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# Thinking and Implementation Approach of Science and Technology Strategy of Well Raising Black Soil—Overall Idea and Implementation Planning of Strategy Priority Research Program of Chinese Academy of Sciences on Black Soil Conservation and Utilization

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# Thinking and Implementation Approach of Science and Technology Strategy of Well Raising Black Soil—Overall Idea and Implementation Planning of Strategy Priority Research Program of Chinese Academy of Sciences on Black Soil Conservation and Utilization


## Abstract

The Science and Technology Innovation Project of Black Soil Conservation and Utilization (Black Soil Granary) is a Strategic Priority Research Program of Chinese Academy of Sciences (CAS), it is the core measure of the "Science and Technology (Sci-Tech) Campaign for Black Soil Granary" launched by CAS together with provinces and autonomous region of Northeast China, and also the core measures to implement General Secretary Xi Jinping's series guiding principle relating to well utilize and protect the black soil in Northeast China. Better utilization and protection of black soil is crucially important to the national food security, and the program of Black Soil Granary aims to solve the key major scientific problems for black soil. According to the principles of question-oriented, led by innovation, and promoted by demonstration, the program will conduct key technological breakthroughs and demonstrating mature technologies following the specification of "purposeful, assessable, applicable, influential, popularizable, and continuable". It is expected that, through the implementation of the Black Soil Granary program, Chinese Academy of Sciences can provide systematic resolutions for the better utilization and protection of black soil, and support national food security and modern agriculture development.



## Keywords

Black Soil Granary, Strategic Priority Research Program, national food security, modern agriculture, sustainable development



## Authors

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# Thinking and Implementation Approach of Science and Technology Strategy of Well Raising Black Soil—Overall Idea and Implementation Planning of Strategic Priority Research Program of Chinese Academy of Sciences on Black Soil Conservation and Utilization

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**Abstract:** The "Science and Technology Innovation Project of Black Soil Conservation and Utilization (Black Soil Granary)" is a Strategic Priority Research Program of Chinese Academy of Sciences (CAS). It is the core measure of the "Science and Technology (Sci-Tech) Campaign for Black Soil Granary" launched by CAS together with provinces and autonomous region of Northeast China, and also the core measures to implement General Secretary Xi Jinping's series guiding principle relating to well raising the black soil in Northeast China. Better utilization and protection of black soil is vital to the national food security, and the "Black Soil Granary" priority program aims to solve the key major scientific problems for black soil. According to the question-oriented, innovation-led, and demonstration-promoted principles, the program will conduct key technological breakthroughs and demonstrate mature technologies following the "purposeful, assessable, applicable, influential, promotable, and sustainable" specifications. It is expected that, through the implementation of the "Black Soil Granary" priority program, CAS can provide systematic resolutions for better utilization and protection of black soil, and support national food security and modern agriculture development. **DOI:** 10.16418/j.issn.1000-3045.20211009001-en

**Keywords:** Black Soil Granary; Strategic Priority Research Program; national food security; modern agriculture; sustainable development

The black soil distribution area in Northeast China, as one of the four largest black soil distribution areas in the world, covers Heilongjiang Province, Jilin Province, Liaoning Province and the three cities and one league in the eastern part of Inner Mongolia Autonomous Region (Chifeng City, Tongliao City, Hulunbuir City, and Xing'an League). This black soil distribution area covers an area of 1.635 billion mu, including arable land area of 537 million mu, with about 278 million mu of typical arable land of black soil. It is the most important grain production base and commodity grain export base in China. In the past five years, the average annual grain output of the black soil area in Northeast China accounted for 1/4 of the total output of China, and the dominant crops corn, rice, and soybeans had the output of 41%, 19%, and 56% respectively. The commodity grain occupied 1/4 of the national total, and grain allocation accounted for 1/3. The top ten ① grain-producing counties in China are all located in this area. Therefore, the black soil area in Northeast China is praised as the "stabilizer" and "ballast stone" of food security in China. However, long-term irrational farming and high-intensity utilization have caused the dilemma of "area reduction and quality regression", and the black soil area is gradually turning from an "ecological function area" to an "ecologically fragile area", seriously threatening China's food security and regional ecological security.

