

Identification of Stable Biparental Maize Hybrids

P. Kumar and S.C. Gupta

Department of Plant Breeding and Genetics, Maharana Pratap University of Agriculture and Technology, Udaipur 313 001, India

Abstract: The biparental hybrids and parental lines were evaluated in four environments. The estimates of stability analysis indicated that additive ($\sigma^2 A$) and non-additive ($\sigma^2 D$) gene actions were responsible for expression of days to silking and maturity, tassel length, LAI, shelling percentage, biological yield and grain yield, while non-additive ($\sigma^2 D$) gene action were pre-dominant for ASI, number of leaves per plant and number of leaves above main cob. Hybrids (X_2W 3121-1-12 x Pop 30-5040-2), (X_2W 3770-2-2-1 x X_2W 3121-1-12), (X_1W 8055-2 x X_2W 3121-1-12), (X_2W 3997-1-1-1-1 x X_1W 8001), (X_2W 3048-3-1-2 x X_1W 1016-2-3-2), (X_2W 3112-1-1-2 x X_2W 3048-3-1-2), (X_2W 3770-2-2-1 x X_2W 3048-3-1-2), (X_1W 1629-1-1 x Pop 30-5047-2), (X_1W 8055-2 x X_1W 8001), (X_1W 1629-1-1 x X_1W 1016-2-3-2) and (X_1W 8052 x Pop 30-5040-2) exhibited suitability under different agro-climatic conditions for grain yield and its contributing and developmental traits, while hybrid (X_1W 8052 x X_1W 1629-1-1) was appropriate for water stress conditions.

Key words: Diallel, biparental, stable, additive, non-additive.

Plant breeders are emphasizing the need for development of single cross hybrids for maize (*Zea mays* L.), due to their high yield potential and uniformity in performance. These hybrids require less land, labor and capital for hybrid seed production, hence reduce the cost of hybrid seed. Consistency in the performance of a superior hybrid is an urgent need to obtain higher yield potential under different agro-climatic situations. The genotype x environment interaction studies could be used as a tool for measuring reaction of genotypes to varying environments. Hence, the present investigation was undertaken to examine G x E interaction and stability of biparental maize hybrids.

Materials and Methods

The experimental material was developed through diallel system, including

12 S_4/S_5 stage diverged inbred lines (X_1W 8052, X_1W 8055-2, X_2W 3121-1-1-2, X_1W 1629-1-1, X_1W 1016-2-3-2, X_1W 8001, X_2W 3770-2-2-1, X_2W 3997-1-1-1-1, X_2W 3048-3-1-2, X_2W 3548-2-2-1-1, Pop. 30-5040-2, Pop. 30-5047-2, derived from divergent heterotic pools- X_1W , X_2W and population 30). These hybrids and parental lines were evaluated under four environments (rainfed and irrigated conditions on clay loam and sandy loam soils, respectively) using randomized block design with three replications and single row plot of 5 m length. The plant-to-plant and row-to-row spacing was 60 cm and 25 cm, respectively. The data were recorded on 10 randomly selected plants for days to 50% silking, days to 75% maturity, anthesis-silking interval (days), tassel length, number of leaves per plant, number of leaves above main cob, leaf area index

(LAI), harvest index (HI), shelling percentage, biological yield per plant and grain yield per plant. Statistical analysis was done as per model suggested by Eberhart and Russell (1966).

Results and Discussion

The joint regression analysis (Table 1) exhibited highly significant mean sum of squares due to genotype, suggesting appropriate genetic variability in the experimental material. Significant MSS due to environment and environment (linear) revealed that environments considerably differed from each other. Significant variances due to genotype x environment and genotype + (genotype x environment) indicated that genotypes interacted with environmental fluctuations. Highly significant MSS values due to genotype x environment (linear) and pooled deviation for all the traits (except anthesis-silking interval, number of leaves per plant and number of leaves above main cob, where only pooled deviation was significant) revealed that linear and non-linear (additive and non-additive gene actions) components of G x E interactions were responsible for expression of these traits. For ASI, number of leaves per plant and number of leaves above main cob, non-linear component of G x E interactions was pre-dominant. Rastogi and Rastogi (1998) and Mani and Singh (1999) also observed similar trends for various traits.

