

SENSING HIDDEN HUNGER USING PRISMA AND SENTINEL-2 IMAGERY

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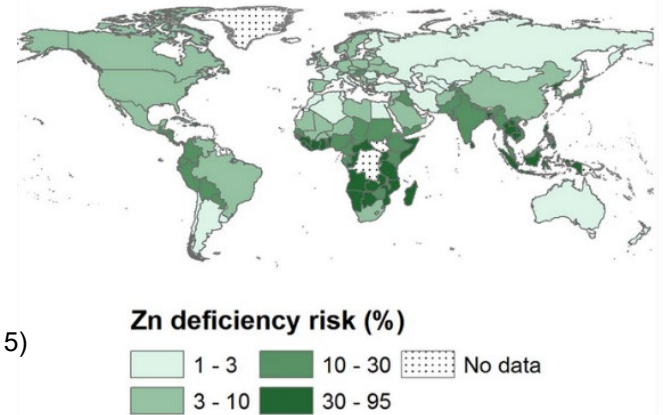
HIDDEN HUNGER

- More than two billion people are at risk of micronutrient (e.g. calcium, zinc, iron) deficiency= **hidden hunger**



growth impairment, immune dysfunction, cognitive impairment

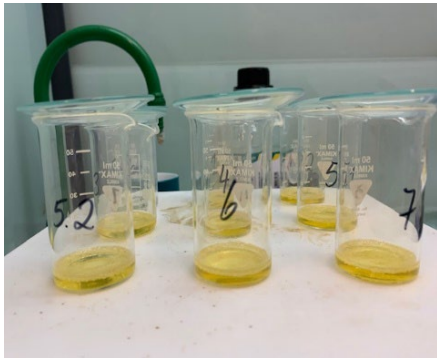
- Hidden hunger is widespread especially in low-income countries where diets are high in cereals and low in animal source products



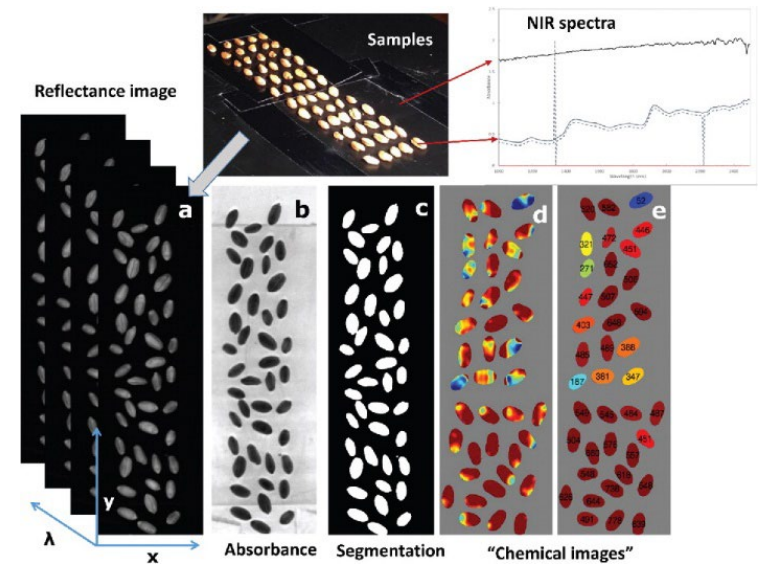
Source: Kumssa et al. (2015)

