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Advances in Water in Agroscience

Introduction

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Avances en agua en Agrociencia

Avanços em água na Agrociência

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Abstract

Worldwide, water is essential for maintaining an adequate agricultural production and fostering a sustainable ecosystem for humanity alongside diverse flora, fauna, and microbial life. However, the intensification of anthropogenic activities, the occurrence of climate variability, and the presence of environmental issues are still threatening the quantity and quality of fresh water. Therefore, integrated water management is critical for the sustainable development of a region. This *Agrociencia Uruguay* Special Issue on "Advances in Water in Agroscience" is designed to draw attention to new concepts, approaches, methodologies, and novel applications aiming to improve sustainable and integrated water resource management. This Special Issue contains fifteen publications sorted into the following macro fields: irrigation and water management, integrated catchment management, and water quality and environmental sustainability.

Keywords: irrigation, sustainable agriculture, water measurement and control, crop simulation, basin management, nutrients in water, modeling

Resumen

A nivel mundial, el agua es esencial para mantener una producción agrícola adecuada y un ambiente sostenible para la población humana y otras formas de vida, como animales, plantas y microbios. Sin embargo, la intensificación de actividades antropogénicas, la variabilidad climática y la presencia de problemas ambientales siguen amenazando la cantidad y la calidad del agua dulce. Por tanto, la gestión integrada del agua es fundamental para el desarrollo sostenible de una región. Este número especial, titulado "Advances in Water in Agroscience" de la revista *Agrociencia Uruguay*, está diseñado para destacar nuevos conceptos, enfoques, metodologías y aplicaciones novedosas que buscan mejorar la gestión sostenible e integrada de los recursos hídricos. El número especial consta de quince publicaciones, clasificadas en tres campos principales: riego y gestión del agua, manejo integrado de cuencas, y calidad del agua y sostenibilidad ambiental.

Palabras clave: riego, agricultura sostenible, medición y control del agua, simulación de cultivos, gestión de cuencas, nutrientes en el agua, modelado

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Resumo

Em todo o mundo, a água é essencial para manter uma produção agrícola adequada e promover um ecossistema sustentável para a humanidade, juntamente com uma diversidade de flora, fauna e vida microbiana. No entanto, a intensificação das atividades antropogênicas, a ocorrência de variabilidade climática e a presença de problemas ambientais ainda ameaçam a quantidade e qualidade da água doce. Portanto, a gestão integrada da água é fundamental para o desenvolvimento sustentável de uma região. Esta Edição Especial da Agrociencia Uruguai sobre " Advances in Water in Agroscience" foi projetada para chamar a atenção para novos conceitos, abordagens, metodologias e aplicações inovadoras com o objetivo de melhorar a gestão sustentável e integrada dos recursos hídricos. Esta Edição Especial contém quinze publicações classificadas nos seguintes campos macro: irrigação e gestão da água, gestão integrada de bacias hidrográficas e qualidade da água e sustentabilidade ambiental.

Palavras-chave: irrigação, agricultura sustentável, medição e controle de água, simulação de culturas, gestão de bacias hidrográficas, nutrientes na água, modelagem

1. Introduction

In the intricate web of terrestrial ecosystems, water is a fundamental driver of agricultural processes, influencing crop growth, ecological balance, and overall well-being(1). In an era marked by a growing global population and climate uncertainties, managing the delicate balance between water resources and agricultural needs has become a critical challenge.

Human activities, including intensified agriculture, urbanization, and industrial practices, now cast significant pressures on finite freshwater reservoirs(2). Concurrently, unpredictable climate variations, characterized by irregular precipitation patterns and extreme weather events, further complicate the situation(3). Environmental issues, such as pollution and degradation, pose additional threats to both the quantity and quality of freshwater resources(4).

This Special Issue on “Advances in Water in Agroscience” is a response to these challenges. It gathers fifteen scholarly contributions that highlight the scientific community's efforts to address pressing water-related issues. The papers explore diverse aspects ranging from the impact of climate variability on agriculture to innovative approaches for irrigation and water management, integrated catchment management, and considerations of water quality and environmental sustainability.

