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REVIEW OF THE APPLICATIONS OF SATELLITE REMOTE SENSING IN ORGANIC FARMING (PART I)

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Abstract

Organic farming is a much more sustainable farming system than conventional farming. It is part of humanity's efforts to preserve biodiversity and provides healthy and safe food to humans. Remote sensing methods are widely used in agriculture. Their use will help the transition from conventional to organic farming. They can help farmers choose the most suitable place to build an organic farm. Remote sensing methods are a very powerful tool for weed control in organic farming. They can be used to determine the level of stress that crops experience. They provide a good opportunity to forecast yields on organic farms. Remote sensing methods can optimize fertilization on organic farms. They can be used to distinguish between organic and conventional agriculture, as well as to monitor biodiversity in agricultural areas. Remote sensing methods can help organic farmers make timely and adequate decisions in managing their farms.

Introduction

A major way to achieve sustainable agriculture is through the integration of remote sensing (RS) technologies. The use of RS technologies is mandatory today to achieve highly productive and sustainable agriculture [1]. The use of aerospace methods can improve the transition from conventional to organic farming. According to [2] RS technologies at various scales often prove to be an appropriate tool for crop monitoring. The potential of these technologies in relation to organic farming has not been fully explored [3]. Remote sensing monitoring in organic farming should generate information at different levels to be used for resource planning and contribute to sustainable agricultural production [4]. The use of remote sensing methods, GPS technology and hyperspectral image analysis is helping farmers to switch to agro-environmental and organic farming, which is a turning point in agriculture [5]. According to [6], the implementation of RS technologies in agriculture and especially their use in organic farming allows not only to obtain significant cost savings of up to 25 %, an increase in productivity by 1.7 to 2.3 and yield, but also effective environmental protection. Research and technological advances in remote sensing have significantly improved our ability to detect and quantify physical and biological loads that affect crop productivity [2, 7]. Precision farming technologies that are based on RS technologies can address some of the problems in organic farming related to water and soil management, plant protection and mechanization [8].

Remote sensing methods are widely used for agricultural applications, they are the basis of precision agriculture and it cannot exist without them [9–11]. Remote sensing methods offer new perspectives and methodological approaches for precision agriculture [12–19]. Historically, the Earth's artificial satellites have dominated this area. Drones can carry spectral sensors, and also allow real-time estimates of crop yields, pests and diseases, and more [11]. Other researchers, such as [10, 20–24] also emphasize the great potential of unmanned aerial vehicles (UAVs) in the field of agriculture. Another very important application of remote sensing methods in agriculture is the ability to track the development of crops in their various phenophases [10, 25]. A number of studies aim to identify crops, assess areas, and identify diseases and pests and more [26]. Differences between vegetation and soil reflective characteristics in the near infrared region have been shown to be successful in separating plants from soils. Biochemical measurements can be performed using the field spectroscopy method. These methods use the reflection spectrum of the measured object. Thus, physiological information is obtained in each pixel. This method is very suitable for use by researchers in organic farming to better understand the biochemical components of biological fields without the need for destructive analysis [11, 19, 27]. Reflected solar radiation in specific visible, near and medium infrared ranges of the electromagnetic spectrum has proved useful in detecting nutrient deficiencies, diseases, pests, and weeds. High-resolution multispectral satellite images can be used to develop monitoring products and to support agricultural solutions. Multispectral vegetation indices derived from crop reflections over relatively wide ranges can be used to monitor plant growth in relation to measured or predicted climate variables. Any deviation from the expected seasonal pattern signals a potential problem and requires further research by farmers [7, 19, 26, 28–30]. Remote sensing allows monitoring phenology of the crops [31]. Precision farming technology based on RS and GIS technologies provides good opportunities for effective crop management [32]. This technology should be used to optimize resources (natural and socio-economic), thus serving to increase the profitability and sustainability of agriculture and support the development of organic farming [8, 33].

The objective of the paper is to attempt to review the use of satellite RS in organic farming in specific problem areas. This study is a continuation of an overview published in Bulgarian by the authors [19].

