Protection and Utilization of Black Land and Making Concerted and Unremitting Efforts for Safeguarding Food Security Promoted by Sci-tech Innovation—Countermeasures in Conservation and Rational Utilization of Black Land

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Abstract
The protection and reasonable utilization of black land and developing a powerful nation in the grain industry are the cornerstone for safeguarding the national security. This study focuses on the main agricultural sources including soil, water, seed, fertilizer, farm chemicals, etc., and analyzes the key problems in grain production, ecological security, and sustainable development in black land in Northeast China. This study proposes to strengthen the research and development of technology and the relevant equipment for the protection of black land and increasing crop yield; to develop the reduction of soil obstacle factors and stress-tolerant plants planting modes; to build a long-term mechanism for black land protection and to comprehensively promote the intensive land management and mechanized production; to fasten the transition of traditional agriculture to precision and smart agriculture and to construct a coordinated and safe development mode for multiple ecosystems. The Chinese Academy of Sciences should give full play to its institutional and multidisciplinary advantages, and build a close union with local government, enterprise and farmers, thereby tackling the key problems and promoting the popularization of core technologies in the protective utilization of black land and soil health management.

Keywords
protection of black land; food security; ecological security; scientific and technological innovation; countermeasures

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Abstract: The protection and reasonable utilization of black land and developing a powerful nation in the grain industry are the cornerstones for safeguarding national security. This study focuses on the main agricultural sources including soil, water, seed, fertilizer, and farm chemicals, and analyzes the key problems in grain production, ecological security, and sustainable development in black land in Northeast China. This study proposes to strengthen the research and development of technology and the relevant equipment for the protection of black land and increasing crop yield; to develop the reduction of soil obstacle factors and stress-tolerant plant planting modes; to build a long-term mechanism for black land protection and comprehensively promote the intensive land management and mechanized production; to fasten the transition of traditional agriculture to precision and smart agriculture and to construct a coordinated and safe development mode for multiple ecosystems. The Chinese Academy of Sciences should give full play to its institutional and multidisciplinary advantages, and build a close union with local government, enterprises and farmers, thereby tackling the key problems and promoting the popularization of core technologies in the protective utilization of black land and soil health management.

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Developing a powerful nation in the grain industry and ensuring food security are underpinning for addressing the numerous challenges such as the pandemic and extreme climates, achieving economic development and social stability, as well as safeguarding national security, amid the great changes in the world. The black land in Northeast China covers an area of 1.09 × 10^6 km^2, which is one of the four major black land areas in the world, and the paramount high-quality commodity grain base of China. The grain yield there accounts for a quarter of the total national grain yield, making the black land function as the “ballast stone” to safeguard the food security of China. In July 2020, when investigating Jilin Province, Xi Jinping, general secretary of the Communist Party of China (CPC) Central Committee, stressed, “We should well protect and utilize the ‘panda of arable land’—black land’ with effective measures, and make it benefit the people forever.” In December 2020, at the Central Rural Work Conference, Xi pointed out, “We should work on protection of black land with priority, and well use and cultivate black land.” In 2021, the No. 1 central document called for the efforts to implement the program of black land protection and popularize protective cultivation modes. Protection and reasonable utilization of black land, and enhancement of the grain yield in the black land area have been lifted up to the national strategy.

Currently, the grain production in the black land area in Northeast China still faces problems such as black land deterioration, unreasonable utilization of water-soil resources, soil obstacles and cold stress, weakening ecological barrier function of the farmland, low yield due to extensive field management, reduced planting return, biomass burning, sand storm, and non-point source pollution due to excessive application of chemical fertilizers and pesticides, which severely threaten the grain production and food security of the state. Scientific and technological innovation is the driving force to overcome the above problems, raise grain production capacity in Northeast China, and realize the national strategic goal of “sustainable farmland use and innovative application of agricultural technology”. This paper focuses on the key issues encountered in the management of the resource factors...
such as water, soil, seed, fertilizer, and pesticide during grain production in the black land area in Northeast China. It clarifies the direction of scientific and technological innovation for promoting the protection and utilization of black land and increasing the regional grain production capacity. In addition, policy suggestions for speeding up the implementation of the innovative scientific achievements have been proposed, so as to provide scientific support for safeguarding food security, regional ecological security, and sustainable development.

