International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 8, 2017, pp.-3871-3875.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECTS OF PARENTS ON *PER SE*PERFORMANCE OF SINGLE CROSS HYBRIDS FOR GRAIN YIELD IN MAIZE (*Zea mays* L.)

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Received: May 31, 2016; Revised: January 31, 2017; Accepted: February 01, 2017; Published: February 18, 2017

Abstract- An investigation was carried out to assess the combining ability and nature of gene action in respect of grain yield and its attributing traits in 87 single cross hybrids of maize developed by crossing three testers with 29 newly developed inbreeds from National Yellow Pool in line × tester mating design and grown in RBD with two replications at AICMIP, ARS, Arabhavi during *rabi/summer* 2008-09. Studies revealed that, the preponderance of non-additive gene action for all quantitative traits under study. Parents, YP⊗4#07-2, YP⊗4#07-26 and CI-5 were identified as good general combiner for earliness and YP⊗4#07-20 is identified as good general combiner for grain yield per hectare. Among 87 SCH, ten hybrids had superior *per se* performance for grain yield and it component characters. Among these crosses, YP⊗4#07-20 × CI-5 recorded significant *sca* effects and the gene action might be of non-additive nature and other nine crosses recorded non significant *sca* effect and the gene action might be of additive nature. Hence, these crosses can be utilized for pedigree breeding programme to evolve high yielding hybrid and varieties, respectively.

Keywords- Additive gene action, Line × tester, Maize, *sca* effects

Citation: Pavan R. and Wali C.M., (2017) Effects of Parents on *Per Se* Performance of Single Cross Hybrids for Grain Yield in Maize (*Zea mays* L.). International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 8, pp.-3871-3875.

Academic Editor / Reviewer: Lynne Carpenter Boggs, Dr Puttaramanaik

Introduction

Maize (*Zea mays* L.) is the world's most widely grown cereal and is the primary staple food in many developing countries [1]. It belongs to the family Poaceae with a chromosome number of 2n=2x=24. It has a wider adaptability as it can be grown from MSL to 3000m above and from 58^{0}N to 40^{0}S latitudes. It has been recognized as an emerging industrial crop because of the diversified products that can be developed like starch, syrup, glucose etc and in some countries, alcohol made from corn is blended in fuel for gasoline-powered vehicles to reduce emission of pollutants.

Maize possesses wide genetic diversity which encourages geneticists and plant breeders for crop improvement. In the breeding program, it is very important to know the combining abilities of inbred lines that are used as parents in hybridization program. Plant breeders can take advantage from such information on combining ability for developing high yielding lines and hybrids. Therefore, knowledge of combining ability is essential for selection of suitable parents for hybridization and identification of promising hybrids in breeding program. In fact, maize has been subjected to extensive genetic studies compared to any other crop [2]. Maize breeders have used several biometrical techniques to study the genetic architecture of quantitative traits including grain yield. Among a large array of biometrical procedures for relative estimation of genetic components, line × tester is an efficient procedures as it allows for inclusion of a large number of lines and provides reliable estimates of genetic components, estimates general combining ability (GCA) of the parents and specific combining ability (SCA) of the crosses and the nature of gene action involved in the expression of quantitative traits and to predict the performance of the progenies. The GCA is the average performance of a particular inbred in a series of hybrid combinations, whereas SCA refers to the performance of a combination of specific inbred in a particular cross [3]. The GCA and SCA variances provide estimation for additive and non-additive gene actions, respectively [4]. Therefore, the present investigation was carried out with an objective to understand the nature of gene action and combining ability of newly developed inbred lines for yield and its attributes through line x tester analysis.

Material and Methods

The experimental material comprised of 29 promising inbred lines selected from National Yellow Pool based on their performance in S_4 generation and three testers *viz*., Prabha, KDMI-10 and CI-5. The selected lines and testers crossed in line × tester fashion to generate 87 single cross hybrids. The newly generated hybrids along with the parents including five checks *viz*., DMH-2, EH-434042 (Arjun), Pinnacle, Bio-9681 and 900M were evaluated at All India Co-ordinated Maize Improvement Project (AICMIP), Agricultural Research Station (ARS), Arabhavi during *rabi/summer* 2008-09 in RCBD with two replications. Each entry was raised in two rows with a row length of 4m and the spacing maintained was 75cm between the rows and 20cm between the plants. The recommended packages of practices were followed to raise a good and healthy crop. The observations on grain yield and its 11 yield attributing traits recorded from ten competitive plants which were selected randomly from each treatment to record observations on days to 50 % tasseling, days to 50 % silking, plant height (cm), ear length (cm), ear circumference (cm), number of kernel rows per ear, number of kernels per row, 100-grain weight (g), shelling percent, grain yield per plant, fodder yield (t/ha) and grain yield (q/ha). The mean values of these ten plants were used for analysis as per the method suggested by Kempthorne [5], which provides reliable information on the general and specific combining ability effects of parents and their hybrid combinations in applied breeding programs. The design has been widely used in maize breeding by several workers and continues to be applied in quantitative genetic studies in maize due to its significance [6].