Materials and methods

This study provides an overview and a comprehensive analysis of articles, reports and materials published on the Internet in the following scientific database Scopus, Research Gate, and Google Scholar. A combination of keywords with logical queries was used when searching the scientific and specialized database for the period from the beginning of space remote sensing from the late 1980s to 2021. The main keywords that we used are: "organic farming" AND "remote sensing", "organic farming" AND "satellite data".

Results and discussion

The analysis of the reviewed literature indexed in CrossRef and parsed by the Scite platform (https://scite.ai), revealed that most cited top 25 publications are published by Elsevier, followed by AAAS, Wiley, and MDPI, see Fig. 1.

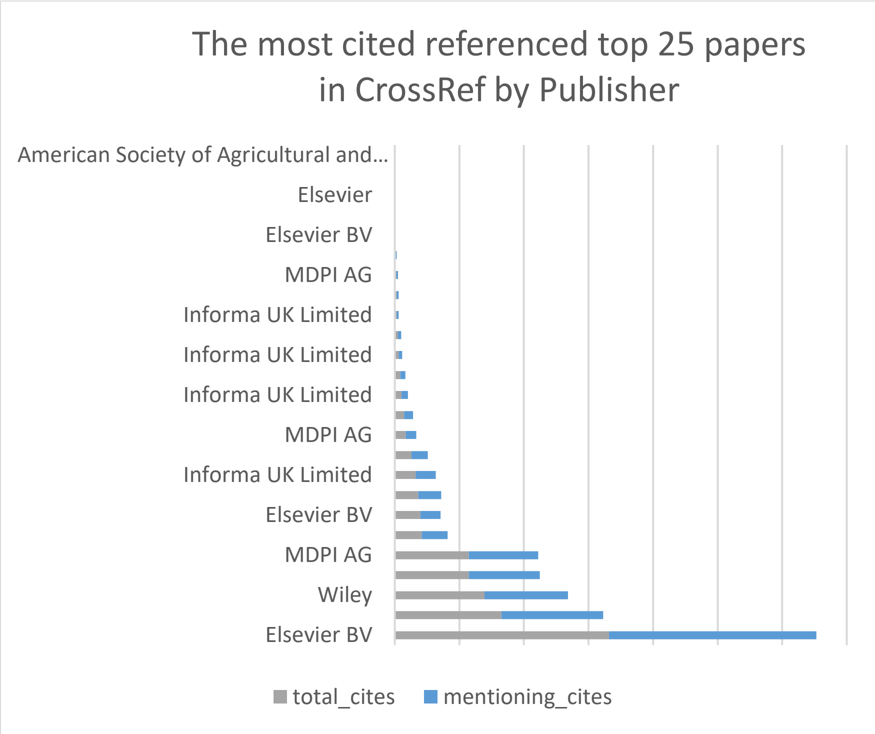

Fig. 1. Top 25 publications referenced in CrossRef by publisher

Interestingly, the most cited of the works is published almost 10 years ago, i.e. in 2013, see Fig. 2. This paper is followed by citations of a paper from 2010 and 2011. It is evidence that the interest in organic farming applications of remote sensing sprout in the last 12 years. Although, the first referenced works in this list are from 1986. The top 3 most cited papers are those of [9] with 972 citations [33] with 641 citations, and [66] with 325 citations.