1 Problem faced by black land protection and grain production

1.1 Severe black land deterioration

Due to cropland management modes such as long-term unreasonable cultivation, straw removal, and excessive application of chemical fertilizers and pesticides, which focuses on utilization rather than maintenance, as well as soil erosion, black land in Northeast China has deteriorated severely. Its health conditions are worsening. ① Black land is thinning and hardening. Data indicate that the thickness of the black land has reduced from 50-90 cm in the 1950s to 20-50 cm, and is reducing at a rate of 2 mm each year [1]. The organic matter content in the black land layer has reduced by 30% on average, and by more than 50% in some farmlands [2]. Compared with the situation in the 1980s, the plow pan depth has increased to topsoil bulk density of 1.21–1.27 g/cm³ from 1.08–1.15 g/cm³ [3]. ② Black land is suffering soil contamination. Excessive application of chemical fertilizers and pesticides has resulted in a severe acidizing trend in the black land area. The cadmium, plumbum, and zinc contents in black land have a rising trend [4]. ③ The soil biological integrity is out of balance. Long-term single plantation structure and continuous cropping have led to worsened nutrient imbalance, hardening and plant diseases in black land soil, which has further led to the deterioration of the soil biodiversity and community structure stability, changes in the metabolic function of the soil organisms, damage to the primitive ecological balance, and increase in the incidence of the soil-borne diseases. Therefore, scientific innovation relying on maintaining technology is urgently needed to guarantee the healthy and sustainable development of black land.

The black land area in Northeast China is in the semi-humid and semi-arid areas, and natural disasters and unreasonable utilization by human beings have destroyed the virtuous circle of the ecosystem. As seasonal drought, especially spring draught, occurs frequently, the black land area is poor in moisture, which has heavily affected spring sowing and crop seedling emergence. According to the statistics in recent 70 years, the incidence of spring drought in the black land area in Northeast China is 70%, and perennial disaster-affected area averaged more than 1.50 million hectares [5]. The high wind in spring has caused severe topsoil erosion [6]. The low temperature in spring and early frosting in autumn has led to frequent crop losses [7]. Rainfall in summer is intensive, which may easily lead to flood disasters [8]. As the black land area in Northeast China is rainfed farming, the black land deterioration has led to the deterioration of the water-retaining capacity of the farmland, lowering the utilization of the natural rainfall. In the west of Northeast China, as it is dry and has little rainfall, groundwater is little utilized for crop growing, and the ability to resist and alleviate disasters here is weak [9], which heavily affects the high and stable yields of the crops.

1.2 Unreasonable utilization of black land resource

After the cultivation of black land in Northeast China, due to the unreasonable management which focuses on long-term utilization rather than maintenance, as well as the predatory business pattern which lacks organic matter input, the soil of the arable land has been in the over-load condition for a long time. As a result, the organic matter contained in black land rapidly ran off, severely affecting soil fertility and crop yield. Research shows that, for every 0.5% decrease of the organic matter contained in the black land, the crop yield will decrease by more than 15% [10]. High crop yield relies excessively on chemical fertilizers, while excessive application of chemical fertilizers may lead to problems such as soil hardening and acidification, water pollution, and greenhouse gas emission, which further aggravates black land deterioration [11–13]. In addition, the plantation structure in black land in Northeast China is simple in the long run. The major agricultural region is mainly maize [14] with a planting area of $2.33 \times 10^5$ m² which accounts for 56.2% of the planting area of the grain crop [15]. This has led to improper proportions of the soil nutrients and reduced soil fertility [16]. Moreover, maize over-yield and long-term continuous cropping may aggravate diseases and insect pests, severely restricting soil fertility improvement and grain yield increase.

1.3 Restriction of grain yield by natural conditions such as soil obstacle factor and cold damage in some local areas

The soil types in the black land area in Northeast China mainly include black land, chernozem, dark brown soil, brown soil, albic soil, and meadow soil. The albic soil distributed over the foothill flat ground and valley terrace in Heilongjiang Province and the east of Jilin Province has poor structures, low fertility, easy drought and waterlogging, and hardened topsoil. Therefore, it is the typical obstacle low-yield soil, especially not good for growing dryland crops. The large-area saline-alkali soil located in the west of Songnen Plain has been deemed as a marginal land resource [17]. Currently, Jilin Province is promoting the interconnection of
rivers (Songhua River, Nenjiang River) and lakes (marsh cluster) in the west of Songnen Plain with great efforts, which may drive the development of the regional large-scale saline-alkali soil paddy field. However, damages such as the high hydrogen ion (pH) stress, osmotic stress, and element toxicity of the sodic saline-alkali soil severely affect the growth and development of the rice. In addition, the nitrogen fertilizer utilization in the saline-alkali soil is low, leading to a low rice yield [18]. In addition to the local soil obstacle, the grain yield in the black land area is also affected by the climate factors such as low temperature. Especially in the northern area (the fourth, fifth and sixth accumulated temperature zones) of Heilongjiang Province, enhancement of the grain production capacity in this region has been restrained severely due to low temperature, low effective accumulated temperature, frequent cold damage, fewer varieties of rice, soybean, and maize resistant to low temperature [19]. Moreover, amid climate change, extreme weather, plant diseases, and insect pests boost, which increase the risk of unstable grain yield.

