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Editorial

Achieving Sustainable Agricultural Development through Crop Management and Environmental Harmony

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1. Introduction

With the surge in global climate warming and the escalation of extreme weather events, agriculture is facing more frequent and intense challenges [1]. Such adverse weather conditions introduce new obstacles to crop growth, pest management, and the overall stability of agricultural systems. Consequently, the need to adapt agricultural practices to climate change has become increasingly urgent. Moreover, a critical concern revolves around the impact of agriculture on greenhouse gas emissions. Certain integral activities in agricultural production, such as fertilizer usage, large-scale livestock farming, and irrigation, contribute to greenhouse gas emissions, thereby exacerbating global climate change [2]. Therefore, reducing greenhouse gas emissions has become a paramount goal in achieving sustainable agricultural progress. Furthermore, the dual objectives of adapting to climate change and reducing greenhouse gas emissions must be aligned with the aim of sustaining and enhancing agricultural productivity. Enhancing agricultural productivity is vital not only for ensuring global food security but also for optimizing resource utilization and promoting environmental sustainability.

To address these pressing issues, it is imperative to implement a comprehensive set of measures. These measures include, but are not limited to, fostering climate-smart agricultural management practices, such as improving irrigation systems and planting techniques, developing climate-adaptive crop varieties, promoting ecosystem conservation and restoration to bolster agricultural resilience, advocating for sustainable agricultural production methods like organic farming and agroecosystem management, and refining strategies for pesticide and fertilizer application to mitigate greenhouse gas emissions, among others. Through research and the practical implementation of climate-adaptive agricultural management, greenhouse gas reduction, and strategies to enhance agricultural productivity, we can make significant contributions to achieving sustainable agricultural development, ensuring food availability, and mitigating the impacts of climate change.

2. Overview of the Special Issue

This Special Issue of *Agronomy* comprises 12 research articles that investigate the impacts of crop management and practices on greenhouse gas emissions, ecosystems, crop yield, and quality. The primary goal of these articles is to explore the intricate relationship between climate-adaptive agricultural management, greenhouse gas reduction, and agricultural productivity, while also proposing potential solutions. This collective effort aims to provide valuable insights for decision makers and practical implementation in the field of agricultural development, all in pursuit of sustainable agriculture and sustainable development. These original research papers can be categorized into three distinct themes:

(1) Effect of management practices on crop yield and quality [3–8];
(2) Impact of crop management on greenhouse gas emissions [9–11];
(3) Impact of crop management on ecosystems [12–14].

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2.1. Effect of Management Practices on Crop Yield and Quality

El-Hendawy et al. [3] conducted a study that explored the impact of different planting patterns and mulching techniques on wheat growth and productivity. They found that plastic film mulching and crop residue mulching significantly enhanced various growth parameters, physiological attributes, grain yield, and water productivity of wheat. The results varied under different irrigation conditions, with flat and raised-bed patterns mulched with crop residues performing better under sufficient irrigation and plastic film mulching being more suitable under limited irrigation. Ridge-furrow planting with plastic film mulching also showed promise, even without mulching materials. This research provides valuable insights into the selection of appropriate planting patterns and mulching techniques based on water availability.

Shang et al. [4] investigated the effects of shading on Indian–Japanese hybrid rice (I-JR) and Indian hybrid rice (IR). They observed that shading negatively affected grain appearance and quality, particularly milling and heading rates, and increased chalkiness. Shading disrupted carbon and nitrogen metabolism, altering traits that influence grain taste perception. I-JR demonstrated relatively better grain quality and more normalized carbon and nitrogen metabolism under shading compared to IR. This study highlights the importance of considering shading effects on rice yield and quality.

Li et al. [5] studied the physiological and molecular attributes of three wheat varieties under low light conditions. They found that the YM158 variety adapted better to low light environments by enhancing photosynthetic parameters and light use efficiency. Proteomic analysis revealed differential regulation of proteins among the varieties, suggesting that specific indicators, like Fv/Fm, ETR, and ΦPS(II), can be used to screen for shade tolerance in wheat breeding.

