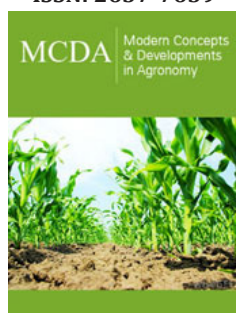


Why has Precision Agriculture Benefited Arable Crops Compared to Managed Pasture Production?

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Abstract

Meeting the goal of agricultural sustainability in the era of climate change and burgeoning global population requires an equal commitment to arable crops and pasture production management. However, technologies that enable Precision Agriculture (PA) are over-emphasized for the former at the latter's expense. In this mini review, we provided an argument that benefits the future of food security in the threat of global issues.

Keywords: Precision agriculture; Intensively grazed pastures; Remote sensing; Sentinel-2


Introduction

Precision Agriculture (PA) is not new in the contemporary scientific literature. Its description intercepts researchers' perspectives with applications and approaches tailored toward the same goal of smart farming using technology and data-driven methods to optimize crop and livestock management. Earlier research has successfully provided science-based information about real or near real-time technology (Geographical Information System (GIS), Rate Variable Applicators (RVA), Global Positioning System (GPS), and remote sensing) powered by the rapidly developed world of Information and Communication Technology (ICT) that has transformed agriculture operations from conventional practices into a data-driven, thus providing a timely and more accurate decision support system to farmers [1-4]. Consequently, increased resource use efficiency has optimized agricultural management, increasing crop and livestock productivity.

However, the adoption of PA by end users, which transcends the scope of "farmers," has been awkwardly slow when examined based on managed pasture production compared to arable crops and regarding the choice of technology. The adoption rate of arable crops followed an exponential increase [1], with grains [5] taking the lead depending on climates and geographical regions. Despite grassland ecosystems occupying over 40% of the global land surface [6] largely dedicated to livestock production with significant importance to reducing climate change through carbon sequestration and supporting over 1 billion households [7], arable crops have received increasing attention [4,8] and adoption more than pasture management. This is evidenced through the use of GPS, GIS, RVA, sensor mounting, and ICT technologies in specific crop management, irrigation scheduling, fertilizer and pesticide application, mechanization (planting, weed control, and harvesting), and yield monitoring [2]. These technologies are also applied to livestock management [9] but are limited to managed pasture production [8].

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Although agricultural production and management are optimally enhanced through various proximal technologies, the benefit of PA is limited without the inclusivity of remote sensing data. Remote sensing through satellite and aerial unmanned vehicles (UAV) provides spatial information from chemical and physical properties (i.e., electromagnetic spectrum or microwaves) capable of monitoring variability in agricultural fields through soil and crop mapping, weed detection, early detection of pests and diseases, irrigation management, environmental monitoring, and climate resilience. However, remote sensing technology is more widely used for arable land than intensively managed pastures [4,10].

Indeed, monitoring intensively managed pastures is more challenging than arable crops. Pastures are heterogeneous [11], unlike arable crops, which exhibit unique canopy architecture from remote sensing data. Thus, the spatial variability of crops is less complex than grasslands since they are grown in rows or follow a specific pattern. Consequently, resource use and efficiency are maximized when operations are directed toward specific field areas. Nearly all crops have predictable growing seasons and follow established agronomic principles [12] compared to managed pastures that are more dynamic. Remote sensing can support intensively grazed pastures with management decisions against overgrazing or wastage of feeds through under-grazing, leading to environmental risks [13]. In contrast, the extensive rangeland system primarily practiced by herders will not catalyze the remote sensing technologies at the management level. Therefore, closing the gap between arable crops and pasture management using PA as incentives for agricultural sustainability may be later than sooner. Farmers, land managers, and other stakeholders must embrace intensive grazing regimes where animals go through a cycle of rotation in a multi-paddock/field system [13]. The intensively managed pasture system is like sustainable agricultural intensification strategies adopted for cropping systems [7,14].

However, a high spatial resolution imagery (1-5m) with timely revisit (1- 5 days) will be needed to fulfill the ambition of on-field remote sensing monitoring of pastures. The finer the spatial resolution of remote sensing imagery, the more suited to support management decisions at the farm level. Currently, Sentinel-2 imagery from the European Space Agency (ESA) operates the constellation of Sentinel-2A and B, imaging global grasslands at 10m spatial resolution every five days, depending on the geographical location, capable of supporting PA at no cost [15]. The Landsat program of the joint venture of the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS) can further be used (singly or in hybrid with UAV) to provide environmental monitoring and climate resilience for pasture monitoring [16].

In conclusion, meeting the aspiration of agricultural sustainability in the era of frequent global issues, such as conflict, COVID-19 [17], extreme weather events, and climate change, the demand for technologies for remote land management in the coming decades will likely increase [7].

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