Introduction to the Bohai Granary Science and Technology Demonstration Project (Postprint)

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Abstract

The "Bohai Granary Science and Technology Demonstration Project" was proposed by Academician Li Zhensheng of the Chinese Academy of Sciences and jointly implemented by the Ministry of Science and Technology, the Chinese Academy of Sciences, together with Hebei Province, Shandong Province, Liaoning Province, and Tianjin Municipality as a National Key Technology Support Program. Addressing the major national demand for food security, and targeting the constraints on grain production in 2.67 million hm² of low-to-medium yield fields and 0.67 million hm² of saline-alkali wasteland in the Bohai Rim region, including scarcity of freshwater resources, poor soil fertility, and salinization-alkalization, the project is based on the overall strategy of "expanding cultivated area, increasing per-unit yield, ensuring water supply, and creating high value." It fully leverages regional advantages in land resources, brackish water resources, concentrated rainfall, abundant sunlight, and rapid economic development in the region, focusing on breakthroughs in key technologies related to regional soil, fertilizer, water, and crop varieties. Demonstration zones for grain yield and efficiency improvement have been established in Hebei, Shandong, Liaoning, and Tianjin within the low plain areas of the Bohai Rim, where stress-resistant crop varieties are developed, integrated, demonstrated, and promoted, along with technologies for saline-alkali land improvement and rapid soil fertility enhancement, safe irrigation with brackish water and efficient rainwater utilization, grain yield increase in low-to-medium yield areas, and increasing grain production in cotton fields. With science and technology commissioners serving as the link and bridge, a demonstration mechanism involving enterprises and new types of agricultural cooperatives has been established to construct a modern agricultural production technology system and demonstration model for moderate-scale operations. Grain yield and efficiency improvement technologies are demonstrated and promoted at scale to substantially enhance the grain production capacity of low-to-medium yield fields in the Bohai Rim region, achieving the target of increasing grain production by

3 million tons by 2017 and 5 million tons by 2020, thereby providing scientific and technological support for building the Bohai Granary and ensuring national and regional food security.

Full Text

Preamble

The Bohai Granary Technology Demonstration Project, advocated by Academician Li Zhensheng of the Chinese Academy of Sciences, is a national science and technology support program jointly implemented by the Ministry of Science and Technology, the Chinese Academy of Sciences, Hebei Province, Shandong Province, Liaoning Province, and Tianjin Municipality. Addressing the critical national demand for food security, the project targets the constraints of freshwater scarcity, poor soil, and salinization that limit grain production across 2.67 million hectares of medium-low yield farmland and 670,000 hectares of saline wasteland in the Bohai Rim region. Guided by the overall strategy of "expanding area, increasing per-unit yield, ensuring water supply, and creating high value," the project leverages regional advantages in land resources, brackish water resources, concentrated rainfall, abundant sunlight, and rapid economic development. It focuses on breakthroughs in key regional technologies for soil, fertilizer, water, and seed, establishing grain yield increase and efficiency demonstration zones in the low plain areas of the Bohai Rim, including Hebei, Shandong, Liaoning, and Tianjin. The project develops, integrates, and demonstrates stress-resistant crop varieties, as well as technologies for saline-alkali land improvement and rapid fertility enhancement, safe brackish water irrigation and efficient rainwater utilization, grain yield increase in medium-low yield areas, and grain increase in cotton fields. Using science and technology commissioners as the link and bridge, the project establishes demonstration mechanisms with enterprise and new agricultural cooperative organization participation, constructs modern agricultural production technology systems and demonstration models for appropriately scaled operations, and scales up the demonstration and promotion of grain yield increase and efficiency technologies to substantially enhance the grain production capacity of medium-low yield farmland in the Bohai Rim region. The project aims to achieve a grain increase of 3 million tons by 2017 and 5 million tons by 2020, providing scientific and technological support for building the Bohai Granary and ensuring national and regional food security.

Since its launch in 2013, the project has achieved remarkable results in breeding new stress-resistant varieties, multi-source water utilization technologies for brackish water–slightly brackish water–rainwater, new saline-alkali land improvement technologies, and cotton-to-grain conversion technologies. It has constructed suitable cultivation and planting systems for different eco-climatic zones and saline-alkali land rice cultivation technologies, enhancing the grain production capacity of medium-low yield areas in the Bohai Rim region. The

main progress is summarized below:

1. Breakthrough Progress in Salt-Tolerant Wheat and Corn Breeding, with a Batch of New Stress-Resistant and High-Yield Crop Materials and Varieties Selected and Developed

Salt-tolerant and high-yield wheat 'Xiaoyan 60' has entered production trials, 'Xiaoyan 103' has entered regional trials, and new variety protection has been applied for. The newly developed corn variety 'Keyu 186' offers advantages including salt tolerance (1.8‰), lodging resistance, high yield, suitability for mechanical harvest, and wide adaptability. In 2015, in three demonstration counties—Jinghai County of Tianjin, Xinyang Town of Shandong, and Nanpi County of Hebei—the yield of 'Keyu 186' exceeded that of locally promoted varieties. The variety passed the 2015 national Yellow-Huai-Hai mechanized harvest group corn variety approval.

