma *et al.*, 2010). World production of barley is 292.9 million tonnes with highest production from Europe region (59.6%) followed by Asian region (14.9%). Russian federation is the highest producing country which produces near about 20.02 million tonnes production, while Indian has thirteenth ranks (USDA, 2015).

It is an important winter cereal crop grown in the northern plains of India comprising the states of Uttar Pradesh, Bihar, Haryana, Rajasthan, Punjab, Madhya Pradesh, Himachal Pradesh and Uttarakhand that makes about 80% of total acreage of India. Rajasthan has a lion's share accounting for 40% of the total production. However, India's share in global production is only 1.0% which is significantly very low. In India barley occupies nearly 0.67 million hectare and producing around 1.75 million tones grains with a productivity of 25.8 q/ha.

There is a need for the development of new barley cultivars that tolerate abiotic and biotic stresses for the improvement of crop productivity (Ellis *et al*. 2000). The rate of progress, however, will depend on the occurrence of desirable genetic variation and the availability of precise methods of identification, selection and transfer of superior genes (Ellis *et al*. 2000). Drought is a major environmental stress reducing crop yield around the world (Bruce *et al.*, 2002). The combined effects of drought and high temperature on the physiology, growth, water relations, and yield are significantly higher than the individual effects (Grigorova *et al.*, 2011). Yet, compared to other cereals, barley is well adapted due to better water-use efficiency and mechanisms of drought escape, avoidance and tolerance. Breeding for drought resistance based on putative traits (traits associated with drought resistance, but easier to select for than grain yield) has been very popular, but the progress is still slow. In several studies, it has been shown that the developmental genes are key factors in the determination of yield potential under drought condition (Baum *et al*., 2003; Forster *et al*., 2004).

MATERIAL AND METHODS

Genetic material of present investigation comprised of 25 genetically diverse genotypes of barley, among them 7 testers and 3 lines (Table 1) were selected for making crosses using L x T design. After doing crossing 21 F_1s crosses were generated, using testers as female and lines as male parents during *Rabi* 2017-18. During *Rabi* season 2018-19, all 18 F_1s crosses were grown with their 9 parents by using compact family randomized block design with three replications at Agricultural Research Farm of School of Agriculture, Lovely Professional University. All material were sown in two rows each of 5 m length having a spacing of 25 cm between rows to row and 10 cm between plant to plant following single seed per hill to keep the plant population at optimum level. Data has been recorded by randomly selecting ten competitive plants from each of the parents and F_1s'from each replication and tagged for recording of data on following quantitative traits, days to 50% flowering, days to maturity, numbers to tillers per plant, plant height, numbers of grains per spike, spike length, awn length, 1000 grain weight, harvest index and grain yield per plant. The mean data of selected ten plants were used for statistical analysis. The Statistical analysis/ Biometric analysis were done on the basis of these statistical tools, Analysis of Variance for line x tester analysis was carried out by according to Kempthorne (1957), GCA and SCA variances (for each cross separately) have been be estimate as per method given by Kempthorne (1957). Heterosis have been calculated over better parent (heterobeltiosis) as well as standard check (economic heterosis) for each cross and test of significance was tested by T test.

RESULT AND DISCUSSION

ANOVA for treatment variations were highly significant for all the crosses, also little significant difference notify in replication in case of days to maturity and grain yield per plant. Variations due to treatment were partitioned into various components, such as parents, cross (F1's) and parent vs. crosses. The mean squares due to parents vs. crosses showed significant differences for all the characters studied except 1000 grain weight (Table 2). The mean squares due to testers were highly significant for most of the characters studied except, days to 50% flowering, days to maturity, plant height, spike length, number of grains per spike. Mean square due to lines was highly significant for all the traits except days to 50% flowering and days to maturity. The line × tester interaction was highly significant for almost all the traits understudy.

General combining ability effects for most of the lines and testers were found significant for most of the characters including grain yield per plant. It might be concluded from the results that the line Ratna was observed superior general combiner for plant height, spike length, awn length, number of grains per spike, harvest index and grain yield per plant and Athoulpa was observed superior general combiner for plant height, number of effective tillers, awn length, number of grains per spike, harvest index, grain yield per plant. Only a single line Azad found to be good general combiner for days to maturity. KR 521 and RD 2508 found to be good combiner for number of effective tillers and harvest index. For 1000 grain weight, RD 2508 and Dolma 6 found to be good combiner, Whereas HUB113 found to be poor general combiner for all the traits. Among Testers, only a single tester *i.e.* BH 902 was observed to be best general combiner for number of effective tillers, spike length,1000 grain weight, harvest index and grain yield per plant. K745 found to be good combiner for awn length, where as K603 found to be good combiner for number of effective tillers. Apparently, there is still scope for improving combining ability for component traits, as none of the high combiners for grain yield was a high combiner or at least an average combiner for all the desirable traits.