Li et al. [6] examined 24 superior rapeseed varieties in the Yangtze River basin and investigated their growth, architecture, lodging resistance, seed yield, and quality. Their study revealed positive correlations between plant biomass, silique number per plant, and seed yield. Path analysis showed that plant architecture directly affected seed yield and lodging. This research identified rapeseed varieties suitable for high yields, good grain quality, and mechanical harvesting, aiding farmers in variety selection and breeding.

Yang et al. [7] explored the impacts of different cultivation and straw management practices on rice yield and soil properties in a rice-ratoon system. They found that no-tillage reduced yield compared to plow tillage but returning straw to the field significantly increased yield. Straw returning also improved soil properties, including total porosity, soil organic carbon content, and enzyme activity. This study suggests that combining no-tillage with straw returning is an environmentally friendly and resource-efficient approach for regenerative rice cultivation.

Yang et al. [8] investigated the factors that contribute to the decline of wheat production in Hubei Province, China. By utilizing descriptive statistics and employing logistic regression analysis using survey data from 791 households, the findings unveiled significant spatial disparities in average wheat yield. Various socio-economic factors, cultivation management practices, and environmental factors all had an impact on the variations in yield. Input cost and economic benefits emerged as noteworthy social factors influencing wheat production. Moreover, disparities in cultivation management methods, soil fertility, and climate factors were identified as the principal drivers behind the variations in yield. In the Jianghan Plain region, the key challenges encompassed issues such as soil waterlogging and erosion. Additionally, extreme weather events were found to contribute to decreased yields in the Jianghan Plain region. This study emphasizes the imperative nature of enhancing cultivation practices, soil fertility, and climate disaster resilience as critical strategies for closing yield gaps and augmenting crop production.

These studies collectively contribute valuable insights into optimizing crop management practices to enhance productivity, quality, and sustainability in agriculture.

2.2. Impact of Crop Management on Greenhouse Gas Emissions

Paliwoda et al. [9] assessed plant growth-promoting rhizobacteria (PGPR) to determine their potential in reducing greenhouse gas emissions in strawberry cultivation. Their study involved the inoculation of various bacterial strains and manipulation of soil moisture levels to measure the emissions of NH_3, CO_2, N_2O, and CH_4. The results highlighted five bacterial strains with significant potential for reducing greenhouse gas emissions, including *Azotobacter* sp. AJ 1.2, *Pantoea* sp. DKB64, DKB63, and DKB68, and *Pseudomonas* sp. strain PJ 1.1. These strains were found to effectively mitigate emissions under varying environmental conditions, offering a foundation for developing inoculants to alleviate abiotic stresses.

In a two-year field experiment by Li et al. [10], the impact of different cropping systems, including traditional double-cropping rice (DR), maize rice (MR), and ratooning rice (Rr), on greenhouse gas emissions, soil factors, and yield was investigated. This study revealed that annual temperature and rainfall significantly influenced greenhouse gas emissions in various planting systems. MR and Rr showed notably lower annual CH_4 emissions compared to DR, while MR had the highest cumulative N_2O emissions, with Rr exhibiting lower levels. Additionally, dry farming practices reduced CH_4 emissions from late rice but increased N_2O emissions. MR not only significantly reduced global warming potential and greenhouse gas intensity but also achieved higher annual yields compared to DR and Rr. This research also established positive correlations between soil temperature and ammonium nitrogen content with methane and nitrous oxide emissions, as well as a positive correlation between soil moisture and nitrous oxide emissions.

