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# COMBINING ABILITY ESTIMATES OF EARLY GENERATION INBRED LINES DERIVED FROM TWO MAIZE POPULATIONS

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## ABSTRACT

The present research work was aimed at forming a heterotic group based on combining ability estimates of early generation inbreds (S1-lines) and their respective crosses. Ten S1-lines were derived from two maize populations namely, Jogia Local and DH8644. The better performing crosses usually had at least one parent with high general combining ability but for ear length. Interpopulation crosses were usually superior to intrapopulation crosses. Nonetheless, a few intrapopulation crosses appeared to be at par with the best performing interpopulation crosses. Based on the mean performance and SCA effects, a total of nine best crosses (20% selection intensity) were used to establish a heterotic group for grain yield which could be used either as improved population or as base population for the next round of improvement.

**Key Words :** *Zea mays* L. early generation inbreds, combining ability, heterotic group

Few studies have been conducted at the population level to identify heterotic patterns amongst CIMMYT populations and pools and there is even less published information on combining ability of lines derived from these populations. Han *et al.* [1] indicated good general interpopulation cross superiority (ICS) for crosses involving lines (S3-lines) derived from different populations. However, a few of the intrapopulation crosses have been reported at par with the best interpopulation combinations. Efforts towards identifying or forming new heterotic groups are few and also not well-documented. Limited attempts have been made in this direction by CIMMYT and other national research institutes [2]. The objectives of this investigation was thus to estimate the combining ability effects of the S1-lines and crosses, respectively and eventually to form a new heterotic group.

## MATERIALS AND METHODS

Jogia Local and DH8644 were taken as the base populations. During kharif 1993, each population was grown separately at normal plant density (75 cm × 20

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**Table 1. Description of the source materials**

| Designation | Source | Description |
|---|---|---|
| Jogia Local | - | A highly adapted local variety,genetically diverse and very good combiner,white and purple coloured grain,resistant to most diseases and pests. |
| DH8644 | - | Developed by recombining high-yielding full-sib families from a CIMMYT population (No. 44), fairly tall, late, white, semident grain, capable of giving high yield under favourable conditions, emphasis on reduced plant height. |
| P1 | Jogia Local | Reduced vigour but fairly tolerant to inbreeding, medium plant height (1.25-1.50m), medium maturity (135 days), white and flint grain. |
| P2 | -do- | Highly reduced vigour, plant height short (< 1.25 m), early maturity, purple and flint grain. |
| P3 | -do- | Vigour-comparable to the source population, medium plant height, late maturity (> 135 days), white and flint grain. |
| P4 | -do- | Vigour reduction is not so-marked, medium plant height as well as maturity, white and flint grain. |
| P5 | -do- | Lean and thin plants with tall stature, early maturity, white and flint grain. |
| P6 | DH8644 | Acute reduction in vigour and height, early maturity, white and semi-dent grain. |
| P7 | -do- | Seeming vigour reduction, tall plants, late maturity, white and semi-dent grain. |
| P8 | -do- | Reduced vigour, medium maturity as well as plant height, white and semi-dent grain. |
| P9 | -do- | Appreciable vigour, medium to tall plant stature as well as maturity, white semident grain. |
| P10 | -do- | Highly reduced plant vigour, medium height, early maturity, white and semi-dent grain. |

cm) in isolated plots (which in turn was sub- divided into five equal grids) of about 150 square meter area. At the time of tassel emergence, ten plants per grid were marked for selfing. The bases of selection were vigour, standing ability, silk - tassel characteristics, disease reaction and the like. The selection pressure was applied again for the economic traits after harvest and only one ear per grid was retained. Thus

a total of five ears (S1-lines) from each populations was selected. The following season (rabi, 1994), all the ten S1-lines were grown and combined in diallel fashion to produce a total of fortyfive crosses. The next year (rabi, 1995), a trial comprising of all the F1-crosses was conducted following randomized complete block design (RCBD) at Dholi research farm under RAU, Pusa, Bihar. The entries were raised at optimum agronomic and plant protection practices. Data were recorded for three traits, *viz.*, days to tassel (50%), ear-length and grain yield per plant. Days to tassel was calculated on per plot basis. However, average values of five randomly selected competitive plants were considered for the remainders. Griffing's Model I, Method IV [3] was used for diallel analysis.

