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Short Communication

Heterosis and combining ability for grain yield and its components in high altitude maize inbreds (*Zea mays* L.)

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The basic material for the present study comprised 13 parents i.e., ten diverse, vigorous and productive maize (*Zea mays* L.) inbred lines *viz.*, L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8, L_9 and L_{10} and 3 well adapted testers of varying genetic base *viz.*, T_1 (C-15) composite, T_2 (PS-66) synthetic and T_3 (PMI-401) inbred line respectively. These were crossed in line × tester mating design during *rabi* 2001-2002 to generate 30 hybrids. These 30 hybrids and 13 parental lines with 2 standard checks *viz.*, C-6 and Rehmat were grown in RBD with two replications in a single row plot of 5 meters length having 60cm × 25cm crop geometry in two environments during *kharif* 2002. The data was recorded on grain yield and yield contributing traits on ten randomly selected competitive plants. Pooled economic heterosis over environments was calculated as per standard procedure and combining ability analysis was carried as per procedure given by Kempthorne [1].

Pooled analysis of variance to test the significance of difference among the treatment (Table 1) revealed highly significant differences for most of the traits except kernel rows per ear reflecting thereby presence of adequate diversity in the genetic material chosen for study. Crosses × environment interactions ranged from significant to highly significant across traits with sole exception of ear diameter, corroborated with findings of [2]. Tester × Environment interaction was non-significant for maximum traits studied except 100-grain weight and ear depth which has been emphasized as an important criterion for accurate relative ranking of genotypes under test which indicated proper choice testers. Pooled analysis over environments showed significant *gca* and *sca* variances for most traits. Based on estimates, higher magnitude of σ^2 *sca* in relation to σ^2 *gca* implied the greater importance of non-additive gene effects in inheritance of maturity related traits, grain yield per plant and most of its component traits. These result were in confirmity with earlier findings of [3 & 4]. Prevalence of greater magnitude of non-additive genetic component of variance relative to additive in present study favours production of hybrid cultivars and detection of genotype × environment interaction for various traits emphasize multi-environmental testing of genetic materials to draw valid conclusions that would help to identify cultivars for specific agro-ecological situations.

Evaluation of parents and there thirty F_1 hybrids was carried out to determine nicking ability. The analysis of combining ability effects revealed that none of the parent possessed desirable *gca* for all the traits (Table 2). However, L_{10} was found to have the highest positive and significant gca value for grain yield followed by L_7, L_2, L_3 and L_9, respectively. Regarding yield components and maturity related traits L_{10} has significant positive value for 100-grain weight, grain depth and significant negative value for maturity traits. L_3 revealed significant positive value for number of kernel rows per ear besides being a good general combiner for maturity related traits. The lines with desirable *gca* should be extensively used in the crossing programme to exploit maximum genetic variability. Superior inbred lines can be used for development of synthetics as direct release for cultivation as short term approach, particularly when production of hybrids is not feasible due to absence of viable private public sector seed industry in Kashmir valley which is necessary for economic hybrid seed production.

The estimates of specific combining ability based on pooled analysis demonstrated eleven cross combinations having highly significant positive *sca* effects. The highest magnitude of desirable *sca* effects for grain yield per plant was detected in $L_9 \times T_2$ and this cross behaved as an average combination for rest of component traits. This cross also showed higher magnitude of economic heterosis (27.89%) and good per se performance for grain yield per plant. $L_6 \times T_1$ was identified as second best cross combination in respect of *sca* effect for grain yield per plant. The cross combination $L_1 \times T_2$ ranked third in respect of desirable *sca* effect for grain yield per plant and it also

Table 1. Pooled analysis of variance (MS) of combining ability for different traits in a line × tester cross of maize

