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Construction and Practice of Transformation System of Scientific and Technological Achievements in Agriculture: A Case Study of Chinese Academy of Tropical Agricultural Sciences

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Abstract Accelerating the transformation of agricultural scientific and technological achievements is a key link in implementing innovation-driven development strategy and rural revitalization strategy, and improving development quality and core competitiveness. How to build a scientific and systematic transformation system of scientific and technological achievements and improve the overall management level of scientific and technological achievements transformation of agricultural scientific research institutes is one of the key tasks to measure how a scientific research institute supports industry and serves society. Taking the Chinese Academy of Tropical Agricultural Sciences as an example, this paper explores the construction and practice of its scientific and technological achievements transformation system since the 13th Five-Year Plan period. By arranging the current situation of resource elements for the transformation of scientific and technological achievements, analyzing the progress of the construction of the scientific and technological achievements transformation system, summarizing the practical results of the scientific and technological achievements transformation system, this paper puts forward 10 strategies and measures (implementing key projects for the transformation and application of scientific and technological achievements; striving to promote the transformation and application of on-duty scientific and technological achievements; accelerating the development and utilization of advantageous and characteristic resources; strengthening the use and protection of intellectual property rights; actively expanding cooperation activities between government, industry and research; increasing special financial support for the transformation of scientific and technological achievements; innovating state-owned asset management to accelerate scientific and technological development; piloting equity incentives to expand scientific and technological development channels to increase income; striving to create a relaxed environment for the transformation of scientific and technological achievements, effectively create scientific and technological value, enhance the development strength of the institute, and promote high-quality industrial development) in order to provide a useful reference for the transformation of scientific and technological achievements of agricultural research institutes.

Key words Scientific and technological achievements in agriculture, Transformation system, Construction, Practice, Chinese Academy of Tropical Agricultural Sciences

1 Introduction

The transformation and application of scientific and technological achievements is an important part of scientific and technological innovation[1]. Quickly promoting the transformation of agricultural scientific and technological achievements is the key link to implement the innovation-driven development strategy and rural revitalization strategy, and improve the development quality and core competitiveness. The 18th National Congress of the Communist Party of China put forward the innovation-driven development strategy, putting innovation at the core of the national development strategy; the 19th National Congress of the Communist Party of China put forward the strategy of rural revitalization and further strengthened the transformation of scientific and technological achievements in the agricultural field. The National People's Congress promulgated the newly revised the *Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements*, the State Council issued a *Notice on the Implementation of Some Provisions of the Law of the People's Republic of China on Promoting the Transformation of Scientific and Technological Achievements*, and issued the *Action Plan for Promoting the Transfer and Transformation of Scientific and Technological Achievements* and the *National Technology Transfer System Construction Plan*, to complete the "four steps" of the transformation of scientific and technological achievements and create a good institutional environment for the transformation of scientific and technological achievements[2]. How to establish a scientific and systematic transformation system of scientific and technological achievements and improve the overall management level of scientific and technological achievements transformation of agricultural research institutes has become a hot issue of general concern to people, which is also a key task to measure how a scientific research institute supports the industry and serves the society[3]. At present, there are some bottlenecks in the transformation of scientific and technological achievements in the majority of agricultural research institutes, such as unsmooth transformation chain of scientific and technological achievements, insufficient sharing of

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transformation information, incomplete transformation institutions, weak transformation talents, little role of transformation platform, insufficient experience in market-oriented operation of achievements, ineffective enterprise-led achievements transformation, little development and utilization of superior resources, and poor transformation and application of regional achievements[4]. As a national tropical agricultural research institution of the Ministry of Agriculture and Rural Affairs, the Chinese Academy of Tropical Agricultural Sciences has thoroughly implemented the "four orientations" for leading the development of science and technology in China in the new era since the 13th Five-Year Plan period, strived to shoulder the heavy responsibility of promoting the transformation and application of tropical agricultural scientific and technological achievements, actively explored the construction and application of scientific and technological achievements transformation system, and vigorously promoted the transformation of scientific and technological achievements and the development of superior resources, to effectively create scientific and technological value, enhance the development strength of the institute, and promote the high-quality development of the tropical agricultural industry[5].

2 Current status of resource elements for the transformation of scientific and technological achievements

During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences adhered to the problem orientation, goal orientation and result orientation, complied with the overall work plan of "strengthening force and expanding influence", strengthened the support of resource elements such as policies, institutions, platforms, teams and funds for the transformation of scientific and technological achievements, so as to provide guarantee for the transformation of scientific and technological achievements to release new potential, cultivate new kinetic energy and expand new space.