SCA effects of crosses show significant results for many characters, such as crosses KR 521 x K 603, Azad x K745, HUB 113 x BH 902, RD 2508 x K 603 were recorded as outstanding specific combiners for grain yield per plant, also crosses *viz.* Azad x BH 902, Dolma 6 x K745, HUB 113 x K745, Dolma 6 x K 603 and Azad x K 603 observed to be good specific combiner for grain yield. For number of grains per spike Azad x K745, RD 2508 x K745 and KR 521 x K 603 found to be the best specific combiners. Crosses *viz.*Dolma x K 603, HUB 113 x BH 902 and Azad x BH902 observed as best specific combiners for plant height with negative significant values. HUB 113 x BH 902 and Azad x K 745 followed by KR 521 x K 603, Athoulapa x K 603, HUB 113 x K745, Ratna x BH 902 observed as good specific combiners, whereas RD 2508 x K 603, Azad x K 603, RD 2508 x BH 902 and KR 521 x BH 902 also found to have positive SCA effects for number of effective tillers. For spike length as a yield contributing trait, cross combinations *viz.* Azad x K 745, RD 2508 x K 745, Dolma 6 x K 603, Ratna x K 745 and KR 521 x K 603. Cross combinations HUB 113 x BH902, Azad x K745, RD 2508 x BH 902, Ratna x K 603, KR 521 x BH 902, Athoulpa x K 745 and Dolma 6 x BH902 observed to have better SCA significant effects. With reference to find the better specific combiners, this is in conformity with early reports of Bornare *et al*. (2014), Fahad *et al.* (2015) Xinzhong *et al.* (2015), Muneer *et al.* (2016), Pesaraklu *et al.* (2016), Patial *et al.* (2016), Rajput and Kandalkar (2018), Rathore and Chauhan(2017), Thomas *et al.,* 2017, Shrief *et al.* (2017), Ahemd *et al.* (2017), Mustafa (2018), Madhukar *et al.* (2018), Madakemohekar *et al.* (2018), and Patial *et al.* (2018).

For grain yield, the maximum per cent heterosis over standard check were observed in HUB 113 x BH 902, Azad x K745, Azad x BH902, Dolma 6 x K745, RD 2508 x K745 revealed greatest value of positive significant heterosis over standard check, while the crosses Azad x K 603 followed by Dolma 6 x K745, RD 2508 x K745, Azad x BH 902 and Azad x K745 showed positive and significant heterosis over better parent. Similar observations were also made by several workers, such as, Ram Daya *et al.* (2006), Kularia and Sharma (2006), Singh *et al.* (2011), Koumber and El gammaal (2012), Potla *et al.* (2013), Saad *et al.* (2013), Bornare *et al.* (2014), Shahzadi *et al.* (2015), Soylu *et al.*(2006), Baloch *et al.* (2015), Kalhoro *et al.* (2015), Pesaraklu *et al.* (2016), Murugan A and Kannan R. (2017), Shrief *et al.* (2017), Patial *et al.* (2018), Patel (2018), Madhukar *et al.* (2018), Lal *et al.* (2018), Madakemohekar *et al.* (2018), Rajput and Kandalkar (2018) and Mustafa (2018). As number of effective tillers is a yield contributing character, crosses HUB 113 x BH902, KR521 x K603 and RD2508xBH902, Azad x K603, HUB113 x K603 revealed significant heterosis over standard check. KR 521 x K 603, RD 2508 x K 745, Azad x K 603, HUB 113 x K 603, Dolma 6 x K 745 revealed positive significant desirable heterosis over better parent. For spike length, crosses *i.e.* RD 2508 x K745, Azad x K745, Ratna x K745, RD 2508 x K 603, KR 521 x K 603 showed positive significant heterosis over standard check and Ratna x K745, RD 2508 x K 745, HUB113 x K745,KR521 x K 603 revealed maximum positive heterobeltiosis. Incase of number of grains per spike, crosses *i.e.* Azad x K745, RD 2508 x K745, KR 521 x K 603, Dolma 6 x K745, HUB 113 x BH 902 revealed highest positive significant heterosis over better parent and recognised as best heterotic combinations, also RD 2508 x K745, Ratna x K 603, Azad x K 603, KR 521 x K 603 and Ratna x K745 observed to have positive significant heterosis over better parent. For 1000 grain weight, Ratna x K 603, HUB 113 x BH 902, RD 2508 x BH 902, Athoulpa x K 603, HUB 113 x K 603 revealed desirable positive significant heterosis over standard check. In case of better parent heterosis, only a single cross *i.e.* RD 2508 x BH 902 revealed significant positive better parent heterosis as adesirable. Similar observation were also observed by several workers for different traits, such as Yılmaz and Konak (2000), Rugen *et al.* (2004), Ram Daya *et al.* (2006), Soylu (2006), Ilker *et al.* (2010), El-aty (2011), Bilgin *et al.* (2011), Singh *et al.* (2011), Vishwakarma *et al.* (2011), Noorka *et al.* (2013), Lamalakshmi *et al.* (2013), Potla *et al.* (2013), Shahzadi *et al.* (2015), Shrief *et al.* (2017), Patial *et al.* (2018), Patel (2018), Madhukar *et al.* (2018), Lal *et al.* (2018), Madakemohekar *et al.* (2018), Rajput and Kandalkar (2018) and Mustafa(2018).

