Development of innovative decision support tools for fertilization of vegetables (cabbage, carrot) - Evaluation of non-destructive analysis tools under controlled conditions

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Introduction

Vegetable producers rely mainly on static methods to manage their fertilizations (eg. N balance before cultivation). Although methods based on the analysis of petiolar juice exist (eg. Pilazo®), these tools present many disadvantages (destructive analysis, difficult implementation, imprecision, lack of reliable references...). In this context, the Nutrinnov project aims to evaluate different non-destructive and portable tools (optical sensors: Multiplex and NIRS, and elemental analyzer: XRF) in order to develop new decision support tools enabling vegetable producers to improve their management for N, P, K, S, Mg and B fertilizations of cabbage and carrot crops.

Methods

Multiplex (Force A)

XRF (Brucker)

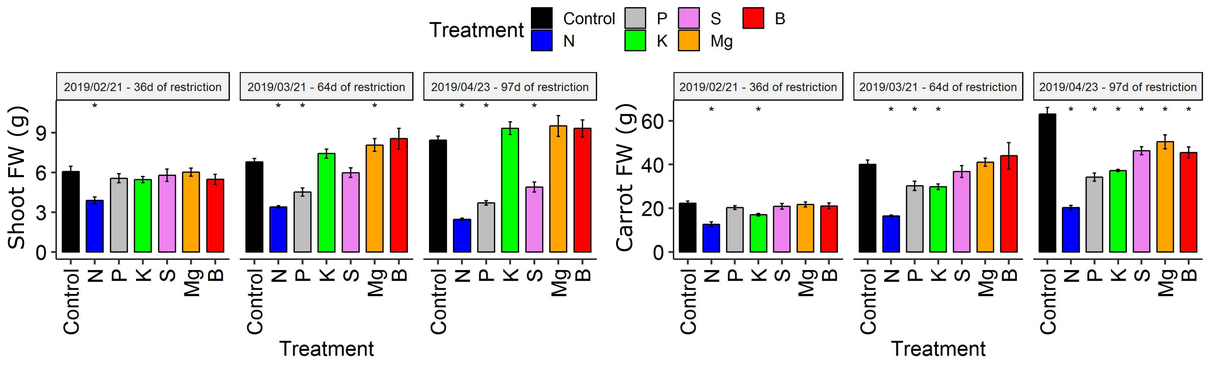
NIRS (Malvern Panalytical)

In order to establish the ability of these tools to detect early and specifically different mineral restrictions, the impacts of N, P, K, S, Mg or B limitations after a period of plethoric nutrition – which lasted about 1 month from sowing – were monitored on a randomized bloc experiment under controlled conditions with the three non-destructive tools. Carrot and cabbage plants were also compared on the basis of (i) growth and (ii) the appearance of visual stress symptoms during development.