2.1 In terms of transformation policy identification During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences systematically sorted out and identified 98 laws, regulations and rules applicable to the transformation of scientific and technological achievements, including 12 laws and regulations, 48 rules and regulations (including 5 documents of the CPC Central Committee, 9 documents of the State Council, 16 documents of the Ministry of Science and Technology, 8 documents of the Ministry of Finance, 2 documents of the Ministry of Human Resources and Social Security, 5 documents of the Ministry of Agriculture and Rural Affairs, 3 documents of the State Intellectual Property Office and 38 local rules and regulations), providing a comprehensive policy basis for the transfer and transformation of scientific and technological achievements by the Chinese Academy of Tropical Agricultural Sciences in the new era.

2.2 In terms of the establishment of transformation institutions During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences strengthened the guidance and management of the transformation of scientific and technological achievements at the institute level. The responsible management department for the transformation of scientific and technological achievements is the Achievement Transformation Department of the Chinese Academy of Tropical Agricultural Sciences. All 14 affiliated units have set up achievement transformation offices (departments), and 2 affiliated units also have established industrial development management departments. There are 386 internal institutions in all units of the Academy, including 59 internal management institutions, 128 scientific research institutions, 128 development institutions, and 71 external institutions, in which the development institutions account for 33.16% of the internal institutions of the Academy.

2.3 In terms of transformation platform construction During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences increased investment in the construction of conditions for the transformation of scientific and technological achievements, and supported all units to carry out the construction of basic conditions such as platforms for the transformation of scientific and technological achievements and resource transformation. The Chinese Academy of Tropical Agricultural Sciences owns a land area of 4 533.33 ha; there are 140 national, provincial and ministerial science and technology platforms, including 65 science and technology innovation platforms, 58 achievement transformation platforms, and 17 international cooperation platforms, in which the science and technology transformation platforms account for 41.43% of the Academy's science and technology platforms. There are 4 self-built tropical botanical gardens, 2 science and technology expo parks and a number of resource transformation platforms such as Haikou Tropical Sciences Square.

2.4 In terms of transformation team configuration During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences increased the construction of talents for the transformation of scientific and technological achievements, and supported all units to improve the management of post setting, allocation, training, use and flow of talents for the transformation and application of scientific and technological achievements. As of the end of 2020, the Chinese Academy of Tropical Agricultural Sciences had 3 579 staff members, including 2 471 permanent staff members and 743 staff members outside the authorized personnel quota. There are 1 160 scientific and technological development personnel, including 105 in development management, 233 in achievement transformation, 77 in resource development, and 745 in business services, in which the scientific and technological development personnel account for 32.41% of the total number of people in the Academy.

2.5 In terms of transformation achievement reserves During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences increased the sustained and stable supply of scientific and technological achievements, broadened the sources of intellectual property achievements, and promoted the transformation and application of scientific and technological achievements of the Academy. During the 13th Five-Year Plan pe-

riod, the whole Academy reserved 4 139 scientific and technological achievements, including 640 scientific and technological achievements awarded at or above the provincial and ministerial level, 2 317 authorized valid patents, 186 approved varieties, 318 software copyrights, 176 key technologies and 502 R&D products, in which patents are the most, accounting for 55.98% of the reserved achievements.

2.6 In terms of transformation capital investment During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences increased capital investment in key scientific and technological achievements transformation projects, and supported all units to carry out scientific and technological activities such as integrated innovation of scientific and technological achievements, pilot test and achievement incubation. During the 13th Five-Year Plan period, the whole Academy invested 210.73 million yuan in scientific and technological achievements transformation projects, in which 49.38 million yuan was invested in financial scientific and technological achievements transformation projects, accounting for 23.43% of the total investment; 62.59 million yuan was invested in horizontal scientific and technological achievements transformation projects, accounting for 29.70% of the total investment; 98.76 million yuan was invested in self-owned scientific and technological achievements transformation projects, accounting for 46.87% of the total investment.

