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# HETEROSIS AND COMBINING ABILITY FOR QUALITY AND YIELD IN EARLY MATURING SINGLE CROSS HYBRIDS OF MAIZE (*ZEA MAYS* L.)

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## ABSTRACT

**Combining ability analysis was conducted in early maturing maize (*Zea mays* L.) inbred lines for quality and yield attributes. Both additive and non additive gene effects were present in the material under study. However, the ratio of additive/non additive genetic variance revealed that there was preponderance of non additive gene action in the expression of yield per plant, protein content and starch content, while for oil content and 100-grain weight there was preponderance of additive gene action. Inbred line $X_2$W-3232-1-1-1-1 was good general combiner for all the three quality traits along with grain yield. Inbred line $X_1$W-1527-2-2-1-1 was also good general combiner for all the three quality traits along with 100-grain weight. Single cross Pop.30-5044-2 × CD(W)-113-2-1-2-1 had positive significant sca effects for oil content along with grain yield per plant and 100-grain weight with highest estimate of economic heterosis for oil content. In general, parental inbreds possessed high *per se* performance for quality traits along with grain yield per plant and 100-grain weight. Significant economic heterosis for starch and protein in content could not be obtained.**

**Key words:** *Zea mays* L., combining ability, quality traits

Corn oil is considered desirable for human nutrition as it posses a very high proportion of unsaturated fatty acids. Limited breeding work has been done in India, for exploiting the potential of maize as a source of edible oil. There is a strong possibility to develop hybrids which are nutritionally superior and industrially important with respect to high oil, protein and starch content. If this objective is realized, maize crop in India can attain very high industrial importance as a supplementary oil seed crop because of its high productivity vis-a-vis traditional oil seed crops [1] and as an important source of starch. Maize oil can impart very high

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economic importance to this crop, if exploited properly through heterosis breeding. Present investigation was therefore, undertaken to assess the nature of gene actions involved in the inheritance of quality traits along with grain yield and to identify best general combiner inbred lines for these traits and also the best single cross hybrids with high sca effects which can be exploited directly as single cross hybrid.

## MATERIALS AND METHODS

Ten diverse, early maturing white seed colour inbred lines of maize were crossed in a diallel mating pattern excluding reciprocals in rabi 1994-95 to generate experimental hybrids for this study. The 45 $F_1$s, 10 parental inbred lines with four standard checks viz., Arun, Kiran , Mahi Kanchan and Deccan-107 were grown in randomized block design with three replications in a single row plot of 5 meters length having 60 × 25 cms crop geometry in four environments in kharif 1995. The data were recorded on quality and grain yield traits on ten randomly selected competitive plants. Total oil content of dry seeds was determined by Nuclear Magnetic Resonance (NMR) technique [2]. Protein content was estimated by the Micro-Kjeldalh's method and starch content was estimated by the Anthrone reagent method. Pooled economic heterosis over environments was calculated as per standard procedure and combining ability analysis was conducted according to Griffing Method 2 model I [3]. Pooled analysis over environments was done according to method suggested by Singh [4, 5].

## RESULTS AND DISCUSSION

In the developing world including India, efforts and research strategies are beign diverted to produce single cross hybrids to achieve quantum jump in production and productivity for grain yield and an improvement in quality on a pattern similar to that achieved in USA and other European countries. In the present investigation the pooled analysis of variance revealed the presence of significant amount of variability among the genotypes, parents and hybrids for all the characters. The interactions of genotypes, parents and hybrids with the environments were significant for all the characters except protein content and starch content (Table 1). The pooled analysis of variance for combining ability revealed presence of significant mean squares due to gca and sca for characters under study (Table 2), thereby suggesting that both additive and non additive gene actions were important for the expression of these traits. The mean squares due to interaction of environments with gca and sca were significant for all the characters except protein content and starch content. However, the ratio of additive/non additive variance showed that non additive type of gene effects were more important in the expression of protein content, starch