1.4 Low level of fine field management, restricting efficient development of the agricultural production

Extensive input of chemical fertilizers and pesticides has led to a serious waste of the agricultural production means, intensified the output load of the field non-point source pollution, and threatened the water environment safety. Meanwhile, excessive application of chemical fertilizers is also an important inducement for ammonia volatilization and greenhouse gas emission. Therefore, it is urgent to carry out accurate and intelligent input of seed, fertilizer, pesticide, and water at a fixed time and fixed location, and with a fixed quantity and fixed recipe. Implementation of integrated water-fertilizer management and achievement of the objectives such as water conservation, fertilizer consumption reduction, pesticide consumption reduction, and yield increase is the inevitable development trend and bright symbols of modern agriculture. Currently, the seed-fertilizer-pesticide-water management during agricultural production in the black land area in Northeast China is mostly based on the traditional extensive mode. In some areas, for example, the Heilongjiang agricultural reclamation system of high intensification and institutionalization levels has a high level of mechanization. However, the input of the seed, fertilizer, pesticide, and water is still relatively extensive, and fine field management technology is lacking. Moreover, the intelligent management technologies available mostly aim at a certain step in the whole agricultural production chain, and there is no intelligent management technology system and platform covering the whole cycle of agricultural production. Big data has become an important agricultural production factor, and intelligent agriculture has constituted the advanced stage for modern agricultural development. Nevertheless, the development degree of intelligent agriculture in the black land area in Northeast China still lags behind that in other advanced countries, which greatly restricts the development of high-efficiency agriculture.

1.5 Lacking synergetic development modes established between agricultural development and ecological protection in the black land area, and the regional agricultural ecological barrier function remaining to be improved

Northeast China is the important commodity grain base of China and has the biggest wetland area in China. The marsh wetland area of Northeast China accounts for 48.3% of the national total wetland area [20], and there are 18 international important wetlands such as Zhalong in Heilongjiang and Xianghai in Jilin. The marsh wetlands in Northeast China serve as the important stations on the international bird migration path between East Asia and Australia, and the main stops for migration and breeding places of international important protected birds, such as the oriental white stork, red-crowned crane, and white crane. Therefore, they are of great significance for maintaining biodiversity and fulfilling the relevant international conventions. In addition, the marsh wetlands essentially guarantee the water resources required for grain growing in the black land area in Northeast China with their hydrological regulation function.

Nevertheless, the long-term large-scale agricultural development has led to severe water shortage and deterioration in the wetlands in Northeast China. Construction of the water infrastructure has changed the original hydrological pattern and cut off the surface replenishment water sources to the wetlands. A lot of groundwater has been extracted for irrigating the rice field, resulting in a drop in the water table. For example, the water table in Jiansanjiang in Sanjiang Plain dropped by 1.60–9.29 m due to rice growth from 1997 to 2017 [21]. A drop in the regional water table has intensified vertical water replenishment to the groundwater from the surface standing water in the wetlands and led to severe wetland drying, directly affecting the functions such as hydrological regulation. As a result, the grain planting in the black land area is faced with a huge challenge of water resources guarantee, thus leading to an uncoordinated development and vicious circle of the grain-water-wetland associated system. The non-point source pollution in the slope cropland and the intensified rice-growing area should not be neglected [22]. Nitrogen and phosphorus discharges have aggravatd the eutrophication risk of the surface water and threatened the water environment safety in the boundary rivers and lakes, such as the Heilongjiang River, Wusuli River, and Xingkai Lake, which has brought stress for China to execute environmental diplomacy. The toxic and harmful pesticides may likely enrich the food chain, threatening the safety of the endangered rare birds. In addition to the wetlands and rivers, the forest and grassland ecosystems play important roles in providing the ecological service to and safeguarding agricultural production owing to their multiple
functions of climate regulation, water storage, soil conservation, and preventing sand wind. Their health and stability will directly affect the sustainability of the regional food security. Currently, however, the synergetic development mode between the agricultural development and protection of multiple ecosystems in the black land area in China has not been shaped yet.