3 Progress in the construction of scientific and technological achievements transformation system

Since the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences has actively assumed the responsibility and mission of promoting the transformation and application of tropical agricultural scientific and technological achievements. In view of the new trends and characteristics of the transformation and application of scientific and technological achievements, it has vigorously promoted the construction of the transformation and application system of scientific and technological achievements, established a scientific and efficient long-term mechanism for the transformation and application of scientific and technological achievements, and accelerated the transformation of scientific and technological achievements and the development of superior resources. The whole Academy presents a good trend of transformation and application of scientific and technological achievements with "continuous improvement in capabilities, continuous improvement in scale, mid-to-high speed growth, and mid-to-high end quality and efficiency"[6].

3.1 Initially building a system for the transformation and application of scientific and technological achievements During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences closely followed the strategic needs of the national modern agricultural science and technology development and the responsibilities and missions of the new era, faced the main battlefield of economic and social construction in tropical areas, and started from all elements, whole process and whole chain of the transformation of tropical agricultural scientific and technological achievements to establish a scientific and systematic basic system for the transformation and application of scientific and technological achievements (including achievement transformation system, technology transfer system, resource transformation system and service system for agriculture, rural areas and farmers) and a support system (including organizational system, institutional system, operation system, incentive system, guarantee system and environmental system), and initially build an open, collaborative and efficient system for the transformation and application of scientific and technological achievements in institutes[7].

3.2 Integrating and innovating a number of scientific and technological achievements transformation systems During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences highlighted the integration and innovation of the transformation system of scientific and technological achievements, constantly optimized the transformation system environment, improved the transformation and application mechanism of scientific and technological achievements, created favorable conditions for the transformation of scientific and technological achievements, and better improved the transformation efficiency of scientific and technological achievements. It formulated and revised a total of 47 institutional plans for the transformation of scientific and technological achievements, including 3 strategic management documents, 20 business management documents, 16 platform management documents, and 8 business implementation plans, thereby improving the level of management in overall transformation and application of scientific and technological achievements of the Chinese Academy of Tropical Agricultural Sciences, mobilizing the enthusiasm of all units for the transformation and application of scientific and technological achievements, and stimulating the innovation and entrepreneurial vitality of scientific and technological personnel.

3.3 Actively exploring the transformation mode of modern scientific and technological achievements During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences actively explored a new mode of transformation and application of scientific and technological achievements around the pain points and difficulties of transformation of scientific and technological achievements, strived to open up the "last mile" transformation channel between scientific and technological achievements and industries, and continuously improved the efficiency and success rate of transformation of scientific and technological achievements. It innovatively proposed and applied the "four-chain" integration-based scientific and technological innovation model of policy chain, innovation chain, industrial chain, and talent chain, the "five-in-one" transformation and application model of science and technology + government + enterprise + finance + Internet, the "four-in-one" science and technology industry development model of results + resources + platform + enterprise, the "three-in-one" plant park development model of scientific research, development and tourism, the synchronous technol-

ogy transfer service model of marketization, networking, platformization, collaboration and internationalization, and the "four-wheel four-drive" technology transfer talent training model of demand, supply, system, environment, profession, curriculum, teaching, and management, in order to effectively promote the engineering-oriented conversion, productization and industrialization of scientific and technological achievements[8].

3.4 Optimizing and building a number of scientific and technological achievements transformation platforms During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences optimized and adjusted the existing platform for incubation and transformation of scientific and technological achievements in accordance with the construction plan of national science and technology innovation base, and promoted the construction of national, provincial and ministerial and academy-level technological innovation, achievement transformation and innovation service platforms, and played a leading and driving role in the transformation and application of scientific and technological achievements[9]. The Academy created 28 transfer and transformation platforms, such as the National Modern Agricultural Science and Technology Demonstration Base, the National Technology Transfer Talent Training Base, the Tropical Agricultural Technology Transfer Center, the Tropical High-Efficiency Agricultural Intellectual Property Achievement Transformation Platform, and the Tropical High-efficiency Agricultural High-Value Patent Cultivation Center. During the 13th Five-Year Plan period, the national, provincial and ministerial transformation platforms increased by 81.25%, effectively supporting the transfer and transformation of scientific and technological achievements of the Academy.

