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Estimates of heterosis for yield and its contributing traits in bread wheat (*Triticum aestivum* L. em. Thell.) under sodic soil

Anand Singh, Vinod Singh and Govind Mishra

Abstract
The present investigation entitled "Estimates of heterosis for yield and its contributing traits in bread wheat (*Triticum aestivum* L. em. Thell.) under sodic soil*"* was carried out with 48 F_1's developed by crossing of lines (FLW-15, FLW-8, KRL-20, K-402, HD-2851, KRL-1-4, DBW-14, CHIRYA-1, KRL-3-4, HI-1563, FLW-2, FLW-11, HD-2009, HI-3118, K-9006 and DBW-39) with 3 testers (NW-1067, PBW-778 and NW-2036) including three checks (KRL-19, KRL-210 and NW-1076). The Proportional contribution of lines, testers and lines x testers revealed that the relative contribution of the lines × testers was higher than its corresponding contribution of lines and testers for all the characters in both Timely (E_1) and Late Shown condition (E_2) except for maturity (E_2). The best five F_1's showed significant heterosis over better parent in positive direction for grain yield were HD-2851 x PBW-778, FLW-8 x NW-1067, HD-2851 x NW-1067, KRL-1-4 x NW-1067 and FLW-11 x NW-1067.

Keywords: Estimates, crossing, tester, contribution and significant

Introduction
Wheat (*Triticum aestivum* L. em. Thell., 2n=42) is a self-pollinated crop belonging to the *Poaceae* family and one of the most leading cereals of many countries of the world including India. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the International food grain trade. It is the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. Wheat is consumed in a variety of ways such as bread, chapatti, porridge, flour, suji etc. Wheat has relatively high content of niacin and thiamin which are principally concerned in providing the special protein called '*Glutin'*. Wheat proteins are of special significance because *Glutin* provides the framework of spongy cellular texture of bread and baked products.
The wheat grown in India is spring type belonging to species *Triticum aestivum* (bread wheat). Wheat is more nutritive as compared to the other cereals. It has good nutrition profile with 12.1 per cent protein, 1.8 per cent lipids, 1.8 per cent ash, 2.0 per cent reducing sugars, 6.7 per cent pentosans, 59.2 per cent starch, 70 per cent total carbohydrates and provides 314K cal/100g of food. It is also a good source of minerals and vitamins *viz*., calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), riboflavin (0.13 mg/100 g) and nicotinic acid (5.4mg/100mg) (Lorenz and Kulp, 1991). Unlike other cereals, wheat contains a high amount of gluten, the protein that provides the elasticity necessary for excellent bread making. Hard wheat had high protein (10-17%) and yields a flour rich gluten, making it particularly suitable for yeast breads. The low-protein (6 to 10%) softer type yields flour lower in gluten and therefore, suited better for tender baked products, such as biscuits, pastries and cakes.

Materials and Methods
The experimental material for present investigation comprised of 48 F1's developed by crossing of lines (FLW-15, FLW-8, KRL-20, K-402, HD-2851, KRL-1-4, DBW-14, CHIRYA-1, KRL-3-4, HI-1563, FLW-2, FLW-11, HD-2009, HI-3118, K-9006 and DBW-39) with 3 testers (NW-1067, PBW-778 and NW-2036) including three checks (KRL-19, KRL-210 and NW-1076). Seventy genotypes comprising 48 F_1, 16 parents and 3 checks (16lines+3 testers + 3 checks) will be evaluated in Randomized Complete Block Design with 3 replications in two environments / conditions (E_1= Timely Shown; E_2= Late Shown). Recommended cultural practices will be followed to raise a good crop.

Each plot consists of single row of 3m length having row to row and plant to plant distance of 30 cm and 10 cm, respectively. Five competitive plants in each parent and F_1 will be randomly selected for taking observations in each replication.

Results and Discussion

Estimates of heterosis over better parent and standard varieties

The magnitude of heterosis was estimated as per cent increase or decrease of F_1 hybrid over better parent (BP) and three standard varieties *viz*., KRL-210, KRL-19 and NW-1076, under E_1 and E_2 environments have been set out in Table 1 respectively. The results are being described character wise here as under.

Table 1: Extent of per cent heterosis over better parent (BP) and standard varieties for 13 characters in wheat

