



Heterosis studies for yield and components traits in 8×8 diallel crosses of (*Zea mays* L.) maize

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Abstract

Heterosis and heterobeltiosis study was undertaken in maize during 2016 at Research area of Department of Plant Breeding and Genetics, Faculty of Agriculture, Gomal University Dera Ismail Khan, Pakistan. 8 x 8 diallel cross combination were made during spring 2016. All the F₁'s hybrids along with their parents and two commercial check hybrids were evaluated in summer 2016. Data were recorded on plant height, ear height, ear length, no of kernels row⁻¹, number of kernels rows ear⁻¹ and 100-kernel weight. The analysis of variances (Table 1) revealed that mean squares due to progenies and their parents were highly significant for all the traits. All the cross combinations showed positive heterosis for plant height, ranged from +3.41% (SY204 x S-202) to +51.21% (A201 x IQ207). Twenty two crosses showed positive heterosis for ear height, the cross (J205 x Sy200) revealed maximum value of +23.90% for ear height, the cross (SY200 x J205) showed maximum value for standard heterosis +38.15 (33M15) and for (32B33) +43.19. For ear length all the crosses showed significant heterosis, mid parent heterosis ranged from -3.72% to 47.33% for the cross (S-202 x A201) and (P203 x S-206), most of cross combinations revealed negative values for standard heterosis over both commercial check hybrids. In case of number of kernels row⁻¹, the crosses proved their superiority over parents, the heterosis ranged from -16.27% (S-202 x J205) to +44.73% (IQ207 x S-202), while heterobeltiosis values ranged from -18.18% (A201 x S-202) to +59.01% (SY200 x IQ207), standard heterosis ranged from -16.11% to +17.52% (33M15) and -27.72% to 8.93% (32M33) for all the crosses. Number of kernels rows ear⁻¹ showed maximum heterotic contribution to high yield ranged from -5.26% (A201 x J205) to +26.31% (S-202 x S-206), while the magnitude of standard heterosis ranged from -18.18% to 13.63% (33M15) and for (32B33) was -21.73% to 8.69% for number of kernels rows ear⁻¹. Significant heterosis was observed +57.11% in cross (P203 x S-206) for 100-kernel weight. Standard heterosis of all cross combinations over both commercial check hybrid ranged from -28.37% to +6.45% were recorded for (33M15) and (32B33) -23.70% to +12.30%.

Keywords: maize, heterosis, heterobeltiosis, standard heterosis, plant breeding

Introduction

Corn is the world most broadly developed cereal and is the principle staple food in many developing countries (Morris *et al* 1999) [12]. It is an adoptable crop with wider genetic variation and capable to grow effectively throughout the world covering tropical, sub-tropical and temperate agro-climatic conditions. In Pakistan maize is grown as multipurpose crop as food and forage, generally by poor resources farmers using marginal land for the cultivation of this crop. In Pakistan maize is planted on a 1.32-million-hectare area for grain production and giving an annual grain production of 3.931 million tones, with average yield of 3809 Kg/ha Government of Pakistan (2014-15) [15]. In Pakistan Punjab and KPK are the leading provinces in term of maize production, 97% of the total grain production of the country. Adding up the importance of this crop, maize has genetic characteristic that permit this species to be broadly studied, so contributing for an understanding of various questions of a genetic behavior. The great economic importance of maize, genetic improvement in this crop is very demanding and mostly in the field of increasing grain yield. Heterosis breeding is a basic tool for developing a good economically workable for production of crops in the form of F₁ hybrids. Information about the heterosis patterns among maize germplasm is important (Beck *et al* 1990; Nazir *et al.*, 2020) [5, 14]. The existence of enough amount of hybrid vigour is an important requirement for successful

