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Methodology for Joint Modelling of Spatial Variation and Competition Effects in the Analysis of Varietal Selection Trials

Developing new statistical models to improve decision making in cocoa breeding programmes

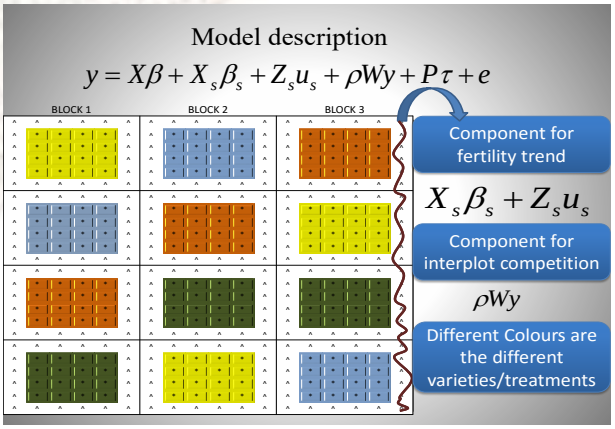
In common with many crops, cocoa breeding trials often involve large numbers of cultivars being tested for numerous traits. In the analysis of such trials it is important to take account of the underlying variation due to factors such as differences in soil characteristics and microclimate, and also competition effects between cultivars with different vigour/growth characteristics. Failure to adequately account for these effects may result in biased estimates and inefficient decision making.

Many statistical models have limited applicability in the analysis of breeding trials with both fertility and competition effects, as commonly encountered in cocoa breeding. This project develops and evaluates Linear Mixed Models approaches suitable for joint, flexible modelling of fertility and competition effects. The objective was to develop statistical methodology that is capable of providing information about the nature of the interaction among plants of different genotypes whilst adequately accounting for any fertility trends in the trial. Knowledge about the nature of interaction among plants can be applied to adjust the genotype estimates to obtain prediction of the performance of the various varieties in a pure or mixed culture.

The approach taken implements a nonparametric regression model for fertility and an auto-regressive model for competition.

The new model formulation was evaluated through simulation studies and was found to be more efficient and to generate more reliable conclusions for plot and tree level analyses. It was used to analyse data from a CRIG breeding trial. This modelling approach could account for a large amount of the variation in the data over and above that accounted for by a traditional core plot analysis. It was shown to be superior to the analysis of plot averages in terms of precision and provided additional information about the pattern of interaction among the plants which may be useful in predicting the performance of different mixture planting options that may be available to a breeder.

Future research could include studies on the capabilities of the modelling approach to handle factors such as missing trees, irregular plot sizes and non-normally distributed data.



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METHODOLOGY FOR JOINT MODELLING OF SPATIAL VARIATION AND COMPETITION EFFECTS IN THE ANALYSIS OF VARIETAL SELECTION TRIALS

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Abstract

Design based methodologies for analysing breeding trials usually fail to fully account for spatial variation and competition effects, leading to poor and unreliable selection decisions. In this thesis, a novel modelling strategy that jointly accounts for spatial and competition effects is developed and evaluated. The proposed approach extends an existing model by relaxing the assumptions about the competition component to allow for more realistic options and to cope with multiple tree plot layout while simultaneously modelling fertility effects.

Autoregressive and cubic spline terms are used to model the competition and fertility effects respectively. Model parameters are estimated based on adjusted profile likelihood. The new model formulation is evaluated through simulation studies against existing methodologies to ascertain its utility. The results indicate the relative superiority of the new methodology in giving efficient and reliable conclusions for both plot and tree level analyses. Difficulties associated with model selection are investigated, discussed and mitigating solutions proposed. The comparative advantage of this model over existing methods is demonstrated using data from Cocoa Research Institute of Ghana.