# ASSESSMENT OF GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY OF PROMISING SUGARCANE GENOTYPES FOR DIFFERENT AGRONOMIC CHARACTERS IN PESHAWAR VALLEY

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**Abstract**

Sugarcane germplasm screening is a regular feature of the breeding program at Sugar Crops Research Institute, Mardan, NWFP, Pakistan. Sixteen genotypes were evaluated in the final stages of selection in three different environments for G x E interaction and stability. Combined analysis of variance showed highly significant variances for Environments (E), Genotypes (G), and their interaction (G x E). The effect of environments was much pronounced for all the characters signifying their importance in the performance of genotypes. None of the genotypes was stable for all characters. However, genotype MS-94-CP-90 showed a relative stability for three characters viz. germination percentage, cane yield (t/ha) and millable canes.

Key words: **G x E Interaction, Environments, Stability, Sugarcane**

## Introduction

Sugarcane is an important field crop of the North West Frontier Province of Pakistan. It is cultivated on an area of 0.1 million hectare with a production of 4.65 million tones and per hectare cane yield amounting to 46 tones per hectare (Agriculture Statistics of Pakistan, 2006-07). Sugar Crops Research Institute (SCRI), Mardan, is mandated with the development of sugarcane varieties which are high yielding, disease and frost

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resistant and with better quality. Germplasm is procured both from within the country and from abroad. It is tested in various selection stages and advanced to final stages of selection. Varieties are sought which would interact minimally with the environment so that their performance could be generalized over a range of environments.

However, Genotype by environment (G x E) interaction complicates selection and testing of plant genotypes. Measuring G x E is important in order to determine an optimum strategy for selecting genotypes with adaptation to target environments (Romagosa et al., 1993; De Lacy et al., 1994; Annicchiriarico, 1997). Productivity stability is shown by some cane varieties in both predictable and unpredictable environments. In a predictable environment (i.e. climatic, soil type, day length and controllable variables such as fertilization, sowing dates and harvesting methods), a high level of genotype and environmental interaction was desirable, so as to ensure a maximum yield or financial return; whereas, in an unpredictable environment (inter and intra-season fluctuation, fluctuation in quantity and distribution of rainfall and prevailing temperature), a low level of interaction is desirable so as to ensure maximum uniformity of performance over a number of locations or seasons (Khan, 1981). However the performance of genotypes in favorable environments does not indicate their adaptability and stability. Hence a breeder is always in a hunt for suitable high yielding genotypes which would interact minimal with the environments and are stable.

The current study was undertaken to assess genotype by environment interaction and stability of 16 sugarcane genotypes for different plant and yield characters.

## Materials and Methods

Three experiments were grown in three environments: 2 at Sugar Crops Research Institute during 2005-06 and 2006-07 and one at Harichand Seed Multiplication Farm during 2005-06. The experimental material comprised 16 advanced lines/varieties including two checks laid out in randomized complete block design. Data were recorded on germination percentage, number of tillers, plant height, cane yield and millable canes.

The data were analyzed using MSTATC version 2.01 (Nissen, 1983). Homogeneity of variances was run after Gomez and Gomez (1984). Combined analyses of variance and stability parameters were worked out using PBSTAT online version 1.0 (Willy *et al* 2008).

## Results and Discussion

### Mean Squares for individual environments:

The mean squares for individual environments are given in table 1. The range of CV for all the characters over the three environments was less than 20 (Gomez and Gomez 1984) and hence were forwarded for combined analysis of variance. Genotypic variances were significant for the characters under study however showing a non significant effect for Number of tillers.

