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RESEARCH PAPER

Heterosis studies for drought tolerant and grain yield traits in maize (*Zea mays* L.)

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Abstract : The present study was conducted to assess heterosis for drought tolerant and grain yield traits in maize. Seventy F_1s generated by crossing ten drought tolerant lines with seven drought susceptible testers were evaluated. The ratio of sca / gca variance revealed that there was preponderance of non additive gene action in the expression of all the traits under study. Among the hybrids, significant standard heterosis over NAH-2049 and NAH-1137 in the desirable direction was exhibited by many crosses for all the characters. Four hybrids SKV-70 × SKV-58, SKV-375 ×SKV-57, SKV-156 × SKV-5 and SKV-69 × CML-322 showed positive standard heterosis for all the drought tolerant traits *viz.*, SPAD chlorophyll meter reading (SCMR), specific leaf area(SLA), anthesis silking interval (ASI), carbon isotope discrimination ($\Delta^{13}C$) and yield, These crosses are from parents with high x low, low × low overall GCA effects. Top ranking hybrids were found to have high (H) heterosis status for several characters studied. Nearly 50 per cent (36 out of 70) hybrids had high overall heterosis.

Key Words : SPAD chlorophyll meter reading (SCMR), Specific leaf area (SLA), Anthesis silking interval (ASI), Carbon isotope discrimination ($\Delta^{13}C$)

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INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop among the cereal crops grown in India. Maize grain is gaining popularity in our country due to huge demand, particularly for poultry feed industry. Besides, maize has diversified uses as food and industrial raw materials. Maize acreage and production have an increasing tendency with the introduction of hybrids due to its high yield potential.

A good number of inbreds developed recently is available at the All India Coordinated Research Project on Maize, Zonal Agricultural Research Station, Mandya whose combining ability has not yet been studied for utilization in hybrid development programme. Most efficient use of such materials would be possible only when adequate information on the amount and type of genetic variation and combining ability effects in the materials is available. A wide array of biometrical tools is available to breeders for characterizing genetic control of economically important traits as a guide to decide upon an appropriate breeding methodology to involve in hybrid breeding. The present investigation was carried out to determine breeding value of genotypes, nature and magnitude of gene action and heterosis for various yield and other important traits in maize (*Zea mays* L.). Line x tester mating design developed by Kempthorne (1957), which provides reliable information on the general and specific combining ability effects of parents and their hybrid combinations was used to generate the information. The design has been widely used in maize by several workers and continues to be applied in quantitative genetic studies in maize (Joshi *et al*., 2002; Sharma *et al*., 2004).

Thus, the objective of the present investigation was to estimate heterosis for drought tolerant traits and grain yield traits.

MATERIALS AND METHODS

Ten drought tolerant lines and seven drought

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susceptible testers were mated in a line x tester design during summer 2009. The resulting 70 F_1s, their parents and two checks NAH 2049 and NAH-1137 were grown in a Randomized Complete Block Design with two replications at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bangalore, which is located at a latitude of 12° 30' N, longitude of 76° 50' E and altitude of 694.65 meters above mean sea level (MSL). The spacing between rows was 75 cm and between plants was 30 cm and one plant per hill was maintained. Observations were recorded on four drought tolerant traits *viz.*,SPAD chlorophyll meter reading (SCMR), specific leaf area(SLA), anthesis silking interval (ASI), carbon isotope discrimination ($\Delta^{13}C$) and yield traits.

The data were subjected for analysis of variance for all the characters studied as per the method suggested by Panse and Sukhatme (1967). The variance of combining ability was estimated as per the procedure developed by Kempthorne (1957). The mean squares for GCA and SCA were tested against desired error variance. Heterosis was computed as per the method of Tuner (1953) and Hayes *et al.* (1955). Overall status of crosses with respect to heterosis was determined by following a method suggested by Arunachalam and Bandyopadhyay (1979) that was slightly modified by Mohan Rao *et al.* (2004).

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that mean squares due to lines, testers and line x testers were significant for all the characters (Table 1a and 1b). This indicated that both additive and non additive gene effects were important in the genetic expression of most of the traits studied. These results are in general agreement with those of Joshi *et al.* (2002) whereas, Sharma *et al*. (2004) reported preponderance of additive genetic effects. The mean sum of squares for crosses was highly significant, which indicated the diverse performance of different cross combinations for all traits. The parents versus hybrids mean sum of squares were highly significant for all traits, which revealed the presence of heterosis due to the significant difference in the mean performance of hybrids and parents.

The data showed that, among sixteen characters studied all manifested higher degree of sca variance as compared to gca variance. The higher sca variance revealed the predominance of non additive genetic variance. Contrarily, importance of additive gene effects was reported by Alamnie *et al.* (2006). From the results it was evident that per cent contribution of line x tester interaction appeared high to the bulk of the variation observed in hybrids. Similar findings were reported for ear length and ear diameter by Kanta *et al.* (2005).