Source of variance	df	Ear length (cm)	Kernel rows per ear	Kernels/ row	Ear diameter (cm)	Grain depth (cm)	100 grain weight (g)	Grain yield/ plant (g)
Environment	1	1.316	0.270**	31.110*	0.075	0.034*	0.507	5.742
Lines	9	4.230	6.106*	14.415	0.218	0.030	14.879	932.993
Testers	2	1.167	1.278	21.740	0.776**	0.017	46.171*	1244.482
Lines × testers	18	2.070**	1.865**	10.455	0.120**	0.013*	13.701**	703.015**
Lines × environments	9	3.926	1.334	19.910	0.066	0.015	11.858	722.358
Testers × environments	2	3.604	0.060	7.375	0.005	0.058*	66.406**	768.121
Lines × testers × environments	18	3.451**	1.195	21.612**	0.075*	0.010	5.565**	541.484**
Pooled error	58	0.995	0.593	7.710	0.043	0.006	7.497	348.783
σ^2 gca		0.065	0.119*	0.686**	0.019	0.000	1.135	41.792*
σ^2 sca (Lines × testers)		0.268	0.317**	0.456	0.006**	0.001	3.173**	175.217*

*,**Significant at 5 and 1% levels respectively

Table 2. Pooled estimates of *gca* effects for different traits in lines and testers of maize

Code name	Pedigree	Ear length (cm)	Kernel rows/ear	Kernels/ row	Ear diameter (cm)	Grain depth (cm)	100 grain weight (g)	Grain yield/ plant (g)
L_1	PMI-13	0.553	0.363	0.376	–0.150*	–0.052*	–0.275	–2.848**
L_2	PMI-14	1.178**	–0.696**	1.151	0.167*	0.029	0.442	7.213**
L_3	PMI-56	–0.630*	1.621**	0.974	–0.075	–0.034	–0.183	7.010*
L_4	PMI-73	0.056	–0.038	1.284	–0.075	–0.035	–2.142**	–11.687**
L_5	PMI-86	–0.780*	–0.221	–1.583*	0.050	–0.010	0.333	–0.470
L_6	PMI-88	0.411	–1.013**	0.400	–0.242**	–0.079**	0.267	–7.819**
L_7	PMI-94	–0.155	0.146	–1.008	0.125*	0.074**	–0.058	7.773**
L_8	PMI-96	–0.239	0.396	0.117	–0.017	0.014	–1.292**	–14.262**
L_9	PMI-105	0.070	0.271	–1.116	0.142*	0.033	1.150**	4.808**
L_{10}	PMI-114	0.464	–0.104	1.342	0.075	0.059*	1.758**	10.271**
T_1	C-15	0.121	0.001	–0.244	0.146**	0.023	1.239**	–1.626**
T_2	PS-66	0.074	0.178	–0.362	–0.014	–0.018	–0.671**	–4.584**
T_3	PMI-401	–0.195	–0.179	0.333	–0.132**	–0.005	–0.568**	6.210**

*,**Significant at 5 and 1% levels respectively

has significant *sca* effects for 100 grain weight. The $L_{10} \times T_3$ cross combination involving the inbred line PMI-401 as tester displayed its superiority by recording highest magnitude of economic heterosis (35.96%) and significant positive *sca* effect for grain yield per plant. This was a cross of High × High *gca* effect for grain yield per plant and *per se* performance of parental inbred lines of this cross was also good. Most crosses showing significant positive *sca* and highest economic heterosis for grain yield involved inbred line PMI-401 as tester. These promising crosses can be tested extensively over environments in the future and good performers can be utilized profitably by maize breeders. For grain yield per plant crosses showing high *sca* effect in the favourable direction involved either High × Low or Low × Low or High × High *gca* effects and confirmed the earlier reports of [5]. The results therefore revealed that high *gca* value of a parent is no guarantee of high *sca* effect of their crosses and conforming the earlier reports of [6] and thus selection of parent should be based on their specific combining ability tests. $L_{10} \times T_3$ single cross hybrid involving inbred testers was identified as superior most combination that surpassed the better check by a significant margin of 36% for grain yield and at par with better check in respect of maturity. The cross therefore merits consideration for extensive testing to verify stability of its performance, for commercial exploitation for higher elevation of Northern Hill Zone, especially high altitudes of Kashmir valley where till-date no hybrid has been released in the public sector, and will go a long way in increasing the productivity of maize and improving the economic condition of the poor and marginal farmers.

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