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Opening and Sharing of Large-scale Instruments and Equipment in Agricultural Research Institutes: A Case Study of Environment and Plant Protection Institute of Chinese Academy of Tropical Agricultural Sciences

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Abstract The article introduces the main practices and achievements of the Environment and Plant Protection Institute of Chinese Academy of Tropical Agricultural Sciences in promoting the sharing of large-scale instruments and equipment in recent years, analyzes the existing problems in the management system, management team, assessment incentives and maintenance guarantee, and proposes improvement measures and suggestions from aspects of improving the sharing management system, strengthening management team building, strengthening sharing assessment and incentives, improving maintenance capabilities and expanding external publicity, to further improve the sharing management of large-scale instruments and equipment.

Key words Agricultural scientific research institution, Large-scale instrument and equipment, Opening and sharing, Existing problem, Suggestion

1 Introduction

Large-scale scientific instruments are the technical basis and important means for carrying out agricultural scientific research, exploring and discovering the laws of agricultural science, achieving breakthroughs in major key technologies, and serving agricultural development[1-2]. In recent years, as China's investment in science and technology has continued to increase, the scale of scientific research facilities and instruments of agricultural scientific research institutions has continued to grow, and the technical level has been significantly improved. However, the problem of low utilization and low sharing level of large-scale instruments and equipment has gradually emerged at the same time. There are also many problems such as scattered resources, repeated purchases, closed management, inefficient use, and poor professional service capabilities[3]. Therefore, the State Council, the Ministry of Science and Technology, the Development and Reform Commission, the Ministry of Finance, the General Administration of Customs and other ministries and commissions and various local governments have successively introduced a series of related policies and management measures to promote the institutionalization of the opening and sharing of large-scale scientific research instruments and facilities, with a view to improving resource utilization and sharing level. In 2015, the State Council issued the *Opinions on the Opening of National Major Scientific Research Infrastructure and Large-scale Scientific Research Instruments to the Society* (Guo Fa [2014] No. 70). It is required that scientific and technological resources such as major national scientific research infrastructure and large-scale scientific research instruments and equipment are accelerated to the society, the level of opening and sharing services is improved by strengthening the construction of opening and sharing mechanism, and the utilization of resources is further improved, making the opening and sharing work of large-scale scientific research equipment and facilities enter the stage of institutionalization[4]. In 2017, the Ministry of Science and Technology, the National Development and Reform Commission, and the Ministry of Finance jointly promulgated the *Administrative Measures for the Opening and Sharing of National Major Scientific Research Infrastructure and Large-scale Scientific Research Instruments* (Guo Ke Fa Ji [2017] No. 289), which further regulated the opening and sharing management work of central-level research and development institutions and colleges and universities[5]. In 2018, the Ministry of Science and Technology and the Ministry of Finance jointly formulated the *Administrative Measures for the National Science and Technology Resource Sharing Service Platform* (Guo Ke Fa Ji [2018] No. 48), to standardize the management of the national science and technology resource sharing service platform, promote the opening and sharing of science and technology resources to the society, and improve resource utilization efficiency[6]. In the same year, the Ministry of Science and Technology and the General Administration of Customs also formulated the *Administrative Measures for the Opening and Sharing of Duty-Free Imported Scientific Research Instruments and Equipment Included in the National Network Management Platform* (Trial) (Guo Ke Fa Ji [2018] No. 245) to promote the unified management of the inclusion in the national network management platform and the open-

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ing and sharing of duty-free imported scientific research instruments and equipment that enjoy the import tax policy of scientific and technological innovation[7]. In this article, taking the Environment and Plant Protection Institute of Chinese Academy of Tropical Agricultural Sciences as the example, the practices and achievements of implementing relevant national and local documents and promoting the sharing of large-scale instruments and equipment in recent years are introduced, the existing problems are analyzed, and suggestions for improvement are put forward, so as to provide reference for strengthening the sharing of large-scale equipment in agricultural research institutes.

2 Main practices and achievements

In order to implement the *National Medium and Long-term Science and Technology Development Plan Outline* (2006 – 2020), the central treasury established the Special Fund for the Purchase and Repair of Central-level Scientific Institutions (hereinafter referred to as the "Special Fund for Repair and Purchase"). With the strong support of the central government and the Special Fund for Purchase and Repair, based on functional positioning and advantages and characteristics, focusing on the major demand for plant protection and environmental protection of agriculture in tropical areas, with the enhancement of technological innovation capabilities as the core, overall plans are made for technological innovation platform. By making full use of the investment channels such as the Special Fund for Purchase and Repair and basic construction and scientific research projects, in accordance with the principle of "sharing, opening and collaboration", a public laboratory and large-scale equipment sharing system with clear positioning and reasonable layout is established, thereby solidly promoting the construction of scientific research conditions and earnestly serving the main responsibility of scientific and technological innovation.

