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HETEROSIS AND COMBINING ABILITY IN INTERVARIETAL CROSSES OF MAIZE

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ABSTRACT

The combining ability and heterosis were estimated from a number of crosses comprising 10 elite varieties of *Zea mays* L. obtained from diverse geographical regions. 'AB male bulk' was the best general combiner for grain yield and kernel/row. Two single crosses *viz*'AB male bulk x composite V_2' and 'Hemant x CIMMYT Pool 23' significantly outyielded the standard check 'Vijay Composite', and the hybrid check 'Deccan 103'. for grain yield. The extent of heterosis over better parent and economic heterosis revealed that crosses which had higher estimates of heterosis for grain yield also exhibited higher estimates of heterosis for the major yield components as well.

KEY WORDS : Maize, Intervarietal Crosses, Heterosis Combining Ability

The criteria for selection of parents for hybridisation is one of the crucial tasks often faced by the plant breeders. It is generally viewed that the selection criteria for grain yield is not only primarily be based on the yield *per se* of the parents but also based on the sound consideration of the estimates of combining ability of the parents to be used as well. This is mainly with the view that only the most desirable and high yielding cross combinations could be quickly picked up from a number of cross combinations available. In meaningful yield improvement programmes, therefore, the understanding of combining ability effect and heterosis over better parent and over the standard checks become essential and *a priori*.

MATERIALS AND METHODS

Ten white materials of maize,*Zea mays* L. ('Laxmi', 'Hemant','M 12', 'M 13', 'AB male bulk','CIMMYT Pool 23','CIMMYT Pool 28','CIMMYT Pool 32', 'Composite V_2' and UPB 742') were selected to represent a wide spectrum of ecogeographic diversity. These elite populations were crossed in a diallel mating system during *kharif* 1985 to obtain 45 F_1 crosses. A total of 59 treatments comprising of ten varieties, their 45 F_1's and four checks *viz*, the hybrid check 'Deccan 103' and three popular variety checks 'Vijay composite', 'Tarun' and 'Janupur variety checks 'Vijay Composite', 'Tarun' and 'Jaunpur Local' were planted in randamised block design with three replications. Each entry was planted in two row plot of five m length with 60 X 25 cm spacing. The data were recorded on days to 50 per cent silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of kernel rows/ear, number of kernels per row, thousand grain weight (g) and grain yield/plot (kg). Data related to days to 50 per cent silking and grain yield were recorded on whole plot basis while data relating to other characters were recorded on ten randomly selected plants and were later averaged out. The combining ability analysis was done according to Griffing (1956) methods 2 model I. Heterosis over better partent (heterobeltiosis) and standard cecks (economic heterosis) were estimated as Heterobeltiosis = $\frac{F - BP}{BP}$ x 100 and economic

Table 1. Analysis of variance for nine characters in maize

Source of variation	D.F.	Grain yield	Days to silk	Plant height	Ear heigh	Ear length	Ear diameter	Number of kernel rows	Number of kernels row	1000 kernel weight
Replication	2	19.99	9.03	143.79	215.48**	0.18	0.03	0.08	0.15	906.21
Genotype	58	45.55**	63.12**	297.36*	168.80**	2.96**	0.10**	0.70**	11.84**	748.97*
Error	116	12.65	2.97	82.75	37.90	0.38	0.02	0.25	0.61	530.60

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

heterosis = $\frac{F_1 - \overline{C}}{\overline{BP}}$ x 100 where, $\overline{F_1}$ = mean value of F_1, $\overline{BP}$ =mean of the better parent and the $\overline{C}$ = mean value of standard check.

