#7549 CROPSAT – OPPORTUNITIES FOR APPLICATIONS IN PRECISION AGRICULTURE IN AFRICA

O. Alshihabi[1], I. Nouiri[2], M. Mechri[3], H. Angar[3], K. Piikki[1], J. Martinsson[4], and M. Söderström[1]
[1]Swedish University of Agricultural Sciences (SLU), Skara, Sweden; [2]National Agronomic Institute of Tunisia (INAT), Tunis, Tunisia; [3]National Institute of Field Crops (INGC), Bou Salem, Tunisia; [4]Dataväxt AB, Grästorp, Sweden, omran.alshihabi@slu.se

ABSTRACT

The present paper aims at describing the CropSAT system, a Sentinel-2-based interactive decision support system (DSS) that provides vegetation index (VI) maps free-of-charge all across the globe for different applications in precision agriculture. We summarize research results from the ongoing developmental process and pointing to opportunities for development and application in precision agriculture in Africa. The DSS was initially developed in a research project at the Swedish University of Agricultural Sciences (SLU), and has since its launch in 2015 been continuously developed in a private-public-partnership between SLU, private companies and the Swedish Board of Agriculture. One of the main applications of CropSAT is providing spatial variation maps of several VIs to be used in variable rate application (VRA) of any input in agriculture (fertilizers, pesticides or growth regulators). These maps could be either downloaded in different formats compatible with a wide range of spreaders/sprayers available in the machinery market or printed out to be used manually or with the help of smart phones localization apps, for example to support discussion in advisory situations. Such a DSS is an appropriate platform for developing other application using the satellite images like nitrogen uptake estimation, protein content/yield prediction and water stress assessment. Ongoing research is now running to develop and integrate models in CropSAT for new applications and the tool is subject of research and development projects in other countries worldwide. An initial study was carried out to test the DSS in Tunisia in collaboration between SLU, the National Agronomic Institute of Tunisia (INAT) and the National Institute of Field Crops (INGC) to assess the feasibility for application under arid and semi-arid climate where different crops varieties are used. Further development in Tunisia will focus on integrating crops water status indices in order to use the tool for irrigation water management. Now CropSAT has continuously updated global coverage with new satellite images (about every three days in North Africa), and is provided in multiple languages including English, Arabic and French.

Keywords: CropSAT, decision support system, Sentinel-2, precision agriculture, nitrogen fertilization

INTRODUCTION

Increasing crop yield and improved quality is a main target of nitrogen (N) application. Well-adjusted N rates means improving nitrogen use efficiency and in turn better profit and minimized risk of negative environmental impact associated with non-optimal nutrient application, such as nitrate leaching (Delin et al., 2014) and emissions of gaseous nitrous oxide (Balafoutis et al., 2017). The web-based decision support tool CropSAT (Dataväxt AB, Grästorp, Sweden) allows the optimization of the application of fertilizers and pesticides using variable rate application (VRA) technology at the within-field scale (Söderström et al., 2017, Alshihabi et al., 2020). The system has global coverage and is free of charge. CropSAT It is a decision support system that was initially based on DMC low-cost data with 22m spatial resolution, with 30-m Landsat 8 as backup. From 2015 and 2017, the first of two Sentinel-2 satellites became available, with higher spatial resolution (10 m) and some additional spectral bands within the red edge region of the crop canopy reflectance spectra with 20-m resolution (Figure 1), dedicated to vegetation studies. The vegetation index (VI) used, after initial performance tests, was the modified soil adjusted vegetation index (MSAVI2; Eq.1; Qi et al. 1994). Other indices were considered but rejected because they reached saturation too early in the season (e.g. the normalized difference vegetation index NDVI; Rouse et al. 1973). Common broadband vegetation indices (e.g. NDVI, MSAVI2) are based on the reflectance differences in the NIR and RED regions (ρ_{RED} and ρ_{NIR}).

$$MSAVI2 = \frac{1}{2}\left[(2 \times \rho_{NIR} + 1)\sqrt{[(2 \times \rho_{NIR} + 1)^2 - 8 \times (\rho_{NIR} - \rho_{RED})]}\right] \quad (1)$$

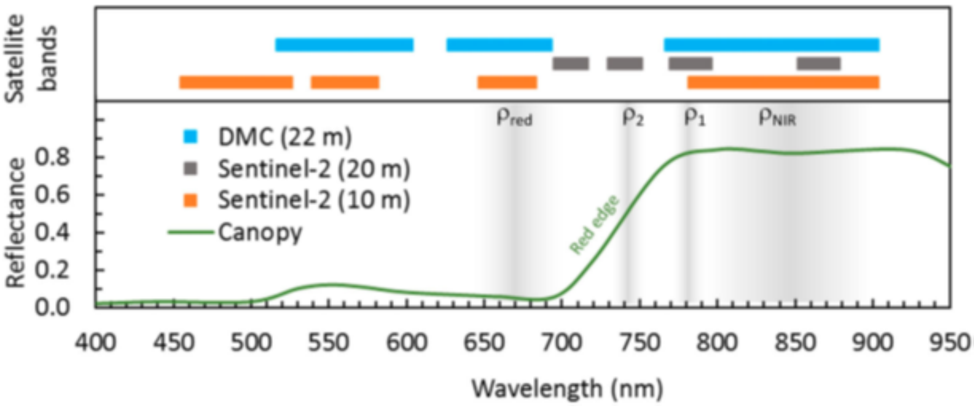

Figure 1. Spectral bands of the satellites used in CropSAT in part of the visible to near-infrared (NIR) region.

