Geomatic Techniques to Support Phytosanitary Products Tests whithin the EPPO Standard Framework

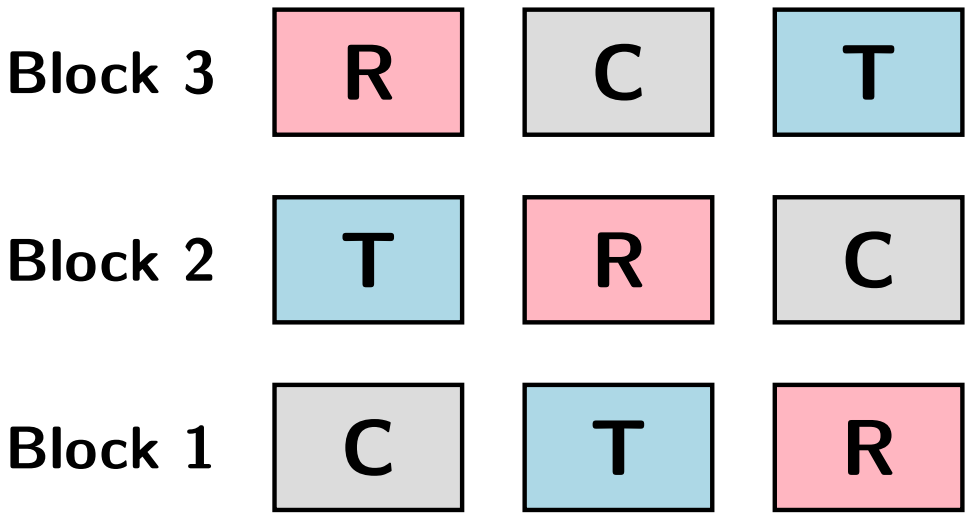
Samuele Bumbaca

University of Turin

August 28, 2025

UNIVERSITÀ
DI TORINO

The Traditional Approach to Agricultural Trials



C Control
T Tested Product
R Reference Product

ANOVA Model:

$$y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$$

Where:

- y_{ij} = response
- μ = overall mean
- α_i = treatment effect
- β_j = block effect
- ε_{ij} = random error

Note:

This is the **additive model**. Modern approaches may include interaction terms: $\alpha_i \times \beta_j$

Key Assumptions of Traditional ANOVA

Statistical Assumptions:

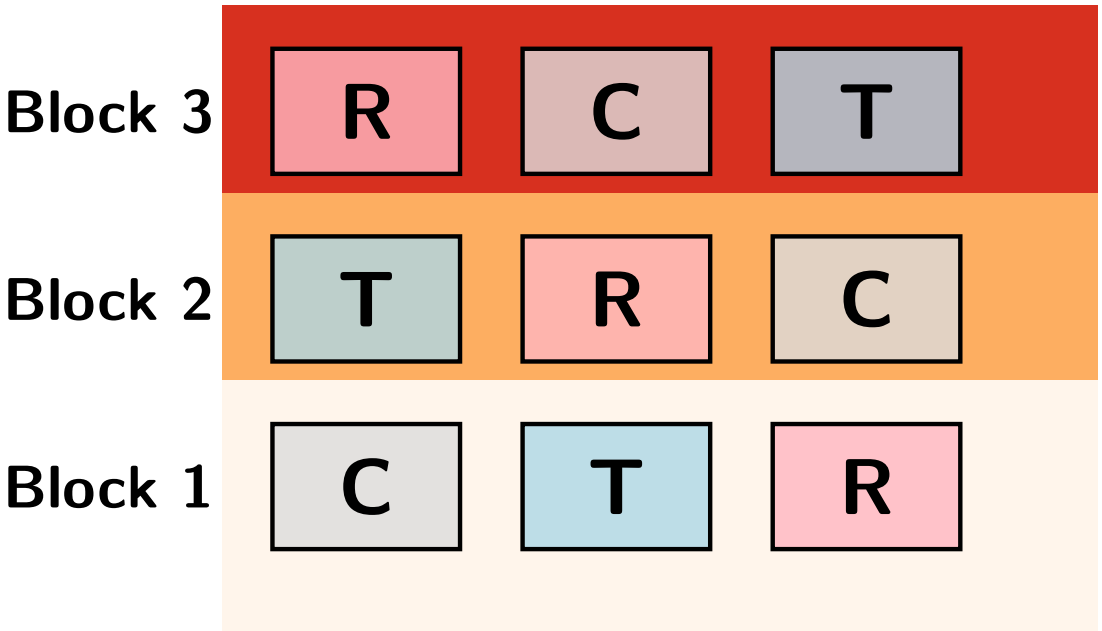
- **Randomization**: Treatments randomly assigned within blocks
- **Replication**: Each treatment appears in each block
- **Independence**: Observations are independent given the design
- **Homoscedasticity** : Equal variances across treatments
- **Normality**: Residuals follow normal distribution