production of hybrid. Various researchers have been reported existence of heterosis in significant quantity for grain yield and yield components in various F₁ maize hybrids. Heterosis for grain yield, plant height, ear height, ear length, kernels rows ear⁻¹, 100 kernel weights have been reported by (Devi *et al* 2007) [7]. Heterosis and combining ability for grain yield and its components in a diallel cross in maize, the significant amount of heterosis for grain ear⁻¹ over mid and better parents were estimated by (Alam *et al* 2008; Danish *et al.*, 2020) [1, 6]. Maximum average and better parent's heterosis for plant height, ear height, ear length, ear diameter and for grain yield plant⁻¹ in various crosses of maize were also recorded by (Muhammad *et al* 2011; Yaqoob *et a.*, 2020) [13, 19]. Thus, a study was carried out to understand the effect in various crosses for selection of good parental lines which are suitable for future breeding programme.

Material and methods

Eight inbred lines of maize namely SY200, A201, S-202, P203, SY204, J205, S-206 and IQ207 were crossed in an 8x8 full diallel fashion to obtained 56 F₁ hybrids in the spring season of 2015 at the Department of Plant Breeding and Genetics, Faculty of Agriculture, Gomal University Dera Ismail Khan Pakistan. In the following summer season 2015 all the hybrids with their parents and two commercial check hybrids namely 33M15 and 32B33 were grown in a

randomized complete block design with three replications. Each plot was comprised of 2 rows of 5-meter-long. Spacing between row to row and plant to plant was kept 75 and 20 cm respectively. Standard cultural practices were kept constant during the whole experiment. Five randomly competitive plants were chosen from each plot in each replication for recording observations on plant height, ear height, ear length (cm), number of kernels row⁻¹, number of kernels rows ear⁻¹ and 100-grain weight. The data pertaining to various characters under study was statistically analyzed by using the standard analysis of variance techniques as outlined by Steel *et al.* (1997) [17], Heterosis and heterobeltiosis was calculated in terms of percent increase (+) or decrease (-) of a hybrid against its mid and better parents. Heterosis, MP= 100× (F1-MP/MP), Fehr (1987) [8] Heterobeltiosis, BP= 100× (F1-BP/BP), Fonseca (1965) [9], MP= Mid parent, BP= Better parent. According to Wynne *et*

al. (1970) [18] statistical significance of heterosis and heterobeltiosis was determined by “t” test as under.

$$T = F1ij / \sqrt{3/8EMS}$$

Where Fij= The F1 hybrid value of ith and jth parents

MPij= Mid parent value for ith and jth parents

EMS= error mean square for the respective traits

Table 1: Estimation of mean square and F. ration at (0.01%) for analysis of variance for different yield and other traits

Mean Square					
Traits	Rep	Genotypes	Error	F.Ratio	C.V%
Plant Height (cm)	35.16	485.29	45.02	10.78**	5.6349
Ear Height (cm)	2.26	107.24	37.32	2.87**	10.381
Ear length (cm)	0.8732	7.0871	0.9129	7.76**	9.2377
No. of kernels row ⁻¹	7.873	27.193	7.531	3.61**	10.7426
No. of kernels rows ear ⁻¹	0.020	2.94	1.395	2.11**	7.1603
100-grain weight	6.912	19.89	3.84	5.19**	9.9337

** Significant at P≤0.01

Table 2: Heterotic, heterobeliotic and standard heterosis effect on various traits in 8 x 8 diallel crosses of maize in F₁'s generation