	Test Weight(g)								Biological yield per plant(g)							
	E1				E2				E1					E2		
	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3
FLW-15 X NW-1067	14.03	13.69	6.11	10.56	4.48	9.72	6.06	12.90	2.38	101.70**	18.73**	98.18**	-13.19**	133.10**	43.85**	126.80**
FLW-15 X PBW-778	14.97	19.35	11.39	16.06	-4.48	0.31	-3.03	3.23	-4.05**	83.75**	8.16	80.54**	-30.17**	87.50**	15.71**	82.44**
FLW-15 X NW-2036	15.22	14.88	7.22	11.72	-4.48	0.31	-3.03	3.23	-22.40**	39.28**	-18.01**	36.85**	-10.16**	131.25**	42.71**	125.00**
FLW-8X NW-1067	15.50	13.10	5.56	9.99	-13.40	-3.13	-6.36	-0.32	-4.90**	116.71**	27.56**	112.92**	-10.07**	131.50**	42.86**	125.24**
FLW-8 X PBW-778	14.85	22.02	13.89	18.67	-15.92	-5.96	-9.09	-3.23	-0.35	100.28**	17.90**	96.79**	-27.24**	87.29**	15.58**	82.23**
FLW-8 X NW-2036	3.64	10.12	2.78	7.09	-11.72	-1.25	-4.55	1.61	-20.50**	56.85**	-7.67	54.11**	19.91**	90.98**	17.85**	85.82**
KRL-20 X NW-1067	7.02	8.93	1.67	5.93	2.92	10.34	6.67	13.55	2.40	97.29**	16.13**	93.84**	1.30**	90.41**	17.50**	85.26**
KRL-20 X PBW-778	8.94	13.10	5.56	9.99	1.75	9.09	5.45	12.26	1.57	79.39**	5.60	76.26**	-21.11	48.28**	-8.50**	44.27**
KRL-20 X NW-2036	2.92	4.76	-2.22	1.88	-0.29	6.90	3.33	10.00	-8.62**	33.43**	-21.46**	31.10**	11.41**	82.58**	12.67**	77.65**
K-402 X NW-1067	7.29	5.06	-1.94	2.17	30.31	30.72	26.36	34.52	-3.54*	63.24**	-3.91	60.39**	5.67**	81.00**	11.70**	76.11**
K-402 X PBW-778	3.50	7.44	0.28	4.49	26.56	26.96	22.73	30.65	-5.33**	46.19**	-13.95**	43.64**	-16.20**	37.33**	-15.25**	33.62**
K-402 X NW-2036	-3.90	-4.76	-11.11	-7.38	23.13	23.51	19.39	27.10	-4.81*	-1.76	-42.17**	-3.47	-14.77**	128.88**	41.24**	122.69**
HD-2851 X NW-1067	10.30	8.33	1.11	5.35	9.83	13.48	9.70	16.77	0.54	125.05**	32.48**	121.12**	-0.91**	166.10**	64.21**	158.91**
HD-2851 X PBW-778	19.27	23.81	15.56	20.41	6.49	10.03	6.36	13.23	7.71*	136.10**	38.98**	131.97**	-20.49	113.51**	31.76**	107.74**
HD-2851 X NW-2036	14.71	13.69	6.11	10.56	-2.91	0.31	-3.03	3.23	-14.11**	79.61**	5.73	76.47**	-14.25**	138.19**	46.99**	131.75**
KRL-1-4X NW-1067	7.14	16.07	8.33	12.88	-8.32	4.70	1.21	7.74	-2.81**	128.23**	34.35**	124.25**	-14.32**	138.01**	46.88**	131.57**
KRL-1-4X PBW-778	24.18	34.52	25.56	30.82	-17.65	-5.96	-9.09	-3.23	7.00*	139.28**	40.85**	135.10**	-30.82**	92.18**	18.60**	86.99**
KRL-1-4X NW-2036	14.01	23.51	15.28	20.12	-14.91	-2.82	-6.06	0.00	-20.29**	67.95**	-1.14	65.02**	-16.83**	165.69**	63.96**	158.50**
DBW-14X NW-1067	7.90	5.65	-1.39	2.75	-9.01	-0.31	-3.64	2.58	-5.94**	127.00**	33.62**	123.03**	-17.04**	165.00**	63.53**	157.84**
DBW-14X PBW-778	11.24	15.48	7.78	12.30	-2.15	7.21	3.64	10.32	-6.69**	108.30**	22.61**	104.66**	-13.17**	133.14**	43.87**	126.84**
DBW-14X NW-2036	3.43	7.74	0.56	4.78	-17.02	-9.09	-12.12	-6.45	-24.42**	61.27**	-5.07	58.45**	-31.27**	119.56**	35.49**	113.62**
CHIRYA-1X NW-1067	3.04	0.89	-5.83	-1.88	14.29	17.87	13.94	21.29	-3.92**	126.06**	33.07**	122.11**	-11.57**	131.72**	43.00**	125.46**
CHIRYA-1X PBW-778	3.21	7.14	0.00	4.20	15.50	19.12	15.15	22.58	-7.47**	107.32**	22.04**	103.70**	-12.36**	129.67**	41.73**	123.46**
CHIRYA-1X NW-2036	-0.90	-1.79	-8.33	-4.49	0.91	4.08	0.61	7.10	-17.95**	55.45**	-8.50	52.73**	-29.00**	86.06**	14.82**	81.03**
KRL-3-4 X NW-1067	3.09	9.23	1.94	6.22	-8.07	2.82	-0.61	5.81	-6.61**	76.69**	4.01**	73.61**	6.34**	92.00**	18.49**	86.81**
KRL-3-4 X PBW-778	20.13	24.70	16.39	21.27	-7.23	3.76	0.30	6.77	2.47**	60.83**	-5.33**	58.02**	5.23**	90.00**	17.25**	84.86**
KRL-3-4 X NW-2036	7.87	14.29	6.67	11.14	-15.92	-5.96	-9.09	-3.23	-4.42	14.14**	-32.81	12.14	-19.18**	45.92**	-9.95**	41.97**
HI-1563 X NW-	6.71	4.17	-2.78	1.30	-4.71	1.57	-1.82	4.52	1.67*	101.47**	18.59**	97.95**	-5.60**	96.67**	21.36**	91.35**

