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Research Article

Combining ability analysis of newer inbred lines derived from national yellow pool for grain yield and other quantitative traits in maize (Zea mays L.)

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Abstract:
Information on combing ability is important for effective breeding strategies in a cross pollinated crop like maize. Twenty nine inbred lines were derived from national yellow pool based on their performance in their S4 generation. Twenty nine lines, three testers and their 87 hybrids from a line x tester design were evaluated for grain yield and its components. The SCA variance was higher than GCA variance for all the characters indicating the predominance of non-additive gene action. Line x tester interaction variance was found significant for all the traits except ear length, ear circumference, shelling percentage and fodder yield. The line YP⊗4#07-20 was the best general combiner and the cross YP⊗4#07-20 X CI-5 was identified as good specific combiner.

Key words: Combining ability, GCA, SCA, Maize

Introduction

Maize (*Zea mayz L.*) is the world's most widely grown cereal and is the primary staple food in many developing countries (Morris *et al.*, 1999). From the national yellow pool, 29 inbreds have been derived recently and their utility in hybrid development was needed to be tested. The concept of general combining ability (GCA) and specific combining ability (SCA) introduced by Sprague and Tatum (1942) helps the breeder in assessing many of the lines to be used as parents in the production of hybrids and also in identifying the superior hybrids having desired genetic background. General combining ability is the average performance of a strain in a series of cross combinations, estimated from the performance of F1's, whereas specific combining ability is used to designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of average performance of lines involved. Griffing (1956) had shown relationship between various heritable variance components and GCA and SCA variances. The value of any population depends on its potential *per se* and combining ability in crosses. The usefulness of these concepts for the characterization of an inbred in crosses have been increasingly popular among the maize breeders since last few decades. In the present study 29 lines derived from national yellow pool were tested for their combining ability in line x tester design.

Material and methods

The experiment consisted of twenty nine best promising inbred lines, selected from national yellow pool, based on their performance in their S4 generation and these selected 29 inbred lines were crossed with three testers *viz.*, Prabha, KDMI-10 and CI-5 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2008. The ears were harvested, dried and shelled manually. These were kept in controlled environment for use in the trials in the next growing season.

The resulting 87 F_1s along with their parental lines and five national checks (DMH-2, EH-434042 (Arjun), 900M, Bio-9681 and Pinnacle) were evaluated at the All India Co-ordinated Maize Improvement Project (AICMIP), Agricultural Research Station (ARS), Arabhavi during *rabi/summer* 2008-09 for their performance. Hills were overplanted and thinned after emergence for a final plant density of about 56,000 plants ha^{-1}. The experiment was conducted in Randomized Complete Block Design with two replications and each entry was raised in two rows of 4m length. The spacing maintained was 75 cm between the rows and 20 cm between the plants. The recommended packages of practices were followed to raise a good crop. The observations on grain yield and its 11 important component traits were recorded from five randomly selected plants from each treatment. Combining ability analysis was computed according to the model given by Kempthrone (1957).

Results and discussion

Analysis of variance for combining ability in respect of 12 quantitative characters under study is presented in Table 1. Mean sum of squares for parents and females were highly significant for all the traits. Mean sum of squares for males were significant for 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 of squares for female versus male was significant for all the traits except ear length, ear circumference, shelling percentage and fodder yield per hectare indicating the suitability of the material.

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.

The SCA variance was higher than the GCA variance indicating predominance of non additive genetic variance for all the characters. These results are in conformity with the findings of Sanghi *et al.*, (1982), Pal *et al.*, (1986), Guo *et al.*, (1986), Herbert and Gallis (1986), Paul and Duara (1991), Vasal *et al.*, (1992), Mohammad (1993), Sedhom (1994), Sinobas and Monteagudo (1994), Satyanarayana *et al.*, (1994), El-Hosary *et al.*, (1994), Pal and Prodhan (1994), Dehghanapour *et al.*, (1997).