Hybrid/Cross combination	Plant Height				Ear height				Ear length			
	Het%	Hbt%	SH% 33M15	SH% 32B33	Het%	Hbt%	SH% 33M15	SH% 32B33	Het%	Hbt%	SH% 33M15	SH% 32B33
SY200x A201	22.0**	54.40**	4.02	3.82	-1.16	12.77	18.53	22.86	10.12*	19.01*	-9.79	-13.28
SY200xS-202	16.10*	15.05*	-1.03	-1.23	-11.55	-9.90	6.07	9.94	7.23	1.76	-12.15	-15.55
SY200x P203	20.10**	22.22**	2.40	2.20	2.83	10.92	23.32	27.83	9.542*	31.76**	-10.26	-13.73
SY200x SY204	15.59*	18.14*	-1.43	-1.63	-17.12	-16.44	-0.60	3.02	29.63**	36.20**	6.19	2.087
SY200x J205	20.10**	32.56**	2.40	2.20	15.19*	27.60*	38.15	43.19	10.36*	25.03**	-9.59	-13.09
SY200x S-206	16.02*	26.56**	-1.07	-1.27	2.53	10.35	22.96	27.45	14.21*	23.11*	-6.43	-10.05
SY200x IQ207	18.94*	24.80**	1.41	1.21	-11.24	0.68	6.43	10.32	30.74**	44.57**	7.10	2.96
A201xS-202	48.84**	16.58*	0.28	0.08	15.83*	3.40	21.74	26.19	15.70*	1.60	-12.29	-15.69
A201x P203	29.13**	3.84	-12.99	-13.16	-3.75	-9.01	1.15	4.84	20.91*	34.57**	-8.34	-11.89
A201x SY204	36.49**	10.23*	-8.03	-8.22	-16.06	-25.84	-11.78	-8.56	15.18*	11.97*	-12.69	-16.07
A201xJ205	37.09**	19.57*	-7.63	-7.81	-7.16	-9.87	-2.43	1.13	2.68	7.64	-22.16	-25.18
A201xS-206	43.10**	23.35*	-3.58	-3.77	-9.13	-14.28	-4.49	-1.00	14.40*	14.10*	-13.28	-16.64
A201xIQ207	51.21**	25.37*	1.82	1.67	8.90	8.27	14.45	18.63	3.20	5.59	-21.77	-24.80
S-202x P203	18.68*	21.83*	2.08	1.87	-12.5	-7.43	2.91	6.67	19.43*	51.39**	3.09	-0.89
S-202xSY204	15.38*	18.97*	-0.74	-0.94	-5.05	-6.02	11.78	15.86	-2.58	7.84	-15.91	-19.16
S-202x J205	17.97*	31.35**	1.47	1.27	5.57	14.81*	24.30	28.84	2.97	22.93*	-11.11	-14.55
S-202x S-206	17.76*	29.59**	1.29	1.09	-8.46	-3.27	7.776	11.71	12.41*	27.68**	-2.96	-6.71
S-202x IQ207	14.35*	21.04*	-1.63	-1.83	-17.75	-8.39	-3.15	0.37	11.89*	30.37**	-3.41	-7.15
P203 xSY204	20.57*	21.10*	1.03	0.82	-5.35	-11.54	5.22	9.06	21.44*	6.07	-17.29	-20.49
P203x J205	15.74*	25.54**	-3.01	-3.21	9.39	12.34	21.62	26.07	13.50*	6.90	-22.70	-25.69
P203x S-206	13.91*	22.11*	-4.55	-4.74	-12.78	-12.97	-3.03	0.50	47.33**	32.02**	0.33	-3.54
P203x IQ207	5.36	8.64	-11.71	-11.89	-9.83	-5.17	0.24	3.90	46.46**	34.63**	-0.25	-4.11
SY204x J205	13.75*	22.84**	-5.10	-5.29	-14.50	-6.06	1.70	5.41	12.55*	21.37*	-12.23	-15.63
SY204x S-206	20.23*	28.32**	0.30	0.10	-23.79	-18.64	-9.35	-6.04	35.01**	38.51**	5.27	1.19
SY204x IQ207	15.50*	18.58*	-3.64	-3.83	6.33	19.65*	26.48	31.10	26.98**	33.65**	-0.98	-4.81
J205x S-206	14.54*	13.20*	-11.51	-11.69	9.53	6.43	18.59	22.92	11.27*	5.87	-19.54	-22.65
J205x IQ207	21.71*	15.71*	-5.97	-6.16	13.69*	16.43*	23.08	27.58	22.85*	19.90*	-11.17	-14.61
S-206x IQ207	30.11*	25.15**	1.70	1.49	3.92	9.54	15.79	20.02	2.49	5.14	-22.10	-25.12
IQ207x S-206	6.22	10.43*	-13.68	-13.85	-12.10	-1.37	-6.43	4.25	8.06	4.79	2.15	-22.36
IQ207x J205	17.28*	23.36*	-4.69	-4.88	11.03	8.41	17.37	21.66	23.18*	26.20*	-8.74	-12.27
IQ207xSY204	5.70	2.95	-14.10	-14.27	-0.91	-11.95	4.73	8.56	15.72*	9.94	-14.27	-17.59
IQ207x P203	21.29*	17.63*	-1.43	-1.63	6.55	1.31	12.63	16.75	25.12*	36.11**	-7.30	-10.89
IQ207x S-202	26.69**	19.69*	2.95	2.74	-3.79	-13.62	1.70	5.41	39.88**	20.05*	3.63	-0.37
IQ207x A201	25.42**	51.27**	1.92	1.71	-2.52	-1.96	3.03	6.80	10.39*	7.89	-18.21	-21.38
IQ207x SY200	22.83**	17.06*	-0.18	-0.38	-5.86	-17.02	-0.48	3.14	33.83**	21.03*	-0.84	-4.68
S206x J205	16.59*	17.97*	-8.86	-9.04	-4.58	-1.79	6.31	10.20	0.15	5.26	-23.88	-26.83
S206xSY204	15.82*	8.51	-9.47	-9.65	-3.38	-9.49	7.65	11.58	18.07*	15.08*	-10.26	-13.73
S206xP203	18.12*	10.19*	-7.67	-7.85	-7.96	-7.75	2.55	6.29	25.97**	40.57**	-4.26	-7.96
S206xS-202	22.52**	11.34*	-4.22	-4.42	-14.72	-19.29	-4.98	-1.51	15.84*	1.98	-11.96	-15.37
S206xA201	4.73	21.50*	-18.13	-18.29	-12.10	-6.82	-2.06	1.51	8.57	8.85	-17.48	-20.68
S206x SY200	26.43**	15.90*	-1.17	-1.37	8.39	0.70	20.77	25.18	14.88*	6.57	-12.69	-16.07
J205x SY204	31.49**	21.76*	1.57	1.37	-2.58	-11.33	5.46	9.31	18.29*	9.69	-14.46	-17.77
J205xP203	11.94*	3.21	-13.51	-13.69	8.08	5.24	17.01	21.28	1.91	8.20	1.39	-29.16