3.5 Continuously expanding various forms of transformation of scientific and technological achievements During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences strengthened the cooperation between colleges and universities, local governments and enterprises, between institutes, enterprises and industries, and realized the transformation from the original relatively single development and application of technological achievements to self-implementation, cooperative implementation, industry-university-research cooperation, achievement transfer, licensing, evaluation in terms of shares, business incubation and other forms of application, accelerating the deep integration of science and technology and economy, and accelerating the transformation of scientific and technological achievements into real productivity. During the 13th Five-Year Plan period, the whole Academy implemented a total of 1 944 transfers and transformations of scientific and technological achievements, including 14 transfers of achievements, 109 licenses, 12 evaluations in terms of shares and 1 809 industry-university-research collaborations, which effectively led the development direction of high-efficiency agricultural research and innovation with tropical characteristics.

3.6 Developing and launching a number of new scientific and technological products During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences vigorously strengthened the construction of pilot transformation bases for scientific research of agricultural products, vigorously promoted the research and development of tropical crop scientific and technological products, pilot test and market application of products, and successively developed 257 kinds of scientific and technological products such as new foods, new fertilizers, new materials and new equipment, 114 kinds of scientific and technological products on the market and 37 authorized new varieties. Science and technology support the creation of "small crops and big industries" and promote the market-oriented application of scientific and technological products of the Chinese Academy of Tropical Agricultural Sciences. Specialty products such as "Xingke" spicy beverage have improved people's quality of life; "Xiangfeng" electric rubber tapping knives have been widely used in major rubber-growing countries; a series of new varieties such as "Reyan" natural rubber, forage grass, "Huanan" cassava, "Zhongtang" sugarcane, "Renong" mango and "Wenye" coconut have become the leading varieties in the main planting area.

3.7 Developing and utilizing a number of advantageous and characteristic park resources During the 13th Five-Year Plan period, Chinese Academy of Tropical Agricultural Sciences gave full play to its advantages in biological resources, science and technology culture, built a "green bank", established an innovation alliance of tropical botanical gardens, expanded the market operation of four botanical gardens, including Xinglong Tropical Botanical Garden, Hainan Tropical Botanical Garden, Hainan Coconut Grand View Garden and Zhanjiang South Subtropical Botanical Garden, and carried out the construction and operation of three science and technology expo parks including Haikou Science and Technology Expo Park, Danzhou Science and Technology Expo Park, and Zhanjiang Science and Technology Expo Park. There are currently two 4A-level scenic spots and three 3A-level scenic spots. It focused on the construction of Haikou Innovation and Entrepreneurship Incubation Park and Scientific and Technological Achievements Transfer and Transformation Center, and launched the construction of Danzhou, Zhanjiang, Xinglong, and Sanya Innovation and Entrepreneurship Incubation Parks and Scientific and Technological Achievements Transfer and Transformation Centers to promote the interconnection and development and sharing of scientific and technological resources and markets.

3.8 Cultivating and strengthening a number of subjects for the transformation of scientific and technological achievements During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences promoted the gathering of innovative elements in institute-run enterprises, and focused on the new requirements of high-quality development of tropical agriculture. In nine industrial sectors, including scientific and technological services, modern tropical seed industry, high-tech agricultural materials, characteristic and efficient breeding, agricultural product processing, ecological agriculture, leisure agriculture, agricultural product circulation and health services, scientif-

ic and technological achievements were encouraged to to be invested in the establishment of scientific and technological enterprises, the innovation entities of the enterprises run by the institute were cultivated and strengthened to give full play to the main role of enterprises in technological innovation, enhance the transfer, transformation and absorption of scientific and technological achievements, and promote the deep integration of government-industry-university-research. At the end of the 13th Five-Year Plan period, there were 39 institute-run enterprises, an increase of 62.5% compared with 24 enterprises at the end of the 12th Five-Year Plan period, including 18 wholly-owned or holding enterprises in operation, and 21 shareholding enterprises; it strengthened the operation and management of institute-run enterprises, and improved the standardized management ability of enterprises. During the 13th Five-Year Plan period, two new national high-tech enterprises were added, and there are three national high-tech enterprises at present.

3.9 Gradually forming a high-end national science and technology service brand During the 13th Five-Year Plan period, professional and international services in research and development, technical training, technical consultation, inspection and testing, business incubation, and intellectual property rights of the Chinese Academy of Tropical Agricultural Sciences continued to expand, and high-end national science and technology service brands gradually formed. It organized and applied for the registration of 10 trademarks in 223 categories such as "Rekeyuan" and "Zhongrekeji", and initially built a academy-level trademark and brand system. It organized and launched the selection of the Academy's top ten brand products and transformation results, with 50 outstanding products and 8 provincial-level famous brand products selected for the China International High-tech Achievements Fair. It used science and technology to support the construction of more than 10 regional brands, including Wenchang coconut, Xinglong coffee, Panzhihua mango, Nujiang Amomum tsao-ko, Xuwen pineapple, and Danzhou chicken, enhancing the influence of the Chinese Academy of Tropical Agricultural Sciences on tropical industries.

