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

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Presentation Structure (40 minutes)

1. **Introduction & Background** (20 minutes)
   - Research problem and motivation
   - Theoretical framework
   - Methodology overview
2. **Three Case Studies** (18 minutes total)
   - Plant Counting (6 minutes)
   - Phytotoxicity Scoring (6 minutes)
   - Anomaly Detection (6 minutes)
3. **Conclusions & Future Work** (2 minutes)

Current Limitations in Agricultural Statistics

Traditional Approach Issues:

- **Human-dependent blocking**: Environmental variability assessment relies on experimenter experience
- **A priori identification**: Must identify variance sources BEFORE data collection
- **Limited statistical power**: When assumptions fail, must resort to non-parametric tests
- **Regulatory requirements**: EPPO standards demand $R^2 > 0.85$ performance

The Challenge:

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

The Missing Link: Spatial Coordinates

Geostatistical Methods Advantages:

- ✓ **Mathematical modeling** of environmental variability
- ✓ **Post-hoc analysis** - no need for prior knowledge
- ✓ **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 minimum dataset requirements for digital data collection
2. Demonstrate feasibility across all EPPO variable types
3. Validate performance against traditional methods
4. Provide practical implementation guidelines

European Plant Protection Organization (EPPO)

Key Standards:

- **PP 1/152(4)**: Design and analysis of efficacy evaluation trials
- **PP 1/333(1)**: Digital technology adoption guidelines

Variable Types in EPPO Assessments:

1. **Continuous/Discrete**: Plant counts, measurements
2. **Ordinal**: Severity scales (0-100%), damage ratings
3. **Binary/Nominal**: Healthy/diseased, disease classification

Benchmark: $R^2 > 0.85$ compared to manual assessment

PPP Categories:

- Fungicides
- Insecticides
- Herbicides
- Plant growth regulators
- Acaricides
- Nematicides

Critical Evaluation Needs:

- **Efficacy**: Does it work?
- **Selectivity**: Is it safe for crops?
- **Environmental impact**: Side effects?

Technical Arsenal

Core Technologies:

- **Photogrammetry**: 3D model generation from 2D images
- **Spectral Imaging**: Multi/hyperspectral sensors
- **Machine Learning**: Object detection, classification, regression
- **GNSS/UAV**: Precise spatial positioning

[Technology diagram would go here]

Study 1: Automated Plant Counting

Problem Statement:

Manual plant counting is:

- **Time-consuming**: Hours per plot
- **Subjective**: Inter-observer variability
- **Error-prone**: Missed or double-counted plants
- **Non-spatial**: No coordinate information

Solution Approach:

- UAV photogrammetry
- Deep learning object detection
- Automatic spatial referencing
- $R^2 > 0.85$ validation

[Plant counting example image]

Minimum Dataset Findings

Architecture	Images Needed	R^2
RT-DETR (Transformer-mixed)	60	0.89
YOLOv8 (CNN)	110	0.87
YOLOv5 (CNN)	130	0.86
Few-shot models	N/A	< 0.85
Zero-shot models	N/A	< 0.85

Table: Performance comparison across architectures

Critical Finding:

NO out-of-distribution trained model achieved $R^2 > 0.85$

In-domain training data is essential for agricultural applications

Questions & Discussion

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Key Publications:

1. "On the Minimum Dataset Requirements..." - *Remote Sensing* (2025)
2. "Supporting Screening of New Plant Protection Products..." - *Agronomy* (2024)
3. "Anomaly Detection for Plant Disease Classification" - *In preparation*