Results and Discussion

Analysis of variance for parents and females were highly significant for all the traits, indicating the presence of sufficient variation for all the traits in the parents [Table-1]. Further, the variation due to males was highly significant in five characters *viz*., number of kernels per row, 100-grain weight, grain yield per plant, fodder yield per hectare and grain yield per hectare. The mean sum squares for females versus males were significant for days to 50 per cent tasseling whereas highly significant for all traits except ear length, ear circumference, shelling percentage and fodder yield per hectare.

The mean sum of squares for hybrids were highly significant for days to 50 per cent tasseling, days to 50 per cent silking, number of kernel rows per ear, number of kernels per row, 100-grain weight, shelling percentage and fodder yield per hectare. The parents versus hybrids mean sum of squares were highly significant for all traits *viz.,* days to 50 per cent tasseling, days to 50 per cent silking, plant height, ear length. ear circumference, number of kernel rows per ear, number of kernels per row, 100-grain weight, shelling percentage, grain yield per plant, fodder yield per hectare and grain yield per hectare, indicating the presence of high heterosis response in the material studied.

The SCA variance was higher than the GCA variance indicating predominance of dominance variance. Dominance was greater than additive variance for all the characters indicating the predominance of non-additive gene action [7-22].

Table-1 *Mean sum of squares for parents and hybrids in respect of 12 quantitative traits in maize*

Sources of variation	Degrees of freedom	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear length (cm)	Ear circumference (cm)	Number of kernel rows per ear
Replication	1	57.52	94.54	1610.96	38.88	0.48	5.69
Parents	31	5.98**	4.87**	412.71**	5.29*	1.52**	0.87**
Females (Lines)	28	6.51**	5.15**	437.01**	5.51*	1.62**	0.76**
Males (Testers)	2	0.50	0.67	18.67	4.67	0.69	0.17
Females Vs Males	1	1.98*	5.38**	520.50**	0.27	0.29	5.28**
Hybrids	86	2.68**	4.87**	245.35	3.51	0.84	0.57**
Parents Vs Hybrids	1	156.12**	86.23**	8169.72**	78.26**	56.75**	4.80**
Error	118	1.38	2.25	210.05	3.67	0.94	0.37
σ^2GCA		0.01	0.02	1.19	0.01	0.00	0.00
σ^2SCA		-0.01	0.06	-49.44	-0.57	-0.19	0.03
σ^2GCA/ σ^2SCA		-0.15	0.39	-0.02	-0.01	-0.01	0.03

Sources of variation	Degrees of freedom	No of kernels per row	100-grain weight (g)	Shelling (%)	Grain yield per plant (g)	Fodder yield (t/ha)	Grain yield (q/ha)
Replication	1	67.77	0.04	5.97	64.57	2.07	12.50
Parents	31	32.01**	59.77**	11.91**	165.29**	5.11**	69.48**
Females (Lines)	28	29.23**	61.45**	13.01**	140.81**	5.60**	60.71**
Males (Testers)	2	12.33**	41.17**	2.43	443.89**	0.71**	169.75**
Females Vs Males	1	149.31**	50.26**	0.01	293.58**	0.08	114.33**
Hybrids	86	16.66**	42.51**	6.43**	84.48	5.16**	38.07
Parents Vs Hybrids	1	1550.76**	1066.18**	94.51**	110834.70**	195.50**	11577.87**
Error	118	2.53	2.25	3.41	85.39	0.19	36.08
σ^2GCA		0.02	0.12	0.01	0.07	0.02	0.05
σ^2SCA		5.63	14.38	1.46	-2.95	1.74	-1.17
σ^2GCA/ σ^2SCA		0.004	0.01	0.01	-0.02	0.01	-0.04