On July 22, 2020, General Secretary Xi Jinping pointed out during investigation in Jilin province that effective measures should be taken to better protect and utilize the black soil—"panda of arable land", thus benefiting the people forever. Later, General Secretary Xi continued to state at several major meetings that "it is necessary to implement the national black soil conservation program" and "focus on black soil conservation to well raise the black soil". Black soil conservation has become an important national strategy to ensure food security in China.

On the basis of active implementation of General Secretary Xi's instructions on black soil conservation, bearing the historical responsibilities, concerning about the "national

① Data source: *China Statistical Yearbook* and *Outline of Black Soil Conservation Planning in Northeast China (2017–2030).*

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affairs" and shouldering the "national responsibilities", the Chinese Academy of Sciences (CAS) prepared an important strategic decision on the implementation of the Science and Technology (Sci-Tech) Campaign for Black Soil Granary and the conservation of black soil in December 2020. Hou Jianguo, President and Party Secretary of CAS, ZHANG Tao, Vice President and Party Group Member, and other leaders investigated and guided the Science and Technology (Sci-Tech) Campaign for Black Soil Granary for several times. CAS has signed strategic cooperation agreements with Jilin Province, Heilongjiang Province, and Liaoning Province, to jointly implement and promote the Science and Technology (Sci-Tech) Campaign for Black Soil Granary.

The planning and implementation of the Strategic Priority Research Program (Category A)—"Science and Technology Innovation Project of Black Soil Conservation and Utilization (Black Soil Granary)" (hereinafter referred to as the "Black Soil Granary" priority program) by the CAS are the key links and core means of the Science and Technology (Sci-Tech) Campaign for Black Soil Granary. In the first half of 2021, as organized by the Bureau of Science and Technology for Development, CAS, and supported by the Northeast Institute of Geography and Agroecology, CAS, over 50 units, including Institute of Soil Science, Institute of Geographic Sciences and Natural Resources Research, Institute of Applied Ecology, Institute of Computing Technology, and Institute of Genetics and Developmental Biology, CAS, assumed the important historical mission of winning the Science and Technology (Sci-Tech) Campaign for Black Soil Granary. All the units performed multiple rounds of discussions, investigations and consultations, and developed the implementation planning for the "Black Soil Granary" priority program.

## 1 Overall idea of the "Black Soil Granary" priority program

Through deeply implementing the series instructions of General Secretary Xi regarding black soil conservation and utilization, and with the goal of "well raising black soil", the "Black Soil Granary" priority program intends to implement the national strategies involving food security, agricultural modernization, rural revitalization, and northeast revitalization, thereby giving full play to the advantages of the CAS in terms of complete discipline system, and the experience in organizing agricultural campaigns and black soil monitoring, utilization and conservation. In view of the major theoretical needs and technical shortcomings of "well raising black soil", scientific research should be conducted in four fields of "monitoring and evaluation, mechanism discovery, technology research and development, and model construction". The systematical investigation should be performed to identify the status of black soil for preparing a list of soil resources, and reveal the mechanism of black soil degradation and its prevention and control for breaking through the conservation and productivity improvement technologies, and establishing a black soil resource and environmental monitoring and perception system. Besides, we should research and develop key technologies and equipment for intelligent agriculture for constructing an intelligent management and control system and decision support platform, and establish a long-term mechanism for the conservative utilization of black soil and comprehensively demonstrate the development of modern agriculture based on black soil suitable for different types of regions.

For ensuring stable and increased grain production under the premise of black soil conservation, the "Black Soil Granary" priority program provides long-term strategic services for supporting the construction of the "Black Soil Granary", and also provides the "Chinese Academy of Sciences System Solution" for supporting the modern development of black soil agriculture in Northeast China. Thus the following major innovation goals are achieved: "creating the institutionalized national strategic scientific and technological strength for black soil conservation, forming a modern agricultural system solution covering all types of black soil, and achieving the balance between black soil conservation and utilization".

In combination with the tasks of black soil conservation and utilization in China, the "Black Soil Granary" priority program has launched six major scientific and technological research tasks (Figure 1) and constructed seven major demonstration areas (Figure 2) based on the organization pattern of "item + demonstration area".