**Table 1: Mean squares for the characters over individual environment**

| Environments | Source of Variation | D.F | Germination %age | No. of Tillers | Plant Height | Cane Yield | Millable cane |
|---|---|---|---|---|---|---|---|
| E1 | Reps | 2 | 12.771 $^{ns}$ | 2541.396 $^{ns}$ | 1563.271 ** | 50.333 $^{ns}$ | 20.813 $^{ns}$ |
| | Genotypes | 15 | 221.022 $^{**}$ | 8645.106 ** | 577.654 ** | 312.706 ** | 177.321 ** |
| | Error | 30 | 43.726 | 639.418 | 138.538 | 111.556 | 22.79 |
| | CV | | 12.1 | 10.61 | 8.1 | 12.62 | 4.94 |
| E2 | Reps | 2 | 134.021 * | 4497.646 * | 280.750 ns | 180.063 $^{ns}$ | 21 ns |
| | Genotypes | 15 | 120.465 ** | 4456.800 ** | 453.222 ** | 389.343 ** | 941.443 ** |
| | Error | 30 | 31.932 | 1015.646 | 148.106 | 91.351 | 38.822 |
| | CV | | 11.16 | 13.08 | 7.52 | 16.18 | 7.03 |
| E3 | Reps | 2 | 6.083 $^{ns}$ | 446.333 $^{ns}$ | 63.521 $^{ns}$ | 59.313 $^{ns}$ | 95.063 ** |
| | Genotypes | 15 | 59.194 ** | 642.706 $^{ns}$ | 1626.376 ** | 90.154 ** | 47.699 ** |
| | Error | 30 | 2.61 | 378.156 | 395.876 | 20.913 | 15.507 |
| | CV | | 4.74 | 14.25 | 11.43 | 8.74 | 9.17 |

ns: non-significant **: Highly Significant *: Significant

**Mean performance of the genotypes over environments:**

Genotypic means are given in table 2. Mean performance of the genotypes for germination percentage showed that MS-94-CP-90, MS-92-CP-1100, and MS-91-CP-965 performed better than the rest with a mean range of 51 to 54. In number of tillers, genotypes Mardan 93, MS-94-CP 90, and MS-91-CP 965 outperformed the rest of the genotypes. MS-91-CP-288, Malakand 17, MS-94-CP-90 and MS-92-CP-623 were taller than the rest of the genotypes. Regarding cane yield (t/ha) MS-91-CP-920, MS 92-Cp-623, MS-91-CP-623, and CP 77/400 performed well. Higher Millable canes were given by MS-92-CP-623, Mardan 93, and MS-94-CP-90, respectively.