2.1 Sharing goals and ideas Surrounding the goal of building a "first-class tropical environment and plant protection scientific and technological innovation center", based on the principle of "sharing, opening and collaboration", two basic sharing modes: "complete sharing within the institute" and "selective sharing within the academy, within the subject area and within the region" have been constructed. It has actively carried out co-construction and sharing exploration from multiple levels, including the unit, the unit's relatively concentrated area, subject area, industry and department. A management system centered on the sharing mechanism has been established and improved. Large-scale instruments and equipment with sharing conditions are included into the sharing management system. On the basis of ensuring the full implementation of sharing within the Environmental and Plant Protection Institute, large-scale instruments are classified and shared in the whole academy and within the region.

2.2 Sharing foundation The existing equipment assets of the Environmental and Plant Protection Institute are more than 78 million yuan, and there are more than 3 000 sets of various instruments and equipment, including 134 sets of instruments and equipment above 100 000 yuan (worth more than 46 million yuan) and 21 sets of instruments and equipment above 500 000 yuan (worth 25.11 million yuan). During the Twelfth Five-Year Plan period, focus was placed on strengthening the construction of specialized laboratories. In order to meet the management needs of a large number of large-scale scientific research equipment purchased centrally and improve the level of service and sharing, open and shared public laboratories are established, including microscope laboratory, analysis and testing room, molecular biology laboratory, insect breeding room, tissue culture room, artificial climate chamber, sterilization and shaker room, environmental behavior laboratory and environmental toxicology laboratory.

2.3 Sharing measures

2.3.1 Establishing a sharing center. In order to give full play to the benefits of instruments and equipment and improve equipment utilization, in accordance with the principle of "sharing, opening and coordination", the equipment sharing center of the Environment and Plant Protection Institute is established, and all existing instruments and equipment worth more than 50 000 yuan are included into the sharing center. There are management office and expert group under the sharing center. The management office is linked to the base and condition construction department. It is composed of director, deputy director and full-time management personnel. The expert group is composed of more than 20 experts who are proficient in various instruments and equipment in the institute. The large-scale instruments and equipment purchased from various channels are centralized in the open and shared laboratory, managed centralizedly and arranged unifiedly for use. At present, multiple technology platforms such as analysis and detection, microscopic observation, genomics, and proteomics have been built. A series of management systems, including *Administrative Measures for the Public Laboratory of the Environment and Plant Protection Institute*, *The Measures for the Management of Instruments and Equipment of the Environment and Plant Protection Institute*, *The Measures for the Management of the Instruments and Equipment Sharing Center of the Environment and Plant Protection Institute*, *The Management Staff Composition and Management Measures for the Classification of Instruments and Equipment in the Sharing Center of the Environment and Plant Protection Institute and Management Measures for the Sharing of Large-scale Instruments and Equipment of the Environment and Plant Protection Institute*, *Chinese Academy of Tropical Agricultural Sciences* (Trial) are formulated to standardize the management of the sharing center.

2.3.2 Establishing a network management platform. A large-scale equipment sharing center platform management website is established. According to the relevant information, instruments and equipment are included into the website, and subjected to classification and sharing. First, the instruments and equipment more than 50 000 yuan are shared on the sharing management system website to realize the sharing within the whole institute. Second, large-scale instruments and equipment of more than 200 000 yuan

are included into the sharing network of the Chinese Academy of Tropical Agricultural Sciences and shared with brother units throughout the academy. Third, instruments and equipment worth more than 500 000 yuan are included into the Hainan Large-scale Scientific Instrument Collaboration and Sharing Network to realize sharing within the region. Managers register their personal accounts on the appointment platform of the large-scale instrument and equipment sharing center of the Chinese Academy of Tropical Agricultural Sciences and the instrument and equipment management system of the sharing center of the Environment and Plant Protection Institute, and through the sharing center platform, the technical indicators, main functions, service areas, charging standards and other information of the managed instruments and equipment are updated timely. An open plan is formulated. According to the appointment (manual appointment and online appointment), appointments are arranged to use in time, greatly facilitating the use of large-scale instruments by scientific and technical personnel inside and outside the institute.