The gca effects calculated for each parent are presented in Table 2. Among the 32 parents, the highest and significant gca effects for grain yield per plant was observed in YP⊗4#07-20 (5.95), YP⊗4#07-27 (4.21), YP⊗4#07-28 (3.85). The parent YP⊗4#07-20 (5.95) was also found to be the best general combiner for the characters plant height and fodder yield per hectare, while YP⊗4#07-1 was the best general combiner for plant height, ear circumference, 100-grain weight and fodder yield per hectare. The parent YP⊗4#07-2 had highest negative gca effects for days to 50 per cent tasseling (-2.46) and days to 50 per cent silking (-2.07). These parents may therefore be used in breeding programme for earliness. For plant height, three lines YP⊗4#07-19 (13.42), YP⊗4#07-29 (12.42), and YP⊗4#07-1 (12.25) and two testers Prabha (2.74) and KDMI-10 (1.41) showed significant positive gca effects in the positive direction.

The crosses having desired significant specific combining ability effects are presented in Table 3. Out of 87 crosses, only YP⊗4#07-20 X CI-5 showed significant positive sca effects and higher degree of heterosis over standard check (Pinnacle) for grain yield per hectare. For earliness, two hybrids YP⊗4#07-13 X CI-5 for days to 50 per cent tasseling and YP⊗4#07-6 X CI-5 for days to 50 per cent silking depicted significant sca effects. In the present study, top ten hybrids with high *per se* performance *viz.*, YP⊗4#07-20 x CI-5, YP⊗4#07-4 x Prabha, YP⊗4#07-24 x Prabha, YP⊗4#07-8 x Prabha, YP⊗4#07-3 x KDMI-10, YP⊗4#07-26 x KDMI-10, YP⊗4#07-23 x KDMI-10, YP⊗4#07-28 x KDMI-10, YP⊗4#07-27 x CI-5 and YP⊗4#07-25 x CI-5 showed high sca effects for grain yield per hectare and yield components like 100-grain weight, grain yield per plant, number of kernel rows per ear, number of kernels per row, shelling percentage and fodder yield per hectare.

Two factors are considered important in the evaluation of an inbred line in the production of hybrid maize; characteristics of the line itself and behavior of the line in a particular hybrid combination. On an average, crosses produced by crossing inter-population lines had more positive sca effects than those produced by crossing intra-population lines. These findings are supported by Vasal *et al*. (1992) and Gama *et al* (1995). As performance of hybrids can be sub-divided into two categories i.e. general and specific combining ability (Rojas and Sprague, 1952), superiority of a line on the basis of combining ability estimates can only be decided precisely after knowing the purpose of a certain breeding programme. Lines which had higher GCA effects can be used in synthetic variety development more effectively. However, when high yielding specific combinations are desired, especially in hybrid maize development, sca effects could help in the selection of parental material for hybridization.

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Table 1: Mean sum of squares for parents and hybrids in respect of 12 characters 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

* Significant at 5% ** Significant at 1%

Table 2: General combining ability (gca) effects of parents in respect of 12 characters

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Females (Lines)												
YP ⊗ 4 #07-1	-0.13	0.93	12.25*	0.28	1.17**	0.41	2.06**	4.14**	-1.8**	3.9	0.48**	2.51
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
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	2.6
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
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
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*
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
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
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
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**	-0.4
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
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
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
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
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
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
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
YP ⊗ 4 #07-18	1.37**	1.76**	8.59	1.14	0.34	0.01	-0.04	0.8	-1.81**	-1	2.16**	-0.34
YP ⊗ 4 #07-19	1.71**	1.76**	13.42*	-0.79	-0.29	-0.43	-2.37**	-0.7	0.72	-4.43	1**	-3.56
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*
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
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
YP ⊗ 4 #07-23	0.71	0.76	3.59	-0.64	0.09	-0.26	-1.57*	-4.36**	0.3	-2.42	0.98**	-1.57
YP ⊗ 4 #07-24	-0.63	-1.91**	0.42	0.58	-0.11	0.21	1.23	-0.03	0.95	2.9	-0.55**	1.7

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Table 2: Contd…

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Female (Lines)												
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	3.82
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
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
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
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)												
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
KDMI-10	-0.06	0.01	1.41	0	0.06	0	0.03	0.37*	-0.18	0.16	0.17**	0.03
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

X5 - Ear circumference (cm)
X6 – Number of kernel rows per cob
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)

Table 3: Specific combining ability (sca) effects of single cross hybrids of maize in respect of 12 characters