**Table 2: Genotypic means of the 16 genotypes combined over environments.**

| S.No. | Genotype | Germination %age | No. of Tillers | Plant Height | Cane Yield (t/ha) | Millable Cane* |
|---|---|---|---|---|---|---|
| 1 | Malakand 17 | $40.22^{de}$ | $159.67^{ef}$ | $177.22^{ab}$ | $53.00^{d}$ | $47.00^{d}$ |
| 2 | MS-92-CP-623 | $44.11^{bcd}$ | $225.67^{abc}$ | $168.44^{abc}$ | $71.11^{ab}$ | $83.89^{a}$ |
| 3 | MS-92-CP-624 | $45.78^{bcd}$ | $198.89^{bcdef}$ | $163.11^{abc}$ | $67.67^{abcd}$ | $77.78^{abc}$ |
| 4 | MS-91-CP-611 | $34.89^{e}$ | $189.22^{cdef}$ | $149.56^{cd}$ | $60.33^{abcd}$ | $73.22^{c}$ |
| 5 | MS-91-CP-572 | $38.33^{de}$ | $210.67^{bcd}$ | $157.67^{bcd}$ | $65.22^{abcd}$ | $76.33^{abc}$ |
| 6 | MS-91-CP-288 | $45.00^{bcd}$ | $204.56^{bcd}$ | $183.44^{a}$ | $68.11^{abc}$ | $77.56^{abc}$ |
| 7 | AEC-86-347 | $47.00^{abcd}$ | $202.00^{bcde}$ | $166.33^{abc}$ | $66.89^{abcd}$ | $76.33^{abc}$ |
| 8 | Mardan 93 | $42.11^{cde}$ | $258.22^{a}$ | $155.33^{bcd}$ | $69.11^{abc}$ | $82.11^{ab}$ |
| 9 | MS-91-CP-471 | $50.00^{abc}$ | $211.00^{bcd}$ | $132.33^{d}$ | $63.22^{abcd}$ | $76.78^{abc}$ |
| 10 | MS-91-CP-623 | $50.56^{abc}$ | $203.33^{bcde}$ | $154.00^{bcd}$ | $70.89^{ab}$ | $77.44^{abc}$ |
| 11 | MS-91-CP-920 | $39.44^{de}$ | $177.33^{def}$ | $144.44^{cd}$ | $72.22^{a}$ | $79.33^{abc}$ |
| 12 | MS-91-CP-965 | $51.67^{ab}$ | $234.56^{ab}$ | $160.56^{abc}$ | $57.00^{bcd}$ | $74.00^{bc}$ |
| 13 | MS-92-CP-1100 | $51.44^{ab}$ | $200.22^{bcdef}$ | $149.22^{cd}$ | $66.00^{abcd}$ | $78.78^{abc}$ |
| 14 | MS-94-CP-90 | $54.78^{a}$ | $234.67^{ab}$ | $168.56^{abc}$ | $63.67^{abcd}$ | $81.11^{abc}$ |
| 15 | CPF-236 | $45.22^{bcd}$ | $156.89^{f}$ | $166.44^{abc}$ | $56.00^{cd}$ | $74.67^{bc}$ |
| 16 | CP 77/400 | $50.22^{abc}$ | $231.33^{abc}$ | $165.33^{abc}$ | $70.00^{abc}$ | $75.33^{abc}$ |

* Means followed by the same letters do not differ significantly.

**Genotype – Environment Analysis**

G x E analysis in table 3 revealed highly significant variances for Environments (E), Genotypes (G), and their interaction (G x E). The effect of environments was much pronounced for all the characters signifying their importance in the performance of genotypes. However, mean square differences were also significant for genotypes showing that the differences among the genotypes were persistent along the environments. These were higher than G x E interaction mean squares indicating the varied response of the genotypes was a permanent characteristic for locations. Similar results were found by Tai et al (1982) wherein they found significant cultivars differences over interactions. However, variance components analyses showed that interaction variance was larger for the characters except germination percentage. Higher phenotypic variance revealed the control of environmental factors in the genotypes. Similar results were found by Singh and Singh, 1987, wherein they found significant mean squares for environments, Genotypes and their interaction for all the characters studied.

**Table 3: Mean Squares for environments and genotypes in Combined analysis of variance**

| Source | df | Germination | Tillering | Plant Height | Cane Yield | Millable Canes |
|---|---|---|---|---|---|---|
| Environments(E) | 2 | 7215.05** | 175140.36** | 9559.15** | 13109.42** | 39277.75** |
| REP*E | 6 | 50.96 ns | 2495.13** | 635.85* | 96.57 ns | 45.63 ns |
| Genotypes (G) | 15 | 282.97** | 6726.29** | 1443.88** | 301.92** | 604.07** |
| G*E | 30 | 58.86** | 3509.16** | 606.69** | 245.14** | 281.19** |
| Error | 90 | 25.97 | 677.74 | 226.51 | 74.61 | 25.54 |
| CV | | 11.16 | 12.63 | 9.4 | 13.28 | 6.67 |
| Variances | | | | | | |
| $V_P$ | 31.44 | 747.37 | 160.43 | 33.55 | 67.12 | |
| $V_G$ | 24.9 | 357.46 | 93.02 | 6.31 | 35.88 | |
| $V_{GxL}$ | 10.96 | 943.81 | 126.73 | 56.85 | 85.22 | |
| $h^2_{bs}$ | 79.2 | 47.83 | 57.98 | 18.81 | 53.45 | |

$V_G$= Genotypic Variance $V_{GxL}$= Interaction Variance $V_P$= Phenotypic variance $h^2_{bs}$= Broad Sense Heritability.

