# IN-SEASON NITROGEN MANAGEMENT FOR WHEAT IN TUNISIA USING PROXIMAL AND REMOTE SENSING

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## Abstract

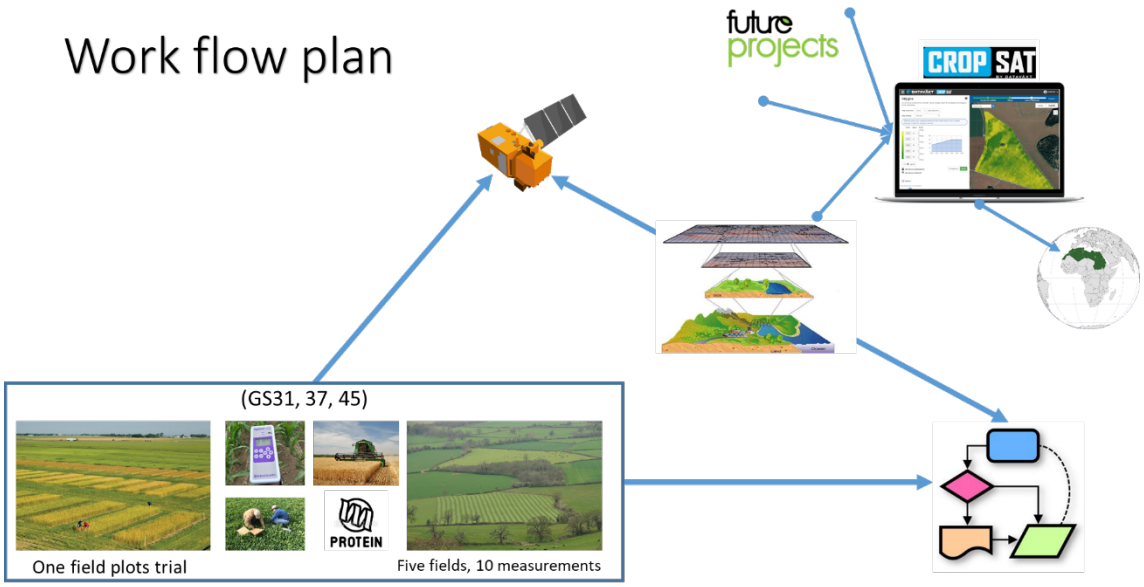
The study aims to develop an approach and a work flow to optimize the in season nitrogen (N) application in wheat cultivation in Tunisia, using the remote sensing techniques. The preliminary results showed the need to adopt simple technique first, like the zero plot, in the farmers' fields to detect the N stock in the soil from the previous season to optimize the N fertilization practices.

## Introduction

While the cereal sector represents an important factor in the social and economic farming structure in Tunisia, the national wheat average yield is very low, estimated to 1.4 t/ha. However, the frequent spreading of nitrogen in large quantities to raise yields can lead to low use efficiency of N and groundwater pollution. In Sweden, digital tools using proximal and remote sensing for variable rate application (VRA) of nutrients were developed and widely used by farmers to optimize fertilization (e.g. via the global, free-of-charge tool https://cropsat.com/ developed by the Swedish University of Agricultural Sciences/SLU in collaboration with partner organizations). An ongoing research project (2023-2024) in collaboration between Sweden and Tunisia aims to develop basic knowledge, methods, calibration models and workflows to use proximal and remote sensing in wheat production in Tunisia, which shall be used as the basis for a decision support system for optimizing N recommendations to wheat farmers. The project collaborates with a wider project on N application management (NUTCAT) covering several African countries (Tunisia, Morocco, Senegal, Ivory Coast, Ghana, Togo, Nigeria, Tanzania and Kenya).

## Methodes

The joint research program in Tunisia covers five climatic zones, varies from sub-humid in Beja (rainfed production) via Manouba and Siliana to semi-arid in Kairouan (irrigated system). In each climatic zone, two types of trials where implemented in farmers' fields: one is nitrogen response trial on small plots (3×12m), and 2-3 larger trials (2ha). The N response trial covers different rates of N application, which vary from 0 to 185 kg $ha^{-1}$, while the large scale trial is split into two parts, one for the optimal practices (OT) designed by the National Institute of Field Crops (INGC), and the second part is the farmer practices (FP, business as usual). Data was collected from all trials for soil, crop and georeferenced vegetation indices (VIs) using simple radiometer proximal sensors (RapidScan CS-45, Holland Scientific, USA and GreenSeeker handheld, Trimble, USA), satellite images, mainly from Sentinel-2, were downloaded and correlated with the ground truth measurements and proximal data. The approach and the workflow aim at developing two correlations, one between the ground truth N uptake and the VIs from the proximal sensors measured in the N response trials using the SPAD-502 chlorophyll meter (Konica Minolta, Japan), the second is a correlation between the VIs measured from the proximal sensors in the large trials and those calculated from the satellite images. The two correlations allow establishing a direct correlation between the satellite based VIs and the N uptake in wheat, which can be used in precision in-season N application at within-field scale. The final correlation can be implemented in satellite-based VIs mapping tools like CropSAT to be accessible for wheat producers in Tunisia, see figure below.




## Results

The collected data for the season 2023, was statistically analyzed. The Coefficient of Variation (CV) showed a low dispersion of data around the means (CV<0.2). The ANOVA test showed no significant variations between the different metrics (e.g N content, vegetation indices, yield), at significance level 5%, between the different N rate application plots in the N response trials, even in the zero plot (no N added). The vegetation indices were quickly saturated (end of February), only the first measurement in the beginning of February showed variations between the measurements of the different N treatments. The correlation between the N content the VIs for the first date was weak with a coefficient of determination $r^2$=0.2.

## Conclusion

The preliminary results of the collected data in the first season 2023, showed:

- The residual N content in the soil from the precedent season is very high.
- Measurements of VIs using the proximal sensors should starts earlier in January to avoid saturation and detect the variation between treatments.
- Farmers should adopt the zero plot technique to detect the N storage from the previous season and to optimize the N rate application.