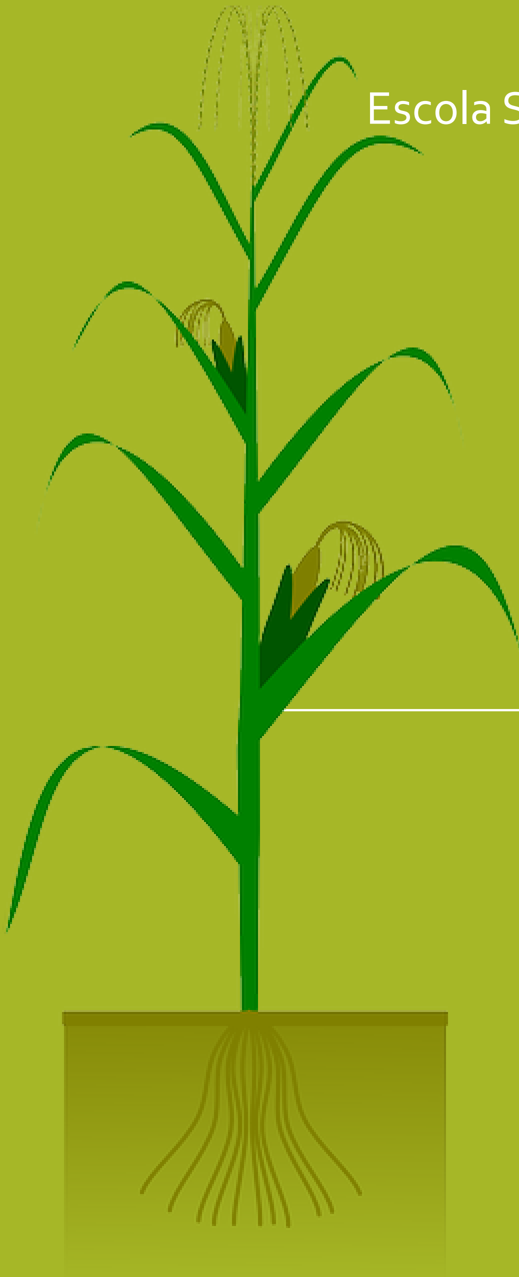

University of São Paulo
Escola Superior de “Luiz de Queiroz” College of Agriculture

HIGH THROUGHPUT PHENOTYPING ADJUSTED BY FINE ENVIRONMENTAL CHARACTERIZATION

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Motivation

Crop yield potential

Motivation

Crop yield potential

$$Y_p = S_t . \varepsilon_i . \varepsilon_c . \eta$$

$$Y_p = \cancel{S_t} . \varepsilon_i . \varepsilon_c . \cancel{\eta}$$

$$Y_p = \varepsilon_i . \varepsilon_c$$

$$\boxed{GY = \varepsilon_i . \varepsilon_c}$$

INDIRECT MEASUREMENT OF GY

Motivation

Crop yield potential

Issues of indirect measurement of GY:

1. Difficulty of measuring ε_i and ε_c;
2. Influence of microenvironments;

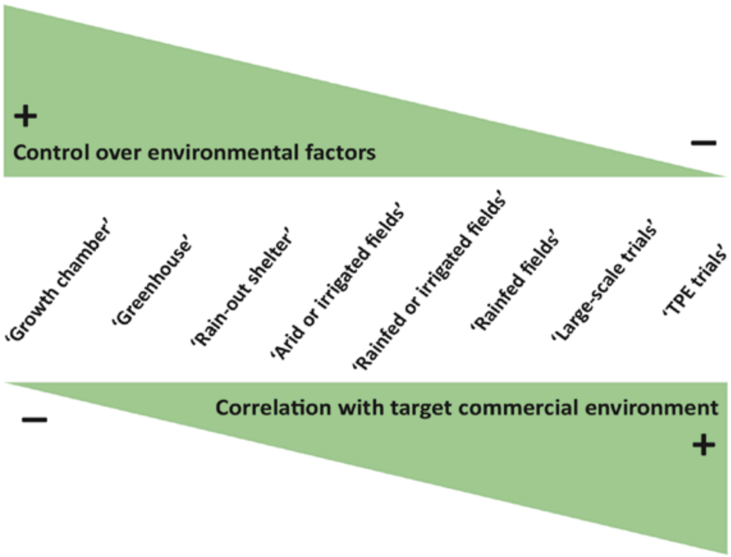
Solving problem 1: Image-based phenotyping;