## 2 Six major tasks of the "Black Soil Granary" priority program

(1) Task 1: defining black soil degradation process and key technologies for its prevention and control. For realizing black soil conservation and utilization, it is necessary to prevent the continuous degradation of black soil. Therefore, the program takes this task as the entry point, and sets Task 1 from the prevention and control of black soil degradation, that is, defining black soil degradation process and key technologies for its prevention and control. This task focuses on explaining the degradation rate and distribution pattern of the "thinned, fertility reduced, hardened and polluted" black soil. In addition, it intends to clarify the process and driving mechanism of black soil degradation, and develop key technologies and modes for degradation prevention and control, thus providing scientific theories and system solutions for prevention and control of black soil degradation. Furthermore, the program also focuses on carrying out studies involving black soil degradation diagnosis and evaluation system, compound soil erosion process and key technologies for prevention and control, decay process of soil organic matters and key technology improvement, process of soil

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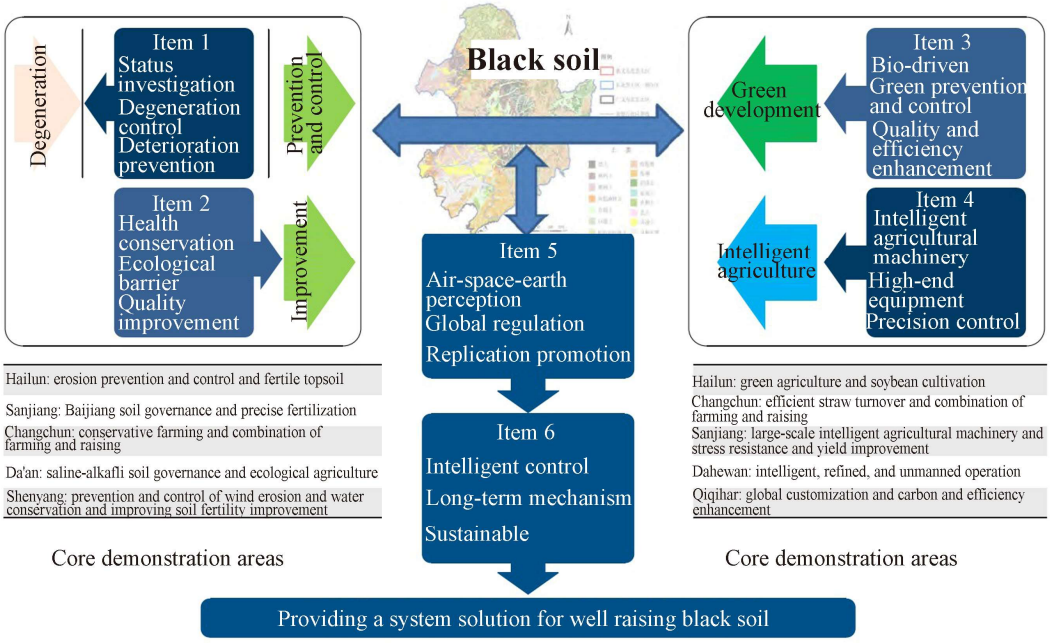


**Figure 1** Special research task setting of Strategic Priority Research Program (Category A) "Science and Technology Innovation Project of Black Soil Conservation and Utilization (Black Soil Granary)" of Chinese Academy of Sciences

compaction and structural obstacle formation and key technologies for reduction, and typical organic pollution process and key technologies for reduction [1–5].

(2) Task 2: developing black soil health and conservation technology. After the degradation of black soil is controlled, it is more critical to increase the productivity of the black soil, and maintain the healthy black soil at the same time. On such a basis, the program sets Task 2—"developing black soil health and conservation technology". In view of the problems such as unclear health status of black soil resources, the need of improving collaborative technology between soil conservation and productivity, and the incomplete agricultural water and soil resources security system in the black soil area, this task can provide theoretical and technical support for the improvement of productivity and health conservation of black soil. It mainly focuses on studying black soil health evaluation, directed cultivation of biological health, water and nutrient efficient utilization technology system, black soil conservative cultivation and farming and circular agricultural technology system, and the water-wetland-grain linkage mechanism and collaborative security assurance [6,7].