**Table 1. Pooled analysis of variance for different traits in a diallel cross of maize**

| Source | d.f. | Oil content | Protein content | Starch content | Grain yield per plant | 100-grain weight |
|---|---|---|---|---|---|---|
| | | Mean squares | | | | |
| Environment | 3 | 1.15** | 0.06. | 0.63 | 57469.74** | 530.75** |
| Genotypes | 54 | 1.03** | 5.19** | 113.48** | 1581.45** | 21.30** |
| Parents (P) | 9 | 0.69** | 6.23** | 146.43** | 301.75** | 16.30** |
| Hybrids ($F_1$) | 44 | 1.09** | 4.83** | 109.11** | 590.53** | 20.07** |
| Genotype × Env. | 163 | 0.12** | 0.04 | 0.25 | 250.02** | 7.18** |
| P × Env. | 27 | 0.26** | 0.003 | 0.08 | 29.87** | 13.41** |
| $F_1$ × Env. | 132 | 0.10** | 0.04 | 0.28 | 172.36** | 5.98** |
| Pooled error | 432 | 0.20 | 0.17 | 1.16 | 14.42 | 2.38 |

** Significant at P = 0.01; * Significant at p = 0.05

content and yield per plant, while for 100-grain weight and oil conent additive gene effects were more important in their expression (Table 2). Similar results have also been reported by Jha and Khera [6] and Kulmi [7] for grain yield, and by Poneleit and Bauman [8] for oil percent. However, Wang [9] and Liu [10] reported importance of aditive gene effects for protein percent.

**Table 2. Pooled analysis of variance of combining ability for different characters in a diallel cross of maize**

| Source | d.f. | Oil content | protein content | Starch content | Grain yield per plant | 100-grain weight |
|---|---|---|---|---|---|---|
| | | Mean squares | | | | |
| Environment | 3 | 0.38** | 0.02 | 0.21 | 19156.58** | 176.91** |
| GCA | 9 | 0.88** | 3.77** | 27.22** | 408.43** | 19.22** |
| SCA | 45 | 0.23** | 1.32** | 39.94** | 550.89** | 4.67** |
| GCA × Env. | 27 | 0.05** | 0.01 | 0.07 | 28.77** | 2.70** |
| SCA × Env. | 135 | 0.04** | 0.01 | 0.08 | 94.25** | 2.33** |
| Pooled error | 432 | 0.01 | 0.05 | 0.38 | 4.80 | 0.79 |
| $\sigma^2 g / \sigma^2 s$ | | 3.7216 | 0.0484 | 0.0113 | 0.0123 | 4.1121 |

** Significant at P = 0.01; * Significant at P = 0.05

A persual of gca effects revealed that inbred $X_2W$-3232-1-1-1-1 was good general combiner for grain yield, oil content, protein content and starch content, while inbred Pop.30-5029 was good general combiner for all the characters except oil content. Inbred line $X_1W$-1527-2-2-1-1 was good general combiner for all the three quality traits and 100-grain weight. However, two inbreds lines viz., CD(W)-113-2-1-2-1 and $X_2W$-3527-2-2-1-1 were good general combiners for oil content along with grain yield per plant and 100-grain weight (Table 3).

**Table 3. Pooled estimates of gca effects for different traits in inbred lines of maize**

| S.No. | Parents/pedigree | Oil content | Protein content | Starch content | Yield per plant | 100-grain weight |
|---|---|---|---|---|---|---|
| 1. | Pop.30-5029 | –0.30* | 0.45** | 0.22** | 4.07** | 1.26** |
| 2. | Pop.30-5044-2 | –0.14* | –0.12* | –0.53* | 1.20** | 0.26* |
| 3. | Pop.30-87-1-35 | 0.09** | 0.01 | –0.94* | –2.66* | –0.25* |
| 4. | CD(W)-55-1-1-3-1 | 0.07** | –0.13* | 0.52** | –5.82* | –0.80* |
| 5. | CD(W)-113-2-1-2-1 | 0.13** | –0.40* | –0.31* | 1.11** | 0.28* |
| 6. | $X_2W$-3232-1-1-1-1 | 0.03** | 0.09** | 0.72** | 2.50** | –0.29* |
| 7. | $X_2W$-3527-2-2-1-1 | 0.14** | –0.34** | –0.17* | 1.21** | 0.40** |
| 8. | $X_1W$-1527-2-2-1-1 | 0.04** | 0.10* | 0.95** | –0.62* | 0.50** |
| 9. | $X_1W$-1627 | –0.05* | –0.13* | 0.76** | –2.30** | -0.74* |
| 10. | $X_1W$-173-3-1-1 | –0.14* | 0.43** | –1.22* | 2.09** | –0.43* |