2. Construction of Water-Adapted Irrigation Systems and Supporting High-Efficiency Multi-Source Water Utilization Technologies for Farmland, Providing Support for Water Conservation and Grain Yield Increase

Based on regional water quantity and quality characteristics and irrigation demands, a regional water-adapted irrigation system has been constructed: winter storage irrigation for cold resistance and seedling protection; spring drought-resistant irrigation for salt suppression and growth promotion; summer emergency irrigation to meet water requirements; and water-saving irrigation to improve water use efficiency. Supporting technologies include integrated wheat-corn annual brackish water irrigation technology, wheat-corn micro-irrigation water-fertilizer integration technology, and water-saving cultivation technology with optimized sowing and harvest timing for stable summer and increased autumn yields. Application of these achievements can save 50% of freshwater, achieve ton-grain yields in brackish water irrigation areas, and 1.5-ton grain yields in high-fertility soils. Calculated for a promotion area of 2 million hectares, 1.8 billion cubic meters of deep freshwater can be saved, exploring a new path for regional groundwater pressure reduction and sustainable, efficient water resource utilization.

3. Establishment of a New Saline-Alkali Land Improvement and Utilization Technology System

The core technology, "saltwater winter freezing irrigation for saline-alkali land improvement," has obtained a national invention patent. Using underground brackish water with salinity less than 15 $g \cdot L^{1}$ for winter freezing irrigation on heavy saline land, combined with plastic film mulching and summer rainwater

leaching after spring melt infiltration, the salt content in the soil plow layer can be controlled below 3 g · kg ^{1}, achieving cotton seed cotton yields exceeding 3000 kg · ha ^{1} in the same year. Combined application of microbial organic fertilizer improves soil physical and chemical properties, forms large aggregates, and promotes soil salt leaching. Supporting cultivation of salt-tolerant crops and halophytes can rapidly enhance the biological productivity of saline-alkali land.

4. Construction of a Cotton-to-Grain Conversion Technology System, Significantly Enhancing Grain Production Capacity in Medium-Low Yield Areas of the Bohai Rim Region

Influenced by grain-cotton comparative benefits and mechanization levels, the cotton-to-grain conversion trend in the Bohai Rim region has further strengthened. According to remote sensing data, Hebei' s cotton planting area was 400,000 hectares in 2013 and 230,000 hectares in 2015, a reduction of 170,000 hectares. Most of the reduced cotton fields have been converted to grain fields, with preliminary estimates indicating that Hebei' s cotton-to-grain conversion can increase grain production by 1.5–3 billion kilograms. Addressing cotton-to-grain conversion needs, the project team has constructed multiple planting patterns tailored to regional characteristics in Hebei, Shandong, and Tianjin. Hebei has established a cotton field grain increase pattern, achieving a wheat yield increase of 6000 kg · ha ^{1} and water savings of 750 m^{3} · ha ^{1} without reducing cotton yield. In Hebei and Shandong, a two-year-three-crop technology has been constructed, increasing grain yields by 9000 kg · ha ^{1}, supported by cotton-to-grain soil optimization fertilization and cotton field soil plow layer reconstruction technology models. In Shandong, a cotton-to-grain increase pattern based on wheat-corn double-crop technology, rice-wheat rotation technology, and ETS microbial fertilizer + Hekang soil improvement technology has been constructed. In Tianjin, a spring wheat–summer corn double-crop technology model has been established. Additionally, coarse cereals–millet production technology demonstrations have been conducted in cotton-converted fields.

5. Construction of a Rain-Fed Dry Farming Crop Yield Increase Technology System, Forming Core Technologies for Moisture Storage, Sowing Preservation, and Income Increase in Rain-Fed Dry Farming Areas, Providing Support for Grain Yield Increase and Efficiency Improvement in Plain Dry Farming Areas

Spring corn ridge mulching side-sowing technology increases yields by 20–40%; summer corn wide-narrow row single-double plant density increase technology increases yields by 50%; winter wheat "six-step method" dry farming planting

technology increases yields by 12–30%; and winter wheat micro-ridge mulching side-sowing technology increases yields by 20–30%.