4 Practical results of scientific and technological achievements transformation system

4.1 The development strength of the institute continues to increase During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences promoted the scientific and technological development vitality of all affiliated units through the construction, popularization and application of the scientific and technological achievements transformation and application system. Various businesses such as scientific and technological achievements transformation, resource transformation and scientific popularization developed well, improving the self-creation ability of the Chinese Academy of Tropical Agricultural Sciences, effectively realizing the scientific and technological value and enhancing the development strength of the institute. From the perspective of overall development strength, the total scientific and technological development income of Chinese Academy of Tropical Agricultural Sciences during the 13th Five-Year Plan period was 1.739 billion yuan, of which the institute's own income was 1.385 billion yuan, the enterprise's operating income was 354 million yuan, and the average annual scientific and technological development income was 348 million yuan, indicating that the overall development potential is relatively strong. From the perspective of self-creation ability, the self-owned income of the Chinese Academy of Tropical Agricultural Sciences in 2020 was 400 million yuan, accounting for 31.39% of the total income of the whole Academy (1.274 billion yuan), an increase of 14% over 2016. The self-creation ability was gradually enhanced, effectively making up for the lack of financial funds. From the perspective of development income growth rate, the scientific and technological development revenue of the Chinese Academy of Tropical Agricultural Sciences in 2020 was 475 million yuan, an increase of 78.28% from 266 million yuan in 2016, with an average annual growth rate of 19.57%. The average annual income created by scientific and technological developers in the Academy in 2020 was 409 700 yuan, an increase of 50.51% from 272 200 yuan in 2016, and the growth rate of development income was relatively high. From the perspective of development income structure, the accumulated scientific and technological development income of the Chinese Academy of Tropical Agricultural Sciences during the 13th Five-Year Plan period was 1.739 billion yuan, of which the achievement transformation income was 1.253 billion yuan, accounting for 72.05% of the scientific and technological development income; the resource conversion income was 132 million yuan, accounting for 7.59% of science and technology development income; the company's operating income was 354 million yuan, accounting for 20.36% of the scientific and technological development income. The development income structure is relatively reasonable.

4.2 The external influence of the institute continues to expand During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences strengthened its support for the agricultural industry in tropical areas through the popularization and application of scientific and technological achievements. New varieties, new technologies and new products basically covered the key areas of tropical agriculture and the whole industrial chain, and were affirmed by governments and departments at all levels and recognized by farmers in boosting poverty alleviation and rural revitalization through science and technology. The external visibility and influence of the Chinese Academy of Tropical Agricultural Sciences have been greatly improved.

First, the promotion and application of scientific and technological achievements is highly valued by national leaders. On April 13, 2018, General Secretary Xi Jinping pointed out at the celebration meeting commemorating the 30th anniversary of the establishment of Hainan Special Economic Zone that it is necessary to strengthen the construction of the National Southern Scientific Research and Breeding Base (Hainan), build a national tropical

agricultural science center, and support Hainan in building a global animal and plant germplasm resource introduction and transfer base. It is necessary to implement the rural revitalization strategy, give full play to the climate advantages of tropical regions, strengthen and optimize high-efficiency agriculture with tropical characteristics, build a national tropical modern agricultural base, and further launch the brand of tropical agricultural products in Hainan[10]. On May 8, 2021, Hu Chunhua, member of the Political Bureau of the CPC Central Committee and Vice Premier of the State Council, visited the Danzhou Branch of the Chinese Academy of Tropical Agricultural Sciences to inspect the seed industry, and fully affirmed the research and development and promotion of new varieties and applicable machinery such as natural rubber of the Chinese Academy of Tropical Agricultural Sciences, emphasizing that germplasm source security should be placed at a strategic height related to national security, a solid job should be done in the survey, protection and utilization of germplasm resources, to lay a solid foundation for the seed industry to bring about an upswing.

