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COMBINING ABILITY ANALYSIS IN VARIETAL CROSSES OF MAIZE

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ABSTRACT

Eight varieties of maize were evaluated following diallel mating design for determining their utility as parents in the development of hybrids and/or high yielding composites. For days to 50% tasselling and silking, and 1000-grain weight, variety (v_i) effects; for plant and ear heights, ear length and diameter, both v_i and specific heterosis (s_{ij}) effects; and for grain yield, s_{ij} effects were the most important contributors to the total entries sum of squares. Average heterosis ($\bar{h}$) and variety heterosis (h_i) effects were not so important for any trait. Cross between cvs. Navin and Population 26 showed significant and positive s_{ij} effects for grain yield, plant height, ear height and ear length. These two varieties represented a good choice to initiate interpopulation improvement.

Key words: Combining ability, varietal diallel, maize, heterosis.

The first attempt to utilize varietal hybrids in maize for increasing yield was made by Beal [1]. Interest in the heterotic patterns of varietal crosses was limited during the early stages of commercial use of double crosses and single crosses, but dramatically increased after 1950 with the understanding of the theoretical background of recurrent selection. Lonnquist and Gardner [2] and Moll et al. [3] used a fixed set of random mating parental varieties and their diallel crosses in their experiments. Later on, the variety or population diallel has been used to evaluate crops for several traits with the primary emphasis on yield. In the present experiment, we have attempted to examine the combining ability of parent varieties and their crosses.

MATERIALS AND METHODS

Materials for the study comprised eight varieties, of these four composites (Tarun, Navin, Kanchan and D-765) were released from GBPUAT, Pantnagar. The other four parents

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were Kiran, Population 26, Suwan 1, and Pool 18. Kiran is an early maturing variety from Punjab, while Suwan 1 is a composite developed in Thailand. Population 26 and Pool 18 were collected from CIMMYT. Diallel crosses, excluding reciprocals, were made during kharif 1993 and their progenies evaluated in rabi 1994. Thirty six populations including eight parents and 28 F_1s were evaluated in randomised complete block design with three replications. Each plot consisted of two 5 m long rows. The spacing of 75 x 25 cm was adopted. Observations were recorded in plot basis for days to 50% tasselling and 50% silking, and grain yield. However, plant height, ear height, ear length, ear diameter and 1000-grain weight were recorded from five random competitive plants from each plot.

Analysis II model devised by Gardner and Eberhart [4] was used to estimate the genetic effects. Singh [5] and Ordas [6] have provided details of the necessary calculations. Variety effect (v_i) is the difference between the mean per se performance of each parent and the mean of all parents, and is generally used to provide information on importance of additive genetic effects. Heterosis effect (h_{ij}) arises as a consequence of differences in gene frequencies in two varieties and dominance of more favourable alleles. Again, the h_{ij} effect is partitioned into three components ($\bar{h}$, h_i and s_{ij}). The average heterosis ($\bar{h}$) contributed by a particular set of parents used in the crosses is the difference between the mean of all crosses and the mean of all parents. The variety heterosis (h_i) effect is the heterosis contributed by variety i. The specific heterosis (s_{ij}) effect measures the deviation between the observed performance of the specific cross and its expected performance based on the v_i, $\bar{h}$ and h_i effects.

RESULTS AND DISCUSSION

The aim of the plant breeder is to estimate the general combining ability (gca) effects of each parent and specific combining ability (sca) effects of each cross to compare these effects and, on that basis, the best parents or cross combinations could be selected. Singh and Paroda [7] analysed data for nine cultivars and 36 F_1s of chickpea using different models and designs. They concluded that the analyses of Gardner and Eberhart [4] provided maximum information. Singh and Singh [8] also concluded that Analysis II of Gardner and Eberhart [4] provided more information on heterosis. Thus, Analysis II is believed to be the best for the material studied.