ASSESSING CROP NUTRITIONAL STATUS

- Wet chemical analysis of crop grains



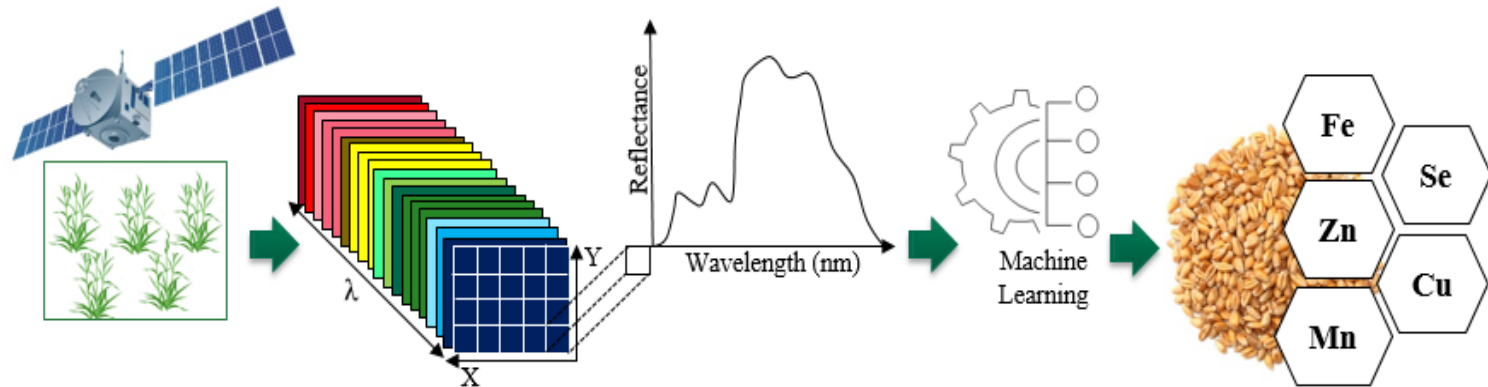
- Near-Infrared spectroscopy and hyperspectral imaging of crop grains



Source: Caparoso et al, 2018

OVERALL GOAL

- Evaluate the potential of **Sentinel-2** and **PRISMA** images to estimate and predict the abundance of **nutrients** in crop grains



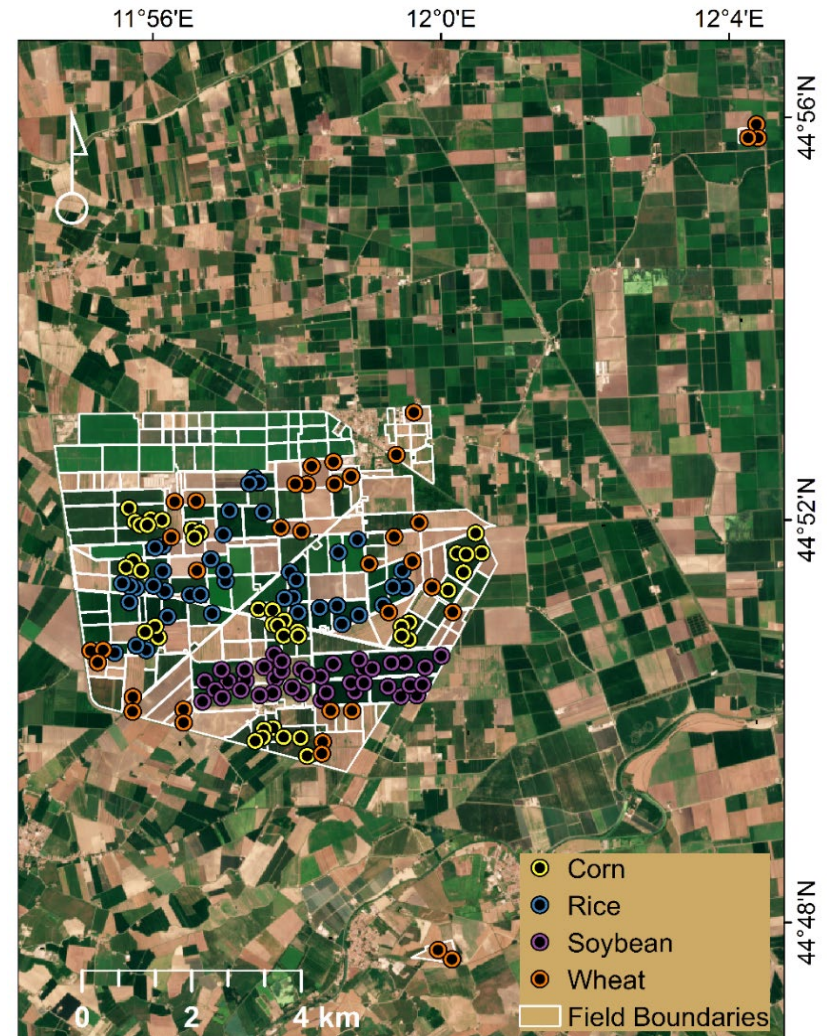
- **Macro-nutrients:** Potassium (K), Phosphorus (P), Nitrogen (N), Sulfur (S), Calcium (Ca)
- **Micro-nutrients:** Iron (Fe), Magnesium (Mg), Zinc (Zn)
- **Crops:** Wheat, Rice, Corn, Soybean