Second, the promotion and application of scientific and technological achievements has received positive instructions from provincial and ministerial leaders. During the 13th Five-Year Plan period, the role of Chinese Academy of Tropical Agricultural Sciences in promoting rural revitalization in Hainan Province received affirmative instructions from Deputy Secretary Li Jun of Hainan Provincial Party Committee; the use of science and technology by the Chinese Academy of Tropical Agricultural Sciences to promote the development of mango industry in Panzhihua was affirmatively approved by the Ministry of Agriculture and Rural Affairs; suggestions such as the use of science and technology by the Chinese Academy of Tropical Agricultural Sciences to promote the development of Hainan's "Three Trees" industry were affirmatively approved by then Governor Shen Xiaoming and Vice Governor Liu Pingzhi of Hainan Province; supporting the Chinese Academy of Tropical Agricultural Sciences to build an intellectual property service industry cluster received positive instructions from Vice Governor Shen Danyang of Hainan Province.

Third, the promotion and application of scientific and technological achievements has been commended at the national, provincial and ministerial levels. During the 13th Five-Year Plan period, the Chinese Academy of Tropical Agricultural Sciences organized and implemented the work of science and technology commissioners, and as the only national agricultural scientific research institution, it was commended as role model by the Ministry of Science and Technology; the poverty alleviation model of Panzhihua mango and Nujiang Amomum tsao-ko industry promoted by science and technology was included in "the second batch of typical examples of industrial poverty alleviation in China" by the Ministry of Agriculture and Rural Affairs and the Poverty Alleviation Office of the State Council[11]. Chinese Academy of Tropical Agricultural Sciences won the Excellent Organization Award at 2018 National New Farmers and New Technology Entrepreneurship and Innovation Expo, the Excellent Organization Award at 2019 China International High-tech Fair, and the Excellent Organization Unit at Hainan Science and Technology Activity Month for five consecutive years.

5 Strategies to promote the transformation of scientific and technological achievements

5.1 Implementing key projects for the transformation and application of scientific and technological achievements It is necessary to establish and improve the organizational mechanism for the transformation of scientific and technological achievements, and ensure the implementation of key tasks for promoting the transformation and application of scientific and technological achievements. It is necessary to take into account the characteristics and advantages of the transformation of scientific and technological achievements of the Chinese Academy of Tropical Agricultural Sciences and strive to promote key projects of transformation and application of scientific and technological achievements. The first is the "Ten Million Yuan Level Achievement Transformation Project". It is necessary to focus on building 10 national-level service platforms for technological innovation, achievement transformation and incubation, focusing on transforming more than 100 new varieties, new technologies, new products, new materials, new devices, new systems and new models with high application technology content and good market prospects, and carrying out more than 1 000 government-industry-university-research cooperation projects in demonstration, pilot test and transformation, industrial development and innovation and entrepreneurship in various ways. The second is the "Three Hundred Science and Technology Service Action". It is necessary to promote 100 experts to contact or enter 100 villages, promote 100 new varieties, new technologies and new models, and build 100 rural revitalization science and technology demonstration sites.

5.2 Focusing on promoting the transformation and application of on-duty scientific and technological achievements It is necessary to establish and improve the empowerment mechanism for the transformation of scientific and technological achievements, and clearly define the ownership, use, disposal and income rights in the transformation of scientific and technological achievements. For the on-duty scientific and technological achievements that have obtained authorized patents, varieties, *etc.*, the affiliated units of the Academy should organize the confirmation of the achievements and rights, and independently decide to carry out transfer and transformation activities by means of transfer, licensing, cooperation or investment. Except for those involving state secrets and national security, no approval is required[12]. It is necessary to grant the achievement completer the right to use the achievement and implement the transformation, so as to promote the rapid transfer and transformation of the achievement; if the person who completed the achievement fails to organize the implementation of the transformation for more than one year without justifiable reasons, the right to use the achievement shall be transferred to the affiliated unit to carry out the implementation of transformation; if the

affiliated units and the person who has completed scientific and technological achievements fail to organize and implement the transformation for more than 2 years without justifiable reasons, the right to use the achievements will be transferred to the Academy to coordinate the implementation of transformation, and the affiliated units shall support and cooperate. The right to income from transformation should be allocated in combination with the ownership and use rights of achievements.