1067																
HI-1563 X PBW-778	9.52	13.69	6.11	10.56	-8.82	-2.82	-6.06	0.00	9.61	80.13**	6.03**	76.98**	10.24**	129.67**	41.73**	123.47**
HI-1563 X NW-2036	9.91	8.93	1.67	5.93	-14.12	-8.46	-11.52	-5.81	-10.72**	46.23**	-13.92**	43.68**	-14.13**	78.89**	10.39**	74.05**
FLW-2 X NW-1067	15.50	13.10	5.56	9.99	21.82	26.02	21.82	29.68	1.96**	93.72**	14.03	90.34**	-8.74**	115.48**	32.98**	109.66**
FLW-2 X PBW-778	11.81	16.07	8.33	12.88	-0.61	2.82	-0.61	5.81	4.73	75.92**	3.56**	72.85**	-8.55**	115.92**	33.25**	110.09**
FLW-2 X NW-2036	16.82	15.77	8.06	12.59	12.12	15.99	12.12	19.35	-6.20**	30.09**	-23.42**	27.82	-27.52**	71.14**	5.61**	66.51**
FLW-11 X NW-1067	10.48	16.07	8.33	12.88	-13.31	-4.08	-7.27	-1.29	6.00**	127.38**	33.85	123.41**	-11.00**	134.85**	44.93**	128.50**
FLW-11 X PBW-778	14.45	20.24	12.22	16.93	-15.01	-5.96	-9.09	-3.23	-2.38**	108.61**	22.80	104.97**	-10.95**	135.00**	45.02**	128.65**
FLW-11 X NW-2036	14.45	20.24	12.22	16.93	-8.78	0.94	-2.42	3.87	-9.05	56.66**	-7.79	53.92**	-27.75**	90.67**	17.66**	85.51**
HD-2009 X NW-1067	6.99	4.76	-2.22	1.88	10.98	14.11	10.30	17.42	-3.52**	128.80**	34.68**	124.80**	-13.98**	142.92**	49.91**	136.35**
HD-2009X PBW-778	18.98	23.51	15.28	20.12	3.45	6.36	2.82	9.45	-2.62**	140.26**	41.43	136.06**	-14.85**	140.46**	48.39**	133.96**
HD-2009X NW-2036	14.11	13.10	5.56	9.99	9.76	12.85	9.09	16.13	-15.53*	83.52**	8.03	80.32**	-30.44**	96.44**	21.22**	91.13**
DBW-14X NW-2036	6.70	7.14	0.00	4.20	-5.04	0.31	-3.03	3.23	-3.46**	72.64**	1.62**	69.62**	6.85**	90.96**	17.84**	85.80**
HI-3118 X PBW-778	15.25	19.64	11.67	16.35	1.48	7.21	3.64	10.32	11.10*	77.56**	4.52	74.46**	5.76**	89.00**	16.64**	83.89**
HI-3118 X NW-2036	3.73	4.17	-2.78	1.30	-2.08	3.45	0.00	6.45	-9.28**	14.39	-32.66**	12.40	-18.88**	44.97**	-10.54**	41.05**
K-9006 X NW-1067	12.46	10.12	2.78	7.09	9.82	12.23	8.48	15.48	10.23**	83.86**	8.23**	80.65**	25.97**	100.63**	23.81**	95.20**
K-9006 X PBW-778	15.25	19.64	11.67	16.35	10.74	13.17	9.39	16.45	5.54**	66.33**	-2.09	63.42**	8.54	134.15**	44.50**	127.82**
K-9006 X NW-2036	10.81	9.82	2.50	6.80	7.36	9.72	6.06	12.90	-15.19*	20.85*	-28.86**	18.74	-15.11	83.14**	13.02**	78.19**
DBW-39 X NW-1067	6.38	4.17	-2.78	1.30	14.74	12.23	8.48	15.48	8.19**	97.06**	16.00	93.62**	-0.22**	103.27**	25.44	97.78**
DBW-39 X PBW-778	3.78	7.74	0.56	4.78	12.18	9.72	6.06	12.90	3.58**	79.10**	5.43	75.97**	0.33**	104.38**	26.12	98.85**
HI-3118 X PBW-778	-5.11	-5.95	-12.22	-8.54	5.77	3.45	0.00	6.45	-12.42**	29.04**	-24.04**	26.79*	-23.27**	56.31**	-3.54	52.09

	Harvest index (%)								Grain yield per plant (g)							
	E1				E2				E1				E2			
	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3	BP	SV1	SV2	SV3
FLW-15 X NW-1067	-10.31	8.68	5.97	12.13	-11.32	18.08	-2.46	0.89	8.71*	101.70**	18.73**	98.18**	-1.51	175.29**	40.34**	128.85**
FLW-15 X PBW-778	-4.06	5.99	3.34	9.35	-6.70	13.31	-6.39	-3.18	1.42	83.75**	8.16	80.54**	-5.81	163.29**	34.22**	118.87**
FLW-15 X NW-2036	-0.94	-0.98	-3.46	2.15	-0.86	3.20	-14.75	-11.82	-23.13**	39.28**	-18.01**	36.85**	-30.77**	93.51**	-1.35	60.86**
FLW-8X NW-1067	7.45	31.15	27.87	35.31	-3.67	28.27	5.96	9.59	2.18	116.71**	27.56**	112.92**	-9.36**	196.62**	51.21**	146.58**
FLW-8 X PBW-778	-5.23	15.68	12.78	19.34	-7.33	17.81	-2.68	0.66	-5.57	100.28**	17.90**	96.79**	-16.58**	172.99**	39.17*	126.94**
FLW-8 X NW-2036	-6.97	13.55	10.71	17.15	-5.90	19.63	-1.17	2.21	-26.05**	56.85**	-7.67	54.11**	-31.53**	124.07**	14.23**	86.27**
KRL-20 X NW-1067	-6.09	25.79	22.64	29.77	3.55	40.99*	16.47	20.46	6.33	97.29**	16.13**	93.84**	5.14	169.10**	37.19**	123.71**
KRL-20 X PBW-778	-10.23	20.24	17.23	24.05	-5.15	29.15	6.69	10.35	5.57	79.39**	5.60	76.26**	-3.92	145.91**	25.36*	104.43**
KRL-20 X NW-2036	-14.11	15.04	12.17	18.69	-9.20	23.63	2.13	5.63	-21.48**	33.43**	-21.46**	31.10**	-28.35**	83.39**	-6.51	52.46**
K-402 X NW-1067	-8.79	10.52	7.76	14.02	-24.34	0.75	-16.77	-13.92	-12.02**	63.24**	-3.91	60.39**	-13.24*	84.00**	-6.20	52.96**
K-402 X PBW-778	-4.84	5.13	2.50	8.46	-14.66	3.65	-14.38	-11.44	-9.91*	46.19**	-13.95**	43.64**	-9.83	87.60**	-4.37	55.95**
K-402 X NW-2036	-2.60	-6.70	-9.04	-3.75	-0.69	0.16	-	-	-7.28	-1.76	-	-3.47	-15.84*	37.55**	-	14.35