(3) Task 3: developing modern biological technologies for improving the productivity and quality of black soil. In addition to soil problems, there are also some long-term problems restricting the green and sustainable development of black soil agriculture, such as obstacles of straw turnover and application of fertilizer and pesticide. Therefore, the program sets Task 3—"developing modern biological technologies for improving the productivity and quality of black soil". For addressing important scientific issues such as soil organic matter balance of black soil-plant-microbe interaction, biosynthesis and degradation of lignocellulose, and biological regulation mechanism of soil diseases, and starting from biology, this task intends to develop the transformative and disruptive biotechnologies for improving black soil productivity and soil quality by advanced biotechnological methods such as gene editing, microbiome and synthetic biology. The task aims to provide scientific support and a model for "improving quality and reducing fertilizer, enhancing efficiency by organic matters, preventing pollution and reducing pesticide, achieving high yield and efficiency of black soil". Furthermore, it focuses on studying the black soil quality and efficiency enhancement technology driven by plants, black soil crop productivity enhancement technology driven by microorganism, comprehensive utilization of multisource agricultural waste and targeted composting technology, high-efficiency in-situ decomposing and returning of straw, and high-efficiency biological technology for preventing and controlling black soil pollution and diseases [8,9].

(4) Task 4: studying key technologies of intelligent agricultural machinery for black soil and the equipment. In Northeast China, as an area with the highest level of agricultural modernization in China, the large-scale, unmanned, and intelligent agricultural modernization will be the development trend in the future. However, the lack of independently developed high-end intelligent agricultural machinery equipment affects the modernization process of agriculture in Northeast China. Therefore, the program sets Task 4—"studying key technologies of intelligent agricultural machinery for black soil and the equipment". In combination with the high-degree land intensification in black soil areas in Northeast China and the urgent demand for

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high-end intelligent agricultural machinery equipment, it intends to develop key technologies regarding high-end intelligent agricultural machinery for conservative farming of black soil, and develop complete sets of agricultural machinery equipment to break the monopoly of foreign agricultural machinery companies in the high-end agricultural machinery market. Additionally, the program intends to make technological breakthroughs in ultra-high-horsepower powertrain technology based on clean energy, development of core wear-resistant components of protective machinery, wide-area, space-based positioning technology, design of intelligent agricultural machinery precision control system, and development of complete sets of intelligent agricultural machinery for black soil conservation [10,11].

(5) Task 5: establishing a space-air-ground integrated monitoring and perception system of black soil resources and environment. Based on the research on soil, crop and machinery problems, the current status and changes of black soil resources should be profoundly understood for well raising black soil, and providing targeted technical solutions for black soil conservation and utilization. Therefore, the program sets Task 5—"establishing a space-air-ground integrated monitoring and perception system of black soil resources and environment". This task focuses on establishing a real-time space-air-ground monitoring and perception system of black soil resources and environment, so as to provide continuous and stable data regarding black soil, water, vegetation coverage and growth; in addition, it makes available the basic black soil data of China in multiple dimensions for inventory and rational development of Chinese black soil resources, protection of physical and chemical parameters of black soil, physiological parameters of crops, and innovation of crop evapotranspiration and water use efficiency inversion technology. The task intends to quantitatively reveal health status, energy distribution and biological spectrum of the black soil by the hyperspectral remote sensing and near-surface active and passive non-destructive soil monitoring system, aiming to grasp the current status of black soil use and its spatial variation, and thus promoting sustainable development of agriculture.

(6) Task 6: establishing an intelligent management and control system and long-term mechanism for well raising black soil. Since black soil conservation and utilization is a long-term strategy, it is necessary to apply the achievements of the Science and Technology (Sci-Tech) Campaign for Black Soil Granary to black soil in Northeast China, so as to continuously promote the sustainable development of black soil agriculture. Therefore, the program sets Task 6—"establishing an intelligent management and control system and long-term mechanism for well raising black soil". This task intends to establish an intelligent management and control system for well raising black soil to resolve key scientific problems such as degradation of black soil and incomplete spatio-temporal information, lack of global customization scheme for black soil conservation and utilization and need of improving the level of regional intelligent management and control. Thus it aims to enhance the level of digital management of black soil conservation and utilization and provide globally customized system solutions for black soil areas. Furthermore, the task focuses on studying the map of black soil monitoring and all elements information, food security simulation and early warning of black soil, long-term black soil conservation mechanism, intelligent management and control of black soil, and decision support system [12,13].