**Stability Analysis**

A cultivar with 'b' value less than 1.0 has above average stability and is specially adapted to low-performing environments, a cultivar with 'b' value greater than 1.0 has below average stability and is specially adapted to high performing environments and a cultivar with 'b' value equal to 1.0 has average stability and is well or poorly adapted to all environments depending on having a high or low mean performance (Finlay & Wilkinson 1963) but a cultivar with b = 1.00 and $S^2d$ = 0.00 may be defined as stable (Eberhart & Russell 1966).

Regression values for germination percentage (Table 4) indicated that genotypes MS-91-CP-288, AEC-86-347, MS-91-CP-623 and MS-94-CP-90 were close to 1 and deviation from regression smaller than the others showing a relative stability for this character. Genotypes MS-91-CP-471, MS-91-CP-965, MS-92-CP-1100 and CP 77/400 had $b_i$ values greater than 1 showing these genotypes performed better under favorable environments while the rest of the genotypes exhibited a slope value less than 1 indicating that they were better performing under unfavorable conditions. For number of tillers genotypes MS-92-CP-624, MS-91-CP-572, AEC-86-347 and MS-91-CP-623 had a $b_i$ value close to 1 while genotypes Malakand 17, MS-91-CP-288, MS-91-CP-920 and CPF-236 had less than 1. For plant height only genotype MS-92-CP-624 had a value close to 1, 8 genotypes had a value less than 1 while remaining genotypes exhibited slope value more than 1 and 5 genotypes gave a value less than 1 and remaining more than 1. For cane yield (t/ha) genotypes Mardan 93, MS-92-CP-1100, MS-94-CP-90 and CP 77/400 had a value close to 1 and MS-91-CP-288 genotypes gave a value less than 1. For millable canes genotypes MS-91-CP-288, AEC-86-347, MS-91-CP-471, MS-94-CP-90, CPF-236, and CP 77/400 exhibited a $b_i$ values close to 1. Among the genotypes studied none showed stability for all characters. However, genotype MS-94-CP-90 showed a relative stability for three characters viz. germination percentage, cane yield (t/ha) and millable canes. It can be concluded that G x E interaction and stability analysis should become a regular feature of any breeding program so that genotypes could be sorted out which perform better under multiple environments.