The stability of individual hybrid was judged on the basis of individual stability parameters (Table 2). Hybrid (X₂W 3121-1-1-2 x Pop 30-5040-2) was found stable for days to silking and maturity and LAI, since it exhibited near unity regression

coefficient ($b_i=1$), non-significant deviation from regression ($S^2_{di}=0$) and early silking and maturity over population mean. However, it showed lower mean performance of LAI. This hybrid exhibited below-average response ($b_i<1$) for grain yield per plant and above-average response ($b_i>1$) for anthesis-silking interval, revealed better performance under poor and better environments, respectively. For other traits the deviation from regression was significant ($S^2_{di}>0$), indicating unpredictability of this hybrid under varying environments for these traits.

Hybrid (X₂W 3770-2-2-1 x X₂W 3121-1-1-2) was found stable for days to maturity and LAI. It is expected to perform better under unfavorable environments ($b_i<1$) for biological yield per plant and shelling percentage.

Hybrid (X₁W 8055-2 x X₂W 3121-1-1-2) exhibited stability in performance for days to silking, LAI and shelling percentage.

Hybrid (X₂W 3997-1-1-1-1 x X₁W 8001) was stable for days to silking and maturity, LAI and shelling percentage.

Hybrid (X₂W 3048-3-1-2 x X₁W 1016-2-3-2) was found adaptable for tassel length, number of leaves per plant, number of leaves above main cob and LAI. This was suitable under favorable environment ($b_i>1$) for days to silking and under unfavorable environments ($b_i<1$) for days to maturity.

Hybrid (X₂W3121-1-1-2 x X₂W 3048-3-1-2) exhibited consistency in performance for days to maturity, number of leaves above main cob, LAI and shelling

Table 1. Joint regression analysis for eleven traits in maize

| Source of variation | d.f. | Mean sum of squares | | | | | | | | | | |
|---------------------------------|------|---------------------|----------------------|----------------------------------|--------------------|------------------------|----------------------------------|---------------------|-------------------|-------------------------|----------------------------|-----------------------|
| | | Days to 50% silking | Days to 75% maturity | Anthesis silking interval (days) | Tassel length (cm) | Number of leaves/plant | No. of leaves above main cob (%) | Leaf area index (%) | Harvest index (%) | Shelling percentage (%) | Biological yield/plant (g) | Grain yield/plant (g) |
| Genotype | 143 | 12.31** | 21.61** | 6.88** | 26.80** | 1.65** | 0.73** | 0.63** | 156.17** | 75.51** | 626.12** | 175.50** |
| Environment | 3 | 120.91** | 1871.21** | 11.81** | 41.99** | 18.99** | 14.68** | 33.59** | 2122.50** | 2163.25** | 19700.00** | 6908.77** |
| Genotype x environment | 429 | 3.93*** | 5.34** | 2.64** | 17.79** | 0.69** | 0.31** | 0.14** | 60.28** | 28.64** | 155.55** | 48.96** |
| Genotype + Environment | 432 | 4.75*** | 18.29*** | 2.70** | 17.96** | 0.81** | 0.41*** | 0.37*** | 74.60*** | 43.46*** | 291.28*** | 96.60*** |
| Environment (linear) | 1 | 362.72** | 5613.63** | 35.44** | 125.99** | 56.96** | 44.05** | 100.78** | 6367.51** | 6489.75** | 59100.00** | 20700.00** |
| Genotype x Environment (linear) | 143 | 6.43** | 6.28** | 2.70 | 21.82** | 0.64 | 0.34 | 0.16** | 91.09** | 29.34** | 185.48** | 72.29** |
| Pooled deviation | 288 | 2.67** | 4.83** | 2.59** | 15.67** | 0.70** | 0.29** | 0.13** | 44.56** | 28.08** | 139.61** | 37.04** |
| Pooled error | 1144 | 1.067 | 0.537 | 0.198 | 0.311 | 0.052 | 0.010 | 0.073 | 0.209 | 0.304 | 0.278 | 0.158 |

*, ** Significant at 5% and 1% level, respectively; ** significant at 1% level (against pooled error).