## 3 Seven major demonstration areas of "Black Soil Granary" priority program

For implementation of technological research and development achievements, it is necessary to construct demonstration areas of black soil farmland, so as to truly realize black soil conservation and utilization. Therefore, the program sets seven major demonstration areas based on typical problems in black soil areas (Figure 2), which aims to guide the targeted technical research through completing various tasks and to resolve black soil problems in different demonstration areas, and also implement the existing black soil agricultural technologies to form, demonstrate and promote the technical patterns suitable for each demonstration area on the basis of technology integration and optimization. Moreover, the program, relying on various demonstration areas, performs in-depth cooperation with various local sections and enterprises, to truly promote the technologies of CAS.

(1) Hailun Demonstration Area: Thick black soil conservation and productivity improvement. In view of the bottleneck problems restricting the improvement of grain production capacity such as "thinning, fertility reducing and hardening" of the black soil layer in the north-central Songnen Plain of the black soil area in Northeast China, the "Black Soil Granary" priority program focuses on integrating and demonstrating fertile topsoil construction and conservation mode of thick black soil, black soil erosion control and high-efficiency production mode, black soil rapid fertilization and fertilizer and pesticide reduction and efficiency improvement mode, and high yield and efficiency cultivation mode of high-quality soybeans. In addition, the program also carries out multi-element, three-dimensional monitoring and mode application evaluation in Hailun Demonstration Area.

(2) Changchun Demonstration Area: conservation of thin-layer degraded black soil and improvement of grain production capacity. With regard to the problems such as thinned soil arable layer and decreased content of organic matters in thin-layer degraded black soil areas, reduced regional ecological functions, extensive and low-scale agricultural production management, separation of planting and raising, low agricultural productivity, and environmental pollution caused by wastes (such as straw, excrements of livestock and poultry) that are hard to be processed, the program focuses on integrating and demonstrating the "Pear

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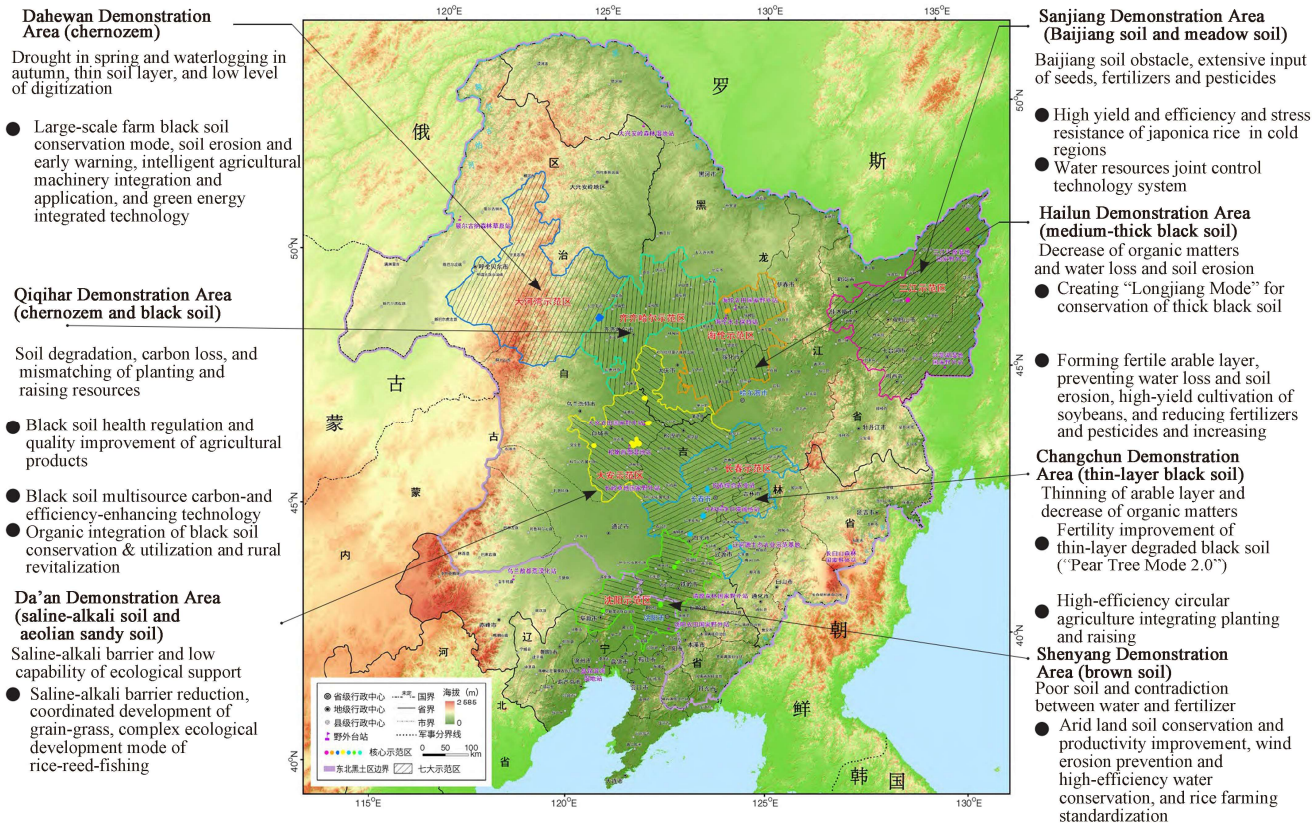