J205xS-202	28.18**	15.12*	-0.97	-1.17	19.86*	10.21	29.76	34.50	17.47*	-1.60	-15.06	-18.34
J205xA201	29.68**	48.69**	0.18	-0.02	20.76*	24.39*	30.74	35.51	8.81	3.80	-21.31	-24.36
J205xSY200	27.48**	15.49*	-1.51	-1.71	23.90*	11.85	34.14	39.04	12.83*	-0.40	-18.41	-21.57
SY204xP203	12.37*	11.88*	-6.25	-6.44	-18.99	-13.33	-3.64	-0.12	4.81	20.00*	-18.27	-21.44
SY204xS-202	4.31	1.17	-12.97	-13.14	-0.51	0.51	18.34	22.67	6.22	-4.04	-17.17	-20.37
SY204xA201	22.51**	51.69**	2.20	1.99	-11.23	0.46	5.58	9.44	9.44	12.57*	-14.66	-17.96
SY204xSY200	13.73*	11.27*	-5.12	-5.31	-13.99	-14.69	2.30	6.04	22.68*	16.77*	-4.34	-8.04
P203xS-202	18.74*	15.67*	-0.50	-0.70	-6.33	-11.55	4.13	7.93	39.01**	9.67	-5.32	-8.99
P203xA201	23.62**	53.73**	3.58	3.37	2.95	8.90	14.45	18.63	24.81*	12.13*	-15.00	-18.29
P203xSY200	16.83*	14.81*	-2.10	-2.30	0.76	-6.58	12.02	16.12	29.85*	7.95	-11.56	-14.99
S-202xA201	18.18*	50.88**	1.65	1.45	-9.90	0.92	6.07	9.94	-3.72	9.63	-16.89	-20.11
S-202xSY200	18.68*	19.72*	2.08	1.87	-10.62	-12.25	5.22	9.06	-1.82	3.44	-15.25	-18.53
A201xSY200	47.58**	16.61*	-0.56	-0.76	11.79	-2.02	17.49	21.78	15.36*	6.74	-12.55	-15.93