* and ** - Significant at 5% and 1% level of significance

Choice of parents: In any plant breeding programme, the choice of parents is of prime importance to meet the desired objectives. Further, the *per se* performance of parents can be considered as one of the important criterion. Among the 32 parents, YP⊗4#07-12 and KDMI-10 showed superior *per se* performance over DMH-2 for grain yield per hectare [Table-2]. It also showed superior *per se* performance for ear length, ear circumference, number of kernel rows per ear, number of kernels per row and shelling percentage than DMH-2. The line YP⊗ 4#07-12 also showed earliness in flowering when compared to checks. Hence, based on the *per se* performance, the line YP⊗4#07-12 and the tester KDMI-10 were considered as the desirable parents.

The second criterion in the choice of the parents is the general combining ability of the parents. Though the *per se* performance is important, the parents selected only based on *per se* performance may not show desirable *gca* effects in event of non-additive gene action. The line YP⊗4#07-20 and the tester Prabha showed high *gca* for grain yield per hectare. In addition, the tester Prabha also showed high *gca* for plant height, ear length, number of kernel rows per ear, number of kernels per row, grain yield per plant and fodder yield per hectare [Table-3]. Results indicated that the parents possess high frequency of favorable genes for these traits. Considering the earliness parameters *viz*., days to 50 per cent tasseling and silking, the line, YP⊗4#07-2, YP⊗4#07-26, YP⊗4#07-13 and the testers CI-5 showed desirable gca effects. Based on aforesaid discussion it may be suggested that line *viz*., YP⊗4#07-20, YP⊗4#07-2, YP⊗4#07-26 and YP⊗ 4#07-13 and the testers, Prabha and CI-5 could be the best general combiners. Thus, the inbred lines which exhibited good general combining ability for at least one trait can be used as donor parents for the accumulation of favorable genes [23, 24]. It may be inferred that the early maturing genotypes can maintain their superiority in *per se* performance and also combining ability effects. However, the parents that showed superior *per se* performance for grain yield and its component characters could not express high gca effect for the respective characters which indicates the poor association between *per se* performance and gca effects of parents for yield component characters.

Choice of hybrids: The *per se* performance hybrids was considered as the first and foremost important criterion for the selection of superior crosses. Ten hybrids *viz*., YP⊗4#07-20 × CI-5, YP⊗4#07-4 x Prabha, YP⊗4#07-24 ×Prabha, YP⊗4#07-8 ×Prabha, YP⊗4#07-3 × KDMI-10, YP⊗4#07-26 × KDMI-10, YP⊗4#07-23 × KDMI-10, YP⊗4#07-28 × KDMI-10, YP⊗4#07-27 × CI-5 and YP⊗4#07-25 × CI recorded superior mean grain yield per hectare than Pinnacle. Based on the *per se* performance, all the above ten hybrids can be considered as desirable.

Breeding strategy: Selection of hybrids for breeding programme is based on their *per se* performance, *gca* effects of their parents and *sca* effects of hybrids. High *gca* effects are due to additive as well as additive × additive type of epistatic gene action [25]. These additive type of gene action are fixable while, non-additive gene

Table-2 *per se performance of parentsfor grain yield and yield attributing traits in maize*