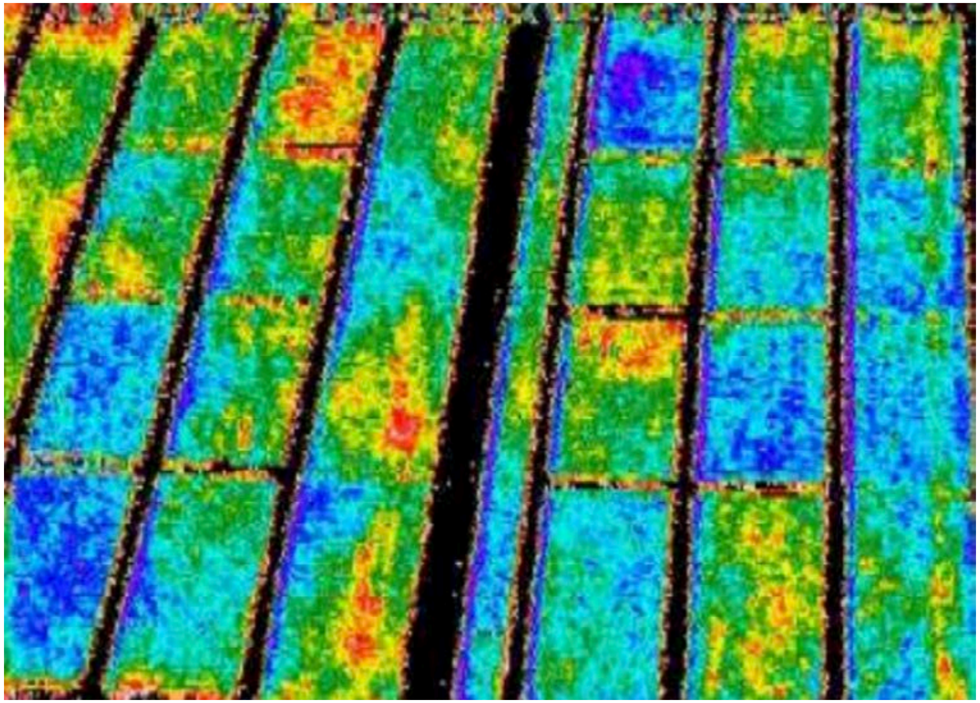
Solving problem 2: ?

Motivation

Challenge

One of the greatest challenges of field phenomics is **dealing adequatelly with uncontrolable variation**.





Motivation

Objectives

Global

Evaluate the effect of the incorporation of environmental factors in HTP studies

Develop a low-budget envirotyping platform

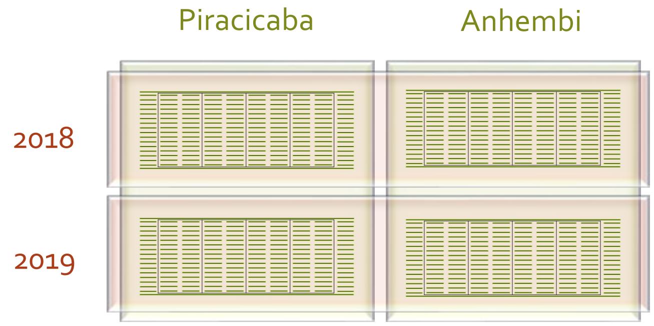
Verify the effect of environmental factors based correction of conventionally and high-throughput evaluated traits

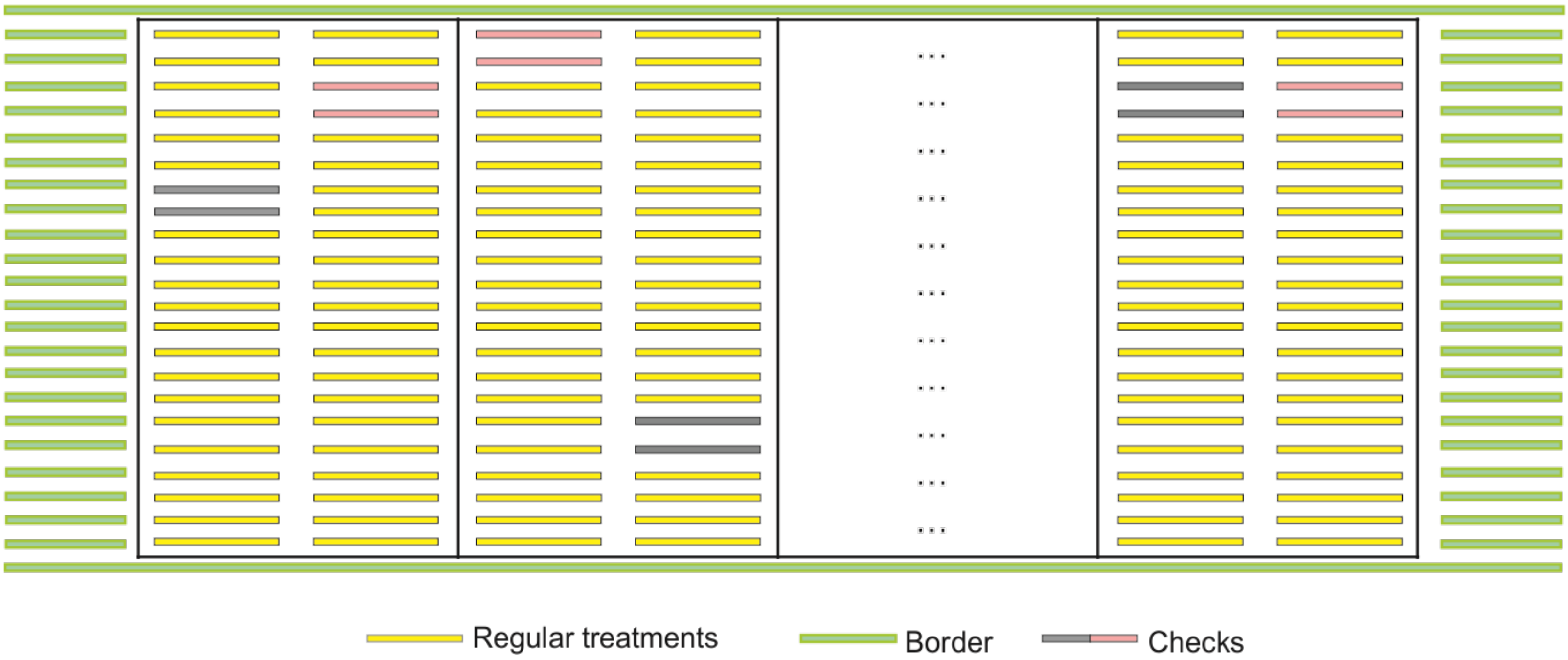
Identify remote and quick yield-related traits