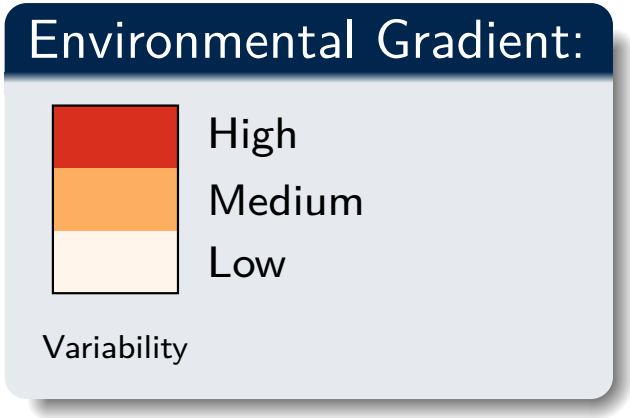
Consequences of Assumption Violations:

- **Invalid conclusions of parametric tests**: Need for non-parametric tests leading to reduced statistical power

Based on R. A. Fisher, Statistical Methods for Research Workers, in S. Kotz & N. L. Johnson (eds.), Breakthroughs in Statistics: Methodology and Distribution, pp. 66–70, Springer, New York, 1992.

The Right Blocking: Capturing Environmental Variability



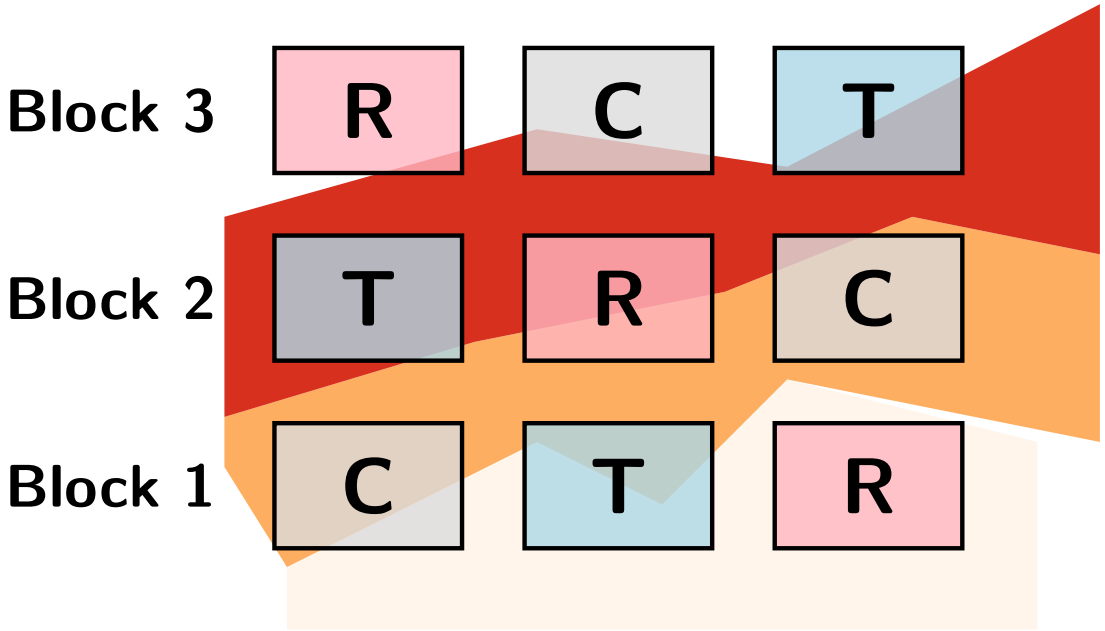


C Control
T Tested Product
R Reference Product

Success of Blocking Strategy:

- **Within-block homogeneity**: Treatments compared under similar conditions
- **Between-block heterogeneity**: Environmental gradient captured by block effects

The Wrong Blocking: Assumption Violation



Environmental Gradient:

High
Medium
Low

Variability

C Control
T Tested Product
R Reference Product

Heteroscedasticity Assumption Violation Problem:

- **Blocks fail to capture environmental variability**: Treatments compared under different conditions
- **Invalid parametric test**: Residual variance differs across treatments

