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Post-print Introduction to the Project "Screening of Spring Maize Varieties Suitable for High-Density Planting, High Yield, and Mechanical Harvesting in North China and Efficient Full-Mechanization Production Technologies" under the Special Project for Scientific and Technological Innovation in G⋯

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Abstract

North China is characterized by a shortage of freshwater resources, which cannot support the wheat-maize double-cropping system. Over the past decades, irrigation practices aimed at pursuing high yields have resulted in severe over-exploitation of groundwater, triggering a series of environmental issues. Developing spring maize monoculture represents the primary approach to reducing groundwater over-exploitation. However, spring maize production suffers from low efficiency due to the lack of varieties suitable for high-density planting and mechanical harvesting, low mechanization levels, and incomplete key technologies for integrated agricultural machinery and agronomy. Therefore, research on screening spring maize varieties with high water-use efficiency, high-density tolerance, and mechanical harvestability, as well as investigating efficient utilization of variety resources under different management practices, is urgently needed to ensure regional food and water security.

Full Text

Introduction

North China faces severe shortages of freshwater resources that cannot sustain the conventional winter wheat-summer maize double-cropping system. Over the past decades, excessive groundwater exploitation for irrigation in pursuit of high yields has triggered a series of environmental problems. Shifting to a single-cropping system of spring maize represents a primary pathway to reduce groundwater overdraft. However, spring maize production in this region suffers from low efficiency due to the lack of density-tolerant and machine-harvestable varieties, low mechanization levels, and incomplete integration of key agricultural machinery and agronomic technologies. Therefore, screening high water-efficiency, density-tolerant, and machine-harvestable spring maize varieties and developing efficient resource utilization technologies under different management practices are urgently needed to ensure regional food security and water security.

Project Overview

The project titled "Screening of High-Density Tolerant and Machine-Harvestable Spring Maize Varieties and Efficient Production Technology for Full Mechanization in North China" (Project No. 2016YFD0300305) is a component of the national key R&D program "Innovative Technology to Increase Grain Yield and Efficiency" during the 13th Five-Year Plan period. Led by the Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences, the project consortium comprises four leading institutions with long-term research expertise in high-yield and efficient spring maize production in North China: the Dryland Farming Research Center of Shanxi Academy of Agricultural Sciences, Inner Mongolia Academy of Agricultural and Animal Husbandry Sciences, Hebei Normal University of Science and Technology, and Cangzhou Academy of Agriculture and Forestry Sciences.

The research team operates more than ten provincial and ministerial-level key laboratories and experimental stations, including the Key Laboratory of Agricultural Water Resources of Chinese Academy of Sciences, the National Maize Regional Technology Innovation Center (Inner Mongolia), and the Shanxi Provincial Engineering Technology Research Center for Dryland Water-Saving Agriculture. These facilities have conducted extensive research on water-saving and high-efficiency maize production, providing strong support for this project.

Research Objectives and Key Problems

This project addresses two critical issues: (1) environmental problems caused by agricultural irrigation-induced groundwater depletion in North China, and (2) low spring maize production efficiency resulting from incomplete integration of full-mechanization technologies. The research strategy centers on screening high water-efficiency, density-tolerant, and machine-harvestable spring maize varieties as the foundation, with supporting cultivation technologies as the breakthrough point.

Through regional network experiments conducted across five representative zones—the Beijing-Tianjin-Hebei cropping system adjustment area, the northern North China supplementary irrigation area, the western North China supplementary irrigation area, the Beijing-Tianjin-Tangshan supplementary irrigation area, and the Beijing-Tianjin-Hebei dryland farming area—the project aims to: (1) screen regionally suitable machine-harvestable, density-tolerant, and high water-efficiency spring maize varieties and establish relevant evaluation standards; (2) develop distinctive key technologies based on analysis of regional limiting factors; and (3) integrate selected varieties, key technologies, supporting technologies, and full mechanization to form regionally adapted machinery-agronomy integration models for demonstration and extension.