Single cross hybrids	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
YP ⊗ 4 #07-1 x Prabha	0.76	0.4	5.59	-0.25	0.06	0.08	0.24	0.76	-1.01	-0.96	1.32**	0.2
YP ⊗ 4 #07-1 x KDMI -10	-0.44	-0.34	7.92	-0.3	0.09	0.04	0.27	-0.21	1.96	1.36	-0.46	0.23
YP ⊗ 4 #07-1 x CI-5	-0.32	-0.06	-13.51	0.55	-0.15	-0.12	-0.51	-0.55	-0.95	-0.4	-0.86**	-0.43
YP ⊗ 4 #07-2 x Prabha	-0.4	-0.1	4.76	-0.75	-0.29	-0.25	-1.39	4.76**	-0.61	-3.1	1.38**	-1.9
YP ⊗ 4 #07-2 x KDMI -10	-0.11	0.16	-7.91	0.2	0.34	0.2	1.23	-6.21**	0.51	3.33	-0.29	2.12
YP ⊗ 4 #07-2 x CI-5	0.51	-0.06	3.16	0.55	-0.05	0.05	0.16	1.45	0.1	-0.24	-1.09**	-0.22
YP ⊗ 4 #07-3 x Prabha	-0.57	-1.26	-8.74	-1.24	-0.57	-0.42	-1.79	-6.91**	0.55	-4.62	-0.73*	-3.3
YP ⊗ 4 #07-3 x KDMI -10	0.72	1.49	1.59	1.77	0.51	0.54	2.13	5.63**	1.83	8.17	1.04**	5.06
YP ⊗ 4 #07-3 x CI-5	-0.16	-0.23	7.16	-0.53	0.06	-0.12	-0.34	1.28	-2.38*	-3.55	-0.31	-1.76
YP ⊗ 4 #07-4 x Prabha	0.26	0.57	6.76	0.43	0.59	0.78	4.18**	2.93**	2.79*	9.37	0.93**	6.38
YP ⊗ 4 #07-4 x KDMI -10	-0.94	-1.17	-1.41	1.03	0.28	-0.16	-0.9	2.46*	-0.44	-1.9	-1.29**	-1.63
YP ⊗ 4 #07-4 x CI-5	0.68	0.6	-5.34	-1.46	-0.87	-0.62	-3.28**	-5.39**	-2.35*	-7.47	0.36	-4.75
YP ⊗ 4 #07-5 x Prabha	-0.07	0.07	9.26	0.73	0.44	0.01	-0.06	2.43*	2.65*	-0.09	1.28**	0.15
YP ⊗ 4 #07-5 x KDMI -10	0.22	0.33	-4.41	-2.02	-0.62	-0.13	-0.33	-0.04	-1.92	-2.05	-1.04**	-0.69
YP ⊗ 4 #07-5 x CI-5	-0.16	-0.4	-4.84	1.29	0.18	0.12	0.39	-2.39*	-0.73	2.13	-0.24	0.54
YP ⊗ 4 #07-6 x Prabha	1.1	4.4**	7.09	1.48	0.84	0.61	3.71**	3.43**	3.19**	4.39	0.15	4.19
YP ⊗ 4 #07-6 x KDMI-10	0.39	-1.84	-0.58	-0.57	-0.12	-0.53	-2.27	3.96**	-1.04	-4.48	0.78*	-3.73
YP ⊗ 4 #07-6 x CI-5	-1.49	-2.56*	-6.51	-0.91	-0.72	-0.08	-1.44	-7.39**	-2.15	0.09	-0.93**	-0.46
YP ⊗ 4 #07-7 x Prabha	-1.07	-0.6	1.93	-0.05	0.34	-0.19	-0.79	4.76**	-0.68	-0.05	0.48	-1.15
YP ⊗ 4 #07-7 x KDMI-10	0.72	0.66	-7.25	0.55	-0.42	0.17	0.63	-2.71**	-0.76	0.64	-1.29**	1.29
YP ⊗ 4 #07-7 x CI-5	0.34	-0.06	5.32	-0.5	0.08	0.02	0.16	-2.05*	1.44	-0.59	0.81**	-0.14
YP ⊗ 4 #07-8 x Prabha	0.6	0.07	2.76	0.25	-0.27	0.41	1.84	-2.57*	1.25	7.06	0.32	4.85
YP ⊗ 4 #07-8 x KDMI-10	-0.11	0.33	-7.41	-1.35	-0.27	-0.23	-1.33	-1.54	-0.87	-3.34	1.39**	-2.82
YP ⊗ 4 #07-8 x CI-5	-0.49	-0.4	4.66	1.1	0.54	-0.18	-0.51	4.11**	-0.38	-3.72	-1.71**	-2.04
YP ⊗ 4 #07-9 x Prabha	-0.9	-1.43	-13.91	-1.04	-0.72	-0.55	-2.72*	-1.57	0.12	-5.04	0.12	-4.06