S.N.	Entries	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
	Lines (Females)												
1	YP⊗4 #07-1	67.00	69.00	133.50	17.10	13.70	13.00	33.70	32.00	83.90	80.64	3.90	43.89
2	YP⊗4 #07-2	64.50	68.00	137.50	16.40	13.40	12.60	30.00	22.00	84.90	77.94	5.60	40.50
3	YP⊗4 #07-3	67.00	70.50	133.50	13.80	12.20	12.10	26.00	22.00	79.10	64.22	3.10	33.67
4	YP⊗4 #07-4	67.00	69.50	140.00	17.10	13.80	12.80	31.90	29.50	82.90	79.97	4.70	42.98
5	YP⊗4 #07-5	67.00	71.00	127.00	14.70	12.70	11.90	24.60	26.50	73.80	65.69	2.50	33.12
6	YP⊗4 #07-6	70.00	72.50	134.00	13.70	11.90	12.10	26.70	26.00	76.90	70.05	4.60	36.04
7	YP⊗4 #07-7	70.00	72.00	129.00	13.70	11.60	13.00	32.90	19.00	83.20	81.42	2.30	43.80
8	YP⊗4 #07-8	65.50	68.00	122.50	12.10	13.00	11.40	22.70	24.00	80.90	58.69	3.90	28.61
9	YP⊗4 #07-9	65.00	68.50	125.00	14.40	12.80	12.10	26.30	19.50	82.90	67.11	3.10	33.83
10	YP⊗4 #07-10	69.00	71.50	110.50	13.00	12.00	11.70	24.50	20.50	81.20	62.88	1.70	32.23
11	YP⊗4 #07-11	65.50	68.00	131.50	14.30	13.50	11.70	24.10	23.50	81.10	61.73	2.90	31.99
12	YP⊗4 #07-12	66.00	67.50	158.00	17.00	14.40	13.90	34.90	30.00	81.50	87.99	5.20	48.28
13	YP⊗4 #07-13	69.00	71.00	131.50	14.70	13.10	12.90	32.70	32.00	83.20	79.87	5.20	43.25
14	YP⊗4 #07-14	66.00	68.50	153.00	14.30	12.20	12.10	26.60	27.50	80.90	68.55	5.40	35.01
15	YP⊗4 #07-15	66.00	70.00	138.50	14.10	12.20	11.40	22.80	25.00	77.10	60.03	2.40	29.27
16	YP⊗4 #07-16	65.50	69.00	113.50	12.30	11.60	11.20	21.20	26.00	79.90	57.77	1.70	27.44
17	YP⊗4 #07-17	67.50	69.50	142.00	15.90	13.70	12.20	27.70	32.00	83.50	73.31	4.00	38.87
18	YP⊗4 #07-18	66.00	69.00	116.50	13.80	11.10	12.60	30.50	20.00	81.90	77.63	1.60	41.38
19	YP⊗4 #07-19	65.00	68.00	159.90	16.20	13.70	12.00	24.80	34.00	80.10	66.90	7.20	33.15
20	YP⊗4 #07-20	68.00	71.00	143.50	13.80	12.70	12.20	28.40	33.50	84.40	74.81	4.20	38.94
21	YP⊗4 #07-21	68.000	70.50	153.00	14.70	13.70	11.60	23.60	37.50	80.60	63.16	8.60	30.41
22	YP⊗4 #07-22	68.50	71.00	142.50	17.60	13.80	12.60	30.60	34.50	82.80	78.59	5.40	41.89
23	YP⊗4 #07-23	70.00	72.50	154.00	17.70	14.50	13.20	34.30	29.00	84.40	83.27	6.40	43.95
24	YP⊗4 #07-24	68.50	70.50	133.00	13.50	12.90	12.70	27.30	18.50	79.60	73.28	2.80	38.86
25	YP⊗4 #07-25	68.00	70.50	147.50	13.70	12.80	11.60	24.10	30.50	80.50	60.51	4.70	31.08
26	YP⊗4 #07-26	65.50	68.00	136.00	17.10	13.50	11.80	24.50	30.50	80.80	62.42	4.70	32.28
27	YP⊗4 #07-27	62.50	66.00	130.50	15.60	13.10	12.60	29.70	30.50	80.90	75.33	4.00	39.68
28	YP⊗4 #07-28	66.00	69.00	114.50	12.30	11.40	12.10	26.70	19.50	84.70	69.26	3.10	35.69
29	YP⊗4 #07-29	66.50	70.50	98.00	14.00	12.50	12.10	26.40	19.50	78.60	66.40	3.00	34.26
	Testers (Males)												
30	Prabha	68.00	71.00	121.00	15.10	12.90	12.90	30.80	19.50	80.20	76.67	3.80	40.39
31	KDMI-10	67.50	71.00	127.00	16.50	13.80	13.40	35.60	28.50	82.40	93.54	4.90	50.92
32	CI-5	67.00	70.00	125.00	13.40	12.70	13.40	32.10	23.00	81.20	63.84	3.90	32.56
	Commercial Hybrids												
33	DMH-2	66.50	70.00	121.50	13.3	13.50	12.10	31.30	32.50	82.80	104.38	4.60	44.31
34	EH-434042 (Arjun)	66.50	69.50	134.50	15.5	14.20	12.20	31.70	34.50	82.90	127.86	4.00	58.04
35	900M	70.00	73.00	131.50	15.8	14.00	12.30	32.00	27.00	80.70	119.62	4.70	51.50
36	Bio9681	69.50	73.00	131.00	14.1	13.20	12.00	30.10	29.00	82.70	125.59	3.00	55.10
37	Pinnacle	70.00	73.00	115.50	14.9	13.50	13.30	37.10	26.50	80.30	128.72	3.00	58.21
	Grand mean	65.60	68.80	142.86	15.73	13.68	12.57	32.29	29.91	82.28	106.94	5.55	48.63
	SEm±	1.18	1.50	14.49	1.92	0.97	0.60	1.58	1.50	1.84	9.24	0.44	6.01
	CD at 5%	2.30	2.94	28.41	3.75	1.90	1.19	3.11	2.94	3.62	18.11	0.86	11.77
	CD at 1%	3.03	3.87	37.39	4.94	2.50	1.56	4.09	3.87	4.76	23.84	1.14	15.50
	CV (%)	**1.79**	**2.18**	**10.14**	**12.18**	**7.09**	**4.83**	**4.92**	**5.01**	**2.24**	**8.64**	**7.94**	**12.35**