2 Scientific and technological innovation direction and key technologies for promoting the protection of black land and enhancing the grain production capacity

2.1 Intensify research and development of technologies and equipment for the protection of black land and stable and high crop yields

Research on the key technologies for the protection of black land and solution to key technological issues should be intensified. Research on the basic theories for the black land deterioration process as well as control, soil healthcare and sustainable utilization, and research and development of key technologies and farming equipment should be conducted by focusing on the key scientific and technological issues such as protection of the soil in the black land area and soil fertility improvement. The science and technology inputs on the breeding of high-quality varieties, protective farming technology, fertile cultivated layer construction technology, water and soil loss control, the overall arrangement of the crop planting system, and integrated planting-breeding agricultural technology should be increased with priority. Science and technology integration and innovation should be reinforced, and a regional protective utilization mode of black land adapting to different geographical and environmental features and meeting the needs for agricultural production should be built. The experience in protection pilot zones and erosion control of black land areas should be summed up, and the modes such as circular agriculture, ecological agriculture, and sightseeing agriculture should be integrated. In this way, the perfect, reproducible, and propagable mode and operating mechanism can be built to safeguard the healthcare of black land, and stable and increased grain yields. The Action Plan for Protective Farming of Black Land in Northeast China (2020–2025) should be fully implemented to achieve the objectives such as sustainable utilization of black land, food security, boost in the farmers’ income, and increase in the agricultural benefits.

2.2 Construct the reduction technology system of soil obstacle factors and optimized planting pattern for the stress-tolerant plant, and reduce the impacts of unfavorable natural conditions on the grain yield

In terms of the albic soil obstacle, the shallow-ploughing and deep-digging cultivated layer construction technology should be researched and developed. The low biomass maturity efficiency due to deteriorated microorganism function under the low-temperature environment in the cold area should be solved by focusing on research, development, and application of the functional microorganism inoculant. The fertile cultivated layer construction and protective farming technology system centered on straw turnover should be established. For the soil obstacle in saline and alkaline land, the focus should be laid on research, development, and application of soil conditioners. For example, the “Alkali Removal 3#” compound conditioner developed by Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences (CAS), can increase the yield of the rice grown in the sodic saline and alkaline land by 3 times. However, all the above soil obstacle elimination measures should be further optimized from the aspects of cultivation and selection of varieties, efficient fertilizer utilization, production process, research and development of supporting machinery, and cost input so as to form a more propagable reduction technology system for soil obstacle. Under the cold climate in Northeast China, it is necessary to reinforce monitoring and early warning of agro-meteorological disasters such as flood, drought, cold damage, and hail, strengthen monitoring and early warning of crop diseases and pests, improve the ability to protect and mitigate natural disasters, provide more efforts on the study of the resistance of the crop to adversity stress, speed up screening and cultivation of stress-tolerant plant varieties, and construct a resource pool of high-quality seeds suitable for different accumulated temperature zones and soil environments. In addition, the crop yield should be increased in combination with the measures such as the crop growth conditioner and optimization management in the seedling stage.

2.3 Construct the long-term mechanism for the protection of black land, intensify the policy support for land trusteeship, and fully promote intensive land management and mechanized production

Excessive decentralization of the land and low transfer level of cultivated land has restricted intensive and scale development of agricultural production. In addition, no overall planning and safeguard mechanism has been made for the protection of black land and the utilization of new technologies. As a result, the farmers, agricultural cooperatives, and new-type agriculture operators do not have high enthusiasm for providing inputs to agricultural production, and the effect of the policy support should have not been generated. It is suggested to explore and specify the incentive policy and compensation system for the protection of black land, well establish the compensation ways, attract the inputs from the policy-guided financial capital, usher in the inputs from the commercial financial capital, and motivate the initiatives of the governments at various levels, farmers and forces from all walks of the society to participate in the
protection of black land. The government should increase the subsidies and support on the total land trusteeship process and scale operation, provide more comprehensive direct subsidies for agriculture to scale operation with land trusteeship and land shares as the motive power, and encourage the new-type agriculture operators such as the major planters, family farms and cooperatives to expand their production scales properly. Provided that it can be guaranteed that the basic farmers’ income from farming will not be decreased, cost reduction and benefiting agriculture should be achieved with the methods such as commercialization of scientific and technological achievements and group purchase of production means to promote intensive scale operation of the land and enhance the land transfer level. The policy support on farming mechanization development should be enhanced to practically promote the implementation of the subsidy policy for the purchase of farming machinery and subsidy policy for scrapping and replacement of farming machinery, simplify the procedure and process for implementation of the policies, and speed up black land protection work.

