Extensions of AI-REML estimation for multi-environment trials

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In 2005 the Grains Research and Development Corporation of Australia implemented a National Variety Testing (NVT) system for the provision of information to farmers on commercial varieties for a range of cereal crops. This system replaced the existing series of Crop Variety Testing (CVT) programs that were run within each state. Prior to NVT, variety information was obtained and reported for each CVT program using analyses of multi-environment trial (MET) data. The method of analysis comprised a mixed model with variance components for variety main effects and variety by trial (VxT) interaction partitioned as appropriate for the data-set.
In the new framework of NVT, focus was the development of a methodology and reporting system that would address the key aim of NVT, namely to provide information to enable growers to choose the best varieties for their particular set of growing conditions. Implicit in this is the ability to quantify “growing conditions”. In the old CVT setting predictions were produced for geographic regions within each state which implied a categorisation of growing conditions into discrete geographic regions. Unfortunately variety by region (VxR) interaction rarely accounted for a substantial proportion of total variety by trial (VxT) interaction.
The use of continuous covariates rather than discrete classifications to describe growing conditions may provide superior predictions in the sense that more of the VxT interaction may be explained. An obvious possibility is the use of measured environmental covariates such as soil pH and long-term average rainfall. The success of this approach depends on the availability of data (which at this time is limited) and how much VxT interaction is explained (at present unknown). An alternative, which we have chosen to adopt, is the use of Trial Mean Yield (TMY) as a covariate. There are several reasons why we have focussed on this approach. First, our experience with fitting factor analytic models to numerous plant breeding METs has shown that the factor that often explains the maximum amount of VxT interaction is strongly related to TMY. Second, the model is well established in the literature in the context of fixed effects models, dating back to Yates and Cochran (1938) and subsequently Finlay and Wilkinson (1963). Finally, TMY is a surrogate for a range of environmental covariates that may not be easily measured and is approximately predictable at a farmer level.
Mixed model versions of the regression on TMY model have been presented by Gogel, Cullis and Verbyla (1995) and Nabugoomu, Kempton and Talbot (1999) but in both these approaches the variety effects were assumed fixed and the trial effects random. In our approach the converse is assumed, leading to the dilemma that parameters associated with TMY occur in both the mean and variance of the model. This precludes the use of the standard method of variance parameter estimation (REML) and thence the use of standard (REML) software.
As a preliminary investigation into the worth of the TMY regression model for Australian NVT data we used an approximate estimation method and this showed that differential varietal response to TMY consistently accounted for a large percentage of the total VxT interaction. Thus it was deemed worth-while to pursue a more exact estimation method.
In this talk we describe an approach to estimation based on Adjusted Profile Likelihood. The algorithm is suitable for implementation into mixed model software such as ASReml.