Table 2. Superior single cross hybrids identified on the basis of stability parameters

| Hybrid | Stability parameter | Days to 50% silking | Days to 75% maturity | Anthesis-silking interval (days) | Tassel length (cm) | No. of leaves per plant | No. of leaves above main cob | Leaf area index (%) | Shelling percentage (%) | Harvest index (%) | Biological yield per plant (g) | Grain yield per plant (g) |
|---------------------------------|------------------------------|---------------------|----------------------|----------------------------------|--------------------|-------------------------|------------------------------|---------------------|-------------------------|-------------------|--------------------------------|---------------------------|
| (X ₂ W 3121-1-1-2) | μ _i | 56.50 | 89.25 | 5.33 | 28.55 | 9.83 | 5.27 | 1.66 | 70.12 | 34.00 | 64.61 | 21.73 |
| x | bi | 0.80 | 1.08 | 4.02** | -4.27 | 0.49 | 2.08 | 0.82 | 0.40 | -0.46* | 1.48 | 0.75* |
| (Pop 30-5040-2) | S ² _{di} | 0.62 | -0.11 | -0.18 | 3.34** | 0.61** | 0.12** | -0.03 | 9.07** | 8.41** | 34.37** | 0.10 |
| (X ₂ W 3770-2-2-1) | μ _i | 57.58 | 85.42 | 5.92 | 30.13 | 11.19 | 6.04 | 2.13 | 74.43 | 41.60 | 72.65 | 30.28 |
| x | bi | 2.29 | 0.80 | 5.43 | 2.98 | -0.48 | 0.49 | 1.03 | 0.55* | 0.43 | 0.56** | 0.54* |
| (X ₂ W 3121-1-1-2) | S ² _{di} | 2.80* | 0.41 | 0.22* | 4.28** | 0.72** | 1.50** | -0.06 | 0.16 | 1.70** | 0.27 | 0.68** |
| (X ₂ W 8055-2) | μ _i | 58.08 | 89.33 | 4.42 | 29.62 | 9.87 | 5.01 | 2.24 | 75.23 | 41.59 | 57.23 | 23.93 |
| x | bi | 1.98 | 1.11 | 6.74 | 4.56 | -0.46 | 0.73 | 1.17 | 0.61 | -0.11 | 0.74 | 0.48 |
| (X ₂ W 3121-1-1-2) | S ² _{di} | 8.14 | 1.26* | 0.58** | 10.67** | 0.22** | 0.05** | 0.04 | 0.01 | 109.23** | 53.79** | 60.81** |
| (X ₂ W 3997-1-1-1-1) | μ _i | 56.83 | 89.00 | 5.92 | 31.70 | 11.38 | 5.25 | 2.70 | 74.97 | 37.75 | 101.45 | 38.44 |
| x | bi | 1.35 | 1.18 | 0.67 | -5.31 | 1.36 | 0.68 | 0.63 | 0.63 | 0.69 | 52.37** | 0.75 |
| (X ₁ W 8001) | S ² _{di} | 2.03 | 10.52 | 5.79** | 18.91** | 0.77** | 0.39** | 0.08 | 0.54 | 2.91** | 65.29** | 12.49** |
| (X ₂ W 3048-3-1-2) | μ _i | 57.08 | 87.67 | 4.58 | 29.84 | 10.81 | 4.93 | 2.12 | 79.88 | 45.65 | 65.29 | 30.17 |
| x | bi | 2.47* | 0.59* | -2.46 | 1.68 | 2.00 | 1.61 | 1.21 | 0.51 | 1.31 | 1.13 | 1.45 |
| (X ₁ W1016-2-3-2) | S ² _{di} | -0.68 | 0.19 | 5.65** | 0.41 | 0.07 | 0.02 | -0.04 | 132.65** | 41.06** | 86.67** | 15.99** |
| (X ₂ W 3121-1-1-2) | μ _i | 55.58 | 89.75 | 5.58 | 33.65 | 10.66 | 6.37 | 2.46 | 78.04 | 45.67 | 92.80 | 43.01 |
| x | bi | 2.03 | 1.04 | -1.30 | 9.54* | 1.51 | 0.79 | 0.82 | 0.66 | 0.70 | 2.27 | 2.14 |
| (X ₂ W 3048-3-1-2) | S ² _{di} | 0.56 | 0.52 | 0.52* | 2.37** | 0.00 | 1.54** | -0.06 | 0.57 | 0.96** | 246.70** | 58.05** |
| (X ₂ W 3770-2-2-1) | μ _i | 58.50 | 91.00 | 4.75 | 28.26 | 10.19 | 4.91 | 1.80 | 76.14 | 38.68 | 69.94 | 27.93 |
| x | bi | 2.34* | 1.51 | -1.54 | -3.07** | 1.88 | 1.34 | 1.07 | 0.66 | 2.16 | 1.17 | 1.69* |
| (X ₂ W 3048-3-1-2) | S ² _{di} | -0.78 | -0.29 | 5.88** | 0.02 | 1.17* | 0.01 | -0.07 | 0.30 | 8.02** | 6.67** | 2.42** |
| (X ₁ W 1629-1-1) | μ _i | 56.92 | 86.00 | 4.67 | 31.86 | 11.09 | 4.90 | 2.59 | 74.98 | 47.04 | 83.64 | 38.56 |
| x | bi | 3.66* | 0.82 | 1.49 | 6.11 | 1.06 | 0.89 | 0.89 | -0.17* | -2.39 | 0.16 | -1.13** |
| (Pop 30-5047-2) | S ² _{di} | 0.82 | 0.10 | 1.42** | 9.32** | 0.00 | -0.00 | 0.08 | 2.63** | 82.78** | 381.67** | 16.33** |