Table 3: Heterotic, heterobeliotic and standard heterosis effect on various traits in 8 x 8 diallel crosses of maize in F₁'s generation

Hybrid/Cross combination	number of kernels row ⁻¹				number of kernels rows ear ⁻¹				100-grain weight.			
	Het%	Hbt%	SH% 33M15	SH% 32B33	Het%	Hbt%	SH% 33M15	SH% 32B33	Het%	Hbt%	SH% 33M15	SH% 32B33
SY200x A201	-1.60	11.76	-10.30	-16.86	0.00	5.26	-9.09	-13.04	13.41*	24.20*	-14.51	-9.82
SY200xS-202	1.34	-2.72	-7.61	-14.37	10.00	15.78*	0.00	-4.34	19.1*2	13.01	-10.21	-5.27
SY200x P203	5.61	24.50*	-3.73	-10.77	10.00	10.00	0.00	-4.34	1.35	17.30*	-23.60	-19.40
SY200x SY204	21.33*	36.90*	10.59	2.51	25.00*	25.00*	13.63	8.69	41.24**	33.50**	6.45	12.30
SY200x J205	-5.00	18.42	-13.40	-19.73	0.00	0.00	-9.09	-13.04	13.41*	20.63*	-14.51	-9.82
SY200x S-206	8.35	19.53*	-1.22	-8.44	0.00	5.26	-9.09	-13.04	39.78**	25.56*	5.36	11.15
SY200x IQ207	28.93*	59.01**	17.52	8.93	15.00*	21.05	4.54	0.00	33.80**	42.76**	0.85	6.39
A201xS-202	-3.17	-18.18	-22.30	-27.98	15.78*	15.78*	0.00	-4.34	39.15**	20.54*	-4.22	1.03
A201x P203	13.85	18.17*	-8.62	-15.30	21.05**	15.00*	4.54	0.00	12.25	18.63*	-22.74	-18.49
A201x SY204	18.15*	17.37*	-5.18	-12.11	10.52	5.00	-4.54	-8.69	41.10**	21.77*	-2.88	2.44
A201xJ205	1.63	11.54	-18.43	-24.40	-5.26	-10.00	-18.18	-21.73	28.56*	24.87*	-11.51	-6.65
A201xS-206	5.49	2.45	-15.34	-21.53	10.52	10.52	-4.54	-8.69	26.30*	3.59	-13.07	-8.29
A201xIQ207	2.13	10.90	-18.03	-24.02	5.26	5.26	-9.09	-13.04	33.45**	30.02*	-8.14	-3.10
S-202x P203	16.82*	43.49**	10.94	2.83	21.05*	15.00	4.54	0.00	33.78**	63.21**	6.29	12.13
S-202xSY204	-4.75	11.97	-9.54	-16.15	15.78*	10.00	0.00	-4.34	30.94**	30.46*	4.03	9.75
S-202x J205	-16.27	8.73	-20.49	-26.30	0.00	-5.00	-13.63	-17.39	13.48*	27.23*	-9.83	-4.88
S-202x S-206	8.27	24.44*	2.82	-4.68	26.31**	26.31*	9.09	4.34	20.09*	17.07*	-4.59	0.65
S-202x IQ207	-9.25	16.60*	-13.82	-20.12	10.52	10.52	-4.54	-8.69	13.84*	28.03*	-9.55	-4.58
P203 xSY204	14.98	10.04	-11.09	-17.59	-5.00	-5.00	-13.63	-17.39	28.03*	4.55	-16.61	-12.03
P203x J205	5.69	11.76	-18.27	-24.25	-5.00	-5.00	-13.63	-17.39	37.71**	26.56*	-10.31	-5.38
P203x S-206	41.83**	32.71*	9.66	1.64	15.00*	21.05*	4.54	0.00	57.11**	21.94*	2.32	7.94
P203x IQ207	40.30**	46.77**	8.47	0.54	10.00	15.78*	0.00	-4.34	44.86**	33.54*	-5.66	-0.47