**Figure 2** Seven demonstration areas of Strategic Priority Research Program (Category A) "Science and Technology Innovation Project of Black Soil Conservation and Utilization (Black Soil Granary)" of Chinese Academy of Sciences

Tree Mode" of conservative farming, straw mulch/mixed return, fertilizer-saving and efficiency-enhancing mode, water and soil ecological restoration and high-efficiency ecological agriculture development mode in hilly areas, and efficient and circular agricultural development mode for fertility improvement based on integrated planting and raising. Moreover, it also carries out multi-element, three-dimensional monitoring and mode application evaluation in Changchun Demonstration Area.

(3) Shenyang Demonstration Area: fertility restoration of degraded black soil and improvement of production capacity. There are sufficient light and temperature resources in the southern part of the black soil area in Northeast China, but due to soil degradation and infertility, such light and temperature resources cannot be used effectively. Besides, considering the regional problems such as imbalanced utilizing and raising, prominent contradiction between water and fertilizer, and frequent seasonal drought, the program focuses on integrating and demonstrating the arid land soil conservation and productivity improvement mode, wind erosion prevention, water-saving and efficient agricultural mode, rice farmland soil fertility maintenance and quality and efficiency enhancement mode. Additionally, it also carries out multi-element, three-dimensional monitoring and mode application evaluation in Shenyang Demonstration Area.

(4) Sanjiang Demonstration Area: quality and productivity improvement of paddy soil and Baijiang soil. In view of the problems such as seasonal decline of groundwater in the Sanjiang Plain, low utilization rate of agricultural water resources, low soil temperature in spring, serious soil obstacles, large-scale and high-level mechanization planting but extensive input of seeds, fertilizers and pesticides, low-level intelligence, and lack of basic agricultural data with high temporal-spatial resolution, the program focuses on integrating and demonstrating optimal allocation and efficient utilization mode of agricultural water and soil resources, arid Baijiang soil land obstacle reduction and soil fertility improvement mode, cold paddy field fertility enhancement and stress resistance and yield improvement mode, and integrated development mode of large-scale black soil conservation and intelligent agriculture. Furthermore, it also carries out multi-element, three-dimensional monitoring and mode application evaluation in Sanjiang Demonstration Area.

