OPTIMAL FIELD DESIGNS AND ANALYSIS OF SPATIALLY AND GENETICALLY CORRELATED DATA USING MIXED MODELS

Lazarus Mramba[1] and Salvador Gezan[1]

The existence of varied levels of environmental heterogeneity and genetic relatedness among genotypes in plant breeding is a major challenge in the design and analysis of field trials. The standard traditional design methods assume independent residual errors, ignore genetic relationships and often treat both blocking and genetic effects as fixed, which often results in suboptimal designs, which are biased and present misleading findings in addition to poorly estimating the genetic values. This study investigates the dynamics of varying levels of heritabilities, spatial and genetic correlations using both A- and D-Optimality criteria to generate optimal field designs. An algorithm to optimize the design of a randomized complete block experiment is presented.

The results from this study indicated that under the D-Optimality criteria, the percentage improvement between the original and the final optimal designs was consistently higher with increasing heritability and spatial correlations for all the genetic scenarios (full-sibs, half-sibs, and independent genotypes). The percentage improvement with respect to the A-Optimality criteria varied with the type of pedigree structure, levels of heritability and spatial correlations. A strong Spearman's correlation between the D- and A- Optimality criteria of about 0.97 was obtained for both the original and final designs, implying that a design with small/large traces (from the A-Optimality criteria) is likely to have small/large determinants values (from the D-Optimality criteria).

Complete datasets with response variables, field patches (surfaces) and nuggets (measurement errors) for both non-optimal and "near optimal" designs were generated and analyzed for prediction of random effects and heritability estimates. Very high Pearson's correlation coefficients were observed ranging from 0.84 to 0.99 between the predicted and the true genetic effects. The optimal designs provided more accurate, consistent and precise estimates of heritabilities and breeding values with smaller standard errors compared to the initial non-optimal designs. In conclusion, the results indicate that simultaneous consideration for both genetic and environmental conditions is indispensable for generation and analysis of optimal field designs.

---

[1] School of Forest Resources and Conservation, University of Florida, Gainesville, FL