RESULTS AND DISCUSSION

The 'F' test indicated that the variance due to genotypes were highly significant for all the traits studied except for 1000 kernel weight which was significant only at 5 per cent level of significance (Table 1). Mean squares due to GCA and SCA were significant for all the traits studied. Estimates of *gca* effects of the parental varieties and mean grain yield were given in Table 2. Parental populations showed significant gca effects ranging from -1.833 to 1.931 and 'AB male bulk' was observed to be the best general combiner for yield. 'CIMMYT Pool 28' was observed to be best general combiner for days to 50 per cent silking which showed highest negative gca effects (-3.898). For height 'CIMMYT Pool 32' was observed to be best general combiner. None of the parents was found to be the good general combiner for all the traits studied. However, 'Hemant' and 'AB male bulk' were good general combiner for yield, ear length, and ear diameter. Some of good combiners had the highest mean values as well. The noncorrespondence between *gca* effects and the *per se* performance may be due to the fact that a particular parentmay have better performance for a character but may not complement with other genotypes. In the desirable direction in a series of hybrid combinations primarily because it may have recessive gene for higher expression of the character which may be dominated by the undersirable dominant genes of the other parents in cross combinations. These findings were smiliar to those of satyanarayan *et al.* (1994).

The estimates of *sca* effects revealed that two crosses namely "Hemant CIMMYT Pool 23" and "AB male bulk x Composite V_2 showed very high sca effect for the grain yield. These two crosses also showed high sca effects for major yield components as well. Satyanarayan *et al.* (1990) also reported high *sca* and high mean for few crosses. Highest value of negative *sca* effects for days to 50 per cent silking was observed for the cross 'M 12 x CIMMYT Pool 23' (-3.86). This was

Table 2. Estimates of mean yield and general combining ability effects of the parents for various characters

Pedigree	Mean grain yield q/ha	Grain yield	Days to silk	Plant height	Ear heigh	Ear length	Ear diameter	Number of kernel rows	Number of kernels/ row	1000 grain weight
Laxmi	37.63	0.761	3.372**	2.232	2.790**	0.253**	0.033	-0.129	0.711**	-3.092
Hemant	36.2	1.486**	3.400**	-1.363	0.445	0.351**	0.023	-0.023	0.957**	2.325
M 12	32.9	-1.549**	-0.461	2.265	0.426	-0.564**	-0.002	-0.003	-1.494**	0.103
M 13	30.0	-0.510	2.650**	0.240	3.906**	0.101	-0.020	-0.217**	0.673**	3.714
AB male bulk	37.5	1.931**	1.678**	6.663**	5.801**	0.331**	-0.003	0.141	1.863**	-0.869
CIMMYT Pool 23	32.5	-0.402	1.178**	-0.985	-3.207**	-0.049	-0.061**	0.005	-0.655**	-4.203
CIMMYT Pool 28	32.1	-1.833**	-3.989**	-4.627**	-0.898	-0.363**	-0.083**	-0.198**	-1.075	-2.814
CIMMYT Pool 32	36.4	1.015	-2.906**	-5.715**	-3.359**	-0.252**	0.110	0.058	-0.487**	4.131
Composite V_2	35.9	0.380	-2.683	2.721*	-2.125*	0.344**	0.077**	0.264**	-0.324**	1.075
UPB 742	34.3	-1.279**	-2.239**	-1.421	-3.779**	-0.152	-0.077**	0.096	-0.167	-0.369
C.D. at 5%		1.036	0.503	3.630	1.730	0.182	0.040	0.148	0.232	6.74
C.D. at 1%		1.325	0.643	3.363	2.213	0.233	0.052	0.190	0.296	8.626

Table 3. Best parent, best F_1, best general combinar and best specific combiner for various characters in maize