SY204x J205	12.53	24.32*	-9.09	-15.73	0.00	0.00	-9.09	-13.04	2.02	14.81*	-18.64	-14.17
SY204x S-206	39.06**	35.95*	12.33	4.12	5.00	10.52	-4.54	-8.69	24.13*	17.97*	-1.00	4.43
SY204x IQ207	36.17**	48.84**	10.00	1.96	15.00*	21.05*	4.54	0.00	18.46*	33.72*	-5.53	-0.34
J205x S-206	15.40	2.11	-15.62	-21.78	5.00	10.52	-4.54	-8.69	1.47	-14.30	-28.09	-24.14
J205x IQ207	22.03*	20.72*	-10.77	-17.29	5.00	10.52	-4.54	-8.69	22.63*	23.01*	-13.09	-8.32
S-206x IQ207	7.15	19.80*	-11.45	-17.92	5.26	5.26	-9.09	-13.04	6.92	27.01*	-10.27	-5.34
IQ207x S-206	12.23	0.39	-17.04	-23.11	0.00	0.00	-13.63	-17.39	15.75*	-2.55	-18.23	-13.73
IQ207x J205	26.37*	27.73*	-6.59	-13.42	5.26	0.00	-9.09	-13.04	10.95	10.60	-21.62	-17.31
IQ207xSY204	16.28*	6.38	-14.05	-20.33	5.26	0.00	-9.09	-13.04	23.19*	9.13	-12.97	-8.18
IQ207x P203	25.95*	20.39*	-6.91	-13.71	10.52	5.00	-4.54	-8.69	31.04**	42.15**	-7.42	-2.33
IQ207x S-202	44.73**	12.63	6.96	-0.84	0.00	0.00	-13.63	-17.39	26.30*	12.30	-10.77	-5.87
IQ207x A201	14.21	5.18	-15.58	-21.75	0.00	0.00	-13.63	-17.39	23.27*	26.52*	-12.91	-8.13
IQ207x SY200	41.22**	14.50	4.37	-3.25	10.52	5.00	-4.54	-8.69	39.47**	30.72*	-1.46	3.94
S206x J205	1.51	14.71	-16.11	-22.25	5.26	0.00	-9.09	-13.04	2.21	21.03*	-14.23	-9.52
S206xSY204	9.76	12.27	-9.30	-15.93	0.00	-5.00	-13.63	-17.39	-0.90	4.26	-16.85	-12.28
S206xP203	24.67*	33.23*	3.01	-4.51	10.52	5.00	-4.54	-8.69	12.32	44.72**	-5.75	-0.57
S206xS-202	16.82*	1.64	-3.46	-10.52	21.05*	21.05*	4.54	0.00	10.11	16.29*	-7.60	-2.52
S206xA201	1.05	4.04	-16.50	-22.60	10.52	10.52	-4.54	-8.69	2.65	25.15*	-13.86	-9.12
S206x SY200	10.03	-0.25	-9.08	-15.72	0.00	-5.00	-13.63	-17.39	19.26*	32.77*	0.07	5.57
J205x SY204	24.74*	12.90	-8.79	-15.45	0.00	0.00	-9.09	-13.04	10.58	-1.73	-21.63	-17.32
J205xP203	12.29	6.19	-17.89	-23.89	-5.00	-5.00	-13.63	-17.39	32.44**	44.11**	-6.15	-0.99
J205xS-202	18.60*	-8.68	-13.27	-19.61	5.00	10.52	-4.54	-8.69	30.65*	16.53*	-7.41	-2.32
J205xA201	9.11	-0.57	-20.21	-26.04	0.00	5.26	-9.09	-13.04	5.22	8.33	-25.43	-21.34
J205xSY200	6.64	-14.4	-22.02	-27.72	-5.00	-5.00	-13.63	-17.39	10.57	3.95	-21.64	-17.34
SY204xP203	9.89	14.81	-11.22	-17.71	10.00	10.00	0.00	-4.34	4.25	27.65*	-16.86	-12.29
SY204xS-202	10.40	-6.08	-10.80	-17.32	0.00	5.26	-9.09	-13.04	19.56*	20.00*	-4.65	0.58
SY204xA201	7.68	8.39	-13.01	-19.37	5.00	10.52	-4.54	-8.69	3.50	19.93*	-17.45	-12.92