Single cross hybrids	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
YP ⊗ 4 #07-9 x KDMI-10	-0.11	-0.17	12.92	1.47	1.01	0.6	2.8*	0.96	0.64	6.26	1.79**	4.51
YP ⊗ 4 #07-9 x CI-5	1.01	1.6	0.99	-0.43	-0.29	-0.05	-0.08	0.61	-0.76	-1.22	-1.91**	-0.44
YP ⊗ 4 #07-10 x Prabha	0.43	0.74	-4.41	0.2	-0.19	0.31	1.81	-2.24*	-1.08	4.87	-1.87**	2.79
YP ⊗ 4 #07-10 x KDMI-10	0.22	-0.01	2.92	0.65	0.19	0.17	0.63	-0.21	-0.16	1.24	-0.24	0.79
YP ⊗ 4 #07-10 x CI-5	-0.66	-0.73	1.49	-0.85	0	-0.48	-2.44*	2.45*	1.24	-6.11	2.11**	-3.58
YP ⊗ 4 #07-11 x Prabha	-0.07	-0.1	0.59	0.38	0.18	-0.02	0.18	3.26**	0.74	0.82	-1.07**	0.1
YP ⊗ 4 #07-11 x KDMI-10	0.22	-0.34	-7.58	-0.32	-0.39	0.14	0.7	-1.21	-1.19	-0.78	-0.14	0.73
YP ⊗ 4 #07-11 x CI-5	-0.16	0.44	6.99	-0.06	0.21	-0.12	-0.88	-2.05*	0.45	-0.04	1.21**	-0.82
YP ⊗ 4 #07-12 x Prabha	0.1	-0.76	9.09	0.71	0.84	0.75	3.94**	-3.41**	-0.93	10.55	1.02**	5.85
YP ⊗ 4 #07-12 x KDMI-10	-0.11	0.99	-4.58	-0.48	-0.27	-0.2	-0.93	1.13	0.89	-4.27	0.19	-2.02
YP ⊗ 4 #07-12 x CI-5	0.01	-0.23	-4.51	-0.23	-0.57	-0.55	-3.01*	2.28*	0.04	-6.29	-1.21**	-3.83
YP ⊗ 4 #07-13 x Prabha	0.76	0.57	-9.07	-1.3	-0.49	-0.05	-0.22	1.26	0.4	-0.29	-1.05**	-0.25
YP ⊗ 4 #07-13 x KDMI-10	1.06	1.33	-0.75	-0.15	0.04	0	0.2	-1.21	-0.12	0.42	1.48**	0.06
YP ⊗ 4 #07-13 x CI-5	-1.82*	-1.9	9.82	1.45	0.45	0.05	0.02	-0.05	-0.28	-0.13	-0.43	0.18
YP ⊗ 4 #07-14 x Prabha	0.6	0.07	0.26	-0.57	0.28	0.11	1.04	7.76**	0.42	0.81	-0.43	0.98
YP ⊗ 4 #07-14 x KDMI-10	-0.61	-0.17	-7.41	0.68	-0.6	-0.43	-2.73*	-3.21**	0.09	-4.25	0.29	-3.14
YP ⊗ 4 #07-14 x CI-5	0.01	0.1	7.16	-0.11	0.32	0.32	1.69	-4.55**	-0.51	3.44	0.14	2.17
YP ⊗ 4 #07-15 x Prabha	-1.4	-1.93	7.09	-1.44	-0.96	-1.05*	-6.99**	-9.91**	-0.35	-9.92	2.57**	-7.51
YP ⊗ 4 #07-15 x KDMI-10	0.39	0.33	-0.58	0.37	0.53	0.5	3.23**	5.63**	-0.02	4.51	-1.56**	3.07
YP ⊗ 4 #07-15 x CI-5	1.01	1.6	-6.51	1.07	0.43	0.55	3.76**	4.28**	0.37	5.41	-1.01**	4.43
YP ⊗ 4 #07-16 x Prabha	-0.57	0.57	2.09	-0.07	0.44	0.08	0.28	-3.41**	-1.95	0.72	0.68*	0.72
YP ⊗ 4 #07-16 x KDMI-10	0.72	0.83	-2.08	0.48	-0.57	-0.06	-0.3	0.13	1.28	-0.2	-0.14	-0.59
YP ⊗ 4 #07-16 x CI-5	-0.16	-1.4	-0.01	-0.41	0.13	-0.02	0.02	3.28**	0.67	-0.51	-0.54	-0.13
YP ⊗ 4 #07-17 x Prabha	0.76	1.07	-15.57	1.25	0.06	-0.02	-0.39	-2.41*	-0.75	-0.96	-1.13**	-0.58
YP ⊗ 4 #07-17 x KDMI-10	-0.44	-0.67	3.75	-2.05	-0.56	-0.46	-2.17	0.13	-1.12	-4.66	-1.01**	-3.16
YP ⊗ 4 #07-17 x CI-5	-0.32	-0.4	11.82	0.8	0.5	0.48	2.56*	2.28*	1.87	5.61	2.14**	3.74

