

Cropping System Adaption in Global Change: Current Trends and Futurology

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Introduction

Cropping systems are facing increasing challenges due to global climate change, necessitating adaptation strategies to maintain and improve agricultural productivity. Current trends in cropping systems research emphasize environmentally sound, ethical, economically viable, and socially acceptable practices, expanding beyond basic production agronomy to encompass ecological, environmental, social, and economic dimensions. As climate change brings rising temperatures and erratic weather patterns, the agricultural sector is disproportionately impacted, requiring adjustments in cultivar selection and cropping system management. Farmers are adapting through changes in farming practices, cropping patterns, and the adoption of new technologies to mitigate adverse impacts, while researchers are exploring transformative adaptations, such as changes in the nature, configuration, and location of farms. The future of cropping systems lies in innovative production systems that are highly productive, environmentally sound, and adaptable to change, including the adoption of dynamic cropping systems that rely on annual strategies to optimize production, economic, and resource conservation goals.

Climate change adaptation in cropping systems involves optimizing crop calendars, managing crop phenology, and selecting appropriate varieties to maximize yield formation and minimize temperature and water stress. The integration of models and decision support systems is also crucial for assessing cropping system prototypes, quantifying input-output relationships, and enabling well-balanced decision-making regarding resource use. Moreover, strategies like agroforestry, multiple cropping, and conservation agriculture are gaining prominence for their potential to enhance resilience, improve soil health, and promote carbon sequestration. Looking ahead, the focus is on designing cropping systems that not only ensure food security but also protect the environment, reduce greenhouse gas emissions, and enhance the adaptive

capacity of agricultural systems in the face of an uncertain future.

Current Trends in Cropping System Adaptation

Climate change significantly impacts agriculture, particularly in tropical regions, necessitating adaptation strategies in cropping patterns. Climate change poses a significant challenge to agricultural systems worldwide, necessitating adaptations to maintain or enhance current production levels. Research indicates that cropping systems are responding to global warming through various strategies, including adjusting planting dates, selecting appropriate varieties, and modifying cropping regions. In Northeast China, warming trends have correlated with increased rice yields, with a 1°C increment in daily minimum temperature potentially increasing yields by approximately 6.0%. Field experiments further suggest that an additional 1°C warming at night could enhance rice yield by about 10.0%. This has led to the prolongation of the rice growth period and a northward shift in rice sown areas. Similarly, in Ghana, a shift from cocoa-based to maize-based cropping systems has occurred due to changing rainfall patterns and increased dry seasons. Farmers are adapting by planting drought-tolerant crops and adjusting planting dates.

Research works show that climate change affects crop preferences, agricultural productivity, and farmer adaptation actions. Some of the key trends observed are:

Changes in Farming Practices: Farmers are adapting to climate change through altered farming practices and cropping patterns, along with the adoption of new technologies, which can help mitigate adverse impacts.

Altered Cropping Patterns: Due to climate change impacts like inadequate or excessive rainfall, some cropping patterns have disappeared, leading farmers to adopt new, dominant patterns such as Mustard-Boro-Fallow and Onion-Fallow-Amon.

Multiple Cropping Systems: Farmers are employing multiple cropping systems—growing two or more crops on the same field simultaneously or

sequentially – as a climate change adaptation strategy.

Double Cropping: Double cropping is identified as a potential adaptation strategy, where warmer climates enable regions to shift from single to rice-wheat double cropping systems. The area suitable for double cropping is nearly tripled, suggesting a strong potential to offset climate-induced production and profit losses.

Strategies for Resilience in Cold Climates: Cultivar selection and cropping system management can address the challenges and opportunities presented by a changing climate. Identifying plant attributes that enhance the resilience of cropping systems to climate change is another key area of focus. Crop adaptation and agricultural management can help maintain or improve crop yields, ensure food security, and protect the environment. Including perennial forages and drought-resistant cover crops in crop rotations can enhance cropping system resiliency and maintain soil cover and fertility in dryland agriculture.

Regional Adaptations and Shifts in Cropping Patterns: Under projected future climate change scenarios, many of the present double cropping areas may be replaced by triple cropping patterns, while current double cropping areas could shift towards the central part of the present single cropping area. The northern boundary of triple cropping areas might shift from the Changjing River to the Huanghe River, a shift of more than 5 degrees of latitude. Shifts in multiple cropping areas can lead to a significant decrease in single cropping areas.

Futurology of Cropping Systems Adaptation

Futurology studies emphasize the importance of models for assessing cropping systems under various pedoclimatic conditions and the potential of adapting cropping systems to climate change. These models help in virtually assessing adaptations and determining if modifications improve agronomic and environmental performance compared to current systems facing climate change. The key areas of focus include:

Modelling Approaches: Utilizing models based on genotypic traits to identify varieties suited for specific environmental conditions can accelerate crop improvement, which is required to adapt African agricultural systems to climate change.

Climate Modeling and Forecasting: Improved climate modeling and forecasting are essential, providing a basis for informed decision-making and the implementation of adaptation strategies.

Genetic Adaptability: Identifying plant attributes that enhance the resilience of cropping systems to climate change is crucial, with genetic adaptability being critical for selecting forage crops suitable for colder climates.

Technological and Agronomic Adjustments: Implementing strategies such as adjusting planting dates, increasing planting density, optimizing fertilizer use, and developing climate-resilient crop varieties are essential for sustaining agricultural productivity under changing climatic conditions.

Challenges and Considerations

Despite the potential benefits of adaptation strategies, several challenges and considerations exist:

Regional Specificity: Climate change impacts and adaptation strategies vary by region, influenced by factors such as temperature trends, rainfall patterns, and the frequency of extreme weather events.

Model Uncertainties: Climate change impact studies face uncertainties due to different global climate models, climate change scenarios, and cropping system assumptions, making it difficult to draw definitive conclusions and develop adaptation strategies.

Socio-Economic Drivers: Understanding the socio-economic drivers underlying specific adaptive measures is crucial for informing adaptation plans. Factors such as access to extension services, education level, and farm size influence the adoption of multiple cropping systems.

Need for Holistic Approaches: Addressing both immediate and long-term agricultural challenges posed by climate change requires sustainable practices and holistic approaches for boosting agricultural output.

Conclusion

However, the impacts of climate change on cropping systems are complex and can vary significantly based on agronomic management assumptions. Neglecting management changes may lead to pessimistic projections for future crop production. Adaptation strategies also involve

managing crop phenology by adjusting growing periods and selecting suitable cultivars. In cold climate regions, cultivar selection and cropping system management are crucial for addressing the challenges and opportunities presented by a changing climate. Studies emphasize identifying plant attributes that enhance resilience to climate change and exploring how crop adaptation and agricultural management can maintain or improve crop yields while ensuring food security and environmental

protection. Furthermore, increasing cropping intensity, where appropriate and sustainable, can provide a means of boosting global crop production. While it's difficult to definitively conclude whether future climate change will be favourable or unfavourable to farming, focusing on the adaptive potential of cropping systems is essential for exploring the positive effects of warming and reducing the risk of yield decrease due to climate instability.

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