Concept of G x E interaction in genotype selection

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Background

• The performance of a cultivar depends on the genetic structure and the environment where it grows (Cooper and Byth, 1996).

• The analysis of G x E interaction is closely linked with the quantitative estimation of phenotypic stability of genotypes over environments (Kang, 1996).

• The extent of performance testing depends on the magnitude of G x E, which occurs when genotypes differ in their relative performance across environments (Bernardo, 2002).
Terms and definitions

**Genotype** - complete set of genes inherited by an individual

**Environment** - the sum total of the effects of physical, chemical and biological factors of an individual other than its genotype (Comstock & Moll, 1963)

Organisms are determined neither by their genes nor by their environment; they are the consequence of the interaction of genes and environment

G x E interaction occurs when differences between genotypes are not the same in all locations within and across years (Edmeades et al., 1989). It is the inconsistency of relative performance of genotypes over environments (Hill et al., 1998)
Genotype

Environment

Phenotype

“Actual environment”

“Noise”
Classification of G x E

- No interaction
- Non cross over interaction
- Cross over interaction (rank change)
No interaction
Non crossover interaction

Yield vs Environment

1  Environment  2
Maximum G x E interaction - rank change
Crossover interaction

Yield vs. Environment

1  Environment  2
Why G x E?

- To select genotypes with wider adaptation
- To properly understand the environmental and genetic factors causing the interaction
- To develop optimum breeding strategy for releasing genotypes with adaptation to target environment
Stability analysis

• The presence of G x E interaction in METs leads to the need for the analysis of genotype stability
• Consistency in performance
• Minimum variation among environments for a particular genotype
• A stable genotype should always give high yield expected at the level of productivity of the respective environments
• Various measures of stability (parametric and non-parametric)
• Finlay and Wilkinson, 1963; b=0
• Eberhart & Russel (1966); b=1
• Wricke's Ecovalence (1962); lowest value stable
• Shukla’s variance (1972); highest value unstable
• Superiority Measure (Lin and Binns, 1988); lowest value stable
• Non parametric Nassar & Huehn (1990)
  (similar ranking across env. Considered stable)
Linear regression models

\[ Y_{ij} = \mu + G_i + E_j + (b_i E_j + d_{ij}) + e_{ij} \]

- Small deviation = Stable
- Large deviation (large \( s_d^2 \)) = Unstable
Table 1: Mean squares of the combined analyses of variance and percentage share of contribution for grain yield of 17 maize genotypes tested across nine environments in 2012-2014

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<th>Sources</th>
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<th>MS</th>
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<td>Residual</td>
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<td>Total</td>
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<td>CV % = 16%</td>
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** P ≤ 0.01
### Mean yield (t ha\(^{-1}\)) and various stability measurements and ranking orders of 17 maize genotypes

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<th>(S^2_{di})</th>
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<th>(W_i)</th>
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Additive Main Effects and Multiplicative Interaction Model (AMMI)
Biplot

IPCA 1 (35.73%)

IPCA 2 (25.22%)

Variables:
- AWAOP
- BAKLN
- BAKOP
- CHDT1
- CHDT2
- CHSDT
- EMBOP
- HRELN1
- HRELN2
- KAKOP
- KBODT
- MLKOP
- RATOP
- IPCA 1 (35.73%)
- IPCA 2 (25.22%)
GGE biplot for which-won-where pattern for 96 maize hybrids (Total - 49.95%)

Sectors of convex hull
Genotype scores
Environment scores
Convex hull

PC1 - 35.35%

Genotype scores
Environment scores
Convex hull
Sectors of convex hull
Delining mega-environments based on GGE biplot

Scatter plot (Total - 39.35%)

Key
- Genotype scores
- Environment scores
- Mega-Environments

Mega-Environments
Environment scores

Genotype scores

Delining mega-environments based on GGE biplot
Maize growing mega environment of SSA
Fertilizer

QB

Oh!

Shame..!!

Please help

Unfavorable environment response of genotype

Managements

Fertilizer

Pest
disease

Chemicals

Climate change

Soil

Rainfall

Insects

Weeds

Temperature

Agronomic practices
Thank you for your interest!