Highest percentage of heterosis for grain yield per plant over standard checks was exhibited by the crosses *viz.*, NAI-148 × CML-322, CML-249 × HKI-1040, NAI-147 × SKV-5, NAI-148 × HKI-1040, NAI-147 × HKI-1040, CML-407 × SKV-19, CML-407×HKI-1040, SKV-69 × SKV-5, SKV-69 × KUI-1411,

Table 1a: Per cent heterosis over midparent (MP), standard checks (SH) of single cross hybrids for drought tolerant, yield and yield contributing characters in maize

Single cross hybrids	SCMR values			Specific leaf area(SLA)			ASI			$\Delta^{13}C$		
	MP	SH_1	SH_2	MP	SH_1	SH_2	MP	SH_1	SH_2	MP	SH_1	SH_2
SKV-70 XKUI-1411	-19.24 **	-56.03 **	-34.92 **	-6.54 **	-30.10 **	-23.15 **	20.00	0.00	-40.00	-16.85 **	-6.07 **	-18.98 **
SKV-70 X CML-322	13.20 **	-37.82 **	-7.97 **	-24.04 **	-54.59 **	-50.08 **	27.27	133.33	40.00	14.45 **	24.56 **	7.45 **
SKV-70 X HKI-1040	-15.24 **	-51.44 **	-28.12 **	7.94 **	-35.89 **	-29.52 **	-53.85	0.00	-40.00	-9.50 **	-2.97 **	-16.30 **
SKV-70 X SKV-5	-32.73 **	-62.39 **	-44.32 **	20.30 **	-28.55 **	-21.45 **	-62.50 **	0.00	-40.00	8.69 **	13.09 **	-2.44 **
SKV-70 X SKV-58	-5.69 **	-45.58 **	-19.45 **	17.74 **	-36.36 **	-30.03 **	-60.00	-33.33	-60.00	-8.40 **	-5.13 **	-18.16 **
SKV-70 XSKV-19	-31.23 **	-60.22 **	-41.12 **	27.37 **	-31.79 **	-25.01 **	-20.00	33.33	-20.00	20.18 **	23.35 **	6.40 **
SKV-70 X SKV-57	15.95 **	-34.00 **	-2.31	-16.77 **	-55.69 **	-51.28 **	-45.45	0.00	-40.00	-0.72	1.75 **	-12.22 **
CML-407 X KUI-1411	-23.23 **	-58.76 **	-38.96 **	-13.60 **	-33.50 **	-26.89 **	66.67	66.67	0.00	-20.60 **	-10.26 **	-22.58 **
CML-407 X CML-322	5.38 **	-42.88 **	-15.45 **	-27.65 **	-55.18 **	-50.72 **	-33.33	33.33	-20.00	-2.23 **	6.48 **	-8.15 **
CML-407 X HKI-1040	-8.82 **	-48.42 **	-23.65 *	49.02 **	-8.25 **	0.87	14.29	166.67 *	60.00	-2.26 **	4.86 **	-9.55 **
CML-407 X SKV-5	6.92 **	-40.99 **	-12.65 *	53.93 **	-5.23 **	4.19 **	-52.94 *	33.33	-20.00	-3.95 **	0.00	-13.74 **
CML-407 X SKV-58	29.69 **	-26.11 **	9.38 *	18.56 **	-33.34 **	-26.71 **	-9.09	66.67	0.00	6.38 **	10.26 **	-4.89 **
CML-407 X SKV-19	-4.94 **	-45.71 **	-19.63 *	-3.87 **	-46.43 **	-41.10 **	27.27	133.33	40.00	-11.83 **	-9.45 **	-21.89 **
CML-407X SKV-57	-21.59 **	-55.94 **	-34.78 *	50.78 **	-16.44 **	-8.14 **	-50.00	0.00	-40.00	19.34 **	22.40 **	5.59 **
NAI-148 XKUI-1411	6.13 **	-46.51 **	-20.82 *	-44.69 **	-57.12 **	-52.86 **	-20.00	-33.33	-60.00	-18.80 **	-7.02 **	-19.79 **

Table 1a: Contd.........

Table 1a: Contd.........