SPECIFIC OBJECTIVES

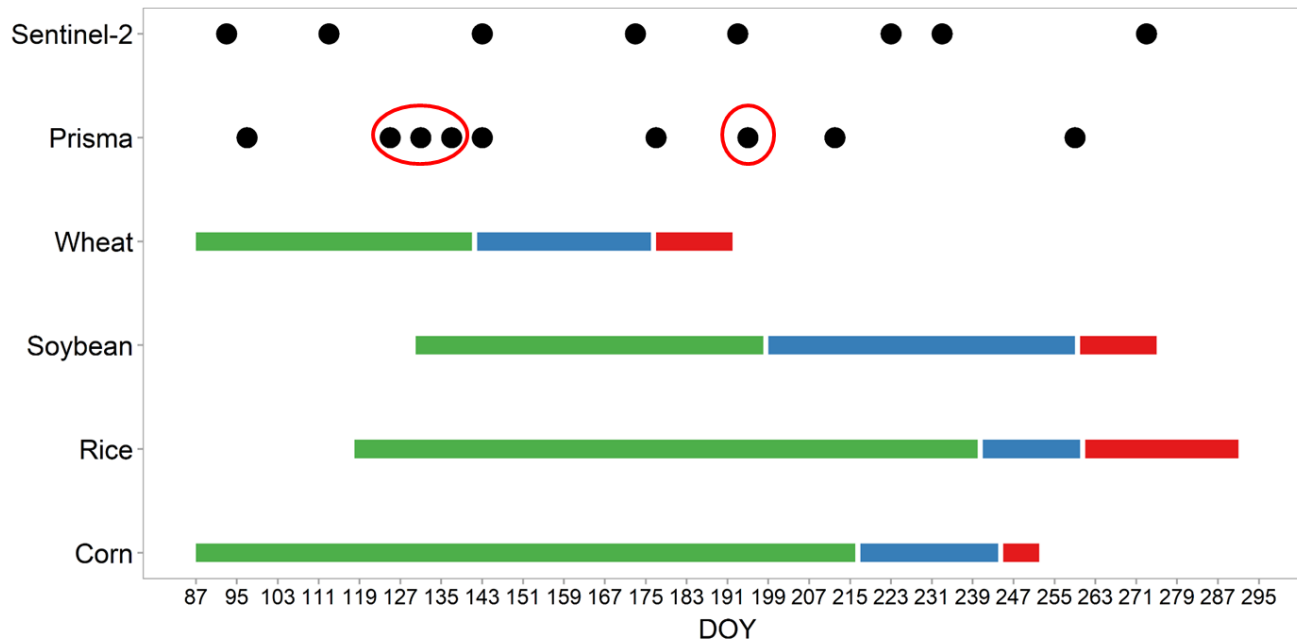
- **Objective 1:**
 - evaluate to what extent the **foliar chemical properties** and **temporal dynamics** as detected by **Sentinel-2** and **PRISMA** of the investigated crops translate to nutrient concentrations in the final agricultural production
- **Objective 2:**
 - determine how robust **Sentinel-2** and **PRISMA** are in predicting nutrient concentrations of the investigated crops in time (**vegetative, reproductive and maturity**).