2.3.3 Building a full-time and part-time management team. Five full-time managers responsible for the sharing of large-scale instruments and equipment throughout the institute are equipped. A classification management plan for large-scale instruments and equipment is developed. Large-scale instruments and equipment are divided into five types of professional equipment, including microscopic observation equipment, microbiology and molecular biology equipment, entomology research equipment, storage and preservation research equipment, and analysis and testing equipment. A full-time person in charge and 3 – 4 part-time equipment management experts are arranged for each type of equipment, further improving the utilization rate and use efficiency, strengthening the refined management, and giving full play to the role of large-scale instruments and equipment in scientific and technological innovation.

2.3.4 Carrying out use approval and computer operation certificate review. To ensure the normal operation and reduce the failure rate of the instruments and equipment, the use of all equipment is subject to approval procedure. The user makes an application and is allowed to use the instruments and equipment only after the approval of the management personnel and the conformance of independent operation. At the same time, according to the function and operating difficulty, the instruments and equipment are divided into three types: equipment with simple operation is operated independently by the applicant, equipment with more complicated operation is operated jointly by the applicant and management personnel, and large and precious precision instruments such as transmission electron microscopes are operated by the management personnel. After use, the user, use time and equipment operation information are recorded in the equipment use register in a timely manner.

2.3.5 Strengthening external relations. The sharing center establishes a large-scale equipment sharing center website, prepares various brochures such as large-scale equipment brochures, microscope center shared equipment brochures, instrument and equipment use technical manuals, and regularly holds equipment use training classes and experimental technology exchange seminars to provide various materials, information and technology exchange platforms for large-scale instruments and equipment to brother units in the academy, relevant universities, scientific research units and enterprises in Hainan Province. Thus, the visibility of the sharing center is increased, a large number of scientific and technological personnel of scientific research units, scientific research and enterprise units are attracted to come to use the instruments and equipment, and the use efficiency of the instruments and equipment is improved.

2.4 Sharing effect The establishment of the sharing center of the Environment and Plant Protection Institute has realized the dynamic management, promoted the shared use and improved the efficiency of the use of large-scale instruments and equipment, and effectively supported the external technological innovation service capabilities. Opening to the outside world has been quite effective in recent years. Among them, the sharing platform of microscopic observation equipment, dominated by transmission electron microscope and laser confocal microscope, has the most effective external sharing. In 2018 alone, the number of samples completed by the transmission electron microscope was 530, and the use time was 1 050.5 h. The ultrastructure of rubber leaves and somatic embryos, the ultrastructure of bougainvillea leaves, and the anther structure of cassava have been observed. More than 20 related papers have been published and 5 national patents have been applied. The sharing center provides technical support for the smooth scientific research carried out by relevant scientific research institutes or enterprises, promotes mutual communication and learning between units, increases the utilization rate of the instruments and equipment and achieves the goal of maximizing social benefits.

3 Problems in sharing work

A total of 21 sets of instruments have been incorporated into the national large-scale instrument sharing platform. The open rate reaches 100%, but the overall utilization rate is 65.0%, still lower than the national average of 72.3%[8]. In addition, the sharing management system needs to be improved, the scale and quality of the support team needs to be improved, the incentive responsibilities are not perfect, the professional service level needs to be improved, and the service and support role of large-scale instruments and equipment for scientific and technological innovation has not been fully brought into play.

3.1 The sharing management mechanism needs to be improved Although some sharing management systems and methods have been formulated to standardize the management of the sharing center, there are still some imperfections. First, a scientific and reasonable sharing fee system has not been established. The current charge is to account for the cost of reagents and consumables and utilities for the operation of shared instruments and equipment. This method only considers the direct cost of reagents and

consumables, and indirect expenses such as maintenance fees for large-scale instruments and equipment, technical training fees for management personnel, and performance rewards have not been considered, nor have it clearly stipulated how the fees collected are used. Second, no intellectual property rights and confidentiality management systems have been established. The shared use logo is not clear. It is also unable to effectively protect user information and all intellectual property rights, data and technical secrets formed during use. Third, the management personnel introduction and training system is not sound. Affected by the existing personnel system and title system of scientific research institutes, the sharing center not only has no indicators for the introduction of professionals, and the existing management personnel are also affected in terms of salary and promotion.