NAI-148 X CML-322	-16.91 **	-57.72 **	-37.42 *	7.14 **	-33.01 **	-26.35 **	-45.45	0.00	-40.00	-1.22 *	9.04 **	-5.94 **
NAI-148 X HKI-1040	-36.33 **	-66.10 **	-49.81 *	14.54 **	-28.83 **	-21.75 **	-38.46	33.33	-20.00	-7.07 **	1.08	-12.81 **
NAI-148 X SKV-5	16.22 **	-39.71 **	-10.75 *	1.38 *	-37.01 **	-30.74 **	-62.50 **	0.00	-40.00	3.13 **	8.91 **	-6.05 **
NAI-148 X SKV-58	15.92 **	-37.80 **	-7.92 *	-17.76 **	-53.29 **	-48.65 **	-60.00	-33.33	-60.00	-0.51	4.59 **	-9.78 **
NAI-148 XSKV-19	-16.69 **	-55.18 **	-33.65 *	23.65 **	-30.39 **	-23.47 **	-20.00	33.33	-20.00	-3.76 **	0.27	-13.50 **
NAI-148 X SKV-57	25.71 **	-33.53 **	-1.60 n	-5.06 **	-46.85 **	-41.56 **	-27.27	33.33	-20.00	-5.97 **	-2.16 **	-15.60 **
CML-249XKUI-1411	1.25	-51.00 **	-27.48 *	-15.69 **	-32.97 **	-26.30 **	-14.29	0.00	-40.00	-15.66 **	-2.97 **	-16.30 **
CML-249 X CML-322	-22.35 **	-62.05 **	-43.82 *	17.47 **	-24.23 **	-16.70 **	-38.46	33.33	-20.00	-8.88 **	1.08	-12.81 **
CML-249 X HKI-1040	-47.22 **	-72.95 **	-59.96 *	-13.93 **	-44.82 **	-39.33 **	-60.00 *	0.00	-40.00	-8.77 **	-0.27	-13.97 **
CML-249 X SKV-5	-37.25 **	-68.71 **	-53.68 *	-2.28 **	-37.35 **	-31.12 **	-66.67 **	0.00	-40.00	1.34 *	7.56 **	-7.22 **
CML-249 X SKV-58	-26.17 **	-61.87 **	-43.55 *	18.72 **	-30.23 **	-23.29 **	-33.33	33.33	-20.00	-4.34 **	1.08	-12.81 **
CML-249XSKV-19	-11.26 **	-54.04 **	-31.97 *	32.43 **	-22.83 **	-15.16 **	-33.33	33.33	-20.00	8.12 **	13.23 **	-2.33 **
CML-249 X SKV-57	43.30 **	-27.10 **	7.90 *	-10.80 **	-48.30 **	-43.16 **	-69.23 *	-33.33	-60.00	-6.71 **	-2.43 **	-15.83 **
CML-357XKUI-1411	20.62 **	-41.20 **	-12.96 *	-20.50 **	-36.69 **	-30.39 **	0.00	0.00	-40.00	-22.68 **	-10.53 **	-22.82 **
CML-357 X CML-322	-28.91 **	-65.00 **	-48.19 *	-9.42 **	-41.46 **	-35.64 **	-50.00	0.00	-40.00	-11.37 **	-1.08	-14.67 **
CML-357 X HKI-1040	-2.57	-49.73 **	-25.58 *	47.00 **	-5.56 **	3.83 **	-57.14 *	0.00	-40.00	-9.57 **	-0.54	-14.20 **
CML-357 X SKV-5	28.35 **	-35.53 **	-4.58 *	13.85 **	-26.86 **	-19.58 **	-29.41	100.00	20.00	-4.74 **	1.75 **	-12.22 **
CML-357 X SKV-58	-6.47 **	-51.36 **	-28.00 *	-50.06 **	-70.58 **	-67.66 **	-27.27	33.33	-20.00	-26.78 **	-22.13 **	-32.83 **
CML-357XSKV-19	48.57 **	-22.52 **	14.68 *	-55.45 **	-73.98 **	-71.40 **	-9.09	66.67	0.00	-4.87 **	0.27	-13.50 **
CML-357 X SKV-57	-4.96 *	-51.31 **	-27.93 *	-48.89 **	-70.31 **	-67.35 **	0.00	100.00	20.00	-25.00 **	-21.05 **	-31.90 **