(5) Da'an Demonstration Area: ecological governance and efficient utilization of saline-alkali soil. In view of the low productivity and degraded ecological security of marginal land in black soil area in the western part of Northeast China, the program, while centering on saline soil improvement technology, targeting at resolving key problems of paddy fields, dry fields, grasslands and wetlands with saline-alkali obstacles, and realizing major demand orientation, focuses on integrating and demonstrating the mode of alkali treatment

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with rice and grain productivity increase in saline-alkali fields, arid saline-alkali land improvement and efficient utilization mode, saline-alkali grassland productivity enhancement and ecological barrier construction mode, as well as the "rice-reed-crab/fish-mushroom" three-dimensional, efficient, composite ecological mode. Additionally, it also carries out multi-element three-dimensional monitoring and mode application evaluation in Da'an Demonstration Area.

(6) Dahewan Demonstration Area: integration and industrial application of key technologies for intelligent agricultural machinery used in black soil. Dahewan Demonstration Area, located in the slopes of the terminal hills of the Greater Khingan Mountains, is complex in terrain and severe in water erosion. The Area, with large-scale planting by state farm groups has the basis for carrying out verification and demonstration of the advanced technical modes. Based on the industrial development planning of the Dahewan Region, black soil conservation, ecological environment conservation, and industrial development are combined, and the program especially integrates and demonstrates black soil erosion control mode on slopes in Dahewan region, green energy-based black soil planting and raising circular mode, and unmanned conservative farming mode of black soil hills. Moreover, it also carries out multi-element three-dimensional monitoring and mode application evaluation in Dahewan Demonstration Area.

(7) Qiqihar Demonstration Area: global customization of Black Soil Granary. In view of the bottleneck problems of black soil areas in Qiqihar City and upper and middle reaches of the Nenjiang River, such as severe soil degradation and carbon loss, mismatching of planting and raising resources, low agricultural benefits, and lack of system solutions for regional development, the program focuses on integrating and demonstrating the black soil health regulation and agricultural product quality excellence mode, black soil conservation and efficiency improvement mode, black soil multisource carbon- and efficiency-enhancing technology mode, and integration mode of black soil conservation & utilization and rural revitalization. In addition, it also carries out creation and demonstration of the global customization mode of the Black Soil Granary.

## 4 Innovation of "Black Soil Granary" priority program

(1) Multidisciplinary integrated innovation. The program gives full play to the complete disciplines of CAS, and integrates the strengths of scientific research to resolve long-term and key scientific issues for black soil conservation and utilization, including revealing the mechanism of black soil degradation, clarifying the mechanism of soil fertility improvement and health conservation, breaking through the limitations of water and heat, and developing efficiently in situ decomposing technology of straw based on microbiome.

(2) Technological mode innovation. Considering the regional characteristics such as different soil types, climate characteristics, and obstacle factors, the program intends to develop the innovative technologies for soil degradation prevention and control, soil health conservation, farming and cultivation, planting and raising cycle, and water and soil resource regulation. It also constructs and improves the "Pear Tree Mode", "Longjiang Mode", "Sanjiang Mode", and other integrated system schemes for black soil conservative utilization in different regions. On the basis of the three-dimensional, intersected organizational structure of tasks and demonstration areas, the program intends to form a black soil conservation technology system integrating research, conservation, cultivation, utilization, and promotion, and make the achievements "promotable and sustainable". In this way, the problems of black soil can be solved generally, such as "thinning" of the black soil layer, decreased content of soil organic matters, soil hardening and thickening and "hardening" of the plow sole.

(3) Intelligent means innovation. Based on the 17 network of field stations and 7 demonstration areas in Northeast China, the program intends to establish an air-earth-space monitoring and perception system; accelerate the localization process of intelligent agricultural machinery, and build an intelligent agricultural system, to realize the real-time monitoring of black soil, and autonomization and localization of intellectual property rights of intelligent agricultural machinery technology system. Furthermore, it establishes a black soil big data and artificial intelligence design control and decision-making system, to realize the sustainable utilization of black soil.

(4) Management mode innovation. With the organizational innovation mode of CAS-province linkage and CAS-department collaboration, the program intends to practically apply the scientific and technological achievements of CAS to black soil through signing strategic cooperation agreements with the four northeast provinces (regions) and the relevant ministries and departments, establishing the leading groups and offices of Science and Technology (Sci-Tech) Campaign for Black Soil Granary at the CAS and province (ministry) levels, setting up front-line headquarters, and sending personnel with deputy titles in the field of science and technology. It also regularly publishes the White Paper, *Black Soil in Northeast China*, to provide theoretical, technical and policy suggestions for well raising black soil, thus guiding the conservation and utilization of black soil.