3.2 The number of managers is small and the quality is not high, and there is a lack of professional experimental technical personnel The management of large-scale instruments and equipment requires a professional management team with rich experience, high level and certain stability[9]. In recent years, with the increase in the shared resources of scientific research equipment, the expansion of the scope of sharing and the deepening of the sharing level, higher requirements have been put forward on the number, professionalism, stability and management mode of the talent team. There are only 5 full-time management staff in the Environment and Plant Protection Institute. In addition to large-scale high-end equipment such as transmission electron microscope, which are managed by dedicated personnel, other equipment is managed by one person, or managed by part-time personnel. Basically, none of these managers have professional backgrounds related to instruments and equipment. Most of them are only familiar with the operation and use of the instruments and equipment. They are incapable of equipment maintenance and function expansion, let alone maintaining, repairing and giving full play to the effectiveness of the instruments and equipment[2].

3.3 Incentives for managers are incomplete A management staff post evaluation mechanism has not been established and carried out in the sharing center of the Environment and Plant Protection Institute. As a result, managers' work performance and performance goals are not clear, and their workload has no direct relationship with year-end appraisal and personal performance pay. Therefore, it is difficult to fully mobilize the enthusiasm of managers. In addition, under the existing professional title evaluation system, the professional title evaluation of full-time equipment management personnel is greatly affected, and it is difficult to have room for improvement, affecting the enthusiasm of managers and the stability of the management team. Furthermore, part-timers are not very enthusiastic about participating in sharing services due to lack of corresponding incentives and fear of affecting the progress of their scientific research projects.

3.4 There is a lack of special funds for operation and maintenance of large-scale instruments and equipment The operation of instruments and equipment requires a certain maintenance cost. In particular, the maintenance cost of some large-scale instruments and equipment is higher. However, most of the existing national and provincial financial research projects at all levels only consider the direct expenditures such as the purchase of instruments and equipment and fuel and power, and do not consider the maintenance costs. Although the Environment and Plant Protection Institute has applied for some major facility operating fees through the Ministry of Agriculture and Rural Affairs, the proportion of expenses involved in the maintenance of instruments and equipment is very low. At the same time, a sharing charge system is adopted, but it only charges operating costs such as consumables and fuel and power fees. The above cost can only solve some small daily maintenance. Once the valuable parts are damaged, it cannot be solved in time and effectively, affecting the normal use and opening and sharing of large-scale instruments and equipment.

4 Measures and suggestions

Large-scale instruments and equipment have the characteristics of commonality and scarcity, *etc.* They are state-owned resources occupied and used by the units. Promoting the opening and sharing of large-scale instruments and equipment to the society can improve the utilization of large-scale instruments and equipment and fully release the service potential[10]. In the new situation, in order to fully guarantee the good operation and opening and sharing of large-scale instruments and equipment, combined with the aforementioned problems, improvement measures should be taken to improve the management system, strengthen the construction of the management team, strengthen the sharing assessment and rewards, improve maintenance and support capabilities, and strengthen publicity, to further improve the level of opening and sharing service capabilities and provide technical support for the construction of first-class scientific research institutes.

4.1 Improving the sharing management system and improving the level of scientific management First, a scientific and reasonable fee management system needs to be developed. According to the principle of cost compensation and non-profit, comprehensively considering the costs of materials, water and electricity, maintenance service fees, technical training fees, travel expenses, and expenses on rewards and performance management staff required for the operation and management of instruments and equipment, a charging and distribution system for paid services of shared instruments and equipment is developed. Second, intellectual property right and confidentiality management system needs to be formulated. The protection of user information and the rights and interests of intellectual property rights, scientific data and technical secrets formed in the process of use should be strengthened. The logo of sharing use is cleared. The rights and interests of large-scale instrument and equipment owners, users and service providers are cleared and effectively protected. Third, the existing talent introduction, training and management system should be reformed. The sharing center will be managed as a research unit in the institute. Preferential support will be provided to it in terms of

talent introduction, training and use, *etc.* The same treatment shall be given to it in terms of professional title review, assessment and evaluation, and distribution of rewards.