STUDY AREA AND DATA

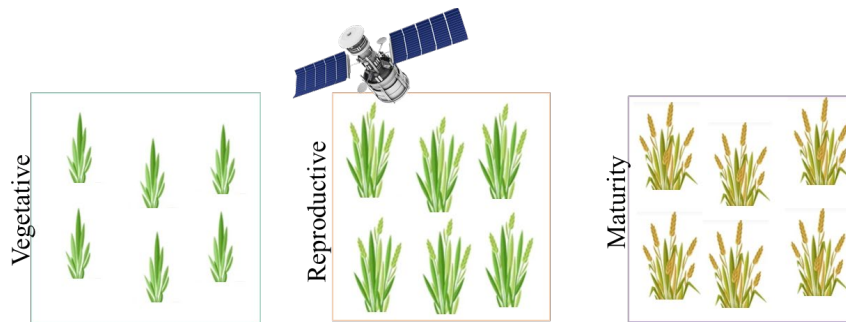
- Jolanda di Savoia, Italy
- Four crops
 - Nine **rice** varieties
 - Six **wheat** varieties
 - Five **maize** varieties
 - One **soybean** variety



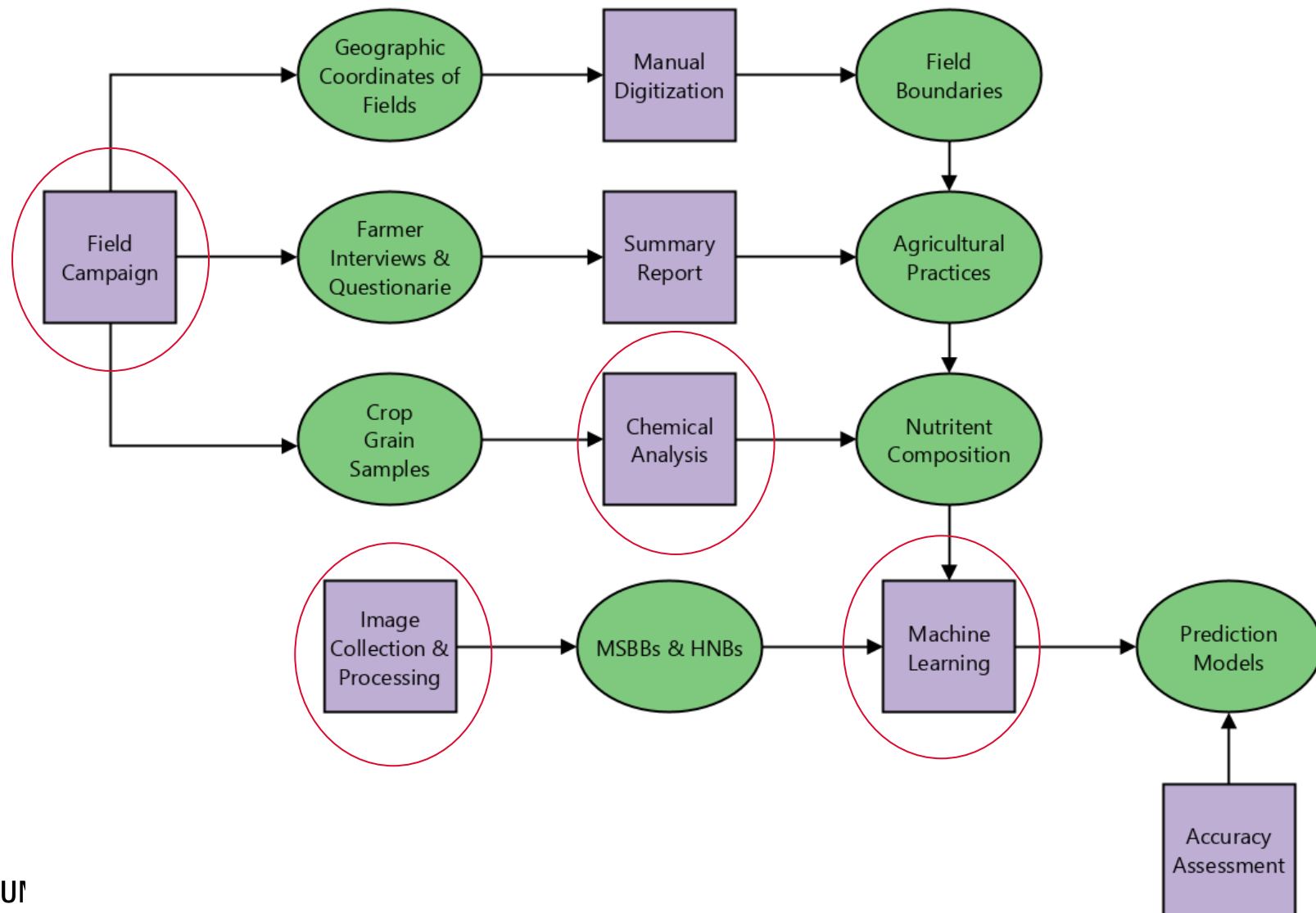
PRISMA & SENTINEL-2 IMAGES



- Vegetative
- Reproductive
- Maturity

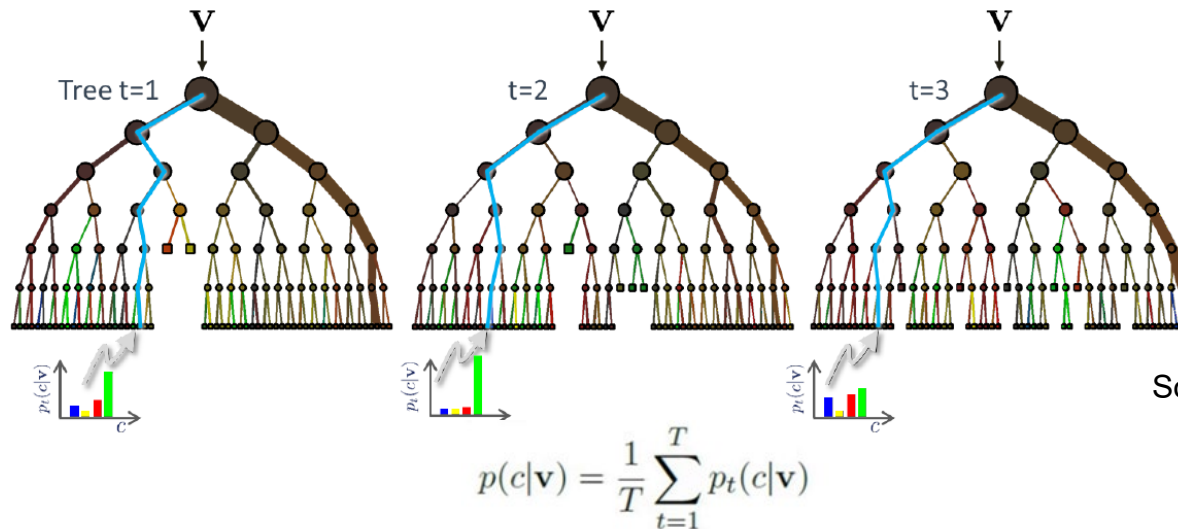


HYNUTRI WORKFLOW

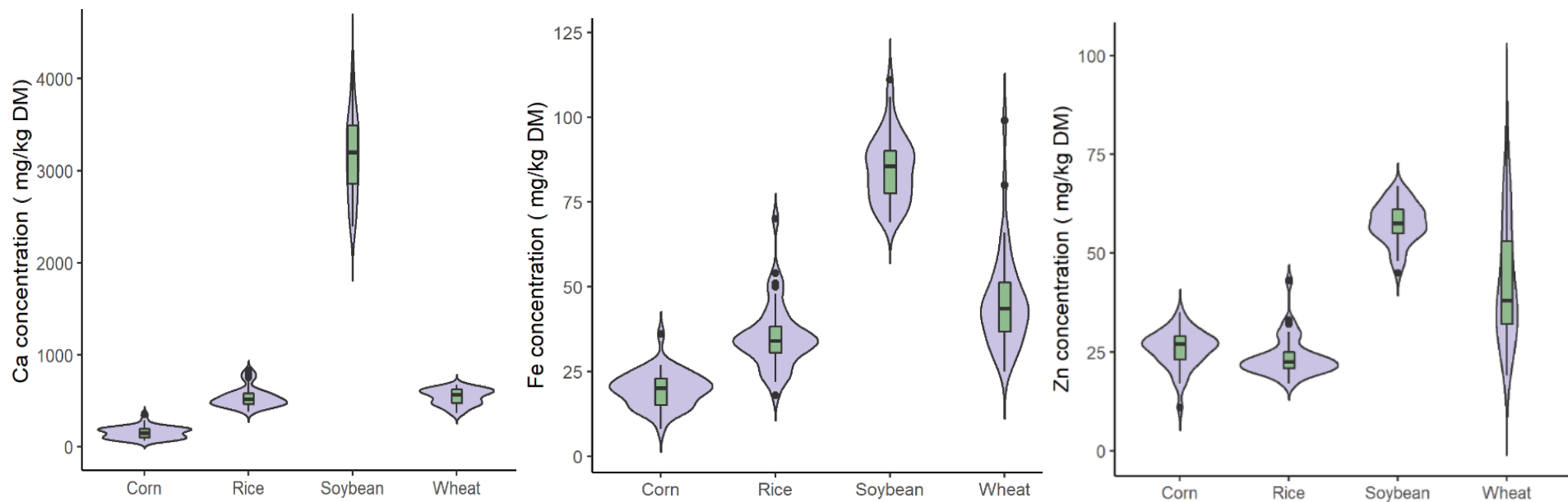


MACHINE LEARNING METHODS