NAI-143 XKUI-1411	-24.67 **	-65.11 **	-48.36 *	1.81 **	-18.81 **	-10.74 **	33.33	33.33	-20.00	-14.82 **	-1.08	-14.67 **
NAI-143 X CML-322	5.42 *	-50.67 **	-26.98 *	-19.80 **	-48.08 **	-42.92 **	-33.33	33.33	-20.00	-17.47 **	-7.56 **	-20.26 **
NAI-143X HKI-1040	23.55 **	-39.26 **	-10.09 *	-34.18 **	-57.64 **	-53.43 **	-42.86	33.33	-20.00	-20.90 **	-12.69 **	-24.68 **
NAI-143 X SKV-5	22.61 **	-41.41 **	-13.27 *	-34.27 **	-57.70 **	-53.49 **	-52.94 *	33.33	-20.00	-5.73 **	1.08	-12.81 **
NAI-143 X SKV-58	26.81 **	-37.14 **	-6.95 *	-21.48 **	-53.66 **	-49.05 **	81.82 *	233.33 **	100.00 *	-6.32 **	0	-13.74 **
NAI-143 XSKV-19	19.84 **	-40.42 **	-11.81 *	-10.45 **	-47.60 **	-42.39 **	-9.09	66.67	0.00	11.35 **	17.81 **	1.63 **
NAI-143 X SKV-57	-10.50 **	-56.33 **	-35.36 *	19.87 **	-30.23 **	-23.29 **	-50.00	0.00	-40.00	-7.66 **	-2.43 **	-15.83 **
SKV-69 XKUI-1411	81.08 **	-17.16 **	22.63 *	-14.96 **	-31.26 **	-24.43 **	14.29	33.33	-20.00	-22.92 **	-9.45 **	-21.89 **
SKV-69 X CML-322	86.66 **	-13.70 **	27.75 *	23.70 **	-18.58 **	-10.49 **	-38.46	33.33	-20.00	-17.02 **	-5.94 **	-18.86 **
SKV-69X HKI-1040	53.22 **	-25.53 **	10.23 *	19.54 **	-21.78 **	-14.01 **	-33.33	66.67	0.00	-17.75 **	-8.10 **	-20.72 **
SKV-69 X SKV-5	5.03 *	-50.40 **	-26.58 *	-30.93 **	-54.81 **	-50.31 **	-22.22	133.33	40.00	-23.31 **	-16.73 **	-28.17 **
SKV-69 X SKV-58	39.97 **	-31.40 **	1.54 n	-25.20 **	-55.05 **	-50.59 **	-50.00	0.00	-40.00	-18.23 **	-11.61 **	-23.75 **
SKV-69 XSKV-19	-21.53 **	-61.43 **	-42.91 *	-38.34 **	-63.26 **	-59.60 **	-16.67	66.67	0.00	10.71 **	18.62 **	2.33 **
SKV-69X SKV-57	54.67 **	-25.40 **	10.42 *	-14.79 **	-49.49 **	-44.47 **	-38.46	33.33	-20.00	-14.88 **	-8.91 **	-21.42 **
NAI-156 XKUI-1411	-5.73 *	-56.65 **	-35.84 *	-11.94 **	-30.34 **	-23.42 **	42.86	66.67	0.00	-25.14 **	-12.42 **	-24.45 **
NAI-156 X CML-322	66.98 **	-22.41 **	14.85 *	-27.67 **	-53.64 **	-49.03 **	7.69	133.33	40.00	-23.61 **	-13.77 **	-25.61 **
NAI-156X HKI-1040	-34.86 **	-68.19 **	-52.91 *	20.53 **	-23.21 **	-15.58 **	-6.67	133.33	40.00	-20.80 **	-11.88 **	-23.98 **
NAI-156 X SKV-5	88.63 **	-10.48 **	32.51 *	-59.18 **	-73.99 **	-71.41 **	0.00	200.00 **	80.00	-16.48 **	-9.72 **	-22.12 **
NAI-156 X SKV-58	25.21 **	-38.34 **	-8.74 *	-35.00 **	-62.06 **	-58.29 **	16.67	133.33	40.00	-13.61 **	-7.02 **	-19.79 **