* and ** - Significant at 5% and 1%level of significance

X1 - Days to 50% tasseling
X2 - Days to 50% silking
X3 - Plant height (cm)
X4- Ear length (cm)
X5 - Ear circumference (cm)
X6 – Number of kernel rows per ear
X7 – Number of kernels per row
X8- 100-grain weight (g)
X9 – Shelling percentage (%)
X10 – Grain yield per plant (g)
X11 – Fodder yield (t/ha)
X12-Grain yield (q/ha)

action are non fixable. The estimates of *per se* performance, *gca* effects of parents and *sca* effects of selected hybrids [Table-4]. Among these crosses, YP⊗ 4#07-20 x CI-5 recorded significant *sca* effects and the gene action might be of non additive. Hence, this cross can be utilized for breeding programme to evolve high yielding early maturing hybrids. The crosses, YP⊗4#07-4 ×Prabha, YP⊗ 4#07-24 ×Prabha, YP⊗4#07-8 × Prabha, YP⊗4#07-3 × KDMI-10, YP⊗4#07-26 × KDMI-10, YP⊗4#07-23 × KDMI-10, YP⊗4#07-28 × KDMI-10, YP⊗4#07-27 × CI-5 and YP⊗4#07-25 × CI recorded non significant *sca* effects and the gene action might be of additive type of epistasis. These crosses also can be utilized for pedigree breeding programme. However, selection should be postponed to later generation due to the presence of additive type of epistatic gene action. Thus, it can be concluded that the present study identified the lines YP⊗4#07-2, YP⊗ 4#07-26 and CI-5 as good general combiners for earliness and the line YP⊗4#07-20 as the desirable parent as donor for grain yield per hectare. Among the 87 crosses, YP⊗4#07-20 × CI-5 was identified as outstanding for grain yield and its component traits due to its high *sca* effect for grain yield per hectare.

Conclusion

An investigation was carried out to assess the combining ability and nature of gene action in respect to grain yield and its attributing traits in 87 single cross hybrids of maize developed by crossing three testers with 29 newly developed inbreeds from National Yellow Pool. Among parental lines, YP⊗4#07-2, YP⊗ 4#07-26 and CI-5 were identified as good general combiner for earliness and YP⊗ 4#07-20 is identified as good general combiner for grain yield per hectare. Among these crosses, YP⊗4#07-20 × CI-5 recorded significant *sca* effects and the gene action might be of non-additive nature and other nine crosses recorded non significant

sca effect and the gene action might be of additive nature. Hence, these crosses can be utilized for pedigree breeding programme to evolve high yielding hybrid and varieties, respectively.

Table-3 *General combining ability (gca) effects of parents for grain yield and yield attributing traits in maize*