- Random Forests (Breiman, 2001)
- Feature selection: backward feature elimination (caret package in R)
 - ntree: 1000
 - mtry: square root of the total number of input variables
 - 100 iterations (ensure robustness of the reported results)



Source: Criminisi et al, 2011



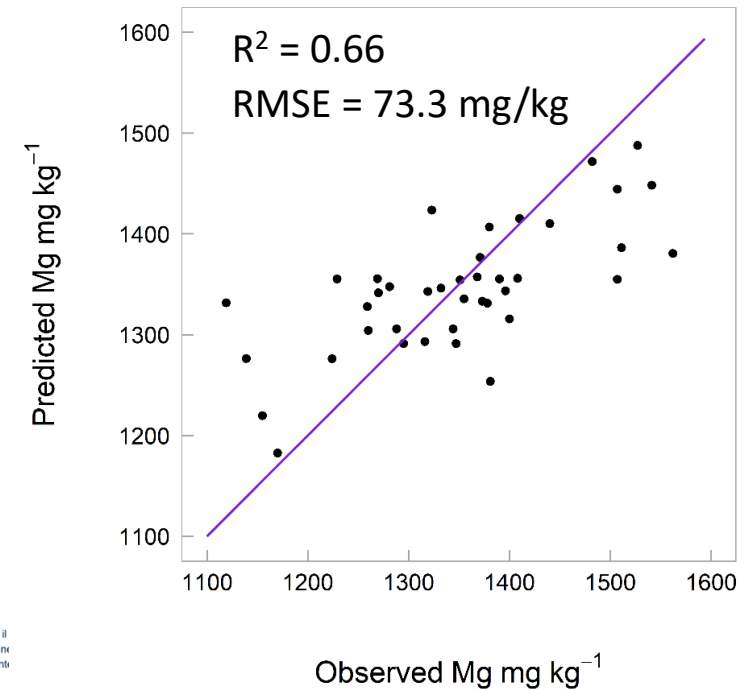
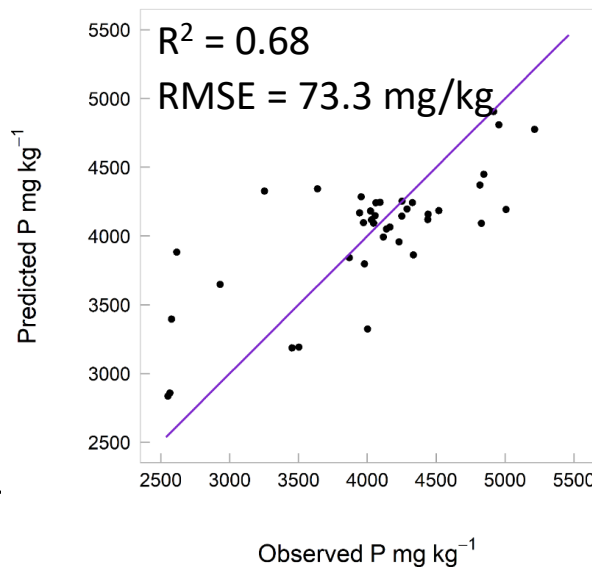
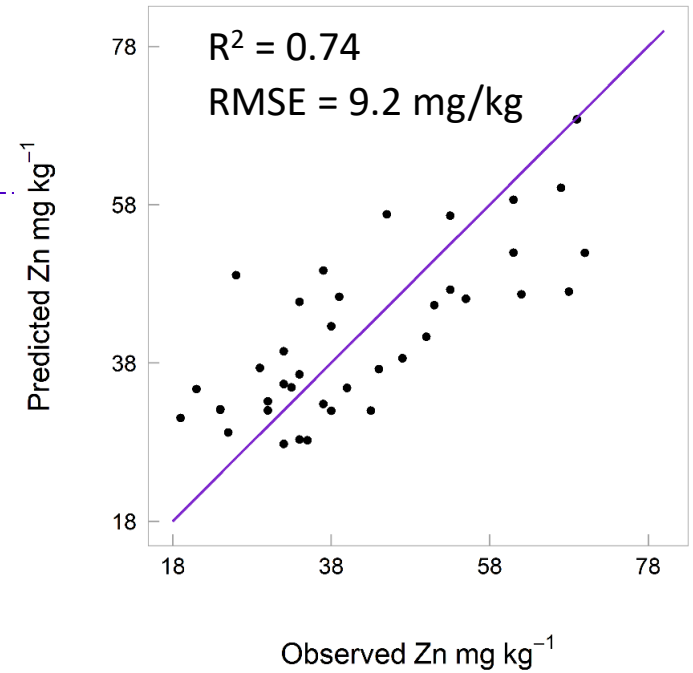
Mean Ca (mg/kg) Mean Fe (mg/kg) Mean Zn (mg/kg)