							17.26	14.42			42.17**				29.88**	
HD-2851 X NW-1067	-3.19	23.49	20.40	27.40	9.19	45.39*	20.11	24.22	-2.67	125.05**	32.48**	121.12**	-6.73*	232.77**	69.64**	176.63**
HD-2851 X PBW-778	-5.20	20.92	17.90	24.75	-3.34	28.42	6.08	9.72	2.11	136.10**	38.98	131.97**	-4.22	241.71**	74.20**	184.06**
HD-2851 X NW-2036	-9.56	15.36	12.48	19.02	-6.67	24.00	2.43	5.94	-22.32**	79.61**	5.73**	76.47**	-25.79**	164.74**	34.96**	120.08**
KRL-1-4X NW-1067	0.68	25.24	22.11	29.21	-1.72	30.86	8.11	11.81	-2.14	128.23**	34.35**	124.25**	-13.38**	211.71**	58.90**	159.12**
KRL-1-4X PBW-778	-4.12	19.27	16.28	23.04	-2.38	26.46	4.47	8.05	2.59	139.28**	40.85	135.10**	-16.36**	201.00**	53.44**	150.22**
KRL-1-4X NW-2036	-9.67	12.37	9.56	15.93	-5.98	21.80	0.62	4.07	-27.99**	67.95**	-1.14**	65.02**	-34.95**	134.08**	19.33**	94.59**
DBW-14X NW-1067	-7.63	11.92	9.13	15.47	-12.65	16.31	-3.92	-0.62	1.58	127.00**	33.62**	123.03**	-10.36**	209.02**	57.54**	156.89**
DBW-252×NW-1012	-6.29	3.53	0.94	6.81	-7.26	12.64	-6.95	-3.76	-6.79**	108.30**	22.61	104.66**	-13.41**	198.50**	52.17**	148.15**
DBW-14X NW-2036	-4.52	-1.05	-3.52	2.09	-1.59	6.20	-12.27	-9.26	-27.83	61.27**	-5.07**	58.45**	-32.36**	133.16**	18.86**	93.83**
CHIRYA-1X NW-1067	7.86	33.01	29.68	37.22	-2.20	30.22	7.57	11.26	3.63	126.06**	33.07**	122.11**	-10.34**	201.75**	53.83**	150.84**
CHIRYA-1X PBW-778	2.72	26.67	23.51	30.69	-2.15	25.68	3.82	7.38	-4.96**	107.32**	22.04	103.70**	-14.24**	188.64**	47.15**	139.95**
CHIRYA-1X NW-2036	-13.14	7.11	4.43	10.50	-6.05	20.67	-0.32	3.10	-28.74**	55.45**	-8.50	52.73**	-33.29**	124.51**	14.45**	86.64**
KRL-3-4 X NW-1067	1.97	23.56	20.47	27.47	-7.84	22.71	1.37	4.84	33.03	76.69**	4.01	73.61**	11.10*	135.61**	20.11**	95.86**
KRL-3-4 X PBW-778	-3.28	6.86	4.19	10.24	-3.36	17.37	-3.04	0.28	-0.89*	60.83**	-5.33**	58.02**	7.19	123.01**	13.69*	85.39**
KRL-3-4 X NW-2036	-10.10	-2.03	-4.48	1.08	-4.04	8.91	-10.03	-6.94	-14.07*	14.14**	-32.81**	12.14	-22.45**	58.93**	-18.98**	32.12**
HI-1563 X NW-1067	-1.16	29.41	26.17	33.50	-1.02	34.97	11.50	15.32	8.58	101.47**	18.59	97.95**	-6.56	165.45**	35.32**	120.67**
HI-1563 X PBW-778	-14.55	11.88	9.08	15.42	-4.93	29.64	7.09	10.76	-2.17**	80.13**	6.03**	76.98**	4.80	197.74**	51.79**	147.52**
HI-1563 X NW-2036	-11.05	16.47	13.56	20.16	-8.60	24.63	2.96	6.49	-20.58	46.23**	-13.92**	43.68**	-21.52**	122.96**	13.66**	85.35**
FLW-2 X NW-1067	-1.62	19.21	16.23	22.99	-11.80	17.44	-2.98	0.34	4.41	93.72**	14.03	90.34**	0.31	153.07**	29.01**	110.38**
FLW-2 X PBW-778	-4.60	5.40	2.76	8.74	-6.97	12.99	-6.66	-3.46	7.59**	75.92**	3.56**	72.85**	-3.29	143.97**	24.37**	102.82**
FLW-2 X NW-2036	-15.18	-12.98	-15.16	-10.22	-1.70	5.03	-13.23	-10.26	-20.44**	30.09**	-23.42**	27.82**	-28.75**	79.75**	-8.37	49.43**
FLW-11 X NW-1067	-2.71	20.43	17.42	24.24	-1.98	30.52	7.82	11.51	22.55	127.38**	33.85**	123.41**	-9.91**	206.52**	56.26**	154.81**
FLW-11 X PBW-778	-3.08	19.97	16.97	23.77	-2.28	25.98	4.07	7.64	-5.39**	108.61**	22.80	104.97**	-12.98**	196.06**	50.93**	146.12**
FLW-11 X NW-2036	-21.88	-3.30	-5.72	-0.24	-6.10	21.06	0.00	3.43	-28.95	56.66**	-7.79**	53.92**	-32.16**	130.82**	17.67**	91.88**
HD-2009 X NW-1067	-0.42	24.41	21.30	28.35	-1.45	31.21	8.39	12.11	-3.93	128.80**	34.68**	124.80**	-13.26**	218.74**	62.49**	164.97**
HD-2009X PBW-778	3.60	29.43	26.19	33.53	-2.51	26.85	4.79	8.38	0.88**	140.26**	41.43	136.06**	-16.99**	205.02**	55.49**	153.56**
HD-2009X NW-2036	-8.77	13.97	11.12	17.58	-6.00	22.31	1.04	4.50	-22.94	83.52**	8.03	80.32**	-34.61**	140.27**	22.49**	99.74**
DBW-14X NW-2036	7.36	16.78	13.86	20.48	-7.89	22.65	1.32	4.79	-6.96*	72.64**	1.62	69.62**	10.44*	134.21**	19.40**	94.70**
HI-1620×NW-1012	0.03	8.81	6.09	12.26	-3.43	17.29	-3.11	0.21	9.42*	77.56**	4.52**	74.46**	6.55	121.68**	13.01*	84.28**
HI-1620×PBW-777	-3.91	4.52	1.91	7.83	-4.01	8.75	-10.16	-7.08	-12.82	14.39*	-32.66**	12.40	-22.13**	57.65**	-19.63**	31.06**
K-1317×HPW-439	-10.10	8.93	6.21	12.38	-12.49	16.51	-3.75	-0.45	-0.91	83.86**	8.23	80.65**	3.96	133.76**	19.17**	94.32**
K-1317×NW-1012	-2.89	7.29	4.61	10.69	-7.90	11.86	-7.60	-4.43	2.50**	66.33**	-2.09	63.42**	16.47**	161.91**	33.52**	117.73**
K-1317×PBW-777	-2.22	-2.14	-4.59	0.96	-1.05	3.14	-14.80	-11.87	-17.07	20.85**	-28.86**	18.74*	-15.99**	88.90**	-3.70	57.03**
MP-1203×HPW-	-1.67	18.96	15.98	22.72	-3.01	29.14	6.68	10.33	6.21	97.06**	16.00**	93.62**	2.27	162.49**	33.82**	118.21**

