# Techniques for monitoring crop mineral requirements in the Mediterranean

## Agroecological zones

| Suburban | Cereal plain | Mountains | Irrigated | Oasis |
|---|---|---|---|---|

## Introduction

In agroecological systems, analysing crops' specific mineral requirements helps to optimise the use of nutrients, reducing or eliminating chemical inputs, while preserving soil fertility in the long term. In the Mediterranean, a semi-arid region with fragile soils, this monitoring is particularly important. Several techniques are available. In agroecology, it is advisable to combine several approaches. Some recent techniques are still limited by the lack of references adapted to the Mediterranean region, but could become effective in the years to come.


**Photo**: "Sol Mobile" mobile soil analysis laboratory (PROSOL project, Tunisia)

**Picture**: Irrigation control probe coupled with a weather station in Kebili (Tunisia)

## Classic techniques

### a. Laboratory soil analyses

Regular soil analyses allow to assess the stocks of mineral elements present in the soil and those that are bioavailable to plants.
Soil samples should be collected at different depths depending on the crop (0-20 cm and sometimes 20-40 cm for annual plants, and 3 depths 0-20, 20-40 and 40-60 cm for most fruit trees). The sample must be representative of the plot, and it is preferable to include samples from 3 location in the plot to constitute a tested sample.

The samples are then analysed in the laboratory to determine the levels of nutrients available: primary nutrients (nitrogen, phosphorus and potassium), secondary nutrients and trace elements (calcium, magnesium, sulphur, zinc, iron, copper, manganese, etc.).

Regular analyses (every two or three years) are recommended to identify trends. To do so, samples must be taken from the same place, at the same depth and at the same time of year. In addition to mineral elements, these analyses also provide an opportunity to assess the soil's organic matter content, electrical conductivity, pH, cation exchange capacity, active limestone content and texture, all of which can be used to adjust fertilization and cultivation practices.

### b. Visual observation of plants

Plant observation can identify visual symptoms of nutritional deficiency or toxicity, such as yellowing or reddening of leaves, deformation, brittle stems, etc. Nitrogen deficiency manifests through yellowing of leaves (chlorosis). Phosphorus deficiency can lead to stunted growth and purple leaves... Visual symptoms vary depending on the crop, and it is best to combine these observations with analyses for a reliable diagnosis. Problems of absorption, soil conditions (temperature, humidity, etc.) and phytosanitary attacks can cause symptoms identical to those of mineral deficiencies or excesses, which can lead to diagnostic errors. But, combined with soil analyses, the appearance of visual symptoms usefully indicates that the element lacking has become limiting, leading to a drop in the plot's yield potential.

### c. Monitoring productivity and product quality

Yield reductions unexplained by the climate, small fruit or low sugar content can be linked to a lack of nutritional elements.

### d. Rapid diagnosis

**Rapid test kits** are used to assess the level of certain nutrients in soil or plants. Rapid diagnosis is often based on colorimetric tests that can be carried out directly in the field. These tests are easy to use, but are generally only indicative and do not cover all mineral elements.

### e. Plant analysis

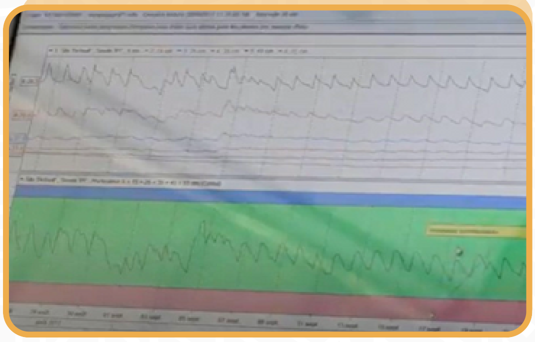
Leaf samples can be taken to rigorously assess mineral element concentrations in the crop. For each species, precise sampling periods must be respected to compare measured values with reference deficiency and toxicity thresholds for each mineral element. These periods are defined by species (mid-June to mid-July, i.e. 105 days after flowering for most fruit species except citrus and date palm, for which sampling is carried out in October; during the 1st flowering for most vegetable species, etc.). The leaves sampled must be whole, well-developed and taken from plants representative of the plot. The results obtained are compared with specific standards for each element and species.

## Recent techniques

Several tools and technologies have been developed more recently. These tools are often coupled with analyses of crop canopy development, plant water status and soil water saturation levels. The integration of these data, sometimes via platforms including a mobile interface, enables the reasoning and optimization of fertilization and crop management.

### a. Soil sensors

Sensors measuring **humidity**, **temperature** and **nutrient** levels in the soil can provide real-time data and enable precise management of mineral inputs. These sensors can be linked to mobile applications or web interfaces for automatic data transmission. **Capacitive** sensors can monitor soil moisture and total conductivity in real time. Specific sensors for major mineral elements are appearing on the market, notably to monitor nitrogen content.



**Source:** INAT, Tunisia

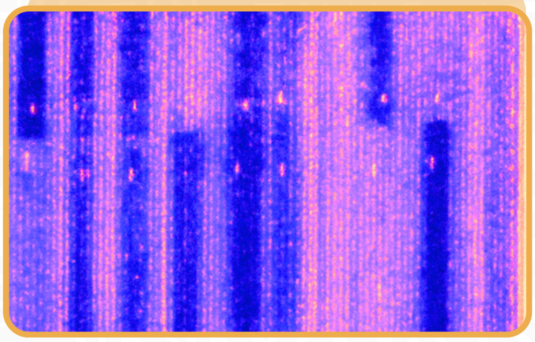
**Source:** INAT, Tunisia

### b. Proximal spectrometry

This method relies on the use of portable spectrometers such as the *Greenseeker*, which estimates the vitality and therefore the nutritional status of a plant cover, enabling the adjustment of inputs, particularly of nitrogen. This technique is non-destructive, fast and less expensive than laboratory analyses, but is sometimes approximate, particularly at the start of a crop. Moreover, it is only calibrated for the most common crops.

### c. Remote sensing and satellite imagery

The use of satellites or drones equipped with thermal, hyperspectral or multispectral sensors, combined with algorithms derived from spatial and temporal data, can help map the mineral status of crops and identify areas requiring additional mineral inputs. These techniques and their calibration are currently being developed.



**This image was created using Artificial Intelligence (DALL-E 3)**

**This image was created using Artificial Intelligence (DALL-E 3)**

## Using analysis results

In agroecological systems, the aim is not to supply mineral elements on an ad hoc basis, but to gradually build sustainable fertility through integrated nutrient management, improving the structure and biological health of the soil, and enhancing the soil's carbon stock. The analyses described above can be used to assess crop nutritional status, and to modulate and adjust fertilization, rotation and tillage programmes. A nitrogen deficit may justify the introduction of legumes in rotation; compost and green manure enrich the soil in nitrogen while improving its structure, water retention capacity and microbial activity; manure provides nitrogen and potassium and enriches the soil in organic matter, etc.

## Challenges and limitations

- Soil and plant analyses require well-equipped, reliable laboratories, which are often lacking in North Africa. Mobile laboratories can provide an adapted solution.
- Specific standards by species and production area are rarely established in North Africa, with the exception of citrus and date palms.
- Imaging and spectrometry techniques require a large database for each crop and sometimes for each variety, if the results are to be properly interpreted.

Funded by the European Union

Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

Funded by the European Union under Grant Agreement no. 101084647. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them. For the associated partner in the NATAE project, this work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).