Table 1: Details of selected barley genotypes.

S.No.	Name of Lines/Testers	Source	Row
	Lines		
1.	Azad	BHU, Varanasi	Six row
2.	KR 521	BHU, Varanasi	Six row
3.	Ratna	BHU, Varanasi	Six row
4.	HUB 113	BHU, Varanasi	Six row
5.	Atahualpa	BHU, Varanasi	Six row
6.	RD 2508	BHU, Varanasi	Six row
7.	**Dolma 6**	BHU, Varanasi	Six row
	Testers		
1.	K 745	BHU, Varanasi	Six row
2.	K 603	BHU, Varanasi	Six row
3.	BH 902	BHU, Varanasi	Six row

Table 2: Analysis of variance for line x tester analysis of yield, its component and drought tolerant traits of barley during Rabi 2018-2019

		Mean Sum of Squares									
Sources of Variations	**df**	**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**Number of effective tillers**	**Spike length (cm)**	**Awn length (cm)**	**Number of grains per spike**	**1000 grain weight (g)**	**Harvest Index**	**Grain yield per plant (g)**
Replicates	2	2.42	33.54*	14.41	0.57	0.02	0.07	1.44	0.87	0.42	7.65*
Treatments	30	27.52**	31.07**	142.12**	53.11**	2.99**	8.83**	118.54**	41.14**	448.22**	621.73**
Parents	9	16.38*	42.68**	232.81**	30.64**	1.96**	6.71**	122.98**	63.03**	62.17**	32.35**
Crosses	20	13.88*	19.26*	104.31**	31.29**	0.65**	3.68**	36.53**	33.14**	259.45**	448.57**
Parents vs. Crosses	1	400.45**	162.93**	82.19**	691.90**	58.98**	130.89**	1718.97**	4.03	7697.99**	9389.40**
Lines (Male)	6	5.83	16.1	201.58**	50.03**	0.30**	3.52**	44.91**	33.42**	304.07**	508.37**
Testers (Female)	2	20.17	7.43	16.78	66.00**	0.23	2.71**	16.51	5.18*	223.14**	932.71**
Lines x Testers	12	16.86**	22.80*	70.26**	16.13**	0.90**	3.92**	35.67**	37.66**	243.20**	337.97**
Error	60	6.82	9.86	10.7	0.37	0.07	0.21	6.09	1.14	2.13	2

* Significant at p=0.05
**Significant at p=0.01

Table 3: Estimates of general combining ability effects for yield and its component traits in barley during Rabi 2018-19.