## RESULTS AND DISCUSSION

The analysis of variance revealed that the mean squares due to crosses were highly significant for all the three traits. Mean squares due to GCA were highly significant except for ear-length (Table 2). However, mean squares due to SCA were significant for all the traits. The estimates of mean squares due to GCA were higher than those due to SCA for days to tassel, indicative of prominence of additive genetic effects for this trait. However, a reverse trend was observed for the remaining two traits. This could be due to preponderance of non-additive effects in the inheritance of these two characters.

**Table 2. Analysis of variance for combining ability**

| Source | d.f. | Mean squares | | |
|---|---|---|---|---|
| | | Days to tassel | Ear-length | Grain yield |
| GCA | 09 | 32.01** | 00.81 | 371.67** |
| SCA | 35 | 05.89** | 02.09** | 649.85** |
| Error | 88 | 01.10 | 00.49 | 065.37 |

**Significant at P = 0.01

***Mean performance of the crosses***

The mean performance of all the fortyfive crosses over three replications for the traits in question are shown in Table 3. The range for days to tassel (50%) varied from 121 days to 136 days for the crosses P2 × P9 and P4 × P6, respectively. The crosses showed somewhat narrow range for ear- length. It was 13.40 cm and 18.83cm for P1 × P4 and P2 × P10, respectively. Grain-yield/plant was the highest (196 g) for the P3 × P8 and the lowest (90 g) for the cross, P5 × P6.

**Table 3. Mean performance and SCA effects of crosses**

| Crosses | Days to tassel (50%) | | Ear-length (cm) | | Grain yield/plant (g) | |
|---|---|---|---|---|---|---|
| | Mean | SCA | Mean | SCA | Mean | SCA |
| P1×P2 | 128.0 | 1.27 | 14.4 | -1.21 | 109.0 | -29.31* |
| ×P3 | 135.0 | 2.39* | 14.6 | -1.10 | 98.0 | -28.81* |
| ×P4 | 130.0 | -2.68* | 13.4 | -2.57* | 101.0 | -28.18* |
| ×P5 | 133.0 | 0.56 | 15.8 | 0.22 | 132.0 | 11.93 |
| P2×P3 | 122.3 | -4.39* | 15.8 | -0.47 | 141.0 | 2.18 |
| ×P4 | 126.0 | -0.81 | 17.9 | 1.38* | 162.0 | 20.81* |
| ×P5 | 128.0 | 1.43 | 14.4 | -1.75* | 111.0 | -21.06* |
| P3×P4 | 132.0 | -0.68 | 16.4 | -0.23 | 119.0 | -10.68 |
| ×P5 | 136.0 | 3.56* | 18.3 | 1.99* | 126.0 | 5.43 |
| P4×P5 | 131.0 | -1.51 | 15.1 | -1.44* | 119.0 | -3.93 |
| P6×P7 | 133.0 | 0.23 | 15.0 | -0.70 | 108.0 | -22.02* |
| ×P8 | 128.0 | -1.60 | 14.3 | -1.31* | 110.0 | -8.81 |
| ×P9 | 130.6 | 0.85 | 16.5 | 0.63 | 115.0 | 0.14 |
| ×P10 | 128.0 | -1.18 | 14.2 | -0.90 | 145.0 | 32.97* |
| P7×P8 | 129.0 | -1.93* | 15.4 | -0.39 | 98.0 | -38.27* |
| ×P9 | 132.0 | 0.52 | 15.6 | 0.47 | 141.0 | 0.93 |
| ×P10 | 130.0 | -0.85 | 15.9 | 0.52 | 120.0 | -8.81 |
| P8×P9 | 127.6 | 0.64 | 15.2 | 0.85 | 107.0 | 24.39* |
| ×P10 | 131.3 | 3.64* | 14.4 | -0.85 | 115.0 | -3.27 |
| P9×P10 | 128.0 | 0.10 | 14.7 | -0.87 | 126.0 | 2.06 |
| P3×P6 | 133.6 | 1.81 | 16.2 | 0.35 | 132.0 | 11.72 |
| ×P7 | 133.3 | -0.18 | 15.0 | -1.09 | 119.0 | -18.06* |
| ×P8 | 130.6 | 0.31 | 17.4 | 1.33* | 196.0 | 69.47* |
| ×P9 | 130.0 | 0.56 | 16.0 | 0.28 | 112.0 | 18.19* |
| ×P10 | 127.6 | -2.26* | 15.1 | -0.48 | 108.0 | -11.06 |
| P4×P6 | 136.0 | 4.06* | 17.3 | 1.15 | 124.0 | 1.35 |
| ×P7 | 133.6 | 0.06 | 16.6 | 0.17 | 153.0 | 13.56 |
| ×P8 | 131.0 | 0.56 | 17.6 | 1.26* | 136.0 | 7.10 |
| ×P9 | 130.0 | 0.64 | 17.6 | 1.04 | 158.0 | 23.43* |
| ×P10 | 131.6 | 1.64 | 15.1 | -0.75 | 98.0 | -23.43* |
| P5×P6 | 128.0 | -3.68* | 16.5 | 0.67 | 90.0 | -23.52* |
| ×P7 | 135.0 | 1.64 | 14.6 | -1.46* | 124.0 | -6.31 |
| ×P8 | 132.3 | 2.14* | 16.6 | 0.59 | 132.0 | 12.22 |
| ×P9 | 130.0 | 0.39 | 16.0 | 0.29 | 162.0 | 36.56* |
| ×P10 | 126.0 | -3.76* | 17.0 | 1.47* | 101.0 | -11.31 |
| Se (sij) | | 0.92 | | 0.62 | | 7.13 |