Single cross hybrids	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
YP ⊗ 4 #07-18 x Prabha	0.26	0.07	14.26	1.93	-0.11	0.28	1.24	1.59	-0.5	2.92	0.73*	2.26
YP ⊗ 4 #07-18 x KDMI-10	0.06	-0.17	-4.41	-0.52	0.08	-0.16	-0.73	-1.37	0.83	-1.07	-0.34	-1.31
YP ⊗ 4 #07-18 x CI-5	-0.32	0.1	-9.84	-1.41	0.03	-0.12	-0.51	-0.22	-0.33	-1.84	-0.39	-0.95
YP ⊗ 4 #07-19 x Prabha	-0.07	-0.43	7.43	0.61	-0.07	0.31	1.58	-1.41	0.87	2.51	-0.2	1.99
YP ⊗ 4 #07-19 x KDMI-10	0.72	0.83	3.25	0.72	0.06	-0.13	-0.1	-3.87**	-0.06	-2.54	1.48**	-0.58
YP ⊗ 4 #07-19 x CI-5	-0.66	-0.4	-10.68	-1.33	0.01	-0.18	-1.48	5.28**	-0.81	0.02	-1.28**	-1.41
YP ⊗ 4 #07-20 x Prabha	0.1	-0.6	0.93	-0.17	0.16	-0.62	-3.06*	-4.24**	-1.2	-10.62	1.47**	-5.91
YP ⊗ 4 #07-20 x KDMI-10	-0.61	-0.34	0.75	-0.07	0.39	-0.16	-0.73	2.29*	-1.32	-2.61	-0.96**	-2.9
YP ⊗ 4 #07-20 x CI-5	0.51	0.94	-1.68	0.24	-0.55	0.78	3.79**	1.95*	2.52*	13.23*	-0.51	8.82*
YP ⊗ 4 #07-21 x Prabha	0.6	0.9	-12.57	-0.45	0.28	0.55	3.44**	-0.07	-0.2	6.44	-0.73*	4.19
YP ⊗ 4 #07-21 x KDMI-10	-0.61	-1.34	6.75	-0.1	-0.29	-0.7	-4.73**	-1.54	-0.42	-7.22	-0.81**	-4.96
YP ⊗ 4 #07-21 x CI-5	0.01	0.44	5.82	0.55	0.01	0.15	1.29	1.61	0.62	0.77	1.54**	0.77
YP ⊗ 4 #07-22 x Prabha	-0.07	-0.6	-4.91	-0.44	-0.82	-0.29	-1.36	1.43	-3.88**	-2.26	-1.83**	-2.16
YP ⊗ 4 #07-22 x KDMI-10	-0.28	0.16	7.92	0.37	1.06	-0.03	-0.23	0.96	1.24	-0.23	1.49**	-0.16
YP ⊗ 4 #07-22 x CI-5	0.34	0.44	-3.01	0.07	-0.24	0.32	1.59	-2.39*	2.64*	2.49	0.34	2.32
YP ⊗ 4 #07-23 x Prabha	0.43	0.57	-6.74	-0.69	-0.31	-0.85	-4.62**	3.26**	-1.36	-9.85	0.22	-6.31
YP ⊗ 4 #07-23 x KDMI-10	-0.28	-0.17	4.59	1.52	0.48	1*	5.1**	-0.71	1.71	11.5	-0.51	8.18
YP ⊗ 4 #07-23 x CI-5	-0.16	-0.4	2.16	-0.83	-0.17	-0.15	-0.48	-2.55*	-0.35	-1.65	0.29	-1.87
YP ⊗ 4 #07-24 x Prabha	0.26	0.24	-1.57	1.25	0.39	0.68	3.98**	-0.07	1.79	11.02	-1.55**	6.49
YP ⊗ 4 #07-24 x KDMI-10	-0.44	-0.51	-1.75	-1	-0.57	-0.46	-2.5*	-2.04*	0.21	-7.92	-0.52	-3.93
YP ⊗ 4 #07-24 x CI-5	0.18	0.27	3.32	-0.25	0.18	-0.22	-1.48	2.11*	-2	-3.09	2.07**	-2.56
YP ⊗ 4 #07-25 x Prabha	-0.4	-0.26	-2.07	-1.44	-0.57	-0.15	-1.26	-2.74**	0.99	-2.39	-1.55**	-1.96
YP ⊗ 4 #07-25 x KDMI-10	0.39	-0.01	2.25	-0.08	0.06	-0.1	-0.03	4.29**	-0.59	-2.35	-0.82**	-1.12
YP ⊗ 4 #07-25 x CI-5	0.01	0.27	-0.18	1.52	0.51	0.25	1.29	-1.55	-0.4	4.74	2.37**	3.09
YP ⊗ 4 #07-26 x Prabha	0.6	0.4	1.59	0.21	0.36	0.18	0.98	1.26	-1.6	0.8	0.45	0.51
YP ⊗ 4 #07-26 x KDMI-10	-0.11	-0.34	5.92	1.07	0.34	0.54	2.5*	1.79	1.28	9.91	-0.17	5.6