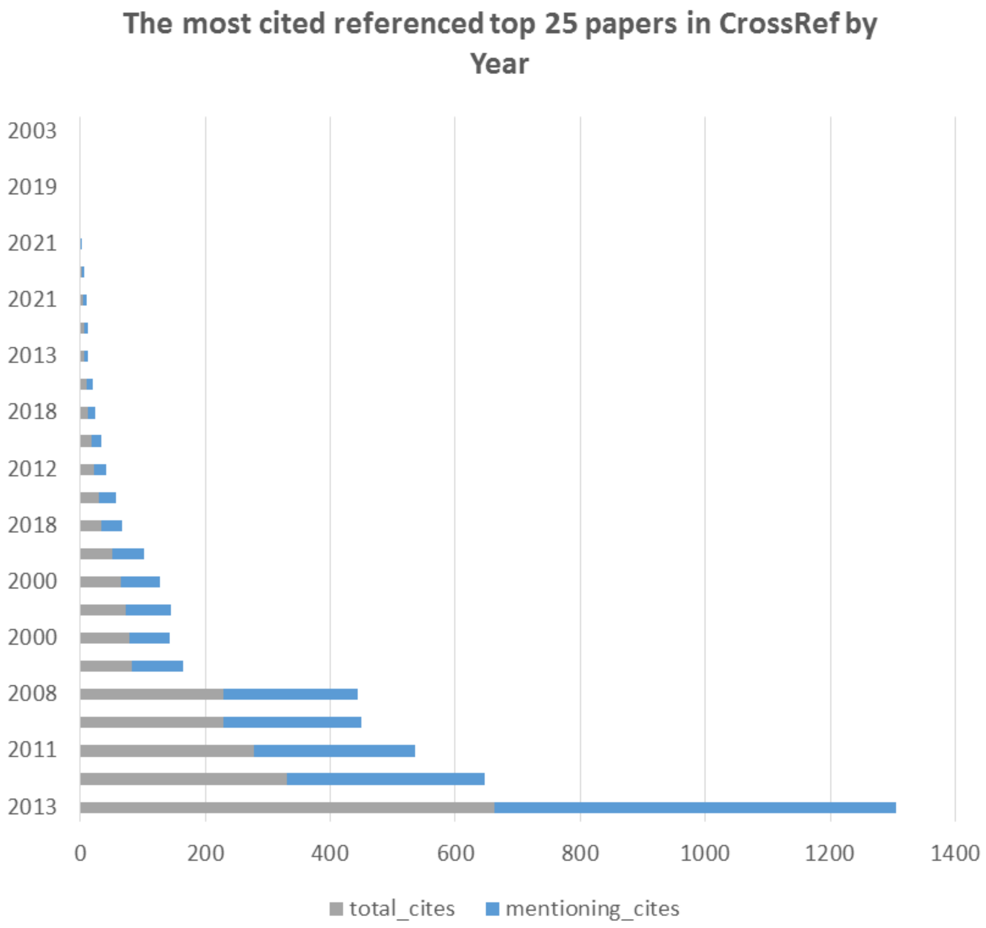

Fig. 2. Top 25 cited papers in CrossRef by number of citations

The content analysis of the titles reveals the following picture, see Fig. 3.