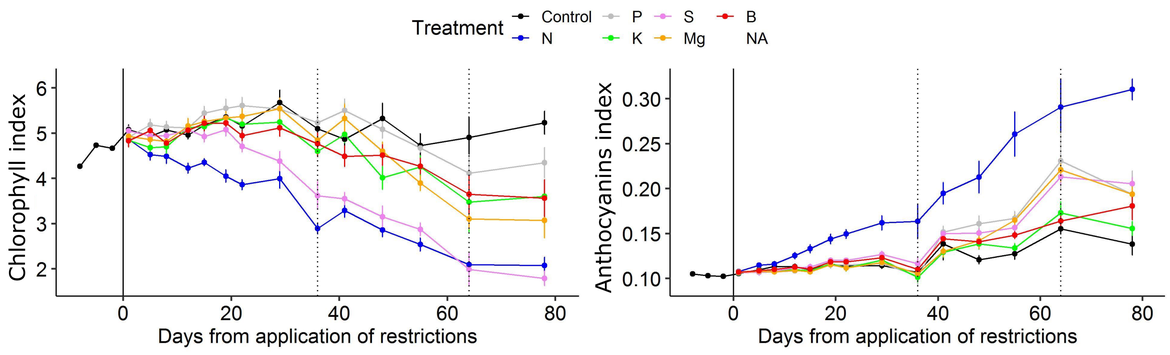
Results

Carrot

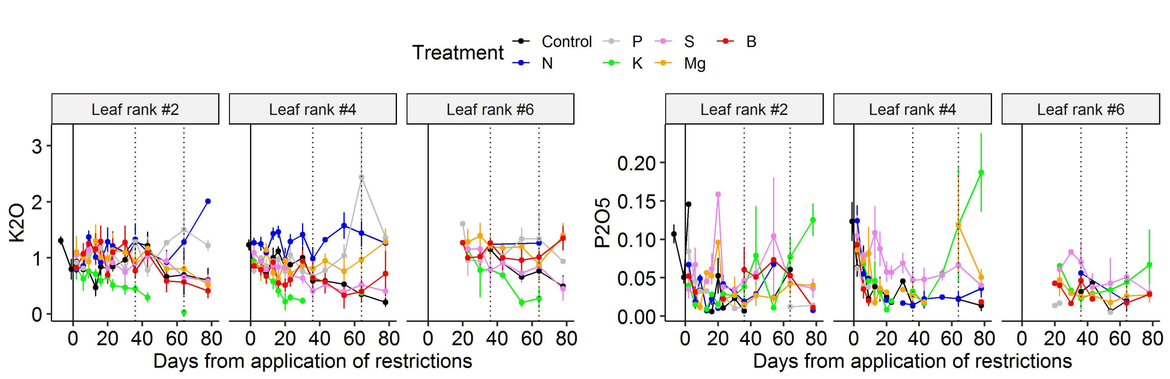
Specific symptoms are highlighted for each mineral deficiency.



Growth is affected and yields are reduced in response to N, P, K, S, Mg or B restrictions.

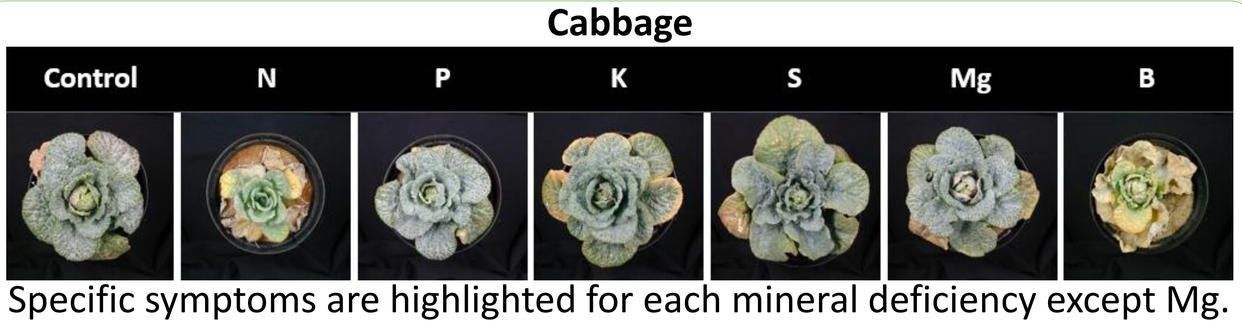


Based on the chlorophyll and anthocyanins index given by the Multiplex, N and S deficiencies can be detected specifically and early (in a few days, before any appearance of visual symptoms).

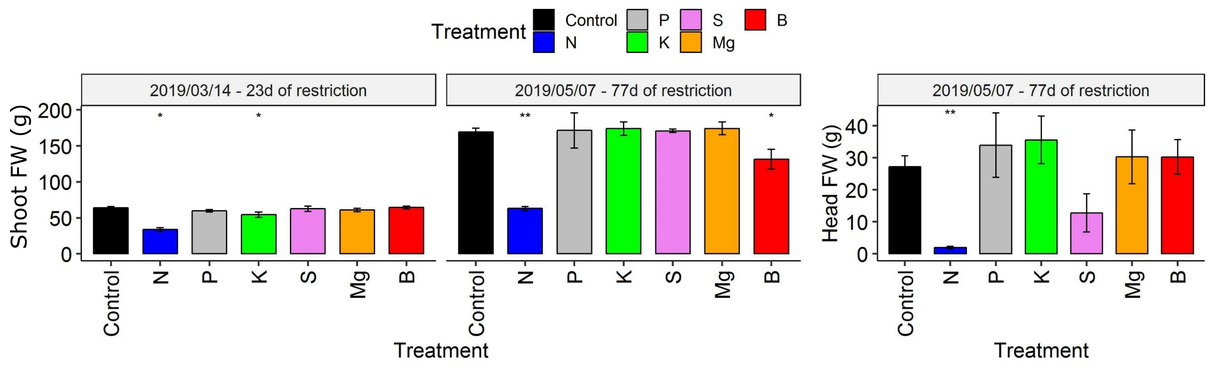


Portable XRF also appears as a relevant tool to diagnose K and S deficiencies in carrot plants (respectively by a reduced relative content in K_2O and by a relative accumulation of P_2O_5 in leaves).

