TEMPORAL N STATUS EVALUATION USING HYPERSPECTRAL VEGETATION INDICES IN A POTATO CROP

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ABSTRACT

The amount and timing of nitrogen (N) fertilization represents a leading issue in precision agriculture, especially for potato (*Solanum tuberosum* L.) crop since N is an essential element for plant growth and tuber yield. Therefore, the ability to assess in-season crop N status from non-destructive methods such as proximal sensing is a promising alternative to optimize N fertilization management and uptake efficiency, as well as minimize environmental losses. The objective of this study was to evaluate the sensitivity of selected vegetation indices (VI) to reveal N status/stress of a Russet Burbank potato crop throughout the 2011 growing season in Quebec, Canada. Four N fertilization rates (i.e. 60, 120, 200 and 280 kg N ha^{-1}; N source: ammonium sulfate applied 40% at-planting and 60% at-hilling) plus an unfertilized control were considered. Crop biomass was sampled biweekly from 40 to 84 days after planting (DAP) for the determination of Nitrogen Nutrition Index (NNI) as the reference for N stress. Moreover, foliar N content analyses were performed on different dates during the growing season. Weekly hyperspectral reflectance data derived from a portative spectroradiometer (ASD FieldSpec HandHeld) was used to compute three different VI: Normalized Difference Vegetation Index (NDVI), Red Edge (RE) 740/720 index and Modified Chlorophyll Absorption Reflectance Index (MCARI). Primary results revealed a high correlation (r^2=0.74) at 66 DAP between RE and foliar N content in addition to significant correlations starting at 50 DAP. Further analyses are conducted to assess other VI corrected for soil effect in order to select the most correlated indices to NNI values.

Keywords: Nitrogen fertilization, proximal sensing, hyperspectral reflectance.

INTRODUCTION

Nitrogen is frequently considered as being the major limiting factor to potato yield and is of concern due to related environmental problems. Remote sensing technology developed in the past decades is being more widely used in agricultural applications. This technology has the potential to offer a cheaper alternative to farmers for characterizing the natural N spatial variability inside a field. Additionally, proximal hyperspectral reflectance produces spectral signatures in narrow spectral range, which represents a promising tool in order to select the best wavelengths and VI correlated to crop N status. The optimal VI could ultimately be integrated into a N management model for variable rate N application in potato fields.

MATERIALS AND METHODS

A randomized complete block design consisting of four N fertilization rates and an unfertilized control was utilized to induce differences in N status as well as spectral signatures. Hyperspectral measurements were performed at nadir one meter above crop canopy on one potato plant of each treatment repeated four times. A Spectralon target from Labsphere served as the white reference.

The hyperspectral reflectance data was processed using ASD ViewSpec Pro software. The Transformed Difference Vegetation Index (TDVI) has been computed and adapted for hyperspectral reflectance using the same wavelengths in the near-infrared and red as used in the NDVI calculation: $TDVI = 1.5\left[(\rho_{800} - \rho_{670}) \Big/ \sqrt{\rho_{800}^{\,2} + \rho_{670} + 0.5}\right]$ where ρ_{800} and ρ_{670} are the reflectance at 800 and 670 nm, respectively.

RESULTS AND DISCUSSION

Specific reflectance signatures were observed for each fertilization rate at 55 DAP (Fig. 1). Preliminary results indicated that TDVI values showed a significant linear relationship at 55 DAP. High correlation (r^2=0.74) was observed between RE and foliar N content at 66 DAP. However, those preliminary results revealed that no VI was able to discriminate efficiently crop N status at earlier stage than 55 DAP. It suggests that early N stress detection in a potato crop, essential in a context of in-season N management, may be studied by other methods than reflectance measurements such as fluorescence indicators.

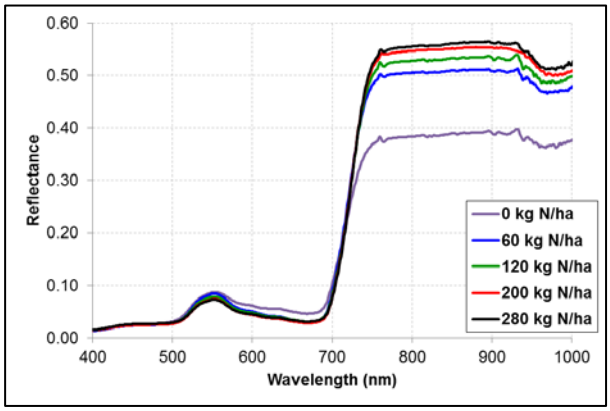

Fig. 1. Average reflectance of each N rate at 55 DAP.