Table 2 contd...

Contd.. Table 2 ...

| Hybrid | Stability parameter | Days to 50% silking | Days to 75% maturity | Anthesis-silking interval (days) | Tassel length (cm) | No. of leaves per plant | No. of leaves above main cob | Leaf area index (%) | Shelling percentage (%) | Harvest index (%) | Biological yield per plant (g) | Grain yield per plant (g) |
|---|------------------------------|---------------------|----------------------|----------------------------------|--------------------|-------------------------|------------------------------|---------------------|-------------------------|-------------------|--------------------------------|---------------------------|
| (X ₁ W8055-2) x X ₁ W8001) | μ _i | 57.33 | 88.08 | 4.92 | 29.52 | 10.85 | 5.09 | 1.73 | 69.08 | 29.19 | 67.43 | 19.59 |
| | b _i | 2.24 | 1.52 | 2.91 | 2.16 | 1.29 | 0.73 | 0.79 | 1.66 | 2.19 | 0.18 | 0.88 |
| | S ² _{di} | 1.08 | 2.26** | 7.25** | 4.86** | 0.01 | 0.01 | -0.07 | 28.72** | 29.56** | 63.05** | 3.28** |
| (X ₁ W 1629-1-1) x (X ₁ W 1016-2-3-2) | μ _i | 60.17 | 92.00 | 5.33 | 29.56 | 10.55 | 4.64 | 4.36 | 77.95 | 31.98 | 64.97 | 21.37 |
| | b _i | 1.00 | 0.96 | 5.67 | -6.52** | 1.40 | 0.01 | -3.99 | 0.58* | 1.84 | 0.57 | 0.87 |
| | S ² _{di} | 0.61 | 6.45** | 2.84** | 0.16 | -0.03 | 0.05** | 5.24** | 0.05 | 32.71** | 97.93** | 46.47** |
| (X ₁ W 8052) x (Pop 30-5040-2) | μ _i | 57.00 | 86.50 | 6.17 | 29.93 | 10.90 | 5.28 | 1.55 | 77.77 | 32.41 | 72.58 | 22.38 |
| | b _i | 2.95* | 1.14** | 0.96 | 3.68 | 1.88 | 1.28* | 1.17 | 0.80 | -0.60 | 1.88 | 0.43 |
| | S ² _{di} | -0.66 | -0.51 | 6.08** | 36.38** | 0.07 | -0.01 | -0.06 | 5.81** | 110.76** | 160.32** | 12.14** |
| (X ₁ W 8052) x (X ₁ W 1629-1-1) | μ _i | 56.83 | 83.83 | 2.42 | 27.96 | 10.80 | 4.89 | 1.70 | 69.56 | 28.99 | 58.13 | 17.23 |
| | b _i | 1.77 | 0.18** | -1.55 | 3.61* | 0.39 | 0.84 | 1.39 | 2.48 | 1.38 | 0.72 | 0.84 |
| | S ² _{di} | -0.42 | 0.23 | 0.22 | 0.49 | 0.11* | 0.43 | 0.12 | 16.75** | 11.48** | 38.76** | 7.51** |
| | PM(x) | 58.54 | 90.08 | 4.79 | 27.83 | 10.42 | 4.83 | 1.99 | 74.42 | 37.12 | 68.96 | 25.99 |
| | S.E.(b) | 1.01 | 0.35 | 3.24 | 4.23 | 1.33 | 0.97 | 0.42 | 0.79 | 1.00 | 0.58 | 0.51 |