M&M

Genetic material and experimentation

- 780 single-cross corn hybrids;
- 39 incomplete blocks;
- 2 checks.

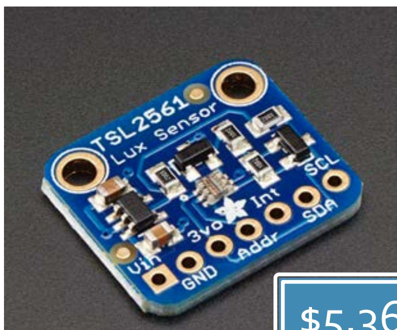




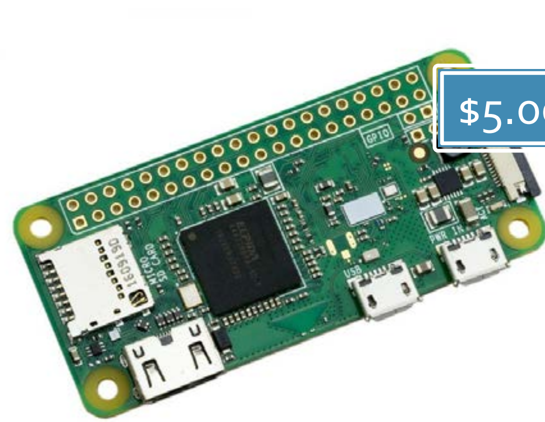
M&M

Fine environmental characterization (Temporal)

Lux sensor



$5.36

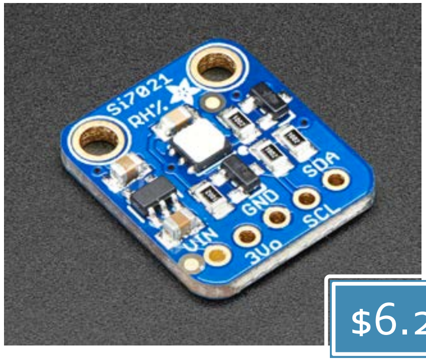


$5.00

Minicomputer

Soil humidity and temperature

$44.96



$6.26

Air humidity and temperature

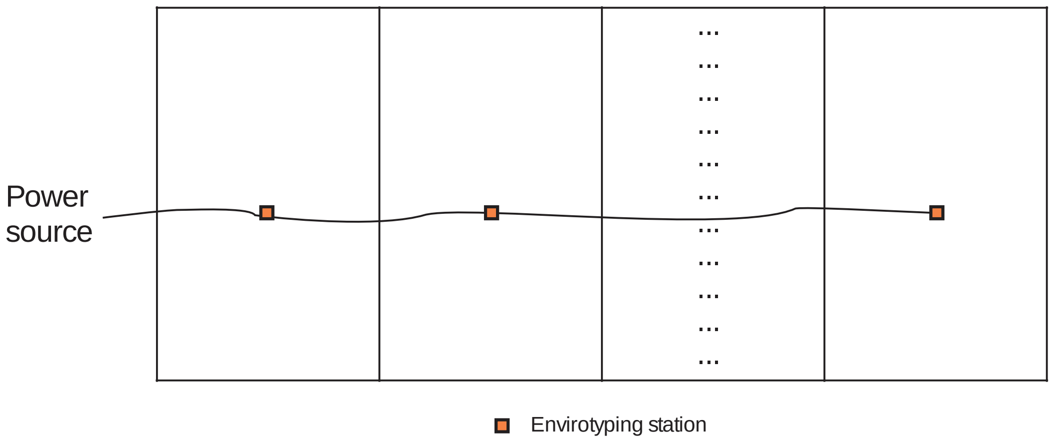
$31.90

Ammonia sensor

$93.48

M&M

Fine environmental characterization (Temporal)



