

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

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The Traditional Approach to Agricultural Trials

Block 3	R	C	T
Block 2	T	R	C
Block 1	C	T	R

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

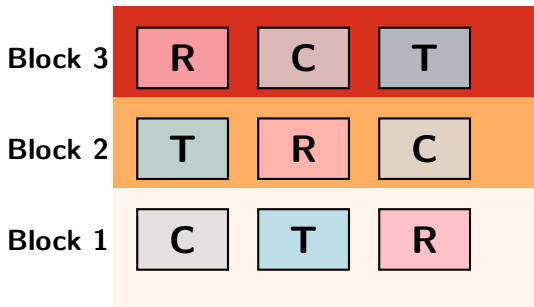
Statistical Assumptions:

- **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

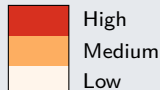
Consequences of Assumption Violations:

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

The Right Blocking: Capturing Environmental Variability



Environmental Gradient:



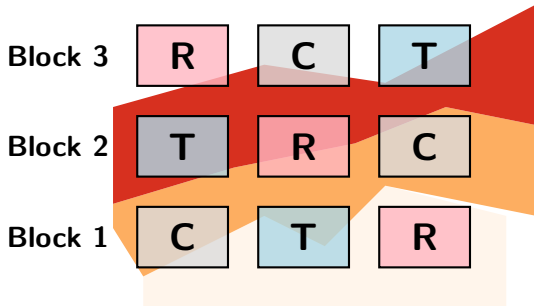
Variability

C Control
T Tested Product
R Reference Product

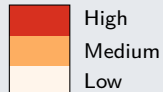
Success of Blocking Strategy:

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

The Wrong Blocking: Assumption Violation



Environmental Gradient:



Variability

C Control
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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

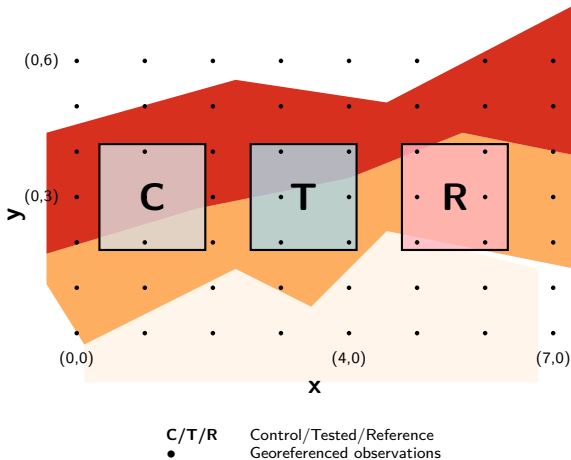
Traditional Approach Issues:

- **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



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

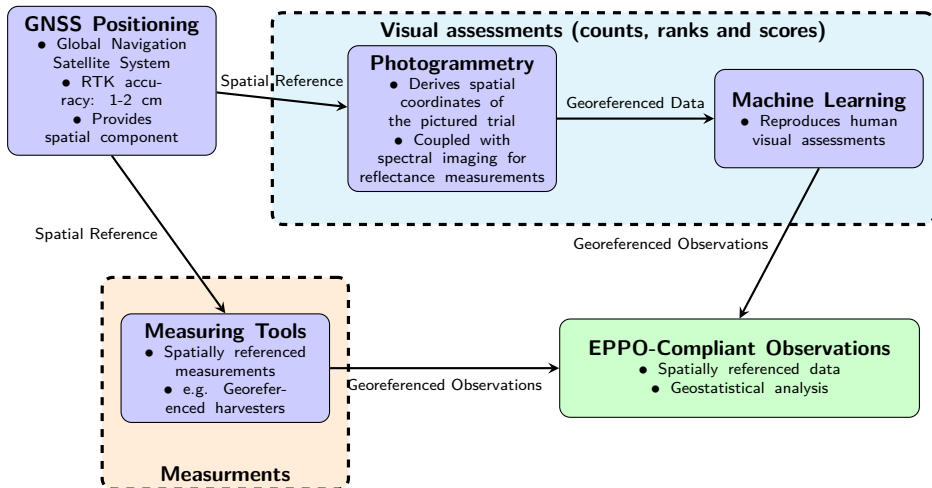
Central Research Question

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



Georeferencing EPPO Standard Assessments

Table: Different modes of observation and types of variables

Type of Variable	Measurement	Ranking	Scoring
Binary			X
Nominal			X
Ordinal		X	X
Discrete	X		
Continuous limited	X		
Continuous not limited	X		

Summary from EPPO PP 1/152: Design and analysis of efficacy evaluation trials

Current State of Georeferencing in Agricultural Trials:

EPPO's continuous, unbounded measurements are typically tool-collected and easily georeferenced (e.g., yield harvesters), whereas other regulated variables depend on experimenters' visual assessments, complicating spatial integration.