Characters	Best parent (on the basis of mean values)	Best general combiner in F_1	Best F_1 with respect to mean value	Best F_1 with respect to standard heterosis	Best F_1 cross with respect to specific combining ability
Grain yield	Laxmi	Hemant	AB male bulk x Composite V_2	AB male bulk x Composite V_2	AB male bulk x Composite V_2
Days to 50% silk	Composite V_2	CIMMYT Pool 32	M 12 x Pool 32 and Composite V_2 x UPB 742	Composite V_2 x UPB 742	M 12 x CIMMYT Pool 32
Plant height	CIMMYT Pool 32	CIMMYT Pool 32	Pool 32 x UPB 742	CIMMYT Pool 32 x UPB 742	Hemant x Composite V_2
Ear height	CIMMYT Pool 32	UPB 742	Pool 32 x UPB 742	CIMMYT Pool 32 x UPB 742	M 12 x AB male bulk
Ear length	Composite V_2	Hemant	M 13 x Composite V_2	M 13 x Composite V_2	M 13 x Composite V_2
Ear diameter	Pool 23 and Pool 32	CIMMYT Pool 32	Pool 32 x Composite V_2	CIMMYT Pool 32 x Composite V_2	Hemant x M 12
Number of kernel rows	UPB 742	Composite V_2	M 12 x Composite V_2	M 12 x Composite V_2	M 12 x CIMMYT Pool 23
Number of kernals/row	AB male bulk	AB male bulk	AB male bulk x CIMMYT Pool 32	AB male bulk x CIMMYT Pool 32	Hemant x CIMMYT Pool 23
1000-kernel weight	UPB 742	CIMMYT Pool 32	M 12 x UPB 742	M 12 x UPB 742	CIMMYT Pool 23 x CIMMYT Pool 23

followed by 'CIMMYT Pool 23 x UPB 742' (-3.85). Best F_1, best specific combiner for various traits were given in Table 3.

Among the 45 F_1 crosses studied, cross 'AB male bulk x Composite V_2 (47.8 q/ha) was the higest yielder followed by the cross "Hemant x CIMMYT Pool 23" (46.5 q/ha) and 'AB male bulk x CIMMYT Pool 32' (45.3 Q/ha). The cross 'AB male bulk x composite V_2" gave higher yield than the better parent and over the highest performing check. "Hemant x CIMMYT Pool 23' exhibited 28.2 per cent heterosis over the better parent and best check for a number of yield components (Table 4). The results obtained in the present study are more or less in confirmity with the findings of Singh (1968), Akhtar and Singh (1981) and Debnath (1984) with regards to grain yield. The present findings are also in line with that reported by Robinson *et al.*(1956), Mukherjee and Dhawan (1970) for yield and its components, Shehata and Dhawan (1975) for grain yield and positive heterosis for the characters plant and the ear height.

In the present study, two crosses namely "AB male bulk x composite V_2" and "Hemant x CIMMYT Pool 23" appeared to be promising from ...lation improvement point of view as their F_1 hybrid outyielded the performance of the best standard check, hybrid 'Deccan 103' and 'Vijay Composite'. These crosses alongwith "AB male bulk x CIMMYT Pool 32", "Hemant x M 13" and "CIMMYT Pool 23 x CIMMYT Pool 28" could be further studied for evaluation of inbreeding depression in F_2 and later generations. If the inbreeding depression is less it could be desirable to follow composite breeding programme or any population improvement programme in the cross combinations. Since 'Laxmi', 'Hemant ' and 'M 13' were the the good agronomic bases and 'Laxmi' is released as variety, any improvement in them might be worthwile and rewarding for yield improvement programme in maize in the years to come.

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Table 4. Three outstanding F_1 hybrids and their comparative performance with the checks