TEMPORAL ENVIRONMENTAL COVARIATES:

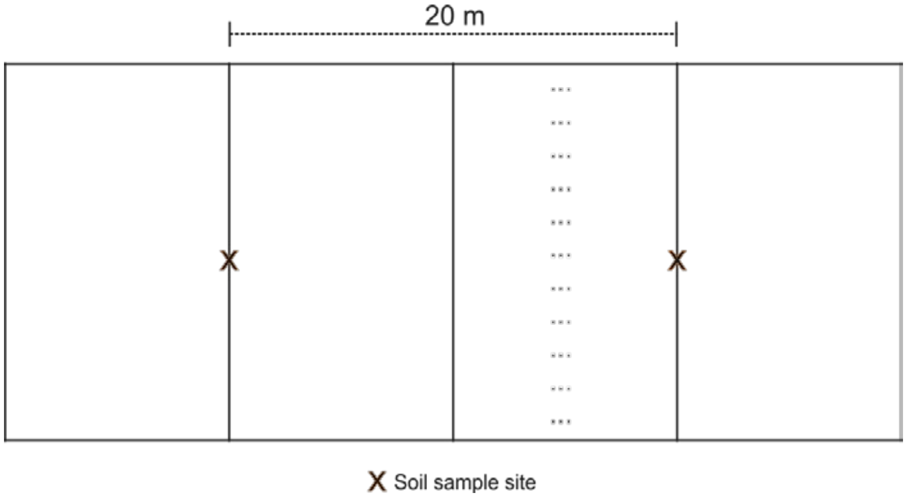
- **Soil temperature**: instant, season mean, maximum (season mean), range (season mean), flowering (mean);
- **Air temperature**: instant, season mean, maximum (season mean), range (season mean), flowering (mean), degree day (total);
- **Soil humidity**: instant, maximum (season mean), minimum (season mean), flowering (mean);
- **Air humidity**: instant, maximum (season mean), minimum (season mean), flowering (mean);
- **Ammonia content**: season sum (total loss);
- **Light intensity**: instant, season mean;

M&M

Fine environmental characterization (Stable)

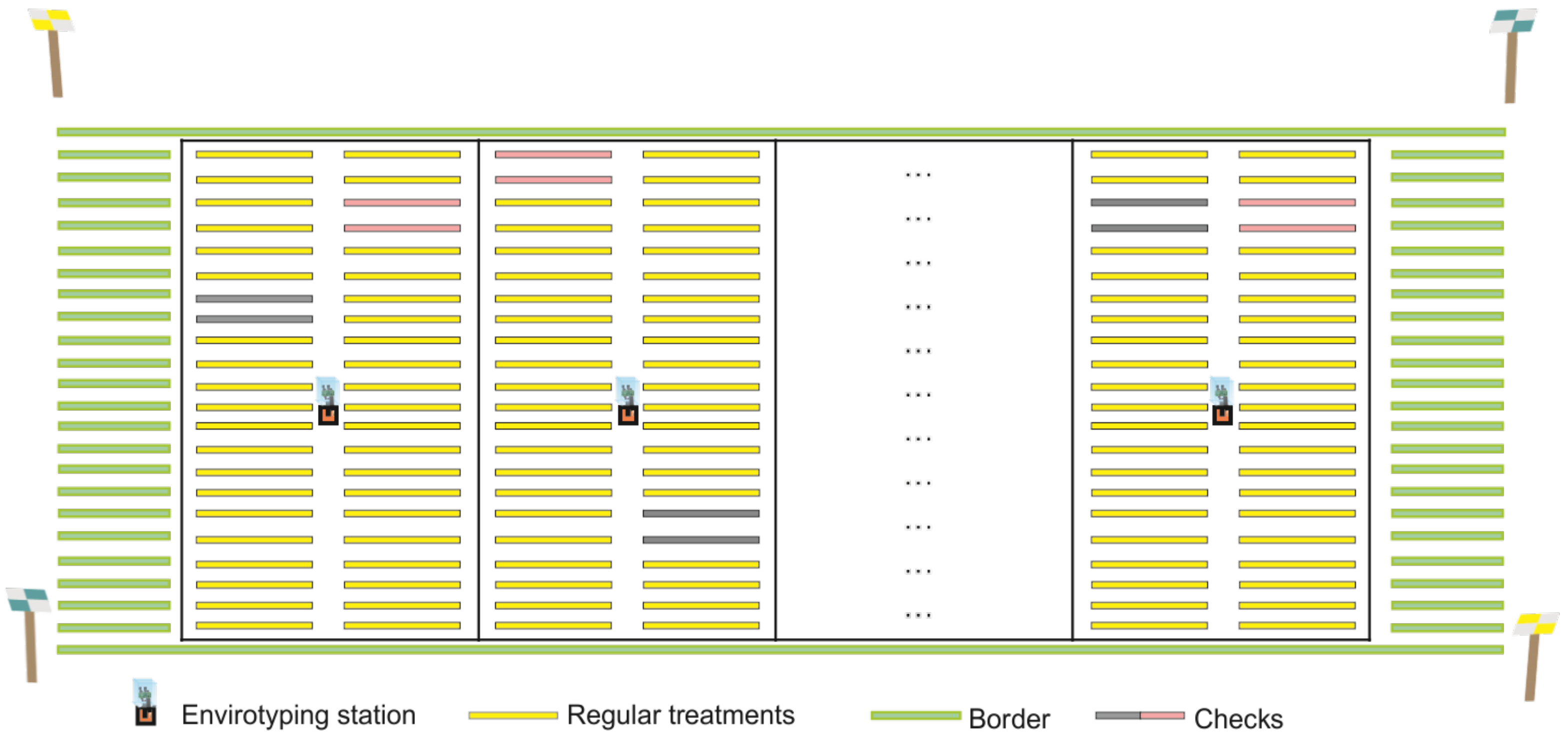
STABLE ENVIRONMENTAL COVARIATES:

- **Soil texture:** Sand, Silt and (Clay);
- **Chemical**: pH; Calcium, Magnesium and Aluminum



M&M

Experiment representation



M&M

High throughput phenotyping

Equipment:

Aerial imagery:

- Temporal resolution: V6, V12, VT, R3 e R6;
- Spatial resolution: 1 cm pixel^{-1} (80% overlapping);

Software:

PhotoScan

3D Modeling and Mapping

Canopy temperature (CO_2 assimilation)

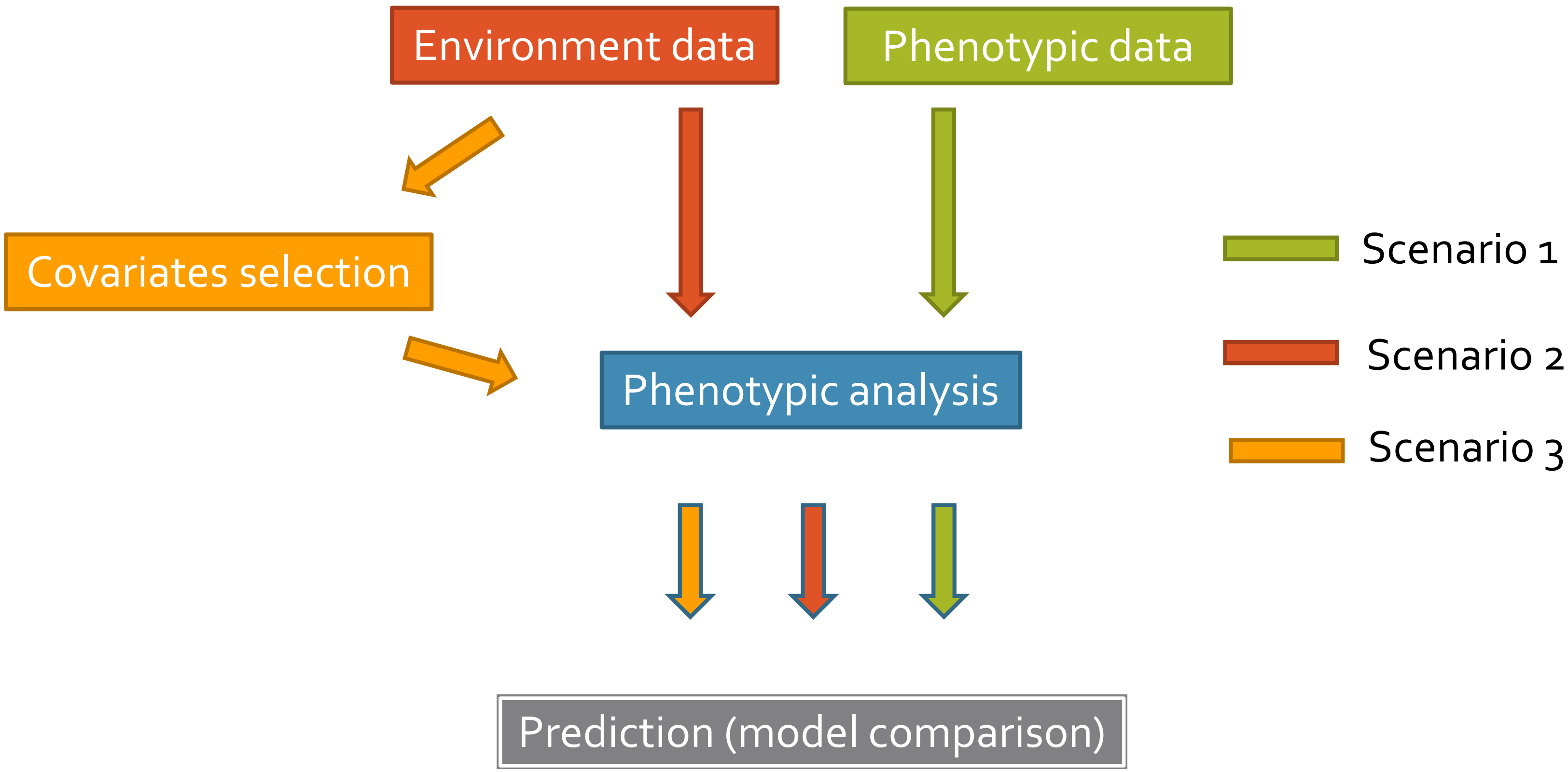
$$GNDVI = \frac{\rho_{NIR} - \rho_G}{\rho_{NIR} + \rho_G}$$