The project targets coordinated improvement in variety screening and efficient resource utilization under different management measures. It focuses on resolving the interaction mechanisms and regulation pathways among varieties, environment, and population adjustment in North China spring maize production. The research will elucidate the interaction mechanisms among high water-efficiency, density-tolerant, and machine-harvestable varieties under different environmental conditions and management practices, and investigate water-nitrogen regulation and yield effects. These efforts will provide theoretical foundations for developing key high-yield technologies under conditions requiring high water-efficiency, density tolerance, and machine harvestability.

Targeting these key issues and focusing on high-yield, high-efficiency, and full mechanization, the project addresses three critical technical problems: (1) screening high water-efficiency, density-tolerant, and machine-harvestable varieties suitable for different ecological zones in North China and establishing evaluation technical standards; (2) regulation technologies for plant and grain traits in high water-efficiency, density-tolerant, and machine-harvestable spring maize populations; and (3) efficient full-mechanization production technology models for high water-efficiency, density-tolerant, and machine-harvestable spring maize in North China.

Research Content

Centered on the overall project objectives and focusing on variety screening and key technological innovation for high water-efficiency, density-tolerant, and machine-harvestable spring maize, the research comprises three components:

1. **Variety Screening and Regional Layout**: Through regional network experiments, evaluate the characteristics of high water-efficiency, density-tolerant, and machine-harvestable spring maize varieties, and establish variety eco-adaptability evaluation standards and regional distribution systems.

2. **Key Technologies for High-Density, High-Yield, and High Water-Efficiency Production**: Through field positioning experiments, investigate the physiological and ecological characteristics, water consumption patterns, and yield performance of spring maize under different densities, sowing dates, and planting methods. Conduct quantitative and process-based analyses of limiting environmental factors (e.g., meteorological and soil conditions) on spring maize production to reveal the high-yield and high-efficiency potential of varieties in different ecological

zones, and develop key technologies including sowing date, density, and annual water management for high yield adapted to regional precipitation characteristics.

3. **Integration and Demonstration of Full-Mechanization Models**: Based on variety-environment-cultivation technology interaction mechanisms, integrate drought-resistant seedling establishment, efficient water-fertilizer utilization, high-density yield enhancement, and full mechanization technologies suitable for regional characteristics and climate conditions. This will produce five integrated high-yield, high-efficiency, full-mechanization technology models for representative regions in North China, establish demonstration zones, and promote application to ultimately improve regional maize production mechanization levels, water-fertilizer resource use efficiency, and production benefits, thereby promoting sustainable spring maize production in North China.

Expected Benefits

Economic Benefits

Project implementation will provide important scientific and technological support for regional spring maize breeding and the integration of agricultural machinery and agronomy, while ensuring food security, cultivated land security, and ecological environmental security. Application of project results will increase mechanization levels in North China spring maize production by over 15%, reduce costs by over 10%, and achieve water and nitrogen savings and yield increases of over 10%. Over the next five years, the technological achievements will be extended to 33,300 hectares, with an expected yield increase of 15 million kilograms and economic benefits of 15 million RMB.

Social Benefits

Integration and demonstration of the developed key technologies will establish a high-density, high-yield, full-mechanization production technology system for maize. Promoting standardized high-yield and high-efficiency cultivation models will significantly reduce labor requirements and facilitate labor transfer. High-yield and high-efficiency maize cultivation will promote the development of maize deep-processing and feed processing industries, which is significant for sustainable agricultural development across different ecological zones in North China. The technological achievements can also be extended to similar ecological regions nationwide.

Ecological Benefits

Based on cost reduction, yield increase, efficiency improvement, and sustainable agricultural development, the project employs appropriate water irrigation to improve water use efficiency by over 10%. Straw conversion and return to fields reduces waste of stem and leaf resources and alleviates air pollution from straw burning. Strict pesticide control and pollution-free production reduce crop contamination, while farmland organic fertilizer application and integrated technologies reduce chemical fertilizer use by over 10%, mitigating environmental pollution and improving farmland ecological conditions and ecological benefits.

Note: Figure translations are in progress. See original paper for figures.

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