Statistical Models for Analyzing Multi-Environment Variety Trials

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Abstract

Series of field trials, known as multi-environment trials (METs, see, e.g. Gogel, Cullis, and Verbyla, 1995), conducted at several locations are the main source for field evaluation of the performance of genotypes. These trials allow the responses of genotypes to environmental conditions to be investigated. Responses of individual genotypes different from the overall average are usually considered as information on differential behaviour of the genotypes across environments, i.e., on the genotype by environment (GE) interaction. The interaction indicates that genotypes react in different ways to changeable environmental conditions.

Several models and statistical methods for analyzing GE interactions have been proposed in literature, and some of them have been met with severe criticism. The question, whether the proposed statistical models and the analytical methods following them are sufficiently good to explain the genotype by environment interaction, is still discussed.

Most of the models used for analyzing multi-environment variety trials, as reviewed by Freeman (1973,1985) and Hinkelmann (1974), result from some modifications of the classical analysis of variance model for the two-way layout.

For studying the genotype by environment interaction Caliński (1960) and independently Wricke (1962) have proposed some methods for measuring the stability of genotypes. Finlay and Wilkinson (1963) and Eberhart and Russell (1966) have introduced kind of "stability analyses" that use a model in which the data from each genotype are regressed on an environmental productivity index, estimated as the main effect of the environment. This model has received much attention in the literature and by including further terms it has been developed into the so-called additive main effects and multiplicative interaction (AMMI) model, strongly adopted by Gauch (1992). A thorough review of the theory and applications of this model has been given by Eeuvijk (1996).

In the analysis of GE interaction an important role is played by mixed effects models of various kinds, as, e.g., reviewed by Denis, Piepho and van Eeuvijk (1997) and by Smith, Cullis and Thompson (2005). Among them a model derived from the principle of randomization applied at every stratum of the nested classification of experimental units has been proposed by Caliński, Czajka, Kaczmarek, Krajewski and Pilarczyk (2005). The considered model depends on the designs chosen for

individual trials and on the selection of locations for conducting the series of trials. It allows estimation of various parameters and also testing the general hypothesis of no GE interaction and some implied hypotheses concerning individual parametric functions. In this model the genotypes are considered as fixed and the environments as random, reversely to the model used by Smith, Cullis and Thompson (2001).

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