Single cross hybrids	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
YP ⊗ 4 #07-26 x CI-5	-0.49	-0.06	-7.51	-1.28	-0.7	-0.72	-3.48**	-3.05**	0.32	-10.71	-0.28	-6.11
YP ⊗ 4 #07-27 x Prabha	-0.4	-0.76	5.26	1.51	0.27	0.01	0.18	-0.57	-0.48	0.28	-1.27**	0.28
YP ⊗ 4 #07-27 x KDMI-10	-1.11	-0.51	0.59	-0.53	-0.05	-0.33	-1.4	-1.04	-2.36*	-4.37	1.21**	-2.97
YP ⊗ 4 #07-27 x CI-5	1.51	1.27	-5.84	-0.98	-0.22	0.32	1.22	1.61	2.84*	4.08	0.06	2.69
YP ⊗ 4 #07-28 x Prabha	-0.57	-0.43	-6.07	-0.19	-0.44	-0.39	-2.06	4.09**	-0.1	-6.47	-0.37	-3.99
YP ⊗ 4 #07-28 x KDMI-10	-0.28	-0.17	0.25	-0.18	-0.16	0.27	1.17	-2.37*	-0.07	3.28	0.01	2.76
YP ⊗ 4 #07-28 x CI-5	0.84	0.6	5.82	0.37	0.6	0.12	0.89	-1.72	0.17	3.19	0.36	1.23
YP ⊗ 4 #07-29 x Prabha	-1.07	-1.43	-1.07	-0.87	0.24	-0.32	-1.96	-1.41	0.92	-5.91	0.67*	-2.83
YP ⊗ 4 #07-29 x KDMI-10	0.72	0.83	-3.25	-1.12	-0.57	0.14	0.87	0.13	-0.01	3.59	0.44	1.32
YP ⊗ 4 #07-29 x CI-5	0.34	0.6	4.32	1.99	0.33	0.18	1.09	1.28	-0.91	2.32	-1.11**	1.52
CD at 5%	2.34	3.16	29.78	3.89	1.97	1.28	3.40	2.74	3.12	18.12	0.84	11.76
CD at 1%	3.11	4.20	39.56	5.16	2.61	1.71	4.52	3.64	4.14	24.07	1.12	15.63
CV%	1.18	1.60	15.04	1.96	0.99	0.65	1.71	1.39	1.57	9.15	0.43	5.94

*****-Significant At 5% Level ******-Significant at 1% level

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 cob
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)