A persual of first five best hybrids on the basis of sca effects for oil content in relation to economic heterosis for oil content revealed that cross Pop.30-5044-2 × CD(W)-113-2-1-2-1 exhibited positive significant sca effects for oil content along with positive significant sca effects for grain yield per plant and 100-grain weight with highest estimate of economic heterosis for oil content against the best check Mahi Kanchan (Table 4). This single cross hybrid also showed good *per se* performance for all the characters. It was in fact a cross of poor × good gca effect parents for oil content. Good × good gca effect single cross (Pop.30-87-1-35 × CD(W)-55- 1-1-3-1) exhibited positive significant sca effects for oil content along with grain yield per plant and 100-grain weight with higher estimate of economic heterosis for oil content and good *per se* performance for all the characters. Cros CD(W)-113-2-1-2-1 × $X_2W$-3527-2-2-1-1 although revealed positive significant sca effect for all the three quality traits, it exhibited non-significant sca effect for grain yield per plant and

**Table 4.** **Pooled sca estimates for different quality and yield traits showing highest sca effects for quality traits with economic heterosis and *per se* performance in maize**

| S. No. | Hybrids/Parent | sca effects | | | | | Economic | *per se* performance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Oil content | Protein content | Starch content | Grain yield per plant | 100-grain weight | heterosis for oil content | Oil content (%) | Protein content (%) | Starch content (%) | Grain yield per plant | 100-grain weight |
| 1. | Pop.30-5044-2 × CD(W)-13-2-1-2-1 | 0.50** | –0.28** | –3.16** | 11.45** | 0.97** | 5.51** | 8.23 | 8.14 | 57.44 | 63.51 | 19.20 |
| 2. | Pop.30-87-1-35 × CD(W)-55-1-1-3-1 | 0.43** | –0.63** | –3.66** | 8.60** | 1.33** | 5.33** | 8.22 | 8.18 | 57.36 | 49.87 | 18.87 |
| 3. | CD(W)-55-1-1-3-1 × $X_2$W-3527-2-2-1- 1 | 0.33** | –0.36** | –2.22** | 2.91* | –1.12** | 4.62** | 8.16 | 8.11 | 61.57 | 45.25 | 16.67 |
| 4. | CD(W)-55-1-1-3-1- × $X_2$W-3232-1-1-1- 1 | 0.41** | –0.45** | 1.88** | –0.41 | –1.00* | 4.24** | 8.13 | 8.45 | 64.56 | 46.01 | 16.84 |
| 5. | CD(W)-113-2-1-2-1 × $X_2$W-3527-2-2-1- 1 | 0.33** | 0.37** | 1.51** | 2.78 | 0.89* | 2.88 | 8.02 | 8.47 | 62.47 | 54.04 | 19.76 |
| 6. | Pop. 30 - 5744-2 | - | - | - | - | - | - | 7.80 | 8.34 | 62.36 | 27.07 | 17.05 |
| 7. | Pop. 30-87-1-35 | - | - | - | - | - | - | 7.70 | 9.81 | 63.20 | 23.05 | 17.14 |
| 8. | CD(W)-55-1-1-3-1 | - | - | - | - | - | - | 7.17 | 10.10 | 56.55 | 23.43 | 15.52 |
| 9. | CD(W)-113-2-1-2-1 | - | - | - | - | - | - | 7.52 | 8.47 | 57.55 | 30.15 | 17.33 |
| 10. | $X_2$W-3232-1-1-1-1 | - | - | - | - | - | - | 7.64 | 8.64 | 65.63 | 37.60 | 17.96 |
| 11. | $X_2$W-325-7-2-2-1-1 | - | - | - | - | - | - | 7.80 | 8.47 | 61.61 | 26.52 | 19.53 |
| 12. | Mahi Kanchan | - | - | - | - | - | - | 7.80 | 9.84 | 67.67 | 36.91 | 15.98 |
| 13. | Arun | - | - | - | - | - | - | 7.67 | 10.76 | 67.85 | 40.17 | 18.45 |
| 14. | Kiran | - | - | - | - | - | - | 7.72 | 11.53 | 69.17 | 42.08 | 17.46 |
| 15. | Deccan-107 | - | - | - | - | - | - | 7.55 | 9.88 | 65.54 | 49.11 | 16.37 |

** Significant at P = 0.01; * Significant at P = 0.05

non-significant economic heterosis for oil content. In general parental inbreds and all the hybrids possessed high *per se* performance for quality traits along with grain yield per plant and 100-grain weight. It is apparent from here that poor × good and good × good general combiners also had high sca values. The parental lines in this study were having diverse genetic background of their source populations and hence their crosses exhibited high sca effects which resulted into high *per se* performance of these hybrids with significant economic heterosis for oil content. However, in this study significant economic heterosis for protein and starch content could not be observed.

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