*Significant at P = 0.05

#All downward crosses including this one are interpopulation inter- line crosses.

*General combining ability*

Highly significant GCA effects for days to tassel were observed with the parent P7 (2.19 days) at one extreme (positive) and with the P2 (4.60 days) at the other. This was not unexpected because these two parents stood in diametrically different directions. The P4 was the sole parent showing positive GCA effects for ear- length. Highly significant and positive GCA effects were noticed with P2 (10.98 gm) and P7 (9.23 gm) for grain yield/plant. As yield is a measure of relative reproductive capacity of a plant which is influenced by so-many characters such as test-weight, number of kernel-rows, number of kernel/row, etc. the parent, P2, somehow managed to transcend all others for this trait.

**Table 4. Estimates of the GCA effects of the parents**

| Parents\Characters | Days to tassel (50%) | Ear-length (cm) | Grain yield/plant (gm) |
|---|---|---|---|
| P1 | 1.27* | –0.44 | –1.01 |
| P2 | –4.60* | 0.13 | 10.98* |
| P3 | 1.27* | 0.22 | 0.51 |
| P4 | 1.35* | 0.49* | 1.85 |
| P5 | 1.10* | 0.16 | –7.26* |
| P6 | 0.52 | –0.22 | –7.55* |
| P7 | 2.19* | 0.01 | 9.23* |
| P8 | –0.97* | –0.07 | –1.30 |
| P9 | –0.76* | 0.21 | 4.35 |
| P10 | –1.39* | –0.51* | –8.76* |
| SE (gi) | 0.35 | 0.23 | 2.71 |

*Significant at P = 0.05

*Specific combining ability*

A total of seven crosses appeared to have significant negative SCA effects for the days to tassel (Table 3). The least estimate was observed with the cross P2 × P3 (–4.39 days). The mean performance of this cross was 122.33 days. One parent of this cross, that is, P2 was also very good general combiner. Considering days to tassel as an index of early maturity this cross could be desirable. The three crosses namely, P2 × P10 (18.83cm), P1 × P7 (18.20 cm) and P1 × P8 (17.93 cm) were observed to have high SCA effects for ear-length. None of the parents of these

crosses appeared to be good general combiners. The two crosses namely, P3 × P8 (69.47 gm) and P1 × P7 (50.43 gm) which had high SCA effects for grain yield excelled all others with respect to the mean performance (196 gm and 187 gm, respectively). Out of these two, only P1 × P7 had one parent (P7) with high GCA effect.