439																
MP-1203×NW-1012	-2.70	17.72	14.77	21.44	-1.65	23.92	2.37	5.88	7.66	79.10**	5.43	75.97**	-1.33	153.27**	29.11**	110.55**
MP-1203×PBW-777	-11.43	7.15	4.48	10.55	-6.69	17.57	-2.88	0.45	-22.43**	29.04**	-24.04**	26.79**	-28.40**	83.77**	-6.32	52.77**

	Grains/ear							
	E1				E1			
	BP	BP	BP	BP	BP	BP	BP	BP
FLW-15 X NW-1067	-17.09	-17.09	-17.09	-17.09	-17.09	-17.09	-17.09	-17.09
FLW-15 X PBW-778	-21.82	-21.82	-21.82	-21.82	-21.82	-21.82	-21.82	-21.82
FLW-15 X NW-2036	-15.27	-15.27	-15.27	-15.27	-15.27	-15.27	-15.27	-15.27
FLW-8X NW-1067	-40.65**	-40.65**	-40.65**	-40.65**	-40.65**	-40.65**	-40.65**	-40.65**
FLW-8 X PBW-778	-40.00**	-40.00**	-40.00**	-40.00**	-40.00**	-40.00**	-40.00**	-40.00**
FLW-8 X NW-2036	-14.52	-14.52	-14.52	-14.52	-14.52	-14.52	-14.52	-14.52
KRL-20 X NW-1067	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00	-12.00
KRL-20 X PBW-778	-22.80	-22.80	-22.80	-22.80	-22.80	-22.80	-22.80	-22.80
KRL-20 X NW-2036	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40
K-402 X NW-1067	8.51	8.51	8.51	8.51	8.51	8.51	8.51	8.51
K-402 X PBW-778	-1.46	-1.46	-1.46	-1.46	-1.46	-1.46	-1.46	-1.46
K-402 X NW-2036	71.43**	71.43**	71.43**	71.43**	71.43**	71.43**	71.43**	71.43**
HD-2851 X NW-1067	-32.93**	-32.93**	-32.93**	-32.93**	-32.93**	-32.93**	-32.93**	-32.93**
HD-2851 X PBW-778	-31.03**	-31.03**	-31.03**	-31.03**	-31.03**	-31.03**	-31.03**	-31.03**
HD-2851 X NW-2036	-20.69	-20.69	-20.69	-20.69	-20.69	-20.69	-20.69	-20.69
KRL-1-4X NW-1067	-33.33**	-33.33**	-33.33**	-33.33**	-33.33**	-33.33**	-33.33**	-33.33**
KRL-1-4X PBW-778	-30.00*	-30.00*	-30.00*	-30.00*	-30.00*	-30.00*	-30.00*	-30.00*
KRL-1-4X NW-2036	-23.33**	-23.33**	-23.33**	-23.33**	-23.33**	-23.33**	-23.33**	-23.33**
DBW-14X NW-1067	-36.84**	-36.84**	-36.84**	-36.84**	-36.84**	-36.84**	-36.84**	-36.84**
DBW-14X PBW-778	-42.11*	-42.11*	-42.11*	-42.11*	-42.11*	-42.11*	-42.11*	-42.11*
DBW-14X NW-2036	-26.32**	-26.32**	-26.32**	-26.32**	-26.32**	-26.32**	-26.32**	-26.32**
CHIRYA-1X NW-1067	-45.45**	-45.45**	-45.45**	-45.45**	-45.45**	-45.45**	-45.45**	-45.45**
CHIRYA-1X PBW-778	-41.82**	-41.82**	-41.82**	-41.82**	-41.82**	-41.82**	-41.82**	-41.82**
CHIRYA-1X NW-2036	-30.91**	-30.91**	-30.91**	-30.91**	-30.91**	-30.91**	-30.91**	-30.91**
KRL-3-4 X NW-1067	-46.81*	-46.81*	-46.81*	-46.81*	-46.81*	-46.81*	-46.81*	-46.81*
KRL-3-4 X PBW-778	-31.71	-31.71	-31.71	-31.71	-31.71	-31.71	-31.71	-31.71
KRL-3-4 X NW-2036	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88
HI-1563 X NW-1067	-8.94	-8.94	-8.94	-8.94	-8.94	-8.94	-8.94	-8.94
HI-1563 X PBW-778	-10.64	-10.64	-10.64	-10.64	-10.64	-10.64	-10.64	-10.64
HI-1563 X NW-2036	11.06	11.06	11.06	11.06	11.06	11.06	11.06	11.06
FLW-2 X NW-1067	-19.51	-19.51	-19.51	-19.51	-19.51	-19.51	-19.51	-19.51
FLW-2 X PBW-778	-24.39	-24.39	-24.39	-24.39	-24.39	-24.39	-24.39	-24.39
FLW-2 X NW-2036	-7.32*	-7.32*	-7.32*	-7.32*	-7.32*	-7.32*	-7.32*	-7.32*
FLW-11 X NW-1067	-23.64*	-23.64*	-23.64*	-23.64*	-23.64*	-23.64*	-23.64*	-23.64*
FLW-11 X PBW-778	-25.45	-25.45	-25.45	-25.45	-25.45	-25.45	-25.45	-25.45
FLW-11 X NW-2036	-9.09**	-9.09**	-9.09**	-9.09**	-9.09**	-9.09**	-9.09**	-9.09**
HD-2009 X NW-1067	-38.33**	-38.33**	-38.33**	-38.33**	-38.33**	-38.33**	-38.33**	-38.33**
HD-2009X PBW-778	-45.00*	-45.00*	-45.00*	-45.00*	-45.00*	-45.00*	-45.00*	-45.00*
HD-2009X NW-2036	-26.67*	-26.67*	-26.67*	-26.67*	-26.67*	-26.67*	-26.67*	-26.67*
HI-3118 X PBW-778a	-34.04*	-34.04*	-34.04*	-34.04*	-34.04*	-34.04*	-34.04*	-34.04*
HI-3118 X NW-2036	-34.15	-34.15	-34.15	-34.15	-34.15	-34.15	-34.15	-34.15
K-9006 X NW-1067	2.86**	2.86**	2.86**	2.86**	2.86**	2.86**	2.86**	2.86**
K-9006 X PBW-778	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17
K-9006 X NW-2036	-21.95	-21.95	-21.95	-21.95	-21.95	-21.95	-21.95	-21.95
DBW-39 X NW-1067	8.11	8.11	8.11	8.11	8.11	8.11	8.11	8.11
DBW-39 X PBW-778	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17	-36.17