SY204xSY200	29.67*	14.92*	4.75	-2.90	10.00	10.00	0.00	-4.34	25.01*	32.26*	-0.30	5.16
P203xS-202	30.85**	6.53	1.17	-6.22	5.00	10.52	-4.54	-8.69	45.19**	19.01*	-5.44	-0.24
P203xA201	15.98*	11.74	-10.32	-16.87	15.00	21.05*	4.54	0.00	11.04	5.07	-27.68	-23.70
P203xSY200	26.26*	7.09	-2.37	-9.51	0.00	0.00	-9.09	-13.04	21.08*	4.61	-21.14	-16.81
S-202xA201	0.23	18.61*	-4.81	-11.77	5.26	5.26	-9.09	-13.04	-9.85	4.06	-28.37	-24.44
S-202xSY200	5.76	10.19	0.44	-6.90	5.26	0.00	-9.09	-13.04	14.94*	21.15*	-8.67	-3.65
A201xSY200	25.62*	10.59	0.81	-6.55	10.52	5.00	-4.54	-8.69	31.95**	20.49*	-9.18	-4.18

Results and Discussion

The analysis of variance for genotypes and parents presented in (Table 1) observed that mean square were significant for the characters, showing that sufficient genetic variability for various traits are present in the existed experimental materials under observation, the ratio of the components of heterosis (Mid Parent), BP (better parent) and SH (standers heterosis) is presented in Table 2 and 3, the character wise discussion are presented as under.

Plant Height

All the cross combinations (Hybrids) showed positive heterosis over mid and better parent for plant height and was significant (Table 2). The magnitude of heterosis in plant height ranged from +3.41% (SY204 x S-202) to +51.21% (A201 x IQ207) and -1.17% (SY204 x S-202) to 54.40% (SY200 x A201) for mid and better parent heterosis respectively. The maximum heterosis was evident in the inbred line (A201) while used as male are female parent. The range of standard heterosis for all cross combination in plant height over (33M15) is -18.13% to +4.02 and -18.29% to 3.82% for (32B33) was recorded. The results are in agreement with those of Asif et al., (2020) [3]; Masood et al., (2020) [11]; Devi et al. (2007), Frascaroli et al. (2007), Aman et al. (2011) [2]. Zeleke et al. (2015) [20], who reported different magnitudes heterotic values for plant height in their research work.