2.4 Speed up the transformation of grain production towards precision and smart agriculture, and achieve the whole process scientific management

It is suggested to speed up the transformation of grain production in the black land area towards precision and smart agriculture, and solve the current problems including extensive application of fertilizers and pesticides, waste of production means, low production efficiency, and environmental pollution. Implementation of “precision agriculture” by the comprehensive application of key technologies such as “3S”, automation, artificial intelligence, Internet of Things, and big data is the inevitable development trend of modern agriculture [21]. Intelligent application of chemical fertilizers and pesticides should be achieved through precision management, with each parcel of the rice field as a unit, and by diagnosing the soil, moisture, photo-thermal conditions, diseases and insect pests, and crop growth in different growth stages to optimize the recipe. Intelligent services should be provided to both the producers and operators through precise control over various kinds of field machinery. Product tracking and query services should be provided to the consumers by constructing the traceability information system for agricultural products, so as to achieve scientific and technological achievements and group purchase of production means to promote intensive scale operation of the land and enhance the land transfer level. The government should increase the subsidies and support on the total land trusteeship process and scale operation, provide more comprehensive direct subsidies for agriculture to scale operation with land trusteeship and land shares as the motive power, and encourage the new-type agriculture operators such as the major planters, family farms and cooperatives to expand their production scales properly. Provided that it can be guaranteed that the basic farmers’ income from farming will not be decreased, cost reduction and benefiting agriculture should be achieved with the methods such as commercialization of scientific and technological achievements and group purchase of production means to promote intensive scale operation of the land and enhance the land transfer level. The policy support on farming mechanization development should be enhanced to practically promote the implementation of the subsidy policy for the purchase of farming machinery and subsidy policy for scrapping and replacement of farming machinery, simplify the procedure and process for implementation of the policies, and speed up black land protection work.

2.5 Build the mountain-water-forest-field-lake-grass living community, and construct the coordinated and safe development mode of multiple ecosystems

The ecosystems such as wetlands, forests, and grasslands can safeguard the safety of the farmland ecosystem, and the building of the mountain-water-forest-field-lake-grass living community and the achievement of synergetic development of various ecosystems are the foundations for safeguarding food security. Provided that the deterioration mechanisms of different ecosystems and their safety thresholds have been specified, restoration and healthcare of the deteriorated ecosystem should be speeded up, so as to optimize regional ecological security patterns which maintain the functional stability of multiple ecosystems and sustainable agricultural development. Especially, for the prominent contradiction between grain production and water resource supply-demand in the wetlands, the regional water resource monitoring, and early warning platform should be established and key technologies for “water-wetland-grain” coordinated security assurance in the black land area should be researched and developed. In addition, the technical pattern for efficient utilization of water resources such as precise water replenishment to the wetlands, water conservation irrigation in the farmlands, and recycling of water drainage from the farmlands should be constructed. With water quality safety as a goal, considering synergistic governance of multiple pollutants and synergistic control over multi-media environmental pollution, the restrictions of unfavorable environmental conditions such as low temperature and saline-alkali stress on the effects of the ecological purification technology should be overcome. The non-point source pollution retaining technologies for slope croplands such as grass strips and ridging check should be developed, and the non-point source pollution purification technology pattern for paddy fields such as ecological ditches and small wetlands should be constructed.

3 Policy suggestions for promoting the application of scientific and technological innovations

Centering on the scientific and technological innovation...
and key technology patterns for the protection of black land and the enhancement of grain production capacity, the key to achieving the objectives of sustainable utilization of black land, and stable and increased regional grain yield is to speed up the application of the scientific and technological innovation achievements.