(LAI)

$$GY = \varepsilon_i . \varepsilon_c$$

M&M

Statistical analysis (Workflow)



M&M

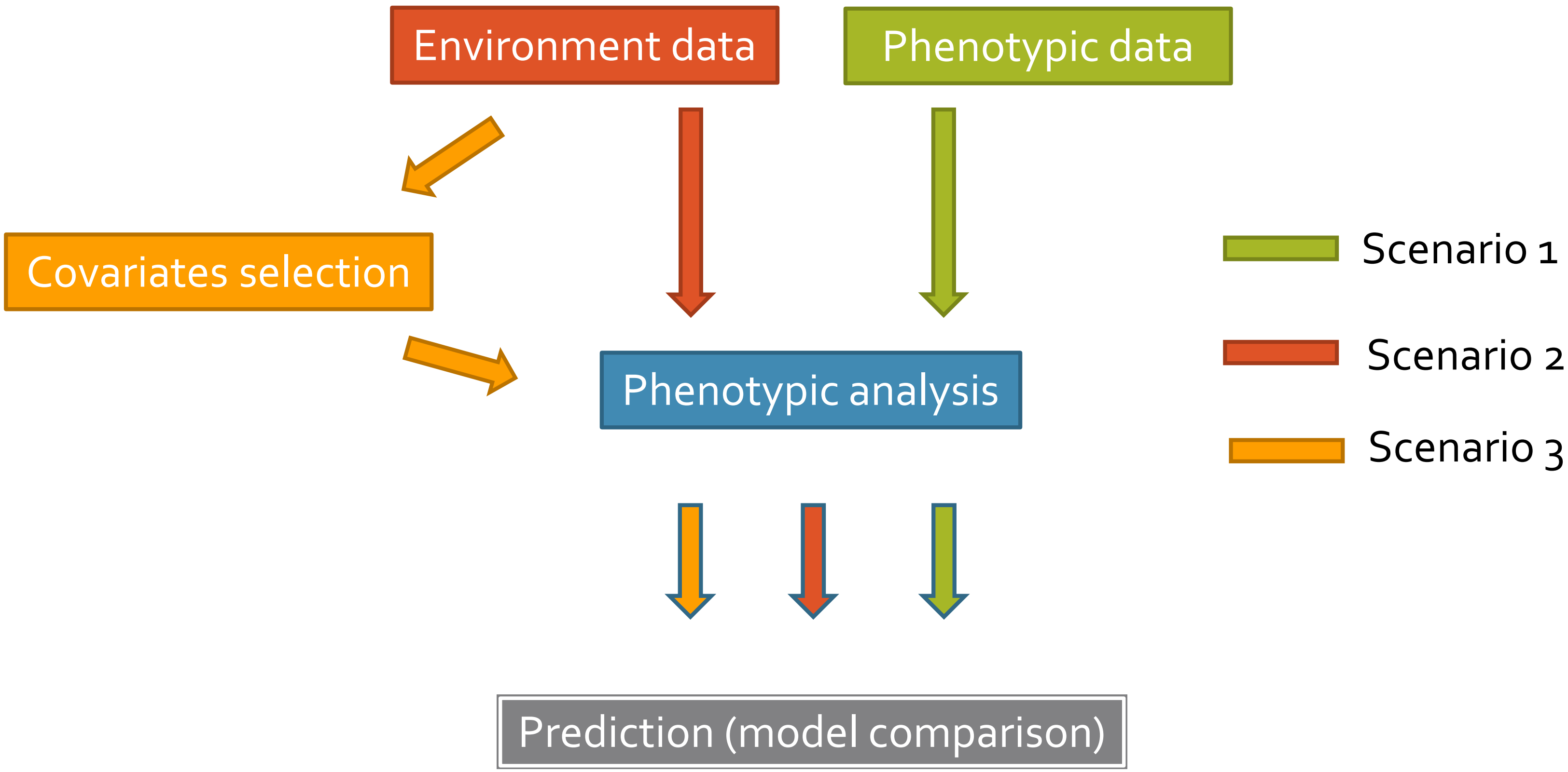
Statistical analysis

Covariates selection:

- Path analysis:
  - Dependent variables: GY, GNDVI and CT (each date);
  - Independent variables: environment covariates.