S.N.	Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
	Females (Lines)												
1	YP⊗4 #07-1	-0.13	0.93	12.25*	0.28	1.17**	0.41	2.06**	4.14**	-1.80**	3.9	0.48**	2.51
2	YP⊗4 #07-2	-2.46**	-2.07**	5.09	0.68	-0.18	-0.06	-0.11	3.14**	-0.25	-0.41	-0.54**	-0.61
3	YP⊗4 #07-3	-0.29	0.09	5.09	1.56	0.16	0.31	1.59*	3.8**	0.59	4.51	-0.07	2.60
4	YP⊗4 #07-4	-1.63**	-1.24	-4.41	0.54	0.39	0.31	1.73*	2.47**	0.25	3.59	-0.14	1.98
5	YP⊗4 #07-5	0.21	1.26	-14.91*	-1.81*	-0.66	-0.53*	-2.34**	-3.03**	0.79	-5.16	-2.19**	-3.89
6	YP⊗4 #07-6	-0.96*	0.93	-19.75**	-1.51	-1.06*	-0.73**	-4.01**	-5.03**	-1.7**	-6.63	-1.7**	-5.67*
7	YP⊗4 #07-7	0.21	0.43	-7.08	-1.42	-0.46	-0.53*	-2.51**	-3.86**	-1.18	-5.22	-0.99**	-3.84
8	YP⊗4 #07-8	0.54	0.76	-3.41	1.48	0.08	0.37	1.86**	-4.53**	1.24	4.34	1.43**	3.05
9	YP⊗4 #07-9	0.54	0.76	11.25	0.96	0.06	0.04	0.43	-1.53**	0.72	0.19	1.68**	0.36
10	YP⊗4 #07-10	0.21	0.59	0.75	-0.72	0.37	-0.03	0.19	-0.36	-1.23	-0.74	2.01**	-0.40
11	YP⊗4 #07-11	-0.79	-1.57*	-16.75**	-0.96	-1.04*	-0.49	-2.57**	-2.36**	-0.6	-6.94	-1.94**	-3.87
12	YP⊗4 #07-12	0.04	-0.91	-2.25	-0.44	-0.06	-0.16	-0.94	-2.7**	-1.53*	-2.94	-0.32	-1.27
13	YP⊗4 #07-13	-1.13*	-1.74**	-12.58*	0.08	0.02	0.34	2.03**	2.64**	-0.01	2.53	1.2**	2.38
14	YP⊗4 #07-14	1.04*	1.26	4.59	0.19	0.2	-0.23	-1.34	1.14*	-0.33	-3.14	0.58**	-2.04
15	YP⊗4 #07-15	0.04	0.26	5.75	-0.29	-0.01	-0.36	-2.31**	-1.2*	0.34	-3.18	0.78**	-2.59
16	YP⊗4 #07-16	0.71	1.26	6.25	1.64*	0.49	-0.09	-0.27	2.3**	-0.41	-1.89	0.21	-0.88
17	YP⊗4 #07-17	1.37**	1.26	1.92	0.58	-0.28	-0.19	-1.01	-5.7**	1.44*	-2.31	0.23	-1.64
18	YP⊗4 #07-18	1.37**	1.76**	8.59	1.14	0.34	0.01	-0.04	0.80	-1.81**	-1.00	2.16**	-0.34
19	YP⊗4 #07-19	1.71**	1.76**	13.42*	-0.79	-0.29	-0.43	-2.37**	-0.70	0.72	-4.43	1.00**	-3.56
20	YP⊗4 #07-20	0.04	0.43	-6.58	-1.01	-0.43	0.71**	3.56**	-0.36	2.09**	8.73*	-1.32**	5.95*
21	YP⊗4 #07-21	1.04*	0.43	-0.58	0.03	0.16	-0.06	-0.84	4.47**	-0.91	-0.97	-0.27	-0.57
22	YP⊗4 #07-22	-0.29	0.43	-4.25	-0.19	-0.19	-0.23	-1.24	-1.03	-1.78**	-3.72	0.33	-2.25
23	YP⊗4 #07-23	0.71	0.76	3.59	-0.64	0.09	-0.26	-1.57*	-4.36**	0.30	-2.42	0.98**	-1.57
24	YP⊗4 #07-24	-0.63	-1.91**	0.42	0.58	-0.11	0.21	1.23	-0.03	0.95	2.90	-0.55**	1.70
S..N.	Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
	Female (Lines)												
25	YP⊗4 #07-25	-0.46	-1.91**	1.92	-0.09	0.31	0.44	2.36**	3.64**	1.55*	4.71	0.00	3.82
26	YP⊗4 #07-26	-0.96*	-2.07**	3.25	0.96	0.82*	0.21	1.13	5.14**	0.94	3.69	-1.25**	2.02
27	YP⊗4 #07-27	-0.96*	-1.41*	-1.41	-0.84	0.21	0.47	2.53**	1.47*	-1.48*	5.37	-1.04**	4.21
28	YP⊗4 #07-28	-0.29	-0.74	-2.58	-0.29	0.07	0.47	2.36**	5.3**	2.04**	5.79	-1.29**	3.85
29	YP⊗4 #07-29	1.21*	0.26	12.42*	0.29	-0.21	0.11	0.46	-3.7**	1.12	0.86	0.53**	0.57
	Males (Testers)												
30	Prabha	0.24	0.26	2.74	0.2	0.04	0.05	0.26	-1.09**	0.05	0.19	0.2**	0.31
31	KDMI-10	-0.06	0.01	1.41	0.00	0.06	0.00	0.03	0.37*	-0.18	0.16	0.17**	0.03
32	CI-5	-0.18	-0.27	-4.16*	-0.2	-0.1	-0.05	-0.29	0.72**	0.13	-0.35	-0.37**	-0.34
	CD at 5% female	1.35	1.83	17.19	2.24	1.14	0.742	1.96	1.58	1.80	10.46	0.49	6.79
	CD at 1% female	1.80	2.43	22.84	2.98	1.51	0.98	2.61	2.10	2.39	13.89	0.65	9.02
	S.Em±	0.68	0.92	8.68	1.13	0.57	0.37	0.99	0.80	0.91	5.28	0.25	3.43
	CD at 5% male	0.44	0.59	5.53	0.72	0.37	0.23	0.63	0.51	0.58	3.36	0.16	2.18
	CD at 1% male	0.58	0.78	7.35	0.96	0.49	0.31	0.83	0.68	0.77	4.47	0.21	2.90
	S.Em±	0.22	0.30	2.79	0.36	0.18	0.12	0.31	0.26	0.29	1.70	0.08	1.10