6. Formation of a Saline-Alkali Land Rice Cultivation Technology System

With expanding rice cultivation area, rice planting has become a new growth point for grain yield increase and efficiency improvement. Salt-tolerant rice varieties such as 'Yanjing 456', 'Yanjing 927', 'Yanfeng 47', and 'Wuyujing 3' have been selected. Developed rice nitrogen-efficient comprehensive cultivation technology increases yields by 5–8% and nitrogen use efficiency by 15–20%. Developed rice water-efficient comprehensive cultivation technology increases yields by 5–10% and water use efficiency by 15–30%. Demonstrations of coastal saline-alkali land rice organic production technology have achieved average benefits of 23,000–30,000 yuan per hectare. Developed simplified technology for medium-low yield field rice increases income by 2460 yuan per hectare. Additionally, focusing on saline-alkali land rice planting, research and demonstrations have been conducted on beach saline-alkali land rice–shrimp, rice–turtle, and rice-crab polyculture technologies, and saline-alkali land pond collection rice planting technology.

7. Development of Integrated Crop-Livestock Circular Agriculture Models, Laying the Foundation for Agricultural Transformation and Development in Medium-Low Yield Areas

Addressing current water-saving and pressure reduction demands, research has been conducted on crop-livestock models such as: dairy enterprise + grain forage + organic fertilizer; chicken enterprise + grain forage + organic fertilizer; pig enterprise + grain forage + processing + organic fertilizer; alfalfa + grain crop rotation technology; alternative grain increase technologies including low-gossypol cotton, oats, silage corn, alfalfa, and ryegrass; saline-alkali land "one grain one straw" double-season corn planting pattern; compound microecological preparation technology to reduce broiler waste; and scale farming waste harmless treatment, resource utilization, and organic fertilizer production technology.

8. Preliminary Construction of "Internet+Bohai Granary," Laying the Foundation for Improving Agricultural Informatization Levels and Developing Modern Agricultural Services in the Bohai Rim Region

Centered on the goals of "water saving, grain increase, and efficiency improvement" and focusing on wheat and corn crops, various expert knowledge, technical patterns, and key technologies have been compiled from aspects of variety

selection, planting technology, multi-source water utilization, water-saving irrigation, and soil fertility improvement. Observation information from agricultural IoT monitoring systems has been integrated to form an expert knowledge base covering four aspects: production knowledge, disease diagnosis, production decision-making, and farming guidance, completing the development of a web-based agricultural expert system. Through network coverage of other regions, the promotion of Bohai Granary demonstration zone technologies and farmer training have been accelerated.

9. Formation of an Academy-Ministry-Province Linked Cooperation and Scaling-Up Mechanism

An academy-ministry-province linked cooperation and scaling-up mechanism has been formed, with the Ministry of Science and Technology deploying national projects, the Chinese Academy of Sciences providing technical leadership and support, and local provinces, cities, and counties providing supporting funds for demonstration zone construction and achievement transfer. The Chinese Academy of Sciences has deployed county-wide grain increase and efficiency actions, forming a partition promotion model based on regional characteristics with supporting technologies and projects. The three provinces and one municipality have formed different scaling-up mechanisms according to local conditions: Hebei has formed a government-led, enterprise-participated, professional cooperative-main, hundred-thousand-million project scaling-up mechanism; Shandong has formed a government-guided, enterprise-main, professional cooperative-participated scaling-up mechanism; Liaoning has formed a technology-led scaling-up mechanism; and Tianjin has formed a large grain grower-participated scaling-up mechanism.

Since project implementation, selected and bred variety materials and constructed technology systems have been comprehensively demonstrated in over 70 counties and cities, transferring 47 applied technology achievements, establishing 95 scaled demonstration zones exceeding 300 hectares each, with a core demonstration area of approximately 10,000 hectares, demonstration area of 100,000 hectares, and radiation area of 1.06 million hectares, achieving a total grain increase of 1.68 million tons and benefit increase of 2.463 billion yuan. The project has established a batch of national and provincial agricultural science and technology parks, driving the development of the seed industry, processing industry, fertilizer industry, animal husbandry, and modern agricultural service industry, promoting the integration of primary, secondary, and tertiary industries, with significant social and economic benefits.

The implementation of the Bohai Granary Technology Demonstration Project has produced important social impact, becoming a regional strategic grain increase project. The 2016 Central No. 1 Document “Opinions of the CPC Central Committee and the State Council on Implementing New Development Concepts to Accelerate Agricultural Modernization and Achieve Comprehensive Moderately Prosperous Goals” explicitly proposed to “implement the Bohai Granary

Technology Demonstration Project, increase scientific and technological support, and accelerate saline-alkali land transformation."

To implement the spirit of the Central No. 1 Document, accelerate project implementation, solve water and soil resource constraints for grain production in medium-low yield and saline-alkali areas of the Bohai Rim, and drive regional grain yield increase and modern agricultural development, relevant papers are now compiled and published as a special issue based on project progress for reference in project implementation.

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