Table 1a. Contd...............

Table 1a: Contd.........

NAI-156 XSKV-19	17.68 **	-41.89 **	-13.98 *	-28.67 **	-58.72 **	-54.62 **	-16.67	66.67	0.00	25.11 **	33.47 **	15.13 **
NAI-156X SKV-57	32.59 **	-35.75 **	-4.89 *	-20.88 **	-54.46 **	-49.94 **	-38.46	33.33	-20.00	19.44 **	27.26 **	9.78 **
NAI-147 XKUI-1411	41.71 **	-36.98 **	-6.72 *	1.70 **	-16.57 **	-8.27 **	100.00	133.33	40.00	-18.19 **	-3.51 **	-16.76 **
NAI-147 X CML-322	72.53 **	-22.44 **	14.81 *	-19.04 **	-45.73 **	-40.34 **	7.69	133.33	40.00	4.45 **	18.89 **	2.56 **
NAI-147X HKI-1040	-7.21 **	-56.09 **	-35.00 *	4.82 **	-30.14 **	-23.19 **	-33.33	66.67	0.00	-9.68 **	1.35 *	-12.57 **
NAI-147 X SKV-5	-28.38 **	-67.09 **	-51.29 *	-6.19 **	-37.48 **	-31.26 **	-22.22	133.33	40.00	-8.91 **	-0.67	-14.32 **
NAI-147 X SKV-58	-8.39 **	-56.27 **	-35.27 *	-15.06 **	-47.93 **	-42.75 **	0.00	100	20.00	-5.41 **	2.70 **	-11.41 **
NAI-147 XSKV-19	-24.60 **	-63.90 **	-46.57 *	32.95 **	-19.15 **	-11.12 **	-33.33	33.33	-20.00	-2.57 **	4.86 **	-9.55 **
NAI-147X SKV-57	59.90 **	-24.93 **	11.13 *	-17.48 **	-50.08 **	-45.11 **	-23.08	66.67	0.00	3.08 **	10.80 **	-4.42 **
SKV-66 XKUI-1411	-2.14	-58.96 **	-39.25 *	-23.46 **	-33.06 **	-26.40 **	42.86	66.67	0.00	-18.30 **	-2.70 **	-16.07 **
SKV-66 X CML-322	29.33 **	-45.13 **	-18.78 *	-3.30 **	-29.93 **	-22.97 **	-38.46	33.33	-20.00	-11.15 **	2.16 **	-11.87 **
SKV-66X HKI-1040	22.68 **	-45.05 **	-18.66 *	-28.58 **	-48.53 **	-43.41 **	-60.00 *	0.00	0.00	-16.07 **	-4.86 **	-17.93 **
SKV-66 X SKV-5	27.02 **	-44.85 **	-18.37 *	-31.15 **	-50.38 **	-45.44 **	-66.67 **	0.00	-40.00	7.65 **	18.62 **	2.33 **
SKV-66 X SKV-58	45.79 **	-34.10 **	-2.45 n	-31.07 **	-54.00 **	-49.43 **	-33.33	33.33	-20.00	3.08 **	13.09 **	-2.44 **
SKV-66 XSKV-19	-16.55 **	-62.16 **	-43.99 *	-24.96 **	-50.30 **	-45.36 **	-50.00	0.00	-40.00	-8.06 **	0.00	-13.74 **
SKV-66X SKV-57	53.47 **	-31.83 **	0.92 n	-0.83	-34.63 **	-28.13 **	7.69	133.33	40.00	6.71 **	15.92 **	0.00
S.E.±	0.37	0.30	0.30	0.61	0.50	0.50	0.94	0.76	0.76	0.02	0.02	0.02

Table 1b: Specific combining ability effects of single cross hybrids for yield characters in maize

Single cross hybrids	Number of kernels per row			Shelling percentage			100- grain weight (g)			Yield per plant (g)		
	MP	SH_1	SH_2	MP	SH_1	SH_2	MP	SH_1	SH_2	MP	SH_1	SH_2
SKV-70 XKUI-1411	53.30 **	17.33 **	19.93 **	-6.69 **	-2.98	9.01 **	43.91 **	-2.95	-3.84	21.33 **	-28.79 **	-9.02 **
SKV-70 X CML-322	-2.89 **	-15.16 **	-13.28 **	-6.13 **	-0.68	11.60 **	34.09 **	-24.17 **	-24.86 **	68.55 **	-28.26 **	-8.35 **
SKV-70 X HKI-1040	37.04 **	15.52 **	18.08 **	-3.76 *	0.24	12.63 **	25.61 **	-19.00 **	-19.74 **	48.02 **	-17.47 **	5.44 *
SKV-70 X SKV-5	48.95 **	28.52 **	31.37 **	-2.5	-3.75 *	8.15 **	48.61 **	-16.24 **	-17.00 **	53.59 **	-28.35 **	-8.45 **
SKV-70 X SKV-58	24.79 **	9.03 **	11.44 **	-4.60 **	-3.14	8.83 **	55.14 **	-16.42 **	-17.18 **	29.96 **	-27.85 **	-7.82 **
SKV-70 XSKV-19	-11.26 **	-1.81	0.37	-5.60 **	-0.99	11.25 **	99.33 **	9.59	8.59	31.31 **	-18.33 **	4.35
SKV-70 X SKV-57	2.75 **	-5.42 **	-3.32 **	-1.9	-4.92 **	6.84 **	40.32 **	-18.45 **	-19.20 **	57.68 **	-34.58 **	-16.42 **
CML-407 X KVI-1411	31.62 **	-7.58 **	-5.54 **	-1.64	-2.02	10.09 **	-2.73	-24.35 **	-25.05 **	12.00 **	-30.77 **	-11.55 **
CML-407 X CML-322	22.49 **	-0.72	1.48	-3.54 *	-2.14	9.95 **	28.83 **	-13.84 **	-14.63 **	76.04 **	-19.59 **	2.74
CML-407 X HKI-1040	36.11 **	6.14 **	8.49 **	-5.55 **	-5.74 **	5.91 **	3.58	-22.51 **	-23.22 **	43.91 **	-15.28 **	8.24 **
CML-407 X SKV-5	47.18 **	17.69 **	20.30 **	2.13	-3.63 *	8.28 **	43.02 **	-4.61	-5.48	63.68 **	-18.53 **	4.09
CML-407 X SKV-58	12.25 **	-9.03 **	-7.01 **	-3.13	-5.87 **	5.76 **	31.32 **	-15.68 **	-16.45 **	32.05 **	-22.58 **	-1.08
CML-407 X SKV-19	-17.65 **	-14.08 **	-12.18 **	-2.55	-2.04	10.07 **	1.13	-33.95 **	-34.55 **	30.41 **	-14.82 **	8.83 **
CML-407X SKV-57	27.16 **	9.03 **	11.44 **	5.63 **	-2.22	9.86 **	15.09 *	-21.22 **	-21.94 **	-1.31	-55.98 **	-43.76 **
NAI-148 XKUI-1411	28.64 **	-1.08	1.11	-15.65 **	-14.56 **	-4	8.99	-27.31 **	-27.97 **	-2.64	-42.48 **	-26.51 **
NAI-148 X CML-322	49.79 **	31.41 **	34.32 **	-0.54	2.55	15.23 **	54.38 **	-13.84 **	-14.63 **	147.82 **	6.44 **	35.99 **