Grains per ear

The estimates of heterosis over better parent ranged from -46.81 (KRL-3-4 x NW-1067) to 71.43 per cent (K-402 x NW-2036) Out of 48 crosses, all of this genotype were found statistically F_1's showed significant heterosis better parents in positive direction and all of this genotype were found statistically for negative direction under Timely Shown condition (E_1).

The estimates of standard heterosis over SV_1 and SV_2 ranged from -24.24 (KRL-3-4 x NW-1067) to 81.82 per cent (K-402 x NW-2036) and -41.86 (KRL-3-4 x NW-1067) to 39.53 per cent (K-402 x NW-2036). Out of 48 crosses, all of this genotype were found statistically F_1's showed significant heterosis over standard varieties in positive direction and all of this genotype were found statistically for negative direction under Timely Shown condition (E_1).

SV_3 ranged from -25.37 (KRL-3-4 x NW-1067) to 79.10 per cent (K-402 x NW-2036). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative

direction were DBW-14 x NW-2036, FLW-15 x NW-2036, KRL-14 x NW-2036, Chirya-1 x NW-2036 and KRL-3-4 x NW-1067.

Under Late sown condition (E_2), The estimates of heterosis over better parent ranged from -40.00 (HI-1563- x NW-2036) to 16.48 per cent (K-402 x PBW-778) Out of 48 crosses, all of this genotype were found statistically F_1's showed significant heterosis better parents in positive direction and all of this genotype were found statistically for negative direction.

The estimates of standard heterosis over SV_1 and SV_2 ranged from -12.34 (KRL-3-4 x NW-1067) to 46.10 per cent (FLW-2 x PBW-778) and -28.38 (KRL-3-4 x NW-1067) to 19.36 per cent (FLW-2 x PBW-778). Out of 48 crosses, all of this genotype were found statistically F_1's showed significant heterosis over standard varieties in positive direction and all of this genotype were found statistically for negative direction.

SV_3 ranged from -14.01 (KRL-3-4 x NW-1067) to 43.31 per cent (FLW-2 x PBW-778). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative direction were DBW-14 x NW-2036, FLW-15 x NW-2036, KRL-14 x NW-2036, HD-2009 x NW-2036 and KRL-3-4 x NW-1067.

Test weight

The heterosis over better parent ranged from -5.11 (HI-3118 x PBW-778) to 24.18 per cent (KRL-1-4 x PBW-778) and -5.95 (HI-3118 x PBW-778) to 34.52 per cent (KRL-1-4 x PBW-778) SV_2-12.22 (HI-3118 x PBW-778) to 25.56 per cent (KRL-1-4 x PBW-778). Out of 48 crosses, the best F_1's showed significant heterosis over better parent in positive direction was, KRL-1-4 x PBW-778 (24.18%). However, over standard varieties cross showed significant heterosis in positive direction. On the other hand, one and two crosses possessed positive significant and negative heterosis over BP and SV_1, SV_2 respectively, under Timely Shown condition (E_1).SV_3 ranged from -8.54 (HI-3118 x PBW-778) to 30.82 per cent (KRL-1-4 x PBW-778). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative direction were HD-2851 x PBW-778, KRL-1-4 x NW-2036, KRL-3-4 x PBW-778, HD-2009 x PBW-778 and KRL-1-4 x NW-2036.