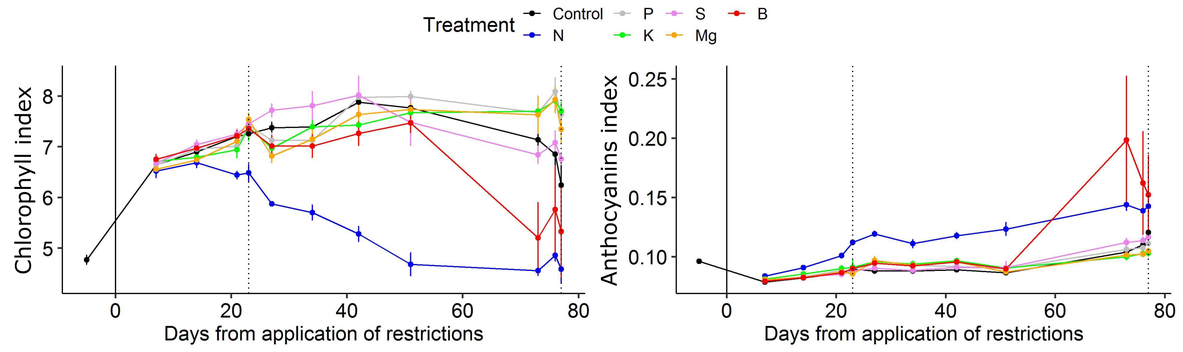
Cabbage



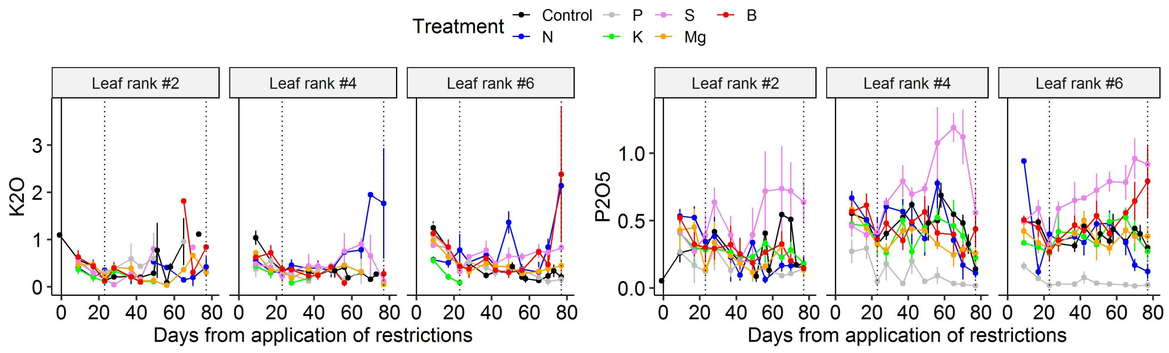
Specific symptoms are highlighted for each mineral deficiency except Mg.



Shoot growth is significantly reduced under N and B restrictions.
Yield is significantly reduced by N restriction and also tends to be reduced by S limitation.



The chlorophyll index given by the Multiplex can be used to rapidly distinguish N deficient plants. A relatively long period (73d) under B restriction also leads to a reduced chlorophyll relative content compared to Control plants.



K_2O is rapidly undetected in young leaves of K-deficient plants.
The relative content of P_2O_5 is reduced in young leaves of P-deficient plants and accumulates in young leaves of S-deficient plants.
The determination of relative contents of K_2O and P_2O_5 in young leaves by XRF appears particularly interesting for identifying P, K and S deficiencies in cabbage.

Discussion & perspectives

The results shows that the tools evaluated are promising for the management of N, P, K, and S fertilizations. IRMS and ICP-MS measurements are in progress for the calibrations of Multiplex index, XRF elemental analysis and spectral signatures by portable NIRS. These promising tools will be tested under field conditions in order to confirm their utilization for the diagnostic of mineral status and fertilization management.

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