5.3 Accelerating the development and utilization of advantageous and characteristic resources It is necessary to establish and improve the asset transformation empowerment mechanism, and clearly define the ownership, use right, disposal right and income right of asset transformation[12]. It is necessary to speed up the construction of 18 tropical agricultural achievements transformation bases of the Academy, rely on the distinctive and advantageous resources of the transformation bases, carry out cooperative operations in various ways, develop and expand the "green bank" in the botanical garden area, cultivate and expand the "smoke-free factory" for scientific and technological training, consulting planning, inspection and testing, certification and evaluation, intellectual property services, and speed up the construction of an open scientific and technological achievements transfer and transformation center and a pilot base for the transformation of scientific and technological achievements. If the affiliated units fail to organize and implement development for more than 2 years without justifiable reasons, resulting in idle resources, the Academy shall make overall plans to carry out external investment and development, and the affiliated units shall give support and cooperate in resource development activities. The right to income from transformation should be allocated in combination with the ownership and use rights of achievements.

5.4 Strengthening the application and protection of intellectual property rights It is necessary to establish a unified disclosure and pre-application evaluation mechanism for on-duty inventions by the Academy, build a market-oriented, professional and full-chain technology transfer center and a platform for the transformation of intellectual property achievements of the Academy, strengthen the mining and layout of high-value intellectual property rights, increase the screening, promotion, trading and protection of technological achievements, smooth the channels for realizing the value of intellectual property rights, transform and apply a number of advanced and practical new varieties, new technologies, new products, new materials, new equipment and new models, and promote the engineering-oriented conversion and industrialization of scientific and technological achievements[13]. It is necessary to strengthen the standardized use and protection of unit names and logos to ensure the continuous improvement of value in the process of promotion and dissemination; efforts should be made to select brands of science and technology products with independent intellectual property rights, cultivate brands of science and technology enterprises with core competitiveness, and build highly attractive agricultural tourism brands.

5.5 Actively expanding government-industry-university-research cooperation activities It is necessary to establish and improve the win-win linkage mechanism of government-industry-university-research cooperation, and strengthen the cooperation between institutes, local government and enterprises. It is necessary to give full play to the resource advantages of institutes in technology, talents, scientific research platforms, *etc.*, actively carry out normalized connection activities with the government, industries and enterprises, speed up the introduction of good resources, and carry out government-industry-university-research cooperation projects such as technology development and technical services; it is necessary to actively carry out joint construction of new R&D institutions, engineering research centers, industrial technology innovation alliances, scientific and technological achievement pilot bases and other R&D organizations and achievement transformation platforms with enterprises; it is necessary to actively participate in local co-construction of agricultural science and technology parks, modern industrial parks, science and technology valleys, characteristic towns, business incubators, creative spaces and other entrepreneurial incubation bases that serve the transfer and transformation of scientific and technological achievements.

5.6 Increasing special financial support for the transformation of scientific and technological achievements It is necessary to establish and improve the diversified investment mechanism for the transformation of scientific and technological achievements, and effectively ensure the smooth development of achievement transformation and application activities. It is necessary to implement the tropical agricultural achievement transformation project, increase the capital investment in achievement transformation and application projects, give full play to the guiding role of the Academy's achievement transformation funds, and support the units directly under the Academy and its affiliated units to implement scientific and technological achievement transformation, brand creation and industrialization projects. It is necessary to encourage affiliated units to set up special funds for the transformation of scientific and technological achievements to support the transformation and application of scientific and technological achievements. It is necessary to actively attract and support angel investment institutions, venture capital institutions and institutes to jointly set up industrial investment funds, and speed up the formation of large-scale scientific and technological achievements transformation fund groups, to accurately invest in scientific and technological achievement transformation projects with obvious competitive advantages and clear market application prospects.

5.7 Innovating state-owned assets management and accelerating scientific and technological development It is necessary to establish and improve the transformation decision-making mechanism of "the owner making decisions and taking responsibilities" to accelerate the transformation and application of achievements[14]. Scientific and technological achievements should be evaluated based on market application, and we can independently

decide whether to conduct asset evaluation or pre-listing pricing. The scientific and technological achievements and state-owned assets owned by the affiliated units of the Academy should be given priority to the transformation and industrialization of scientific and technological achievements in the enterprises run by the institutes. Instruments and equipment and pilot test facilities related to scientific and technological achievements can be operated independently, implemented in cooperation, leased, lent or invested in scientific and technological achievements transformation entities, experimental bases and botanical gardens related to scientific and technological achievements can be operated independently or implemented in cooperation with scientific and technological achievements transformation entities, and intangible assets such as trademarks can be invested in scientific and technological achievements transformation entities.