In case of Late sown condition (E_2), heterosis over better parent and standard variety (SV_1), (SV_2) ranged from -17.65 (KRL-1-4 x PBW-778) to 30.31 percent (K-402 x NW-1067) and -9.09 (DBW-14 x NW-2036) to 30.72 per cent (K-402 x NW-1067) and -12.12 (DBW-14 x NW-2036) to 26.36 (K-402 x NW-1067) respectively. All crosses possessed positive significant and negative heterosis over SV_1, and SV_2 respectively.SV_3 ranged from -6.45% (DBW-14 x NW-2036) to 34.52 % (K-402 x NW-1067). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative direction were HD-2851 x PBW-778, KRL-1-4 x NW-2036, KRL-3-4 x PBW-778, HD-2009 x PBW-778 and KRL-1-4 x NW-2036.

Grain yield per plant (g)

The heterosis over better parent ranged from -28.74 (Chirya-1 x NW-2036) to 33.03 per cent (KRL-3-4 x NW-1067) and -1.76 (K-402 x NW-2036) to 139.28 per cent (KRL-1-4 x PBW-778) SV_2 -7.67(FLW-8 x NW-2036) to 127.38 per cent (FLW-11 x NW-1067). Out of 48 crosses, the best F_1's showed significant heterosis over better parent in positive direction was, KRL-1-4 x PBW-778 (139.28%). However, over standard varieties cross showed significant heterosis in positive direction. On the other hand, one and two crosses possessed positive significant and negative heterosis over BP and SV_1, SV_2 respectively, under Timely Shown condition (E_1). SV_3 ranged from -3.47 (K-402 x NW-2036) to 135.10 per cent (KRL-1-4 x PBW-778). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in Positive direction were KRL-1-4 x PBW-778, FLW-11 x NW-1067, HD-2851 x NW-1067, KRL-1-4 x NW-1067 and FLW-11 x NW-1067.

In case of Late sown condition (E_2), heterosis over better parent and standard variety (SV_1), (SV_2) ranged from -15.84 (K-402 x NW-2036) to 34.95 percent (KRL-1-4 x NW-2036) and 58.93 (KRL-3-4 x NW-2036) to 241.71 per cent (HD-2851 x PBW-778) and -18.98 (KRL-3-4 x NW-2036) to 74.20 (HD-2851 x PBW-778) respectively. All crosses possessed positive significant and negative heterosis over SV_1, and SV_2 respectively. SV_3 ranged from -14.35% (K-402 x NW-2036) to 184.06 % (HD-2851 x PBW-778). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in positive direction were HD-2851 x PBW-778, FLW-8 x NW-1067, HD-2851 x NW-1067, KRL-1-4 x NW-1067 and FLW-11 x NW-1067.Higher magnitude of heterotic response for seed yield in wheat was also reported by Singh *et al*. (2002) [13].

Biological yield per plant (g)

The heterosis over better parent ranged from -24.42 (DBW-14 x NW-2036) to 10.23 per cent (K-9006 x NW-10.67) and -1.75 (K-402 x NW-2036) to 139.28 per cent (KRL-1-4 x PBW-778) SV_2-32.81 (KRL-3-4 x NW-2036) to 42.17 per cent (K-402 x NW-2036). Out of 48 crosses, the best F_1's showed significant heterosis over better parent in positive direction was, KRL-1-4 x PBW-778 (139.28%). However, over standard varieties cross showed significant heterosis in positive direction. On the other hand, one and two crosses possessed positive significant and negative heterosis over BP and SV_1, SV_2 respectively, under Timely Shown condition (E_1).SV_3 ranged from -3.47 (K-402 x NW-2036) to 136.06 per cent (HD-2009 x PBW-778). Out of 48 crosses, all crosses showed Positive and significant heterosis. The best five F_1's showed significant heterosis over better parent in positive direction were KRL-1-4 x PBW-778, HD-2851 x PBW-778, KRL-1-4 x NW-1067, DBW-14 x NW-1067 and HD-2851 x NW-1067.

In case of Late sown condition (E_2), heterosis over better parent and standard variety (SV_1), (SV_2) ranged from -31.27 (DBW-14 x NW-2036) to 25.97 percent (K-9006 x NW-1067) and 37.33 (K-402 x PBW-778) to 166.10 per cent (HD-2851 x NW-1067) and -15.25K-402 x PBW-778) to 64.21 (HD-2851 x NW-1067) respectively. All crosses possessed positive significant and negative heterosis over SV_1, and SV_2 respectively.SV_3 ranged from -33.62% (K-402 x PBW-778) to 158.91 % (HD-2851 x NW-1067). Out of 48 crosses, all crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in positive direction were KRL-1-4 x PBW-778, HD-2851 x

PBW-778, KRL-1-4 x NW-1067, DBW-14 x NW-1067 and HD-2851 x NW-1067.