## 5 Suggestions on black soil conservation and utilization

At present, it is urgent to solve the contradiction or find a balance point between conservation and utilization, ensure sustainable grain production of black soil, and prevent degeneration and even improve the black soil, thereby providing

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powerful guarantee for food security in China. However, we should realize the persistence of black soil conservation and utilization. Although the "Black Soil Granary" priority program can effectively prevent black soil degradation and increase the grain yield, but more attention should be attached to the following four aspects, to truly realize the long-term sustainable utilization of black soil.

(1) Improving the mechanism guaranteeing the technological achievement transformation for well raising black soil. Science and technology is the main solution to realizing black soil conservation and utilization, but due to various types of agricultural techniques and conservation means from various departments, the problems regarding black soil have not been really resolved. Therefore, it is necessary to build practical and effective technology application channels, and break the technical barrier between the laboratory and farmland, and evaluate the effect of the existing black soil conservation technologies to identify the effective ones and promote them rapidly; in addition, we should also combine incentive policies with compulsory measures to mobilize the enthusiasm of the agricultural industry chain entities and all sectors of society in the application of black soil conservation technologies, and promote land circulation to establish new business entities and give full play to the leading role of large-scale operations. Such measures will resolve the scientific problems regarding black soil, and also facilitate the integrated development of science & technology and agriculture in the future.

(2) Innovating and integrating black soil conservation system schemes in different areas. In view of the planting system, soil type characteristics and environmental obstacle factors of black soil, it is necessary to integrate a batch of comprehensive technical modes with matched machinery and agriculture and combination of soil utilization and raising, develop and promote a batch of new technologies, new products, and new equipment, and integrate and assemble a batch of "applicable, reproducible, promotable, and sustainable" comprehensive technical modes for black soil conservation. Furthermore, it is also necessary to continuously improve and popularize the "Pear Tree Mode" and "Longjiang Mode", and develop a new integrated technology mode for restoration of erosion gullies, governance of saline-alkali soil, reduction of Baijiang soil barrier layer, and optimization and control of water and soil resources. In addition, we should integrate the development of circular agriculture, ecological agriculture, and rural revitalization and propose a system solution for well raising black soil.

(3) Performing research and governance regarding soil erosion prevention and control at the watershed scale. There is prominent water and soil erosion in the black soil area in Northeast China, and the area of water loss and soil erosion is 324 million mu, 39.75 million mu of which involves slope farmland. There are still 222 200 erosion gullies to be treated. Suggestions are proposed from the perspective of strengthening the research on water loss and soil erosion control technologies and the occurrence mechanism in black soil areas at the watershed scale, and systematically performing dynamic monitoring of water loss and soil erosion and governance of erosion gullies based on basins. In addition, we should accelerate the small basin governance and irrigation area construction in the black soil area, complete small-scale farmland water conservancy infrastructure, and optimize the pattern of farmland shelter forest.

(4) Establishing a long-term mechanism for black soil conservation. The degradation of black soil has experienced a long process, and its conservation and restoration will inevitably be a long-term project. Therefore, it is necessary to establish a long-term mechanism for black soil conservation. Specifically, we should accelerate the advancement of legislation for black soil conservation at the national level, and establish sound protection policies and effective mechanisms to facilitate black soil conservation. Besides, an evaluation index system should be created for evaluating the effect of black soil conservation, which involves the thickness of the farming layer, content of organic matters, per unit area yield of grain, and arable land quality grade, so as to promote the establishment of black soil conservation evaluation system. Furthermore, it is also necessary to build pilot zones where the subsidy distribution of arable land fertility is associated with implementation of arable black soil conservation measures, to realize the transformation from "fixing farm output quotas for each household" to "fixing quality for each household". One of the core technologies for black soil conservation is reduced tillage and no-tillage of black soil as well as straw turnover to increase the organic carbon content in soil. Therefore, it is suggested to establish a green, ecological and low-carbon subsidy system based on green and low-carbon technologies and modes for black soil areas, so as to discuss the mechanism for achieving the carbon neutrality and peak goals in China.

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