Wheat Italy	541.8	45.4	41.6
Wheat Ethiopia	428.8	45.1	25.9
Corn Italy	153.3	19.7	25.8
Corn Ethiopia	59.1	31.3	21.7
Corn Malawi	59.1	31.3	21.7
Rice Italy	535.8	35.2	23.6
Rice Malawi	94.6	67.5	24.2

PRISMA- BASED PREDICTIONS

WHEAT

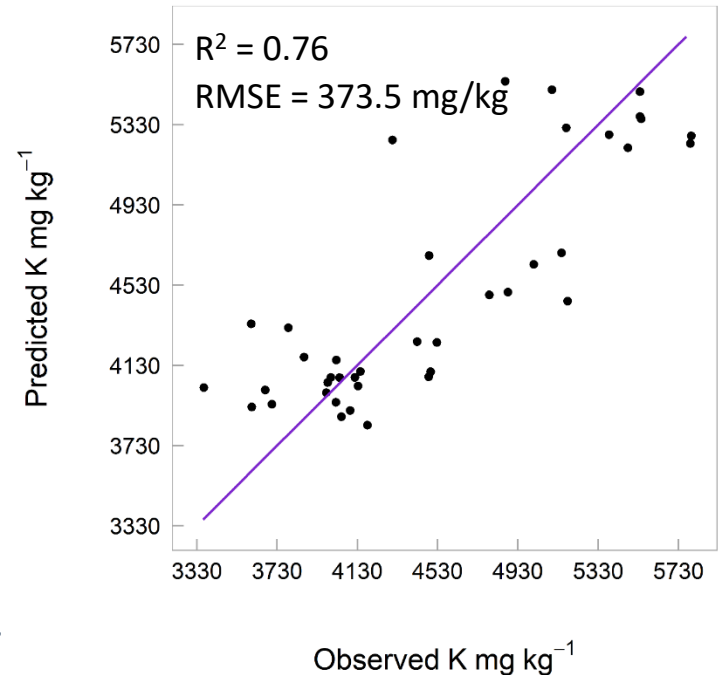
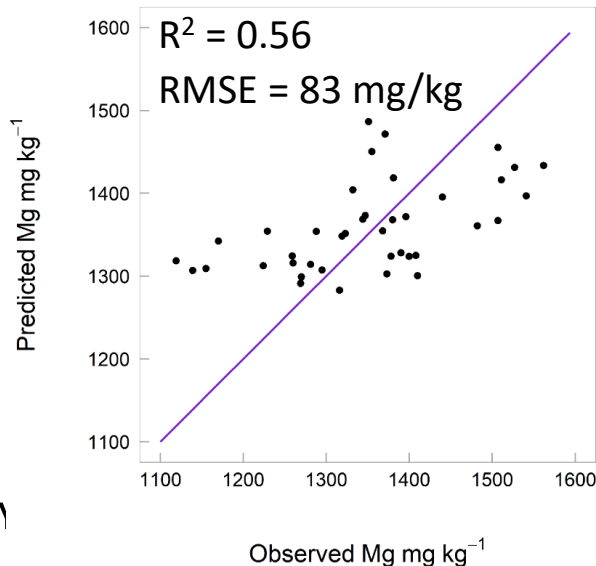
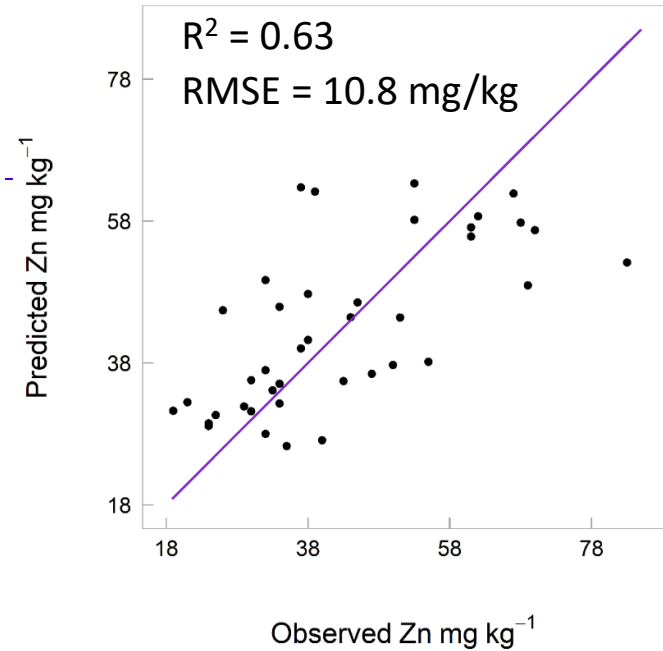
Nutrients	R ²	RMSE mg/kg
Zn	0.74	9.20
P	0.68	411.40
Mg	0.66	73.31
S	0.64	151.66
K	0.63	471.69
Ca	0.61	62.64
Fe	0.57	10.63
N	0.49	0.25



SENTINEL-2 BASED PREDICTIONS

WHEAT

Nutrients	R ²	RMSE mg/kg
Zn	0.63	10.86
P	0.6	500.7
Mg	0.56	83
S	0.54	182.5
K	0.76	373.5
Ca	0.54	64.99
Fe	0.48	12.17
N	0.4	0.29



RESULTS

- Promising results with PRISMA and Sentinel-2
- **PRISMA SWIR** bands proved to be more sensitive to predicting target nutrients
- **Sentinel-2 red-edge and NIR** narrowbands were more important than SWIR bands
- The correlations between spectra and nutrients were strongest at the early stages of crop

LIMITATIONS

- PRISMA and Sentinel-2 cloud-free images did not cover each important growth stage of the target crops
 - Difficult to draw consistent conclusions
- Surveillance:
 - Sample size
 - Need to collect data across several seasons

IMPACT

- Proposed method has the potential to:
 - side-step the scale limitations of traditional laboratory analysis of harvest samples
 - improve the spatiotemporal coverage of crop nutrient data to an unprecedented degree
 - Early interventions



Agricultural and food system

HYNUTRI PROJECT

More information: www.hynutri.nl

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