Table 1b: Contd.........

Table 1b: Contd...............

NAI-148 X HKI-1040	79.96 **	52.35 **	55.72 **	-3.61 *	-2.2	9.88 **	59.77 **	1.85	0.91	67.32 **	-6.06 **	20.02 **
NAI-148 X SKV-5	-6.25 **	-18.77 **	-16.97 **	-0.87	-4.81 *	6.95 **	18.41 *	-34.13 **	-34.73 **	-1.17	-53.51 **	-40.60 **
NAI-148 X SKV-58	-10.70 **	-21.66 **	-19.93 **	-5.09 **	-6.19 **	5.40 *	61.11 **	-14.39 **	-15.17 **	3.24	-42.28 **	-26.26 **
NAI-148 XSKV-19	-23.25 **	-14.80 **	-12.92 **	-8.35 **	-6.35 **	5.23 *	51.02 **	-18.08 **	-18.83 **	-13.74 **	-46.01 **	-31.02 **
NAI-148 X SKV-57	-3.52 **	-10.83 **	-8.86 **	2.81	-3.12	8.86 **	54.98 **	-11.07 *	-11.88 *	63.01 **	-31.74 **	-12.79 **
CML-249XKUI-1411	44.87 **	-18.41 **	-16.61 **	-1.14	-1.74	10.40 **	10.7	-16.97 **	-17.73 **	46.51 **	-28.44 **	-8.58 **
CML-249 X CML-322	42.47 **	-4.33 **	-2.21 *	-13.30 **	-12.23 **	-1.38	19.42 **	-23.43 **	-24.13 **	51.80 **	-50.35 **	-36.56 **
CML-249 X HKI-1040	129.86 **	47.29 **	50.55 **	2.31	1.88	14.47 **	6.27	-23.43 **	-24.13 **	127.90 **	4.62 *	33.66 **
CML-249 X SKV-5	21.31 **	-19.86 **	-18.08 **	7.01 **	0.74	13.19 **	21.50 **	-22.32 **	-23.03 **	89.21 **	-30.36 **	-11.03 **
CML-249 X SKV-58	93.01 **	29.60 **	32.47 **	3.57 *	0.41	12.82 **	41.14 **	-13.28 *	-14.08 **	51.78 **	-30.69 **	-11.44 **
CML-249XSKV-19	2.20 *	-7.58 **	-5.54 **	-1.83	-1.53	10.64 **	32.74 **	-16.97 **	-17.73 **	48.89 **	-22.06 **	-0.42
CML-249 X SKV-57	7.54 **	-22.74 **	-21.03 **	3.28	-4.63 *	7.16 **	1.12	-33.58 **	-34.19 **	101.54 **	-36.24 **	-18.54 **
CML-357XKUI-1411	32.73 **	5.42 **	7.75 **	-6.14 **	-6.48 **	5.08 *	40.00 **	-10.89 *	-11.70 *	-33.22 **	-58.49 **	-46.97 **
CML-357 X CML-322	1.6	-8.30 **	-6.27 **	0.02	1.49	14.03 **	73.43 **	-8.49	-9.32	16.86 **	-46.21 **	-31.28 **
CML-357 X HKI-1040	8.49 **	-5.42 **	-3.32 **	-3.36 *	-3.54	8.38 **	39.82 **	-15.13 **	-15.90 **	-4.93	-43.70 **	-28.07 **
CML-357 X SKV-5	-21.46 **	-29.96 **	-28.41 **	0.91	-4.76 *	7.01 **	67.37 **	-11.99 *	-12.80 *	43.10 **	-28.28 **	-8.37 **
CML-357 X SKV-58	3.20 **	-6.86 **	-4.80 **	-1.57	-4.33 *	7.49 **	78.27 **	-10.70 *	-11.52 *	-2.21	-42.32 **	-26.31 **
CML-357XSKV-19	-25.60 **	-15.52 **	-13.65 **	-3.95 *	-3.42	8.51 **	121.98 **	13.65 *	12.61 *	7.43 **	-29.46 **	-9.87 **