(1) Scientific and technological innovation should be intensified, and key technologies for protection and utilization of black land should be developed by taking advantage of the institutionalized power and well-proven scientific research, and assembling all the forces of CAS, so as to support the enhancement of the grain and agricultural product capacities in black land. To implement Xi’s important direction and spirit on “better using and conserving black soil”, CAS has initiated the science and technology battle of “Granary in the Black Soil” by working with the local governments. They conducted cooperative research and application demonstration of the achievements by organizing the advantageous scientific research and agricultural technology forces both inside and outside the academy to support “better using and conserving black soil” with science and technology. By referring to the rich experience accumulated in the agricultural scientific and technological research tasks such as the “Huang-Huai-Hai Campaign” and “Bohai Sea Granary”, CAS has integrated the state-of-art science and technology systems and patterns and organized a number of forces to conduct interdisciplinary, trans-regional and trans-department joint research to solve key problems by taking the advantages of multi-discipline, institutionalization, and systematization. For the specific problems encountered by grain production in the black land area in Northeast China, the key technical problems which should be solved urgently during the protection and utilization of black land should be overcome. It aims at sustainable utilization of black land, and centering on the aspects such as the black land deterioration mechanism, breeding of high-quality crop varieties, research and development of farming equipment, and bio-green technology. Fertility increase, grain yield increase, agricultural benefit increase and farmers’ income increase from black land should be achieved to provide scientific and technological support for well protecting and utilizing black land.

(2) The nationwide relevant advantageous scientific research institutes should establish core demonstration areas for the technology pattern of black land protection and utilization by working with the local governments and building demonstration models for the sustainable utilization pattern of black land to provide systematic solutions for protective utilization of black land. The black land region in Northeast China covers a vast area, and the soil types and climatic conditions are different from each other from place to place. The nationwide advantageous scientific research institutes such as the research institutes affiliated with CAS should establish a cooperative mechanism with the local governments of “three provinces and one region” in Northeast China, so as to conduct a model demonstration for the protective utilization pattern of the black land at different typical zones. The new-type agricultural operators such as family farms, farm cooperatives, major planters, and leading agricultural enterprises can act as the principals for sustainable utilization demonstration of black land. For the construction of the demonstration pattern, the various production factors such as water, soil, seed fertilizer pesticide, and planting should be taken into comprehensive consideration. Measures such as farming machinery, agriculture, biology, and engineering should be taken comprehensively to develop a systematic solution for the protection and utilization of black land.

(3) The technical research teams and joint demonstration and popularization teams from the agricultural popularization departments should be set up to promote the implementation of the technology pattern for the protection and utilization of black land, safeguard the national food security, and support the strategies of agricultural modernization in black land and revitalizing Northeast China. The well-proven technologies for the protection of black land should be promoted and enlisted as the major agricultural technologies for the local governments to be popularized with great efforts based on the cooperative mechanism between the relevant advantageous research institutes affiliated with CAS and governments of “three provinces and one region” in Northeast China. The linking between the technical research teams and departments for the popularization of the agricultural technologies should be strengthened, and the joint team for demonstration and popularization of black land protection and utilization technologies should be set up, so as to promote the implementation of the new technologies and new pattern for protection and utilization of black land. With the core demonstration bases, a number of radiation-type bases should be constructed to radiate to the surrounding counties and cities as a demonstration. The cooperative mechanism among the organizations for the popularization of agricultural technologies, research institutes, colleges and universities, and professional cooperatives should be established through guidance to enhance the efficiency of the agricultural technical service and speed up the transformation of the advanced technical achievements and application of new-type equipment. Control over the black land deterioration should be shifted to the centralized continuous mode from the scattered mode step by step through demonstration and guidance, so as

② It refers to Heilongjiang Province, Jilin Province, Liaoning Province and Inner Mongolia Autonomous Region.
to reach the rural level and county level from the demonstration base, and then achieve the long-range objective of reaching the provincial level.

4 Conclusion

Enhancement of the grain production capacity in the black land area depends on integrated management of the agricultural resource factors such as water, soil, seed, fertilizer, and pesticide. The grain yield can be stabilized and increased only by accurately identifying the soil quality and fertility improvement, supply of agricultural water resources, breeding of high-quality seeds, precise application of chemical fertilizers and pesticides, and the key scientific and technological issues involved in the maintenance of the ecological barrier function, controlling the scientific and technological innovation direction, and solving the problems systematically. In the new age, we should take scientific and technological innovation as guidance, aim at strengthening the nation with agricultural science and technology, and allow the nationwide advantageous scientific research institutes to play their respective roles. Especially, the multidisciplinary advantage of CAS should be taken to support the construction of agricultural modernization by protecting black land and optimizing the regional water resources and the ecological system healthcare, so as to safeguard the national food security, regional ecological security, and sustainable development.

References


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