	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of effective tillers	Spike length (cm)	Awn length (cm)	Number of grains per spike	1000 grain weight (g)	Harvest Index	Grain yield per plant (g)
						LINES				
Azad	-0.21	-2.64 *	1.3	-2.04 **	0.15	-0.58 **	1.29	-0.89 **	0.83	0.2
KR 521	-0.32	0.59	-1.84	3.18 **	-0.30 **	-1.14 **	-3.38 **	0.21	1.86 **	-3.38 **
Ratna	0.13	0.81	-5.71 **	-2.46 **	0.19 *	0.53 **	1.74 *	-1.52 **	3.65 **	6.17 **
HUB 113	1.57	1.25	-0.95	-1.91 **	0.11	0.26	-1.91 *	0.18	-4.31 **	0.26
Athoulpa	-0.21	-0.08	-4.71 **	1.22 **	0.06	0.52 **	2.29 **	-2.53 **	4.07 **	12.13 **
RD 2508	0.13	0.81	4.80 **	2.72 **	-0.17	0.22	1.56	3.36 **	-11.16 **	-11.14 **
Dolma 6	-1.09	-0.75	7.11 **	-0.71 **	-0.05	0.19	-1.6	1.18 **	5.05 **	-4.25 **
Std . Error	±0.87	±0.99	±1.80	±0.22	±0.08	±0.15	±0.82	±0.32	±0.54	±0.50
						TESTERS				
BH 902	0.75	0.41	-0.89	1.57 **	0.12 *	0.02	-0.56	0.56 *	3.59 **	7.69 **
K 745	0.36	0.27	0.89	-1.92 **	-0.08	0.35 **	1.02	-0.4	-2.78 **	-3.92 **
K 603	-1.11	-0.68	0	0.35 *	-0.04	-0.37 **	-0.46	-0.16	-0.81 *	-3.77 **
Std . Error	±0.57	±0.65	±0.72	±0.15	±0.05	±0.10	±0.54	±0.21	±0.35	±0.33

Table 4: Estimates of specific combining ability effects for yield and its component traits in barley during *Rabi* 2018-19.

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers	Spike length (cm)	Awn length (cm)	Number of grains per spike	1000 grain weight (g)	Harvest index	Grain yield per plant (g)
Azad x BH 902	-1.08	-0.08	-4.61 *	-2.22 **	-0.07	0.39	-0.8	-3.30 **	-3.35 **	6.33 **
KR 521 x BH 902	2.97	2.4	3.12	0.91 *	-0.09	0.53	0.09	2.45 **	-0.96	-12.85 **
Ratna x BH 902	-1.89	-2.32	1.48	1.31 **	0.16	-0.92 **	0.71	0.85	4.31 **	6.53 **
HUB 113 x BH 902	2.36	4.70 **	-6.68 **	2.63 **	0.01	-0.29	-0.93	3.60 **	20.52 **	12.37 **
Athoulpa x BH 902	-2.59	-1.83	2.99	-3.64 **	0.09	-0.22	0.09	-6.88 **	-14.70 **	-9.41 **
RD 2508 x BH 902	0.22	-2.87	3.69	1.02 *	-0.1	0.5	0.84	3.29 **	-5.82 **	-2.96 **
Dolma 6 x BH 902	-1.08	-1.52	1.65	-1.37 **	-0.87 **	-1.41 **	-5.71 **	1.25 *	0.51	-9.25 **
Azad x K 745	-1.37	-1.71	-2.94	2.32 **	0.73 **	-0.21	5.58 **	3.44 **	3.77 **	12.77 **
KR 521 x K 745	2.45	3.24	1.29	-0.95 *	0.14	1.62 **	0.13	-4.69 **	-4.28 **	-3.52 **
Ratna x K 745	0.14	-1.97	-3.5	-2.18 **	0.42 **	0.28	-0.13	-0.81	-1.34	-3.87 **
HUB 113 x K 745	2.52	2.18	1.24	1.61 **	-0.17	0.02	-1.44	-1.52 *	3.44 **	4.88 **
Athoulpa x K 745	-2.67	-0.21	2.27	0.57	-0.25	-0.31	1.57	2.34 **	-2.10 *	-1.01
RD 2508 x K 745	-0.08	1.37	3.78	-0.09	0.70 **	1.13 **	4.67 **	0.43	-6.92 **	-7.67 **
Dolma 6 x K 745	0.63	-2.16	-2.81	-1.16 **	-0.63 **	-0.66 *	-0.44	0.95	2.66 **	5.02 **
Azad x K 603	-0.56	0.79	-0.98	1.24 **	-0.07	-0.47	-4.23 **	-1.38 *	4.26 **	2.66 **
KR 521 x K 603	1.92	0.47	0.74	1.62 **	0.36 *	1.37 **	3.80 *	-2.06 **	0.07	13.19 **
Ratna x K 603	-2.36	0.29	0.22	-1.32 **	0.13	-0.93 **	-2.24	2.79 **	-1.14	-8.25 **
HUB 113 x K 603	0.44	-0.76	-0.96	-0.29	-0.49 **	-0.44	-1.56	-0.74	1.08	-4.94 **
Athoulpa x K 603	-2.19	-2.97	8.63 **	1.62 **	-0.55 **	-1.48 **	-0.91	0.89	-9.49 **	-11.09 **
RD 2508 x K 603	0.19	0.84	-1.83	1.28 **	-0.06	1.47 **	-1.62	-1.23 *	6.94 **	7.85 **
Dolma 6 x K 603	2	2.13	-6.80 **	-2.90 **	0.61 **	0.01	2.53	0.34	2.55 **	3.24 **
Std . Error	±1.52	±1.73	±1.92	±0.40	±0.16	±0.27	±1.44	±0.57	±0.94	±0.88