Yang et al. [11] studied the impacts of different cultivation modes and fertilizer management on greenhouse gas emissions and yield in a four-year field experiment. This study compared the effects of rotary tillage (RT) and no-tillage (NT) on methane (CH_4) and nitrous oxide (N_2O) emissions and rice yield. Four fertilizer management strategies were employed: no fertilizer without straw (CK), inorganic fertilizer without straw (F), inorganic fertilizer with biochar (FB), and inorganic fertilizer with straw (FS). This research indicated that no-tillage significantly reduced CH_4 emissions in early rice and late rice, compared to RT. However, NT led to significant increases in N_2O emissions for early rice, late rice, and during the fallow period. Nevertheless, compared to RT, NT significantly decreased both global warming potential (GWP) and greenhouse gas intensity (GHGI). The F and FB treatments showed significant reductions in GWP under RT, as well as significant reductions in GHGI. Conversely, the FS treatment significantly increased both GWP and GHGI under both cultivation modes. This study suggests that converting straw into biochar and applying it to rice fields is a potential sustainable agricultural strategy that can reduce greenhouse gas emissions and increase yield. Together, these studies provide valuable insights into the potential of PGPR for mitigating greenhouse gas emissions in agriculture and the influence of different cropping systems on emissions, soil factors, and crop yield.

2.3. Crop Management and Ecosystem Adaptation

Jin et al. [12] conducted a study to investigate the influence of different cultivation methods on soil stability and erosion resistance, particularly focusing on soil structure disturbance. The experiments were carried out in a red soil hilly region in China and compared the effects of traditional plowing, compaction cultivation, deep loosening cultivation, no-tillage, and deep loosening compaction cultivation on soil aggregate stability, wet aggregate stability, soil mechanical stability, and soil erodibility. The results revealed significant differences among these cultivation methods in terms of soil stability and erosion resistance. No-tillage was identified as the most effective approach for reducing soil erodibility, while subsoil tillage and soil compaction contributed to soil fertility enhancement, controlled soil erodibility, and reduced risks of machinery-induced soil compaction. The impact of these cultivation methods on soil stability and nutrient storage varied, with soil compaction maintaining stability without improving nutrient storage, and subsoil tillage enhancing both stability and nutrient storage. These findings offer valuable guidance for selecting suitable cultivation methods in red soil hilly regions, aiming to mitigate soil degradation and erosion while enhancing soil productivity.

In the study by Liu et al. [13], it was found that delaying the sowing date to mid or late May significantly increased rice yields in central China. Sowing too early increased the risk of heat stress, which hindered rice growth, while sowing too late raised the risk of low temperatures. Optimal sowing in mid to late May was identified as the most favorable period, ensuring high yields by selecting effective accumulated temperatures, reducing heat stress and low-temperature risks, and effectively utilizing climate resources. This research emphasizes the importance of optimizing rice sowing dates to avoid climate-related stressors, enhance resource utilization, and improve crop yields.

The study conducted by Moukoumbi et al. [14] aimed to assess the diversity of rice genotypes, analyze the relationship between different yield attributes, and mitigate the impact of climate change on the Senegal River Basin. A total of 300 high-yielding rice genotypes were evaluated during the dry season. The results revealed significant variations in both yield and its components among different genotypes. Days to maturity showed a high heritability, indicating the potential for selecting early or late flowering lines. This study found a positive or negative correlation between the studied traits and grain yield. In total, 56 genotypes that performed better than local varieties were identified and classified into four groups based on their performance. These findings provide valuable insights for developing rice varieties with improved traits and stability in the face of climate change.

3. Conclusions

Crops, management practices, and the environment are intricately intertwined elements in agricultural practices, playing vital roles in the overall success of agricultural development. To achieve optimal results, it is necessary to maintain a delicate balance between human intervention and natural processes, while implementing effective strategies and techniques. Sustainable crop production requires a comprehensive approach that recognizes the interrelationships between crops, management strategies, and the environment. Through careful planning, wise decision making, and environmental protection, we can pave the way for future agriculture to achieve more resilient and harmonious agricultural development.

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