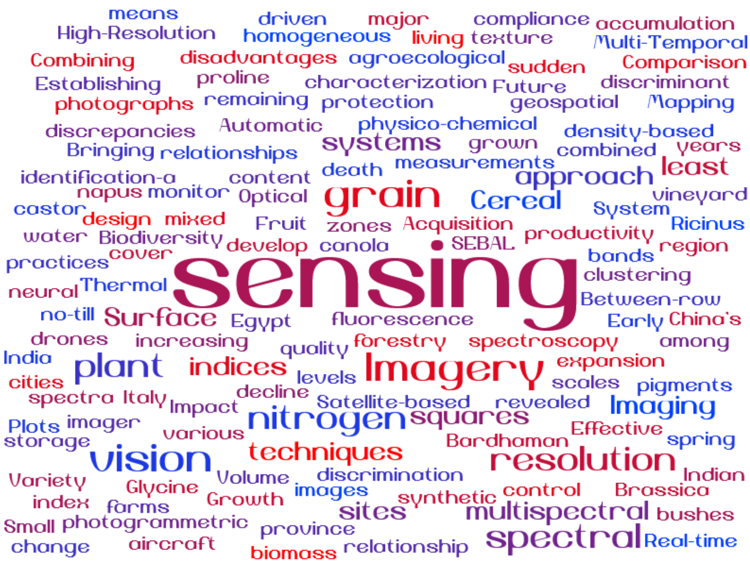

Fig. 3. Word cloud from the titles of the cited works in the review

The word cloud maps 141 words out of 301 unique words using the open WordItOut (https://worditout.com) word-cloud web-tool. The words picked by the algorithm are above 3 characters to filter out the conjugations and linking words. It is evident that ‘sensing’ (remote) is the centre object / technology mentioned in the article (paper) titles. Other frequent words are ‘imagery’, ‘plant’, ‘vision’, ‘resolution’, ‘spectral’, ‘surface’, and ‘grain’. These are more or less revealing the core objectives of the studies in question. A further insight could provide the author provided keywords and the keywords assigned by the indexing databases. However, these typically does not match but could provide information on which categories the papers are assigned to. However, in such case of interdisciplinary works it is of interest only for meta-analysis. Despite that, current work focuses on revealing the main trends in the applications of organic farming and remote sensing which necessitates of reading the papers non-automatically since at present the linguistic analysis of full text is yet not on the required level to provide for understanding of nuances in texts. In addition, not all the databases (including Scopus and Web of Science) contain all the papers in review full texts.

RS and GIS methods for selecting suitable areas for organic farming

Organic farming requires a selection of an appropriate place according to the planned crops to be grown. RS methods in combination with geographic information systems (GIS) can help the process of identifying the most suitable terrain for the purpose [34, 35]. With the help of RS and GIS, suitable terrains are identified, for which different criteria are selected, such as soil types, terrain slope, slope aspect, categorization of agricultural land, etc., with the help of which to create a suitability map [35, 36]. The criteria must be in line with regional natural conditions, local legislation in the field of organic farming, as well as the requirements of the crops to be harvested.

A procedure has been developed to assess the suitability of the land for organic wheat cultivation [37]. It combines seventeen eligibility criteria, which are divided into five main categories, which include climatic parameters, soil characteristics and qualities, soil chemistry, soil fertility and organic matter content, and flood and erosion hazards using GIS, multiple criteria analysis, and square root method. Uddin et al. (2018) [38] use remote sensing methods in combination with GIS and global positioning systems (GPS) to identify vulnerable to floods and low-carbon objects. They believe that this will help manage the soil and crops in organic farming.

In the second part of this publication, the following applications of remote sensing in organic farming will be considered:

- *Satellite remote sensing monitoring of weeds*
- *Remote sensing of crops' stress and the need for irrigation*
- *Forecasting of yields using remote sensing methods*
- *Remote sensing monitoring of plant nutrition*
- *Biodiversity monitoring with remote sensing*

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Conflicts of Interest

The authors reported no potential conflicts of interest.

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ПРИЛОЖЕНИЕ НА СПЪТНИЦИ В БИОЛОГИЧНОТО ЗЕМЕДЕЛИЕ (ЧАСТ I)

М. Чанев, Л. Филчев

Резюме

Биологичното земеделие е много по-устойчива земеделска система от конвенционалното земеделие. То е част от усилията на човечеството да запази биоразнообразието и да осигури здравословна и безопасна храна за хората. Методите за дистанционно наблюдение се използват широко в селското стопанство. Използването им ще подпомогне прехода от конвенционално към биологично земеделие. Те могат да помогнат на земеделските производители да изберат най-подходящото място за изграждане на биоферма. Методите за дистанционно наблюдение са много мощен инструмент за борба с плевелите в биологичното земеделие. Те могат да се използват за определяне на нивото на стрес, което изпитват културите. Те дават добра възможност за прогнозиране на добивите в биологичните стопанства. Методите за дистанционно наблюдение могат да оптимизират торенето в органичните стопанства. Те могат да се използват за разграничаване на органичното от конвенционалното земеделие, както и за наблюдение на биоразнообразието в земеделските райони. Методите за дистанционно наблюдение могат да помогнат на биологичните земеделски производители да вземат навременни и адекватни решения при управлението на стопанствата си.