CML-357 X SKV-57	11.03 **	5.42 **	7.75 **	0.91	-6.57 **	4.97 *	82.34 **	-0.92	-1.83	-24.70 **	-66.15 **	-56.75 **
NAI-143 XKUI-1411	38.42 **	-8.30 **	-6.27 **	-6.06 **	-5.87 **	5.76 **	18.20 **	-12.55 *	-13.35 *	8.00 **	-25.32 **	-4.59
NAI-143 X CML-322	26.46 **	-2.53 *	-0.37	-3.86 *	-1.9	10.22 **	1.75	-35.79 **	-36.38 **	7.29 *	-43.12 **	-27.33 **
NAI-143X HKI-1040	-6.34 **	-30.69 **	-29.15 **	-5.61 **	-5.24 **	6.47 **	18.96 **	-15.50 **	-16.27 **	6.61 *	-29.42 **	-9.82 **
NAI-143 X SKV-5	32.54 **	0.72	2.95 **	4.82 **	-0.48	11.82 **	8.5	-31.73 **	-32.36 **	28.90 **	-26.39 **	-5.95 *
NAI-143 X SKV-58	21.31 **	-6.50 **	-4.43 **	-1.52	-3.72 *	8.18 **	44.43 **	-12.73 *	-13.53 *	13.36 **	-25.22 **	-4.45
NAI-143 XSKV-19	0.72	1.08	3.32 **	-9.53 **	-8.52 **	2.78	45.43 **	-10.52 *	-11.33 *	-19.48 **	-41.50 **	-25.26 **
NAI-143 X SKV-57	22.74 **	0.36	2.58 *	2.94	-4.11 *	7.74 **	38.09 **	-10.70 *	-11.52 *	-29.51 **	-63.39 **	-53.23 **
SKV-69 XKUI-1411	24.61 **	1.44	3.69 **	2.93	0.61	13.04 **	9.05	-16.61 **	-17.37 **	71.19 **	-15.69 **	7.72 **
SKV-69 X CML-322	0.2	-7.58 **	-5.54 **	-4.97 **	-5.37 **	6.32 **	16.46 *	-23.62 **	-24.31 **	84.92 **	-38.75 **	-21.75 **
SKV-69X HKI-1040	-19.03 **	-27.80 **	-26.20 **	1.42	-0.69	11.59 **	26.22 **	-7.20	-8.04	81.78 **	-15.81 **	7.56 **
SKV-69 X SKV-5	19.60 **	9.03 **	11.44 **	8.37 **	0.22	12.61 **	55.71 **	1.85	0.91	126.89 **	-15.56 **	7.88 **
SKV-69 X SKV-58	-24.07 **	-29.96 **	-28.41 **	-4.57 **	-9.06 **	2.18	7.92	-32.10 **	-32.72 **	29.52 **	-40.32 **	-23.75 **
SKV-69 XSKV-19	-14.06 **	-0.72	1.48	-4.22 *	-5.52 **	6.16 **	31.70 **	-15.68 **	-16.45 **	-7.50 *	-51.20 **	-37.65 **
SKV-69X SKV-57	-15.08 **	-17.69 **	-15.87 **	6.88 **	-3.06	8.92 **	6.32	-28.60 **	-29.25 **	111.88 **	-32.10 **	-13.25 **
NAI-156 XKUI-1411	96.36 **	16.97 **	19.56 **	-2.1	-2.36	9.71 **	26.16 **	-12.36 *	-13.16 *	7.47 **	-29.19 **	-9.53 **
NAI-156 X CML-322	2.05	-28.16 **	-26.57 **	-7.78 **	-6.33 **	5.25 *	26.93 **	-25.65 **	-26.33 **	-29.87 **	-65.10 **	-55.41 **
NAI-156X HKI-1040	82.31 **	22.74 **	25.46 **	-7.00 **	-7.07 **	4.41 *	49.24 **	-0.74	-1.65	-22.93 **	-51.48 **	-38.01 **

Table 1b: Contd...........