With this Editorial, our aim is to present a pragmatic understanding of the intricate relationship between water and agroscience. The objective is twofold: *i)* to consolidate and disseminate the latest advancements in the region about the Special Issue topic; *ii)* to promote interdisciplinary communication by identifying and categorizing research solutions that complement each other. This collection aspires to be a repository of knowledge, deepening our understanding of the challenges and offering practical solutions. Through rigorous scientific inquiry, we aim to contribute to the development of actionable strategies, ensuring a more secure and sustainable interface between agriculture and water resources for future generations.

2. Summary

This Special Issue contains fifteen publications, sorted into the following macro fields: irrigation and water management, integrated catchment management, and water quality and environmental sustainability.

2.1 Irrigation and water management

The papers included in this field provide new information to optimize the design and management of irrigation in our region, with the promise of making more rational use of water, soil, and energy resources. The papers cover a wide thematic range from modeling as support to design and decision-making, as well as presenting improvements in the management of irrigation technologies in particular crops.

In their study titled “Performance assessment of furrow irrigation in two different soil textures under high rainfall and field slope conditions,” Ribas and García(5) evaluated the performance of a furrow irrigation system in two soils with different textures in sugar cane, through the efficiency of the water applied and measured in the field and simulated by the WinSRFR model.

In their work “Fitting a numerical model for the analysis of the wet bulb dimensions by drip irrigation,” Sastre and others(6) determined the dimensions of the wet bulb generated by drippers with different flow rates and irrigation times in heavy and stratified soils of Uruguay. The collected data were used to calibrate a numerical model.

In their research "Adjustment of the AquaCrop model in maize with different levels of irrigation in temperate climate conditions in southern Uruguay," Hayashi and Dogliotti[7] evaluated the performance of the AquaCrop model under different irrigation strategies which improve the use of irrigation water in corn cultivation in the climatic conditions of southern Uruguay. Trials were used with different levels of deficit irrigation, with three maximum replacement levels: 3, 6, and 9 mm day-1 and rainfed, using data from two years to calibrate the model and a third year to validate it.

In their study "Using the AquaCrop model to assess the cotton yield response to three irrigation schedules in the Río Dulce Irrigation System, Santiago del Estero, Argentina," Angella and others[8] optimized the response of cotton to narrow furrow irrigation scheduling, using AquaCrop as a model, in the Río Dulce Irrigation System (SRRD), Santiago del Estero, Argentina. Irrigation scenarios were defined considering the farmers' habits and water-delivering customs. The usefulness of combining the use of simulation models, field measurements, and long-term meteorological data to analyze trends in yields and irrigation water use in different scenarios is highlighted.

In their work "New challenges for Uruguayan viticulture: Water management in the context of a changing climate, using modeling techniques," Pereira and Ferrés[9] proposed water needs for a vineyard in southern Uruguay based on pedo-climatic variables. Additionally, the response of the crop to controlled deficit irrigation was evaluated for two consecutive years.

In their research titled "Water productivity associated with the planting system in young 'Nadorcott' mandarin plants," Otero and others[10] proposed different designs in plantation systems and soil management in "Nadorcott" mandarin, focused on accelerating the entry into production and water productivity improvement.

In their paper "Sodium accumulation vs. Nitrate leaching under different fertigation regimes in greenhouse soils in South Uruguay," Berrueta and others[10] measured the accumulation and/or leaching process of NO_3^- and Na^+ in greenhouse tomato production under different fertigation regimes. The drainage of N and Na^+ per hectare, as well as excessive irrigation, was quantified, and techniques for improving control were proposed[11].

In their study "Sunburn damages and stem and fruit water potential of apples *(Malus domestica*) 'Brasil Gala', 'Cripps Pink' and 'Granny Smith', Severino and others[12] studied the relationship between sun damage and the water condition of fruit tissues in three irrigated apple varieties, in addition to the effect of treatments in preventing sun damage. Stem water potential in 'Granny Smith' was recorded under netting and kaolinite spray application.