Current Limitations in Statistics for Agricultural Trials

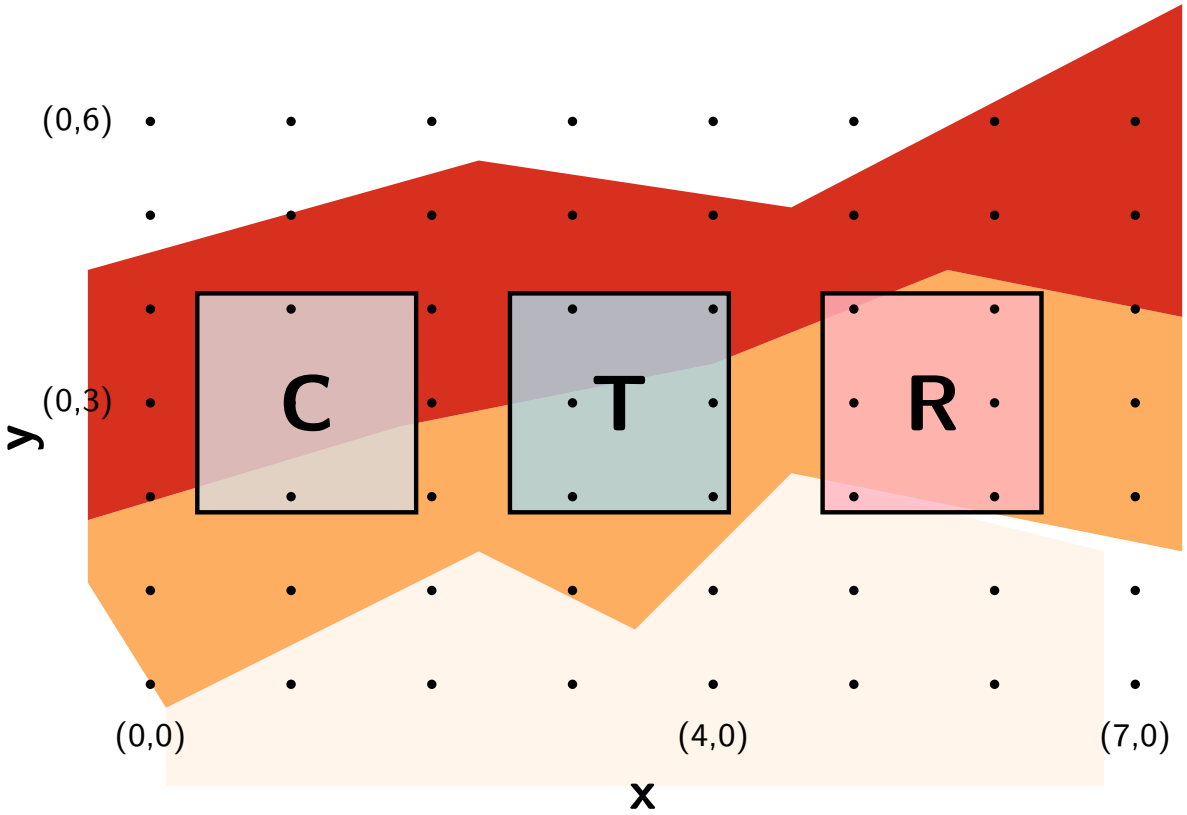
Traditional Approach Issues:

- **Human-dependent blocking**: Environmental variability assessment relies on experimenter experience
- **A priori identification**: Must identify variance sources BEFORE data collection

The Challenge:

How can we capture environmental variability mathematically rather than through human judgment?

Geostatistical Approach: Spatial Linear Mixed Models



C/T/R Control/Tested/Reference
• Georeferenced observations

Spatial LMM:

$$y(s_i) = \mu + \alpha_j + f(s_i) + \varepsilon_i$$

Where:

- $y(s_i)$ = response at s_i
- μ = overall mean
- α_j = treatment effect
- $f(s_i)$ = spatial random field
- ε_i = error
- $s_i = (x_i, y_i)$ = coordinates

Benefits:

- **No blocking**: Spatial correlation captures variability
- **Post-hoc**: No a priori variance identification
- **Homoscedasticity**: Assumption satisfied in more cases in respect blocking

The Missing Link: Spatial Coordinates

Geostatistical Methods Advantages:

- ✓ **Mathematical modeling** of environmental variability
- ✓ **Post-hoc analysis** - no need for prior knowledge of the environment variables and of their distribution
- ✓ **Superior performance** in handling spatial heterogeneity
- ✓ **EPPO recognized** approach

Current Barrier:

- × **Requires spatially referenced observations**
- × **Traditional manual assessments lack coordinates**
- × **Implementation gap** in practical field trials

Central Research Question

Can geomatics technologies provide spatially referenced observations that enable geostatistical analysis within EPPO-compliant Plant Protection Product trials?

Specific Objectives:

1. Establish which geomatics technologies can be used to collect spatially referenced observations
2. Demonstrate the feasibility of collect spatially referenced observations in compliant with EPPO standards
3. Validate performance against traditional methods
4. Provide practical implementation guidelines

Geomatic Technologies: Workflow for Spatially Referenced Observations