Table 1b: Contd..........

NAI-156 X SKV-5	23.96 **	-14.08 **	-12.18 **	1.64	-3.97 *	7.90 **	48.50 **	-13.28 *	-14.08 **	6.88 *	-42.44 **	-26.46 **
NAI-156 X SKV-58	2.56 *	-27.80 **	-26.20 **	-3.43 *	-6.04 **	5.57 **	107.92 **	16.24 **	15.17 **	-17.27 **	-48.12 **	-33.71 **
NAI-156 XSKV-19	-28.32 **	-32.85 **	-31.37 **	-5.94 **	-5.34 **	6.36 **	59.55 **	-9.04	-9.87	-23.55 **	-46.94 **	-32.21 **
NAI-156X SKV-57	48.08 **	11.19 **	13.65 **	3.14	-4.40 *	7.42 **	24.85 **	-24.91 **	-25.59 **	38.47 **	-32.58 **	-13.87 **
NAI-147 XKUI-1411	28.41 **	0.36	2.58 *	-1.35	-3.67 *	8.23 **	52.41 **	-12.55 *	-13.35 *	20.71 **	-33.45 **	-14.98 **
NAI-147 X CML-322	12.78 **	0.36	2.58 *	-8.91 **	-9.39 **	1.81	106.35 **	-4.06	-4.94	112.75 **	-17.03 **	6.01 *
NAI-147X HKI-1040	39.92 **	20.22 **	22.88 **	-0.93	-3.09	8.89 **	40.00 **	-23.80 **	-24.50 **	64.56 **	-14.11 **	9.74 **
NAI-147 X SKV-5	36.34 **	19.86 **	22.51 **	4.46 *	-3.49	8.44 **	110.36 **	-2.58	-3.47	122.06 **	-4.31 *	22.26 **
NAI-147 X SKV-58	1.42	-9.75 **	-7.75 **	-1.43	-6.16 **	5.44 **	89.05 **	-17.16 **	-17.92 **	16.01 **	-39.73 **	-22.99 **
NAI-147 XSKV-19	-13.50 **	-2.89 **	-0.74	-4.69 **	-6.07 **	5.54 **	87.27 **	-15.87 **	-16.64 **	-1.7	-42.36 **	-26.36 **
NAI-147X SKV-57	2.50 **	-3.97 **	-1.85	9.32 **	-0.96	11.27 **	105.76 **	-1.11	-2.01	92.38 **	-27.04 **	-6.78 *
SKV-66 XKUI-1411	6.42 **	-16.25 **	-14.39 **	-1.92	-4.95 **	6.79 **	50.65 **	7.01	6.03	27.73 **	-36.32 **	-18.64 **
SKV-66 X CML-322	2.02 *	-8.66 **	-6.64 **	-0.93	-2.19	9.90 **	82.21 **	9.59	8.59	90.26 **	-35.84 **	-18.02 **
SKV-66X HKI-1040	16.08 **	0.36	2.58 *	-1.94	-4.80 *	6.96 **	40.65 **	-4.24	-5.12	32.78 **	-37.70 **	-20.41 **
SKV-66 X SKV-5	-3.67 **	-14.80 **	-12.92 **	3.51 *	-5.14 **	6.58 **	36.31 **	-18.27 **	-19.01 **	93.56 **	-26.80 **	-6.48 *
SKV-66 X SKV-58	-5.65 **	-15.52 **	-13.65 **	-1.68	-7.13 **	4.35 *	50.24 **	-13.65 *	-14.44 **	-7.35	-56.75 **	-44.74 **
SKV-66 XSKV-19	-28.32 **	-19.13 **	-17.34 **	-2.66	-4.79 *	6.98 **	42.68 **	-16.42 **	-17.18 **	0.5	-46.37 **	-31.48 **
SKV-66X SKV-57	-9.96 **	-15.16 **	-13.28 **	6.62 **	-4.20 *	7.64 **	18.98 *	-26.57 **	-27.24 **	58.81 **	-48.15 **	-33.75 **
S.E.±	0.22	0.19	0.19	1.40	1.14	1.14	1.24	1.00	1.00	2.22	1.80	1.80

SKV-69 × HKI-1040,which are superior in yield than the recently released single cross hybrid NAH-1137. Positive heterosis for grain yield per plant was reported by Verma and Singh (1996), Larish and Brewbaker (1999), Ananth (2004) and Krishna (2006). The other hand crosses *viz.*, SKV-70 × SKV-58, SKV-375 × SKV-57, SKV-156 × SKV-5 and SKV-69 × CML-322 were identified as the best combinations for drought tolerant traits, which are superior than the recently released single cross hybrids NAH-2049 and NAH-1137.

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