Table 5: Estimates of standard heterosis and better parent heterosis for yield, its component of barley during Rabi2018-19.

Traits	Days to 50% flowering		Days to maturity		Plant height		Number of effective tillers		Spike length	
Crosses	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**	**SH**	**BPH**
Azad x BH 902	-2.46	-0.36	-3.78	-7.05 **	-19.82 **	-6.10 *	-13.42 **	28.67 **	5.81 **	12.69 **
KR 521 x BH 902	1.40	5.86 *	-1.89	-5.22 *	-12.36 **	-7.60 **	-15.08 **	26.20 **	3.64	10.38 **
Ratna x BH 902	-5.26 *	-0.37	-6.48 **	-9.66 **	-14.34 **	-7.34 **	-3.02	28.32 **	6.51 **	13.43 **
HUB 113 x BH 902	1.05	3.22	2.71	-3.06	-23.90 **	-18.56 **	32.11 **	21.65 **	2.10	7.71 **
Athoulpa x BH 902	-4.56 *	-0.37	-2.70	-8.16 **	-14.92 **	-10.30 **	-12.07 **	-19.03 **	0.83	6.37 **
RD 2508 x BH 902	-3.16	1.85	-4.32 *	-9.69 **	-15.08 **	-9.11 **	19.31 **	9.86 **	-0.60	4.86 *
Dolma 6 x BH 902	-2.11	-0.00	-2.16	-2.16	-20.41 **	-6.79 **	-11.46 **	36.83 **	-1.84	3.81
Azad x K 745	-2.81	1.47	-2.43	-2.43	-22.60 **	-18.39 **	-10.56 **	38.23 **	12.18 **	18.63 **
KR 521 x K 745	-0.35	4.80 *	0.81	0.81	-19.98 **	-13.44 **	-15.08 **	12.35 **	6.77 **	12.91 **
Ratna x K 745	0.70	2.86	-2.16	-2.69	-20.71 **	-7.15 **	-12.67 **	37.86 **	10.31 **	42.44 **
HUB 113 x K 745	2.81	7.33 **	1.08	0.54	-15.60 **	-11.02 **	-11.30 **	38.70 **	2.44	24.80 **
Athoulpa x K 745	-4.21	0.37	-1.62	-2.15	-15.49 **	-8.59 **	-5.73 *	24.73 **	2.04	11.77 **
RD 2508 x K 745	-1.40	0.71	-0.54	-0.00	-17.95 **	-3.91	11.00 **	71.54 **	12.65 **	42.33 **
Dolma 6 x K 745	-1.06	3.29	-3.51	-2.99	-21.71 **	-17.46 **	-9.65 **	39.63 **	-2.70	18.54 **
Azad x K 603	-3.86	1.11	-1.89	-1.36	-20.98 **	-14.52 **	11.46 **	47.48 **	3.37	13.23 **
KR 521 x K 603	1.05	3.22	-0.54	-2.13	-12.88 **	-0.24	25.49 **	78.54 **	6.84 **	19.84 **
Ratna x K 603	-3.86	0.37	-0.81	-2.39	-11.89 **	-7.11 **	-3.62	37.12 **	2.57	15.04 **
HUB 113 x K 603	-2.46	2.58	-2.43	-3.99	-13.51 **	-6.44 **	11.31 **	47.28 **	-3.17	6.07 *
Athoulpa x K 603	-4.56 *	-2.51	-4.59 *	-6.61 **	-4.89 *	11.38 **	9.97 **	31.13 **	-1.03	7.46 **
RD 2508 x K 603	-2.46	1.83	-1.62	-3.71	-11.68 **	-6.89 **	-7.38 **	10.45 **	1.90	10.65 **
Dolma 6 x K 603	-2.10	2.96	-1.35	-3.44	-16.28 **	-9.44 **	-16.00 **	0.16	9.04 **	18.41 **