**Table 4: Regression slope, and deviation from regression for 16 genotypes**

| S. No. | Genotype | Germination %age | | | No. of Tillers | | | Plant Height | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | $b_i^*$ | $SD_i^{**}$ | Mean | $b_i$ | $SD_i$ | Mean | $b_i$ | $SD_i$ |
| 1 | Malakand 17 | 40.22 | 0.85 | 1.86 | 159.67 | 0.2 | 14.56 | 177.22 | 2.17 | 24.71 |
| 2 | MS-92-CP-623 | 44.11 | 0.89 | 4.61 | 225.67 | 1.19 | 57.36 | 168.44 | 1.37 | 9.86 |
| 3 | MS-92-CP-624 | 45.78 | 0.61 | 2 | 198.89 | 1.08 | 4.81 | 163.11 | 1.04 | 3.85 |
| 4 | MS-91-CP-611 | 34.89 | 0.63 | 3.48 | 189.22 | 1.16 | 7.23 | 149.56 | 1.69 | 15.55 |
| 5 | MS-91-CP-572 | 38.33 | 0.93 | 2.68 | 210.67 | 1.09 | 16.89 | 157.67 | 0.59 | 0.88 |
| 6 | MS-91-CP-288 | 45 | 0.95 | 2.51 | 204.56 | 0.73 | 25.2 | 183.44 | 1.59 | 17.26 |
| 7 | AEC-86-347 | 47 | 1.08 | 1.68 | 202 | 0.95 | 96.17 | 166.33 | 2.45 | 0.03 |
| 8 | Mardan 93 | 42.11 | 0.88 | 1.52 | 258.22 | 1.31 | 0.45 | 155.33 | 1.53 | 5.92 |
| 9 | MS-91-CP-471 | 50 | 1.32 | 7.14 | 211 | 0.91 | 31.69 | 132.33 | 0.41 | 5.75 |
| 10 | MS-91-CP-623 | 50.56 | 0.99 | 0.7 | 203.33 | 1.06 | 2.84 | 154 | 0.52 | 2.28 |
| 11 | MS-91-CP-920 | 39.44 | 0.89 | 2.8 | 177.33 | 0.54 | 26.51 | 144.44 | 0.86 | 12.1 |
| 12 | MS-91-CP-965 | 51.67 | 1.58 | 5.95 | 234.56 | 1.69 | 31.18 | 160.56 | 0.56 | 4.76 |
| 13 | MS-92-CP-1100 | 51.44 | 1.36 | 3.74 | 200.22 | 1.12 | 0.97 | 149.22 | 0.24 | 16.89 |
| 14 | MS-94-CP-90 | 54.78 | 1.02 | 5.9 | 234.67 | 1.28 | 3.61 | 168.56 | -0.43 | 11.66 |
| 15 | CPF-236 | 45.22 | 0.64 | 2.7 | 156.89 | 0.3 | 12.56 | 166.44 | 1.42 | 15.89 |
| 16 | CP 77/400 | 50.22 | 1.39 | 3.3 | 231.33 | 1.4 | 39.07 | 165.33 | 0.01 | 11.47 |

*Regression Slope **Deviation from Regression

**Table 4 (Contd.): Regression slope, and deviation from regression for 16 genotypes.**

| S.No. | Genotype | Cane Yield (T/ha) | | | Millable Canes | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$* | $SD_i$** | Mean | $b_i$ | $SD_i$ |
| 1 | Malakand 17 | 53 | 1.18 | 33.45 | 47 | 0.3 | 34.4 |
| 2 | MS-92-CP-623 | 71.11 | 1.22 | 2.35 | 83.89 | 1.23 | 6.95 |
| 3 | MS-92-CP-624 | 67.67 | 1.16 | 2.27 | 77.78 | 1.12 | 2.59 |
| 4 | MS-91-CP-611 | 60.33 | 0.77 | 6.82 | 73.22 | 1.17 | 3.85 |
| 5 | MS-91-CP-572 | 65.22 | 0.75 | 9.81 | 76.33 | 0.88 | 0.29 |
| 6 | MS-91-CP-288 | 68.11 | 0.75 | 10.33 | 77.56 | 1.02 | 15.43 |
| 7 | AEC-86-347 | 66.89 | 0.84 | 0.25 | 76.33 | 0.99 | 5.56 |
| 8 | Mardan 93 | 69.11 | 0.97 | 3.03 | 82.11 | 1.11 | 1.94 |
| 9 | MS-91-CP-471 | 63.22 | 1.43 | 7.71 | 76.78 | 1.07 | 2.64 |
| 10 | MS-91-CP-623 | 70.89 | 1.6 | 0.4 | 77.44 | 1.1 | 2.69 |
| 11 | MS-91-CP-920 | 72.22 | 1.37 | 1.37 | 79.33 | 0.85 | 1.78 |
| 12 | MS-91-CP-965 | 57 | 0.41 | 7.41 | 74 | 0.81 | 1.58 |
| 13 | MS-92-CP-1100 | 66 | 1.07 | 7.79 | 78.78 | 1.21 | 2.38 |
| 14 | MS-94-CP-90 | 63.67 | 0.9 | 7.27 | 81.11 | 1.08 | 2.93 |
| 15 | CPF-236 | 56 | 0.6 | 1.63 | 74.67 | 1 | 5.37 |
| 16 | CP 77/400 | 70 | 0.98 | 1.9 | 75.33 | 1.06 | 1.17 |

*Regression Slope **Deviation from Regression

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