5.8 Promoting equity incentives on a pilot basis to strengthen the technology industry It is necessary to establish and improve the decision-making, execution and supervision mechanism of institute-run enterprises, improve the corporate governance structure, and make institute-run enterprises bigger and stronger. In principle, for enterprises run by the institute, members of the unit's leadership team must be selected to serve as senior executives (except for the main leader of unit serving as the legal representative). It is necessary to actively cultivate institute-run enterprises to enter multi-level capital markets such as the regional equity market. Staff should be encouraged to engage in the transformation of scientific and technological achievements in institute-run enterprises, and incentives such as income dividends and post dividends should be negotiated and distributed by individuals and units. It is necessary to encourage staff with scientific and technological achievements to set up scientific and technological enterprises in the form of shares or capital contribution, and individuals and units can jointly hold the equity of enterprises. It is necessary to encourage the adoption of equity sales, equity awards, equity options, *etc.* to implement equity incentives for technical backbones and management executives of scientific and technological enterprises affiliated to the Academy[15].

5.9 Striving to expand scientific and technological development channels to increase income It is necessary to establish and improve the reward and recognition mechanism for the development income and the transformation of scientific and technological achievements, and stimulate the enthusiasm of staff for the transformation and application of scientific and technological achievements. It is necessary to strengthen the marketing planning of scientific and technological development business activities, expand the unit's scientific and technological development income through multiple channels, expand the special funds set up by the state and local governments for venture capital guidance, scientific and technological achievements transformation, intellectual property operation and fund income from government purchase of service projects such as open technology promotion and technological innovation vouchers[16], expand the transformation income from achievement licensing and transfer, industry-university-research cooperation income, expand the income from self-transformation of trial-produced products and other results, expand the income from resource development such as land, equipment and facilities, housing leasing, and biological resource development, expand the operating income of enterprises, and property services, and strive to reach the goal of 200 000 yuan/(year · person) in the 14th Five-Year Plan period.

5.10 Striving to create a relaxed environment for the transformation of scientific and technological achievements It is necessary to establish a reward and punishment mechanism for transformation and application oriented by "target management, quantitative assessment, performance-based reward and punishment", and increase collective and individual commendation and incentives for the transformation of scientific and technological achievements[17]. It is necessary to study national and regional development strategies and policies such as Hainan Free Trade Port, and create a development environment and space for the transformation and application of achievements. It is necessary to establish a due diligence, exemption and supervision mechanism for decision-making, information disclosure, supervision and management, and exempt those who carry out scientific and technological achievements transformation activities without seeking illegal benefits from the decision-making responsibility arising from the subsequent value change caused by scientific and technological achievements transformation in the pricing of scientific and technological achievements[18]. For those who use scientific and technological achievements to carry out transformation activities for investment, have fulfilled their obligations of diligence and have not sought illegal benefits and still incurred investment losses, they will not be included in the scope of assessment of the value preservation and increase of the unit's state-owned assets after investment, and the assets will be disposed of in accordance with relevant regulations.

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timize the geometric parameters and material selection of brackets to cope with complex wind environments.

Combining these two algorithms, a hybrid optimization strategy can be formed, which makes full use of the global search ability of genetic algorithm and the local search ability of particle swarm optimization, thus improving the optimization efficiency and the reliability of the results. This intelligent optimization method can not only reduce material costs, but also improve the safety and durability of the bracket, providing guarantee for the stable operation of photovoltaic power stations in mountainous areas.

6 Conclusion

This study explores the design optimization strategies of solar photovoltaic brackets under complex wind environment conditions in mountainous areas, aiming to propose a series of design optimization schemes aimed at enhancing the wind resistance of brackets through systematic analysis and practical innovation. The core of the research is to reveal the key role of optimizing the structural layout of the bracket and rationally selecting materials in improving its stability and economy, as well as multi-objective optimization models and intelligent optimization algorithms to comprehensively improve the performance of solar photovoltaic brackets.

Looking forward to the future, there are still many directions worthy of further exploration in this research field. First of all, with the continuous progress of materials science, new lightweight and high-strength materials such as composite materials and nanomaterials have great application potential in the field of photovoltaic brackets, and their research and application are expected to further promote the double leap of bracket performance and cost-effectiveness. Secondly, strengthening the refined simulation and analysis of photovoltaic brackets in dynamic wind environments, combined with advanced wind engineering experimental technology, can more accurately predict and respond to extreme wind loads and ensure the safe and reliable operation of the brackets.

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