Azad x BH 902	13.04 **	28.34 **	16.71 **	7.31 **	-2.64	-20.38 **	37.47 **	85.53 **	77.96 **	94.18 **
KR 521 x BH 902	16.39 **	18.44 **	20.14 **	10.45 **	8.04 **	-14.50 **	25.50 **	63.92 **	0.97	10.18 **
Ratna x BH 902	1.04	14.72 **	18.93 **	9.35 **	4.99 *	-2.28	47.26 **	93.10 **	49.80 **	63.45 **
HUB 113 x BH 902	4.28	-13.19 **	10.06 **	-3.95	15.16 **	-5.82 **	112.32 **	162.51 **	84.12 **	80.26 **
Athoulpa x BH 902	7.12 **	-10.83 **	13.66 **	-0.81	-10.28 **	-29.00 **	-12.67 **	7.98	0.64	-1.47
RD 2508 x BH 902	7.17 **	-10.79 **	12.65 **	-1.69	12.86 **	5.04 **	19.91 **	48.25 **	17.15 **	14.69 **
Dolma 6 x BH 902	8.19 **	13.19 **	10.52 **	-5.15 *	6.11 **	-13.22 **	57.56 **	116.02 **	53.96 **	62.11 **
Azad x K 745	19.04 **	21.14 **	28.36 **	10.15 **	8.85 **	-13.85 **	48.24 **	93.61 **	79.96 **	89.47 **
KR 521 x K 745	26.92 **	32.80 **	18.75 **	1.90	-8.72 **	-15.04 **	29.92 **	70.36 **	39.63 **	47.02 **
Ratna x K 745	18.29 **	33.83 **	13.20 **	15.57 **	5.29 **	-13.89 **	28.09 **	94.36 **	52.64 **	73.49 **
HUB 113 x K 745	18.81 **	20.90 **	13.57 **	8.47 **	1.59	-19.61 **	23.30 **	61.04 **	45.46 **	64.10 **
Athoulpa x K 745	11.36 **	25.99 **	15.70 **	21.44 **	10.70 **	3.03	12.57 **	47.60 **	31.13 **	57.72 **
RD 2508 x K 745	26.09 **	29.06 **	25.68 **	28.30 **	2.03	-16.56 **	36.49 **	105.15 **	72.79 **	96.40 **
Dolma 6 x K 745	15.83 **	17.86 **	20.78 **	15.35 **	1.07	-20.02 **	46.13 **	90.87 **	75.46 **	97.94 **
Azad x K 603	12.04 **	14.67 **	13.48 **	19.11 **	-3.60	-10.28 **	56.86 **	105.69 **	69.96 **	104.41 **
KR 521 x K 603	25.67 **	20.34 **	23.46 **	17.19 **	9.60 **	-10.36 **	11.69 **	39.42 **	66.78 **	79.70 **
Ratna x K 603	11.69 **	6.96 **	17.27 **	11.32 **	18.27 **	-6.40 **	-11.08 **	10.99 *	-15.85 **	-9.34 **
HUB 113 x K 603	10.10 **	5.44 *	16.16 **	10.26 **	10.94 **	3.25	1.50	26.70 **	-7.19 *	0.00
Athoulpa x K 603	5.25 *	6.11 *	12.56 **	1.08	11.30 **	-8.98 **	31.69 **	21.66 **	23.30 **	32.63 **
RD 2508 x K 603	28.55 **	29.60 **	13.76 **	2.16	4.48 *	-17.32 **	61.95 **	49.62 **	41.62 **	52.33 **
Dolma 6 x K 603	13.13 **	14.05 **	17.46 **	5.48 *	8.48 **	0.97	54.68 **	42.90 **	30.48 **	40.34 **

Where,SH = Standard Heterosis, BPH= Better Parent Heterosis (Heterobeltiosis), * Significant at p= 0.05, ** Significant at p= 0.01

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