F_1 hybrids and checks	Grain yield q/ha	Days to 50% silk	Plant height	Ear height	Ear length	Ear diameter	No. of kernel rows	No. of kernels/row	1000 kernel weight
AB male bulk x Composite V_2	47.75	98.0	215.10	88.70	14.30	4.81	15.38	30.10	301.66
Heterosis percentage over better parent	27.33	-5.76	11.64	5.97	2.87	1.60	6.28	3.43	5.84
Heterosis prcntag over 'Deccan 103'	4.99	-6.36	7.52	9.42	2.07	11.60	8.44	8.27	1.68
Heterosis percentage over 'Vijaya Composite'	14.89	-6.66	6.20	1.75	7.84	5.48	7.31	6.39	7.74
Heterosis percentage over 'Tarun'	18.52	7.30	20.63	34.04	12.24	11.09	8.94	8.74	9.69
Heterosis percentage over 'Jaunpur Local'	38.73	4.25	18.90	19.76	14.13	9.82	5.27	14.88	12.42
Hemant x CIMMYT Pool 23	46.49	103.66	193.56	85.60	15.36	4.40	13.20	30.98	296.68
Heterosis percentage over better parent	28.20	0.0	3.12	2.80	16.08	-2.24	-1.36	11.07	12.72
Heterosis percentage over 'Deccan 103'	2.22	-0.95	-0.75	-0.53	10.78	1.62	-1.05	11.07	4.49
Heterosis percentage over 'Vijaya Composite'	11.86	-1.28	-1.97	-7.50	17.04	-3.94	-2.08	9.16	10.71
Heterosis percentage over 'Tarun'	15.39	13.50	11.34	21.85	21.82	1.15	-0.60	11.56	12.73
Heterosis percentage over 'Jaunpur local'	35.07	10.27	9.74	8.87	23.86	0.0	-3.95	17.86	15.53
AB male bulk x CIMMYT Pool 32'	45.31	96.66	198.53	80.63	15.52	4.38	13.12	30.88	310.00
Heterosis percentage over better parent	20.82	-7.05	7.23	2.23	15.31	-1.79	-1.57	6.46	4.09
Heterosis percentage over 'Deccan 103''	-0.37	-7.64	-3.24	5.60	9.63	2.08	-0.45	11.43	0.0
Heterosis percentage over 'Vijaya Composite'	9.02	-7.94	-4.43	-1.80	15.84	-3.50	-1.49	9.51	5.95
Heterosis percentage over 'Tarun'	12.46	5.83	8.55	29.36	20.57	1.62	0.0	11.92	7.88
Heterosis percentage over 'Jaunpur local'	31.87	2.82	6.99	15.58	22.59	0.46	-3.36	18.24	10.56

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CORRELATION AND PATH ANALYSIS FOR GRAIN NUMBER AND GRAIN WEIGHT USING SOME BIOCHEMICAL PARAMETERS IN RICE

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ABSTRACT

Genotypic correlation and path coefficient analyses of grain number and grain weight with total chlorophyll content, soluble proteins, peroxidase, mitochondrial ATPase and succinic dehydrogenase were carried out on eight rice genotypes at boot stage, flowering, 10- and 20 days after flowering. Correlation coefficients and direct and indirect effects varied with developmental stages. Soluble proteins showed significantly positive correlation with grain number per panicle at boot stage and with grain weight at flowering while mitochondrial ATPase activity indicated close association with grain number at flowering, with grain weight at 20 days after flowering.

KEY WORDS: Path Analysis, Biochemical Parameters, Rice

Correlation studies help in designing appropriate selection strategies while path analysis reveals the cause of association and pin-points the actual parameters to be manipulated. Several workers have reported the relevence of correlation and path analysis for grain yield improvement in rice using morphological parameters (Sharma, 1993; Katoch *et al.* 1993). However, physiological efficiency is also greatly influenced by various biochemical parameters particularly during reproductive stages (Srivastava, 1983; Sharma and Mani, 1990) but they have been least investigated. The present investigation was undertaken with a view to assess the utility of chlorophyll content, soluble proteins, peroxidase, mitochondrial ATPase and succinic dehydrogenase as the selection parameters for high yield in rice.

MATERIALS AND METHODS

The experimental material comprised of eight [illegible] Narendra 1, IR46830A x Narendra 1, Basmati 370, IR46830A x Basmati 370, Mahsuri and IR46830A x Mahsuri. These were planted in randomised block design with three replications. Each replication consisted of 4 rows each of 3.0 m length. The spacing adopted was 20x15 cms. Nitrogen was applied at 120 kg/ha in three split doses with no P and K application because *tarai* soil of Uttar Pradesh contained P and K in abundant amount.

A sample size of 0.5 g of chopped leaf material taken from flag leaf at boot stage, flowering, 10 days and 20 days after flowering from each genotype in each replication was used for analyses.

Total Chlorophyll content was estimated according to Mackinney (1941) by measuring absorbance at 652 nm using 80% acetone as blank. Soluble proteins were determined by dye binding method of Bradford (1976) and BSA was used as standard. Peroxidase activity was assayed as [illegible]