Harvest index

The heterosis over better parent ranged from -15.18 (FLW-2 x NW-2036) to 7.86 per cent (Chiryaa-1 x NW-1067) and -12.98 (FLW-2 x NW-2036) to 33.01 per cent (Chiryaa-1 x NW-1067) SV_2-15.16 (FLW-2 x NW-2036) to 29.68 per cent (Chiryaa-1 x NW-1067). Out of 48 crosses, the best F_1's showed significant heterosis over better parent in positive direction was, Chiryaa-1 x NW-1067 (37.22%). However, over standard varieties cross showed significant heterosis in positive direction. On the other hand, one and two crosses possessed positive significant and negative heterosis over BP and SV_1, SV_2 respectively, under Timely Shown condition (E_1).SV_3 ranged from -10.22 (FLW-2 x NW-2036) to 37.22 per cent (Chiryaa-1 x NW-1067). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative direction were FLW-2 x NW-2036, K-402 x NW-2036, FLW-15 x NW-2036, FLW-15 x PBW-778 and FLW-15 x NW-1067.

In case of Late sown condition (E_2), heterosis over better parent and standard variety (SV_1), (SV_2) ranged from -24.34 (K-402 x NW-1067) to 9.19 percent (HD-2851 x NW-1067) and 0.75 (K-402 x NW-1067) to 45.39 percent (HD-2851 x NW-1067) and -16.77 (K-402 x NW-1067) to 20.11 percent (HD-2851 x NW-1067) respectively. All crosses possessed positive significant and negative heterosis over SV_1, and SV_2 respectively. SV_3 ranged from 13.92 (K-402 x NW-1067) to 24.22 percent (HD-2851 x NW-1067). Out of 48 crosses, 5 crosses showed negative and significant heterosis. The best five F_1's showed significant heterosis over better parent in negative direction were FLW-2 x NW-2036, K-402 x NW-2036, FLW-15 x NW-2036, FLW-15 x PBW-778 and FLW-15 x NW-1067.Beside yield, substantial heterosis over better-parent and standard varieties was also observed in negative as well as positive direction for remaining characters in both environments. However, the number of crosses showing significant estimates and the range of heterosis varied from one character to another. In general, some crosses showed appreciable and high heterosis for most of the characters under study. The existence of wide spectrum of heterosis in either direction with expression of high degree of desirable heterosis by some crosses for all the characters observed in present study is in conformity with the earlier studies reporting presence of high heterosis for such characters in wheat Jaiswal *et al*. (2010) [7], Ali and Falahy, (2011) [1] and Devi *et al*. (2013) [6].

References

1. Ali IH, Falahy MAH. Analysis of partial diallel cross for yield and its components in durum wheat. Bulletin of Faculty of Agril. Cairo-Uni. 2011;62(2):145-152.
2. Anonymous. All India Coordinated Wheat & Barley Improvement Project, Directorate of Wheat Research, Karnal (ICAR), Project Director's Report; c2021. p. 1.
3. Bhatti MS, Bajwa MA, Noor-ul Islam, Asi AG. Combining ability analysis of five wheat varieties. Pak. J of Agril. Res. 1984;5(2):88-91.
4. Baric M, Jercic IH, Keresa S, Sarcevic H. Evaluation of heterosis for important quantitative traits in crosses of winter wheat (*Triticum aestivum* L.). Sjemenarstvo. 2008;25(1):5-12.
5. Bhardwaj SL. Genetic Variability and Heritability Studies in Wheat Genotypes under Late Sown Condition in Chhattisgarh Plains. Int. J Pure App. Biosci. 2018;6(3):513-517.
6. Devi EL, Swati Goel P, Singh M, Jaiswal JP. Heterosis studies for yield and yield contributing traits in bread wheat (*Triticum aestivum* L.). The Bioscan. 2013;8(3):905-909.
7. Jaiswal KK, Praveen Pandey, Shailesh M, Anurag PJ. Heterosis studies for improvement in yield potential of wheat (*Triticum aestivum* L.). AAB-Bioflux. 2010;2(3):273-278.
8. Patil RV, Viswanath Chinnusamy, Sakti Chahan, Ruwali KN, Pandey AN, Renu Khanna Chopra. Evaluation of heat stress tolerance in *T. aestivum* and *T. durum* wheat genotype under continual and terminal heat stress environment. J of plant. Biology. 2008;35(1):1-16.
9. Panse VG, Shukhatme PV. Statistical methods for agricultural workers, II[nd] Ed., ICAR, New Delhi, 381.
10. Sarkar KK, Ghimiray TS, Maji A, Das S. Heterotic breeding lines for yield and quality traits in wheat (*Triticum aestivum* L.). Adv. in Pl. Sci. 2010;23(1): 245-248.
11. Sharma S, Chaudhary HK. Combining ability and gene action studies for yield-contributing traits in crosses involving winter and spring wheat genotypes. Acta-Agronomica Hungarica. 2009;57(4):417-423.
12. Shull. What is heterosis? Genetics. 1914;33:439-446.
13. Singh KN, Ravish Chatrath. Combining ability studies in bread wheat (*Triticum aestivum* L.) under salt stress environment. Indian J Genet. 2002;57(2):127-132.
14. Singh Piyusha, Jaiswal JP, Thakur CL. Analysis of combining ability for yield and its attributing traits in bread wheat (*Triticum aestivum* L.). Annals of Biol. 2014;30(1):58-61.
15. Sprague GF, Tatum LA. General *vs.* specific combining ability in single crosses of corn. J Amer. Soc. Agron. 1942;34:923-932.
16. Tabassum, Anil Kumar, Birendra Prasad. Study of Combining Ability and Nature of Gene Action for Yield and Its Contributing Traits in Bread Wheat (*Triticum aestivum* L. em Thell). Int. J Curr. Microbiol. App. Sci. 2017;6(10):3562-3573.
17. Verma S, Maurya R, Maurya S. Prediction of gene action and combining ability for yield and quality traits in F1 and F2 generations of wheat (*Triticum aestivum* L.). Tropical Plant Res. 2016;3(2):449-459.
18. Zalewski D. Estimation of general and specific combining ability of quantitative traits of winter wheat. Biuletyn Instytutu Hodowli-i-Aklimatyzacji Roslin. 2001;216(2):267-272.