MATERIALS AND METHODS

The global version of the CropSAT system follows a simple interactive workflow:

1. First, an area of interest (often a crop field) is delineated by digitizing the area boundaries manually on the screen.
2. Then, a list of Sentinel-2 images available for that field is previewed and an appropriate image not affected by the clouds or their shadows is selected.
3. Rates of N fertilizer (or any other product) for five intervals of a VI map calculated from the chosen image are specified.
4. A derived VRA map can be modified by interactive tools (e.g. by drawing on the map or by specifying a new mean rate).
5. The VRA map can then be exported in various file formats (for different brands of spreaders or sprayers) or downloaded as a map for manual use.

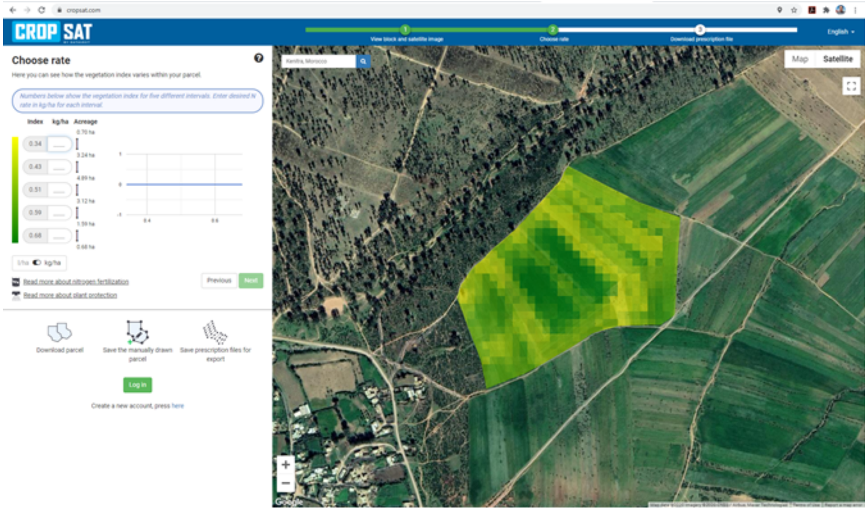

Figure 2. Screenshot from CropSAT, showing a vegetation index map of a field near Kenitra, Morocco, 01 Feb 2020.

An important question that arises in this type of decision support system, is a non-entirely new images can be useful? In this system, only the within-field relative variations are important, and the interpretation of the different index values are left to the user (Figure 2). In some cases, the spatial variation pattern is very stable and a map is more or less similar during a few weeks' time, in other cases, changes in the pattern may occur quicker. Therefore, it is recommended that users do field checks to investigate if the map seems to display the current pattern. In CropSAT, fields with clouds or cloud shadows are automatically removed, and pixels within 15 m of the field borders are removed; removed pixels are subsequently recalculated (through averaging) by the remaining neighboring pixels within the field. The level of crop N requirement should preferably be decided at a few representative locations in the field through user experience or the use of tools such as the Yara N-Tester (which is based on the Minolta SPAD-meter and measures light transmitted by the plant leaf at 650 and 940 nm (e.g. Uddling et al. 2007)) that can assist in providing an N recommendation to the user. Obtained N values are then inserted into CropSAT and a VRA file is generated and can be downloaded and used for controlling the spreader. For an increasing number of countries, there is also a cloud-based solution for transferring VRA files to the spreader.

RESULTS AND DISCUSSION

Several research studies have been, and are being, carried out in the continuous development of the DSS. Methods have been developed for translation of VI maps to N uptake maps (in winter wheat), to N rate maps (oilseed rape) and for spatial grain protein content predictions for harvest planning (malting barley). So far, these further developments are available in the Swedish version of CropSAT. However similar research can be carried on in any country for local conditions and cultivars. The system is now widely used, particularly in Scandinavia, as a DSS for VRA of N but also for VRA of other inputs, e.g. pesticides and growth regulators. In addition to the global version, there are a number of nationally adapted versions, developed and run in collaboration with local organizations in these countries and he tool supports several languages (more than ten different language, including English, French and Arabic), which opens door for possible further developments and dissemination in Africa and the Middle East region. Sustainable uses of natural resources in agriculture in arid and semi–arid areas require integrated management of soil and water. Water scarcity and climate change adaptation/mitigation demand scientifically based DSSs for site-specific fertilizer application and water management in the agricultural sector. In future versions of CropSAT, also VIs related to the water status (such as NDWI; McFeeters, 1996) of the crop could be presented as decision support for variable-rate irrigation and VRA of nitrogen, so that farmers and authorities can manage their natural resources in a sustainable, profitable and practical way. The feasibility of the DSS for use under arid and semi-arid climate will be investigated in a collaboration between SLU and the National Agronomic Institute of Tunisia (INAT) and the National Institute of Field Crops (INGC), two institutions concerned by developing the field crops in the north of Tunisia. The first test on the ground under the Tunisian conditions showed a well functionality of the system under sub-humid to arid climate conditions. The full adaptation of the system to different climate conditions is planned in Tunisia as a starting point for a wider dissemination in arid and semi-arid areas.

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