2.2 Integrated catchment management

Studies in this field highlight the benefits of utilizing hydrological models to tackle diverse aspects concerning agricultural practices on a watershed level. Moreover, they introduce cost-effective methods to measure water quantity. These studies encompass integrated watershed modeling, the creation of predictive models for flash floods affecting rural and agricultural areas, and several innovations in accurately quantifying water flow through channels and controlling structures employed in irrigation.

In the paper titled "Integrated Catchment Models for Policy Development and Decision Making", the authors explored how integrated basin modeling significantly contributes to amalgamating information related to the watershed. This included aspects like alterations in land use, water usage, biodiversity losses, and the identification of data needs. Moreover, it fostered collaborations among researchers from diverse disciplines and decision-makers.

The study titled "Application of the Flood Guidance Model (FG) in the Yi River basin in Uruguay" centered on implementing and adapting the Flash Flood Guidance (FFG) model, originally developed by the National Weather Service (NWS), for its use in Uruguay. By combining the model's results with Sentinel 2 satellite images and the NDWI index, the study evaluates the model's suitability in predicting floods in rural areas[14].

In the work "Flume calibration on irrigated systems by Video Image Processing and Bayesian inference," an economic methodology (utilizing free software) was presented for calibrating flume channels through video image processing. Accurate determination of these flows holds significance for the efficient utilization of water, especially in highly water-intensive crops like rice. The methodology undergoes testing in a cut-throat flume, indicating that calibration using the proposed methodology is feasible. Additionally, the study suggests that the method's uncertainty can be quantified through Bayesian inference[15].

The final work in the section, "Determining flow rates using gates in gravity irrigation systems," focused on establishing the operating curves of

rectangular gates situated at the entrances of circular section pipes, particularly under submerged discharge conditions. These gates played a pivotal role in diverting water to rice production plots and are extensively employed for this purpose. The study showcased experimental findings that enable these gates to serve not only as regulatory structures, but also as water-measuring elements within these systems[16].

2.3 Water quality and environmental sustainability

The papers included in this field delved into a comprehensive analysis of water quality dynamics within Uruguayan watersheds. Different types of models (data-driven and physically-based models) were exploited to explore the interdependencies between land use/land cover and water quality, and shed light on the broader implications of irrigation development, incorporating measures to mitigate environmental impacts. Together, these contributions provide a nuanced understanding of the intricate interplay between landscape factors and water quality variables in diverse watershed settings.

In their work titled "Assessing dependence between land use/land cover and water quality: A comparison at a small and large watershed in Uruguay," Cal and others[17] analyzed the relationships between seasonal water quality variables (nitrates, total phosphorus, and total suspended solids) and landscape metrics at two Uruguayan watersheds characterized by different areas (San Salvador [3118 km2] and Del Tala [160 km2] catchments), using machine-learning techniques. They aimed to identify the main landscape metrics that most affect each different water-quality variable at different watershed scales.

In their first work, "Effects of irrigation development on water quality in the San Salvador watershed (Part 1): Assessment of current nutrient delivery and transport using SWAT", Hastings and others[18] developed a Soil & Water Assessment Tool (SWAT) model able to represent the streamflow and pollutant (sediments, total phosphorus, and total nitrogen) delivery and transport for the San Salvador watershed located in Uruguay.

In their second contribution, "Impact of irrigation development on water quality in the San Salvador watershed (Part 2): Implementation of scenarios in SWAT", Hastings and others[19] used the SWAT model previously developed to simulate and analyze the impact of irrigation development on agricultural production, water quantity, and water quality. Two scenarios were implemented to compare to the baseline representative of the current situation (1992-2021). The first scenario represents irrigation development, and the second scenario adds riparian buffer zones to minimize export from diffuse nutrients, sediment, and chemical losses.

Transparency of data.

Available data: The entire data set that supports the results of this study was published in the article itself.

Author contribution statement

AG: Conceptualization, Writing – original draft, writing - review and editing

LP: Conceptualization, Writing – original draft, writing - review and editing

ÁO: Conceptualization, Writing – original draft, writing - review and editing

CG: Conceptualization, Writing – original draft, writing - review and editing

PG: Conceptualization, Writing – original draft, writing - review and editing

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