* ** Significant at 5% and 1% level, respectively; ++ significant at 1% level (against pooled error).

percentage. It is expected to perform better under high yielding environments ($b_i > 1$) for days to silking and under low yielding environments ($b_i < 1$) for tassel length.

Hybrid (X_1W 1629-1-1 x Pop 30-5-47-2) was stable for days to maturity, number of leaves per plant, number of leaves above main cob and LAI. It was suitable under better environment ($b_i > 1$) for days to silking.

Hybrid (X_1W 8055-2 x X_1W 8001) was found consistent in performance for days to silking, number of leaves per plant, number of leaves above main cob and LAI (with low mean value).

Hybrid (X_1W 1629-1-1 x X_1W 1016-2-3-2) was phenotypically stable for number of leaves with delayed silking. It is likely to perform better under low yielding environment ($b_i < 1$) for tassel length and shelling percentage.

Hybrid (X_1W 8052 x Pop 30-5040-2) was found stable for number of leaves per plant and LAI. This hybrid is expected to perform better under high yielding environment ($b_i > 1$) for days to silking and maturity and number of leaves above main cob.

The anthesis-silking interval and tassel length are related to drought tolerance. The tolerant genotypes should possess low ASI and larger tassel size. Hybrid (X_1W 8052 x X_1W 1629-1-1) may perform better under water stress conditions, since it exhibited below average response ($b_i < 1$) for ASI and above average response ($b_i > 1$) for tassel length and days to maturity. This was stable

for days to silking, number of leaves above main cob and LAI (with slightly low mean value). Rastogi and Rastogi (1998) and Mani and Singh (1999) also identified stable superior hybrids in maize.

Thus, it could be concluded that additive and non-additive gene actions were responsible for expression of days to silking and maturity, tassel length, LAI, shelling percentage, biological yield and grain yield, while non-additive gene actions were pre-dominant for ASI, number of leaves per plant and number of leaves above main cob. Hybrids (X_2W 3121-1-1-2 x Pop 30-5040-2), (X_2W 3770-2-2-1 x X_2W 3121-1-1-2), (X_1W 8055-2 x X_2W 3121-1-1-2), (X_2W 3997-1-1-1-1 x X_1W 8001), (X_2W 3770-2-2-1 x X_2W 3048-3-1-2), (X_1W 1629-1-1 x Pop 30-5047-2), (X_1W 8055-2 x X_1W 8001), (X_1W 1629-1-1 x X_1W 1016-2-3-2), and (X_1W 8052 x Pop 30-5040-2) exhibited suitability under different agro-climatic conditions for grain yield and yield attributes and developmental traits, while hybrid (X_1W 8052 x X_1W 1629-1-1) was appropriate for water stress conditions.

References

- Elberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science* 6: 36-40.
- Mani, V.P. and Singh, N.K. 1999. Stability analysis of yield in maize (*Zea mays* L.). *Indian Journal of Agricultural Science* 69: 34-35.
- Rastogi, N.K. and Rastogi, V.K. 1998. Stability in maize genotypes under varying environments. *Advances in Plant Science* 11: 87-93.