* and ** - Significant at 5% and 1%level of significance

X1 - Days to 50% tasseling	X5 - Ear circumference (cm)	X9 – Shelling percentage (%)
X2 - Days to 50% silking	X6 – Number of kernel rows per ear	X10 – Grain yield per plant (g)
X3 - Plant height (cm)	X7 – Number of kernels per row	X11 – Fodder yield (t/ha)
X4- Ear length (cm)	X8- 100-grain weight (g)	X12-Grain yield (q/ha)

Table-4 *Per se performance of promising hybrids for grain yield and yield attributing traits in maize*

S.N.	Single cross hybrids	Mean grain yield (q/ha)	Heterosis			gca effects female x male	sca effects	Other characters with significant sca effects
			SH	HB	RH			
1.	YP⊗4#07-20 × CI-5	67.29	53.3**	72.77**	88.21**	High x Low	8.82*	HGW,GYP,NKPR,SP
2.	YP⊗4#07-4 ×Prabha	61.54	40.2**	43.17**	47.62**	Low x Low	6.38	HGW,FYH, NKPR,SP
3.	YP⊗4#07-24 ×Prabha	61.35	39.78**	51.89**	54.84**	Low x Low	6.49	NKPR, FYH
4.	YP⊗4#07-8 ×Prabha	61.07	39.15**	51.21**	77.03**	High x Low	4.85	HGW
5.	YP⊗4#07-3 × KDMI-10	60.55	37.97**	18.93	43.18**	High x High	5.06	HGW,FYH
6.	YP⊗4#07-26 × KDMI-10	60.52	37.88**	18.85	45.48**	Low x High	5.60	NKPR
7.	YP⊗4#07-23 × KDMI-10	59.51	35.58**	16.87	25.45*	Low x High	8.18	NKRPE, NKPR
8.	YP⊗4#07-28 × KDMI-10	59.50	35.57**	16.86	37.41**	High x High	2.76	HGW
9.	YP⊗4#07-27 × CI-5	59.42	35.4**	49.76**	64.53**	Low x Low	2.69	SP
10.	YP⊗4#07-25 × CI-5	59.42	35.4**	82.54**	86.77**	High x Low	3.09	FYH

* and ** - Significant at 5% and 1%level of significance

NKRPE= Number of kernel rows per ear, NKPR= Number of kernels per row, SP= Shelling percentage, HGW = 100-grain weight, GYP = Grain yield per plant, FYH = Fodder yield per hectare, GYH = Grain yield per hectare.

Acknowledgement
Authors acknowledge the support provided by the AICMIP, ARS, Arabhavi for carrying out the research.

Author Contributions
This article was a part of M.Sc research conducted by Pavan, R under the guidance of Dr. M. C. Wali.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors

Conflict of Interest: None declared

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