M&M

Statistical analysis (Workflow)



M&M
Statistical analysis

Covariates selection:

- Path analysis:
  - Dependent variables: GY, GNDVI and CT (each date);
  - Independent variables: temporal (1st Chain) and stable (2nd Chain) environment covariates.

Phenotypic analysis

- Analysis of GY, GNDVI and CT (each date);

Scenario 1

$$y = X\beta + Z\theta + \epsilon$$

Scenario 2

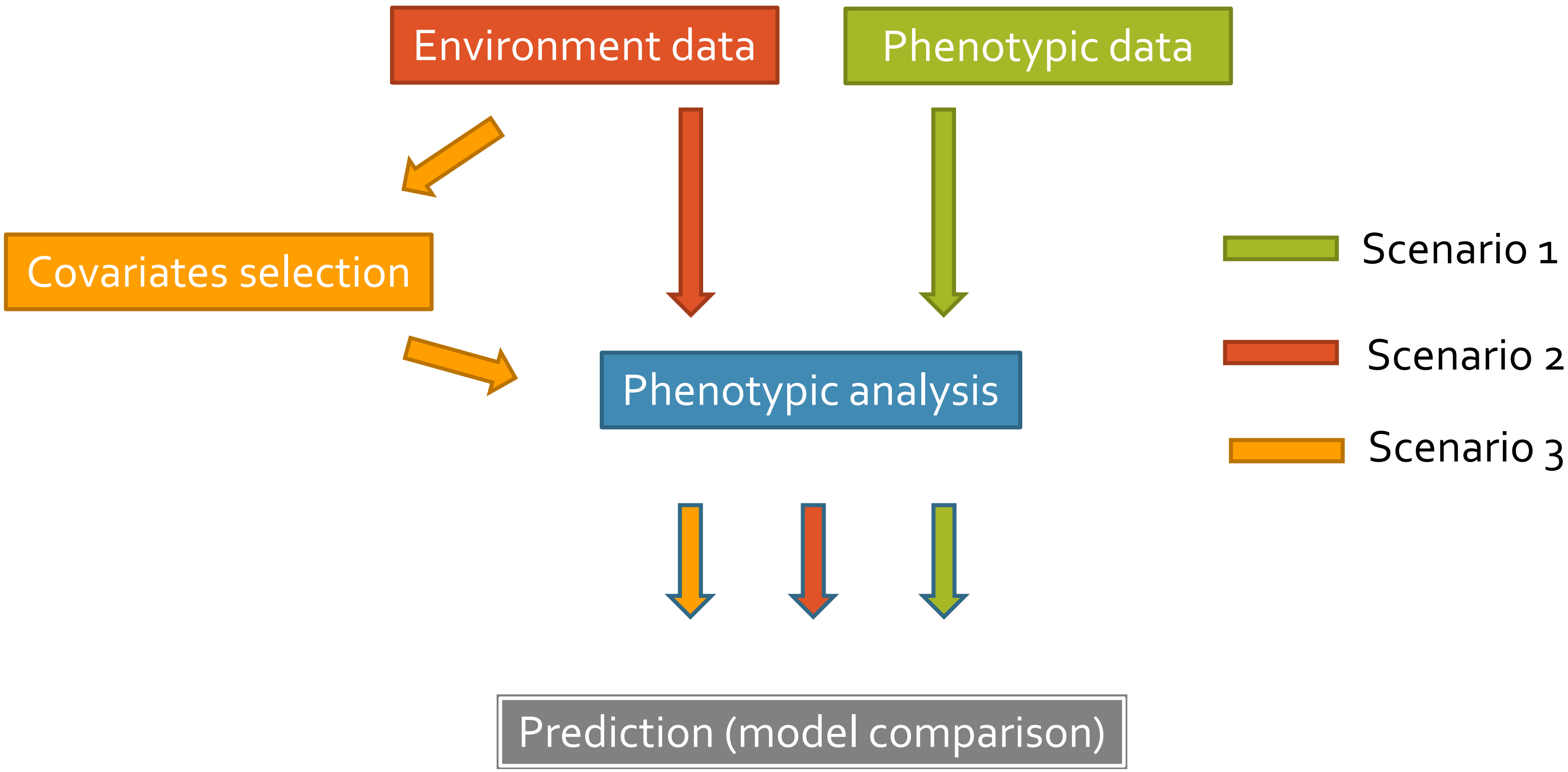
$$y = X\beta + Z\theta + T_1\tau_1 + \cdots + T_a\tau_a + \epsilon$$

Scenario 3

$$y = X\beta + Z\theta + S_1\alpha_1 + \cdots + S_s\alpha_s + \epsilon$$

M&M

Statistical analysis (Workflow)



M&M

Statistical analysis

Prediction:

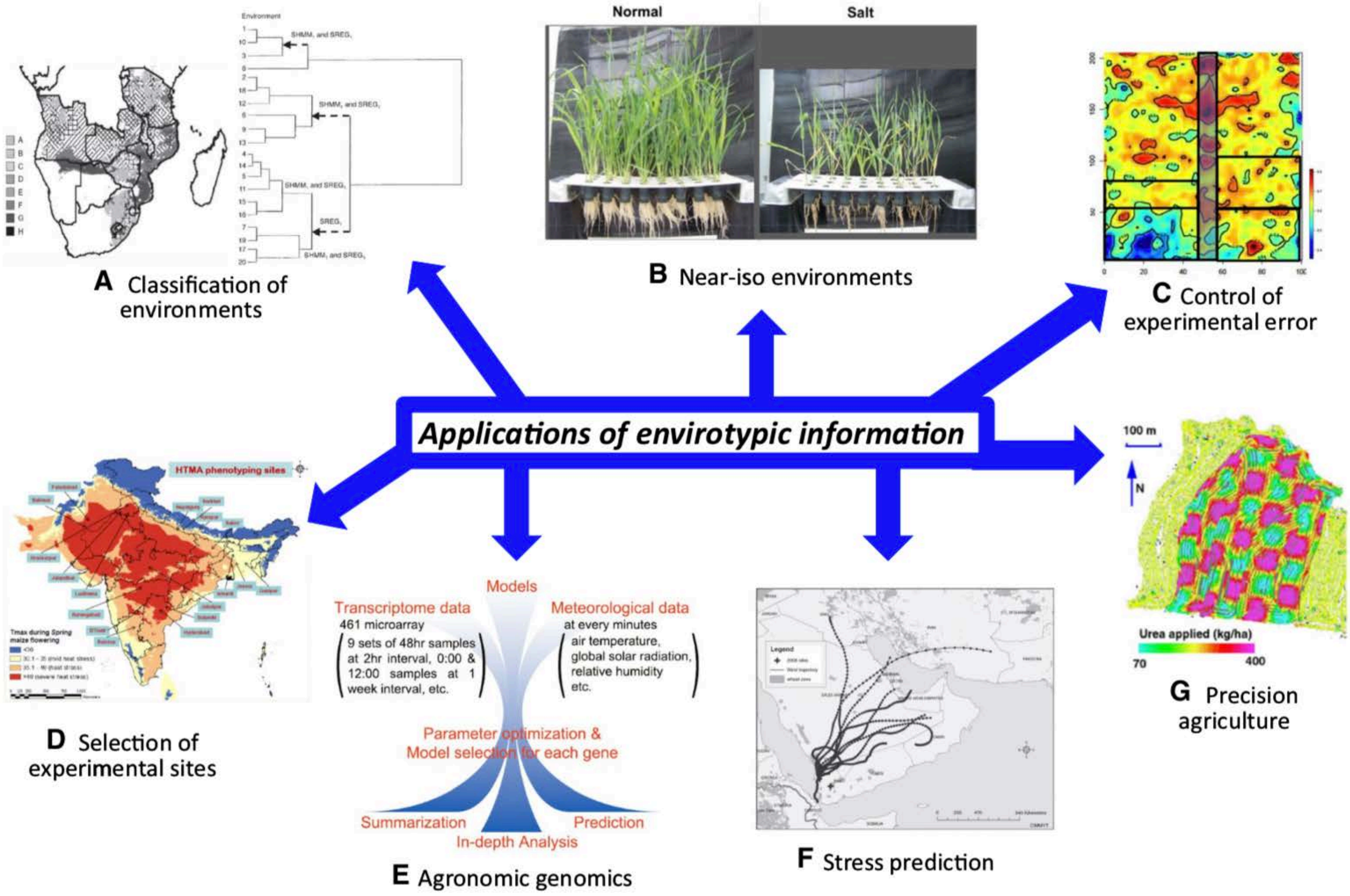
Scenario 1   Scenario 2   Scenario 3

ESTIMATION (80%)	TESTING (20%)
$GY = \beta_0 + gndvi\beta_1 + thermal\beta_2 + \epsilon$	$\widetilde{GY} = gndvi\hat{\beta}_1 + thermal\hat{\beta}_2$

$$r_{y,\tilde{y}} = cor(GY, \widetilde{GY})$$

Pearson & Spearman

Remarks


Applications of envirotypic information
A Classification of environments
Normal
Salt
B Near-iso environments
C Control of experimental error
HTMA phenotyping sites
D Selection of experimental sites
Models
Transcriptome data
461 microarray
9 sets of 48hr samples at 2hr interval, 0:00 & 12:00 samples at 1 week interval, etc.
Meteorological data
at every minutes
air temperature, global solar radiation, relative humidity etc.
Parameter optimization & Model selection for each gene
Summarization
Prediction
In-depth Analysis
E Agronomic genomics
F Stress prediction
100 m
N
Urea applied (kg/ha)
70
400
G Precision agriculture

Remarks

At last:

- Local environmental variation contribute to the residual variance.
- Greater efficiency of genetic variation exploration;
- HTP and noise reduction;
- HTP and GY prediction.

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Thanks

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