Analyzing unreplicated trials in precision agriculture

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Unreplicated trials have an important role in precision agriculture (PA). Nowadays, precise machinery promotes on-farm experimentation (OFE) to assess the effect of changes in input application rates on yields and profits in specific fields. However, limitations in OFE management may preclude more than one replicate of each treatment. Moreover, more input rates can be assessed in unreplicated trials, making OFE more efficiently carried out across fields. Thus, the single-strip treatment trial, where a field is split into two (treatment vs. control), is common in OFE. Factors such as the requirement of field-specific inference and the large number of repeated-measurement points within treatment and control plots motivate the use of permutation tests to compare treatments. However, the data in OFE are spatially correlated, and consequently, sampling is challenging. This work proposes a methodology for local control in unreplicated OFE with spatial data. A protocol integrating spatial analysis and permutation tests is developed for comparing two treatments in unreplicated trials with a probabilistic base. The methodology involves the calculation of the effective sample size (ESS) from a spatial grid defined over the trial residuals, followed by a two-hundred-cell grid random resampling of ESS and one-way permutation ANOVA to obtain the p-value comparing treatments in the randomly sampled data. The median of the empirical distribution of p-values is regarded as the expected p-value associated with the non-treatment effect hypothesis. Four example OFE datasets are used to validate the protocol. The proposed method allows measurement of the statistical significance of treated and control mean differences in unreplicated OFE. It can be extended to compare several treatments using a method for adjusting the derived p-values.

Keywords: permutation, spatial correlation, effective sample size.