Ear Height

In out of 56 hybrids 20 and 22 hybrid showed positive heterosis and heterobeltiosis for ear height as presented in (Table 2). The high range of heterotic effect in ear height from -17.75% (SY202 x IQ207) to +23.90% (J205 x SY 200) and for better parent value range from -16.44% (SY200 x SY204) to +27.60% (SY200 x J205) was observed. The inbred line (SY200) showed maximum heterosis in various cross combination when used as male parent. In case of SH (standard check hybrid) the hybrid (SY200 x J205) showed maximum values +38.15 (33M15) and 43.19% (32B33) for ear height. Most of the cross combination showed positive heterosis over both commercial checks hybrids (Table 2). The above results are generally in accordance with finding of Devi et al. (2007) [7], Aman et al. (2011) [2]. Zeleke et al. (2015) [20] As they reported the similar results for ear height.

Ear length

For length of ear, heterosis ranged from -3.72% to +47.33% for the cross (S-202 x A201) and (P203 x S-206). All the crosses showed significant heterosis except 3 crosses was negative give values for mid parent heterosis, while heterobeltiosis ranged from -4.04% to 44.57% for (SY200 x S-202) and (SY200 x IQ207) respectively (Table 3). The range of commercial check hybrid are -23.88% to +7.10% for (33M15), and -26.83% to +2.96% was recorded for (32B33). The commercial check hybrid (33M15) showed

only five positive values against all the crosses, while (32B33) showed all negative values except 3 crosses for ear length (Table 3). Rokadia et al. (2005) [16] and Zeleke (2015) [20] reported significant positive heterosis for ear length in maize.

Number of kernels row⁻¹

52 direct and reciprocal crosses revealed positive heterotic and heterobeltiosis effect for number of kernels row⁻¹ (Table 3), proved their superiority over parents. The heterosis and heterobeltiosis values ranged from -16.27% (S-202 x J205) to +44.73 (IQ207 x S-202) and -18.18% (A201 x S-202) to +59.01% (SY200 x IQ207) respectively. The inbred line (IQ) showed significant performance in both direct and reciprocal combination in case of number of kernels row⁻¹. The performance of all hybrids ranged from -16.11% to +17.52% (33M15) and -27.72% to 8.93% (32M33) over both commercial check hybrids and its corroboration with the finding of Alam et al. (2008) [1], Atif et al. (2012) [4] and Zeleke (2015) [20] Who also recorded varying levels of heterosis for number of kernels row⁻¹.

Number of kernels rows ear⁻¹

The number of kernels rows ear⁻¹ is important yield component, therefore significant positive heterosis is desirable for them. Most of the crosses showed low heterosis for number of kernel rows ear⁻¹. The percent of heterosis ranged from -5.26% (A201 x J205) to 26.31% (S-202 x S-206), while heterobeltiosis ranged from -10.00% (A201 x J205) to +26.31% (SY202 x SY206) (Table 3). All the crosses showed heterotic effect over both commercial check hybrid ranged from -18.18% to 13.63% for (33M15) and -21.73% to 8.69% over (32B33). Zelleke. (2001) [21], Atif et al. (2012) [4] and Zeleke (2015) [20] Also found significant positive heterosis for number of kernels rows ear⁻¹.

100-kernel weight

In case of 100-kernel weight heterosis was significant and the highest 57.11% in (P203 x S-206) followed by 44.86% (P203 x IQ207). The lowest heterosis was observed -9.85% in (S-202 x A201), all the cross combinations exhibit positive heterosis except two hybrid showed negative values for 100-kernel weight (Table 3). In case of 100-kernel weight, the percent standard heterosis of all hybrids varied from -28.37% to 6.45% were recorded for (33M15), while the hybrid (32B33) exhibit the degree of heterosis ranged from -23.70% to +12.30%. The hybrids (SY200 x SY204) and (S-202 x P203) showed positive heterosis over both commercial check hybrids. Earlier, Devi et al. (2007) [7], Aman et al. (2011) [2] Atif et al. (2012) [4] and Zeleke (2015) [20] reported increase heterosis for 100-kernel weight.

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