Selection is more effective when the combining ability effects are of additive type. But both v_i and h_{ij} (except 50% silking and 1000-grain weight) variances were significant for all the characters (Table 1), indicating the importance of both additive and nonadditive gene effects in their expression. A further partitioning of heterosis variation revealed that h_i variation was significant only for days to tasselling, ear height and diameter; $\bar{h}$ variation for ear diameter, days to tasselling and silking, and s_{ij} variation for all the traits except silking and 1000-grain weight (Table 1). More than 60% of the total sum of squares for heterosis of

Table 1. Contribution (%) of v_i, $\bar{h}$, h_i and s_{ij} effects to the total entries sum of squares for different characters in maize.

Source	Tasselling (50%)	Silking (50%)	Plant height	Ear height	Ear length	Ear diameter	1000-grain weight	Grain yield
v_i	71**	78**	46**	51**	44**	34**	64**	16*
$\bar{h}$	8**	2*	1	0	1	6*	0	2
h_i	8**	6	10	7*	12	18**	4	11
s_{ij}	13**	14	43**	42**	43**	42**	.32	71**

*,**Significant at P = 0.05 and 0.01, respectively.

all traits except tasselling could be attributed to specific heterosis. Sum of squares due to s_{ij} effects for grain yield was not only significant, but also a major contributor (71%) to the total entries sum of squares. As observed in the present study, Crossa et al. [9] also found that nonadditive gene effects were more important in controlling yield (50%). Considering the average grain yield, s_{ij} and v_i effects, they ultimately selected two populations to initiate interpopulation improvement.

A perusal of Table 2 revealed that none of the parent varieties excelled in v_i effects for all the characters, suggesting the use of multiple crosses alone to affect substantial improvement in grain yield. The results on s_{ij} effects for grain yield indicated that only three crosses, i.e. Navin x Population 26, D 765 x Kiran, and Suwan 1 x Pool 18, showed positive effects. Again, the cross Navin x Population 26 showed highest s_{ij} effect for ear height, and third highest for plant height and ear length. On the other hand, the cross D 765 x Kiran showed the lowest s_{ij} effects for these three traits, including ear diameter.

Tarun had the highest (0.59) and Kiran the lowest (–0.42) v_i effects for grain yield. Both these parent varieties, involved in the cross Navin x Population 26, showed high v_i effects for plant height and ear length, and high h_i effects for early tasselling. Navin also showed highest h_i effects for ear height and diameter. Population 26 gave high v_i effects for ear height. The cross Navin x Population 26 gave the highest grain yield, which was about 15% more than the best yield among varieties. This cross had the highest BP heterosis (data not presented) and, therefore, the most heterotic combination.

Considering the above results, two varieties, Navin and Population 26, represented a good choice to initiate interpopulation improvement.

Table 2. Varieties and crosses showing the best genetic effects in maize.

Character	v_i	h_i	s_{ij} (only significant and desirable)
Days to 50% tasselling	D 765 (–6.33) Kanchan (–4.33)	Navin (–2.05) Population 26 (–0.78)	Tarun x D 765 (–1.69) Kanchan x Suwan 1 (–1.80)
Days to 50% silking	D 765 (–7.75) Kanchan (–2.08)	— —	— — — —
Plant height	Kiran (15.96) Population 26 (8.96) Navin (8.29)	— — —	D 765 x Pool 18 (14.33) Tarun x D 765 (13.94) Navin x Population (13.83)
Ear height	Kiran (11.88)	Navin (6.80)	Navin x Population 26 (11.96), D 765 x Pool 18 (11.58)
	Population 26 (7.88)	Pool 18 (4.08)	Tarun x Kiran (10.35), Navin x D 765 (9.35)
Ear length	Population 26 (1.14)	—	Tarun x Kiran (1.40), Tarun x D 765 (1.33)
	Navin (0.31)	—	Navin x Population 26 (1.05)
Ear diameter	Suwan 1 (0.33) Pool 18 (0.13)	Navin (0.27) Tarun (0.10)	Kanchan x Pool 18 (0.23) Navin x D 765 (0.21)
1000-grain weight	Pool 18 (41.04) Kiran (11.04)	— —	— — — —
Grain yield	Tarun (0.59) Suwan 1 (0.54)	— —	Navin x Population 26 (0.80) D 765 x Kiran (0.77) Suwan 1 x Pool 18 (0.62)

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