The results indicated that, in general, there were good association between mean performance and SCA effects of the crosses although it was not complete (Table 5). The cross, P3 × P8 showed high SCA effects for ear-length and grain yield which implied association between these two traits on the basis of SCA effects. It is in partial agreement with the findings of Prasad *et al.* [4]. All traits of the hybrids studied indicated that the relationship between GCA and SCA was either partial or practically absent. However, Zhang and Wang [5] observed clear influence of GCA of the two parents on SCA of a particular cross for all the traits studied and accordingly recommended that equal attention should be paid for selecting the parent with high GCA effect for having high SCA effects of the crosses.

**Table 5. New heterotic group for grain yield/plant based on desirable SCA effects and mean performance of nine crosses.**

| Crosses | SCA effects | Mean performance | Rank correlation |
|---|---|---|---|
| P3 × P8 | 69.47* | 196.0 | |
| P1 × P7 | 50.43* | 187.0 | |
| P5 × P9 | 36.56* | 162.0 | |
| P6 × P10 | 32.97* | 145.0 | |
| P2 × P7 | 30.43* | 179.0 | 0.72* |
| P2 × P6 | 30.22* | 162.0 | |
| P4 × P9 | 23.43* | 158.0 | |
| P2 × P4 | 20.81* | 162.0 | |
| P1 × P10 | 17.43* | 136.0 | |

*Significant at P = 0.05

***Inter vs intrapopulation cross combining ability***

Since each population provided equal number of S1-lines (early-generation) it was possible to look at the cross performance from the inter vs intra-population perspective. Out of the total crosses that showed highly positive and significant SCA effects for the days to tassel, ear-length and grain yield, more than two-thirds were interpopulation crosses. Although partitioning of variation due to SCA from inter

vs intrapopulation point of view was not performed, the apparent superiority of interpopulation crosses over intrapopulation crosses must have been implicated for these traits. It was also not unexpected because cross combining ability increases with genetic diversity (within physiological limits). Han *et al.* [1] also indicated large positive SCA effects and good interpopulation cross superiority for crosses involving inbreds (S3-lines) derived from different populations.

***Formation of a new heterotic group***

It has now become established that there is a good association between SCA effects and mean performance of crosses. However, a few crosses appeared to have high mean value but non-significant SCA effects and vice-versa. Keeping these facts into view, nine best crosses (20% selection intensity) were composited to form a new heterotic group for grain yield (Table 5). It is obvious from the data that the ranking of crosses based on the mean performance and SCA effects was not always the same; however, there was a significant association between these two criteria of ranking. This new group contained about 90% interpopulation crosses.

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## REFERENCES

1. G. C. Han, S. K. Vasal, D. L. Beck and E. Elias. 1991. Combining ability of inbred lines derived from CIMMYT maize (*zea mays* L.) germplasm. Maydica., **36**: 57-64.
2. S. K. Vasal and G. Srinivasan. 1991b. Breeding strategies to meet changing trends in hybrid maize development. Proceeds., Golden Jubilee Symposium; Ind. Soc. Genet. Pl. Breed., Feb. 12-15, 1991: New Delhi.
3. B. Griffing. 1956. Concepts of general and specific combining ability in relation to diallel crossing systems. Australian J. Biol. Sci., **9**: 463-493.
4. R. Prasad, S. Singh and R. S. Paroda. 1988. Combining ability analysis in a maize diallel. Indian J. Genet., **48**: 19-23.
5. D. S. Zhang and G. R. Wang. 1991. Analysis of the combining ability of main photosynthetic and agronomic characters in maize (*Zea mays* L.). Journal of Shandong University., China. **22**: 212-220.