4.2 Strengthening management team building and improving professional service level First, the training of existing personnel should be strengthened. Through professional skills training for management personnel in the use, repair and maintenance of large-scale instruments and equipment, selecting and sending personnel for further study in counterpart scientific research institutions and professional institutions at home and abroad and carrying out advanced business knowledge and laboratory management skills learning and foreign language learning, the professional skills and management level of existing managers will be improved continuously. Second, high-level professional and technical personnel are recommended to be introduced. By introducing talents with higher academic qualification and higher professional level, a technical team is set up around each large-scale instrument or equipment. While satisfying daily inspection service and maintenance management, new functions are utilized and explored constantly, and utilization of instruments and equipment is improved. Third, a professional maintenance team should be established. A capable maintenance service team should be established. Through measures such as training of knowledge and skills of equipment maintenance and repair for managers, the level of daily maintenance and repair will be improved continuously. On this basis, a technical service collaboration network is established with the maintenance forces of brother units in the institute and scientific research units outside the institute to continuously improve the ability and level of maintenance services. Fourth, cooperation and exchanges with universities and research institutes should be strengthened. By carrying out technical cooperation research and exchanges in related fields, the levels of sharing and opening, experimental technology, functional development and management and maintenance will be improved continuously[1].

4.3 Strengthening sharing assessment and incentives to fully mobilize staff's enthusiasm for work First, an instrument and equipment benefit evaluation, sharing assessment and incentive mechanism should be established. According to the classification of different equipment managers, the job responsibilities of managers are set. The indicators such as equipment usage time, sharing service status, function utilization and development, service revenue, equipment operation and maintenance status, *etc.* are evaluated comprehensively. Performance appraisal is carried out regularly, focusing on assessing the quantity and quality of services, and the results of the appraisal are linked with the evaluation results, reward performance and service income distribution[11]. Second, the enthusiasm of various management personnel needs to be fully mobilized. For full-time managers, their career development space can be broadened by opening up individual title review channel for instrument and equipment managers or establishing an "internal certification" type title promotion system. For part-time managers, scientific income distribution method is formulated. According to the quality and quantity of sharing services, corresponding rewards are given to stimulate the motivation of existing personnel and attract outstanding talents to participate[12-13]. Third, managers are encouraged to engage in relevant technological innovations. Support will be provided to management personnel for their declaring and undertaking related scientific research projects, undertaking horizontal service business, publishing academic papers and applying for patents and other scientific research activities. Same reward is given to scientific research personnel to enhance their sense of belonging and acquisition, and stimulate their enthusiasm for scientific and technological innovation in equipment management.

4.4 Taking multiple measures simultaneously to improve maintenance and support capabilities First, special funds should be set up. At the national level, it is recommended to set up special funds for maintenance and repair of large-scale instruments and equipment. It may also stipulate that equipment operation and maintenance costs shall be separately listed in the direct funding of scientific research projects to ensure the normal operation of large-scale instruments and equipment and the orderly progress of opening and sharing work. At the local level, special funds for opening and sharing of large-scale instruments and equipment can be established. Appropriate proportions of test subsidies and operating subsidies are given to users and service providers who use shared instruments and equipment. It is also possible to issue scientific and technological innovation coupons and other measures to encourage local small, medium and micro enterprises and innovation teams to use the shared platform resources to carry out technological innovation. While stimulating the innovation vitality of small, medium and micro enterprises, the revenue of the sharing center will be increased[14]. Second, a shared fund should be established. Large-scale instrument and equipment management units can create rolling income fund from the paid fees obtained from the sharing services, mainly used for the operation, maintenance and updating of instruments and equipment. Part of it can also be used to reward the management personnel of the sharing center[12]. Third, existing policies can be utilize rationally. At present, indirect expenses are set in the funds of competitive scientific research projects at the national and local levels, mainly used for unit management indirect cost expenditure and undertaking project scientific research personnel performance expenditure. Therefore, a certain percentage of funds can be extracted from indirect costs for the operation and maintenance of large-scale instruments and equipment. Post-subsidy can also be applied in accordance with local policies such as the *Management Measures for the Cooperation and Sharing Platform of Large-scale Scientific Instruments in Hainan* (Trial) for the operation, maintenance, repair, function development, upgrading and transformation of instruments and equipment and technical business training of personnel[15]. Fourth, internal payment channel should be opened up. Internal charging standards and procedures are formulated for equipment management units. The collection of operating

and service fees for the internal laboratory testing services of the unit through individual capital account can be explored to improve the service efficiency of large-scale instruments and equipment[9].

4.5 Strengthening external publicity and further expanding the scope of services First, propaganda can be carried out through multiple means. The sharing center and large-scale instruments and equipment are promoted through various means such as the sharing center website, QQ, WeChat public account, mobile APP, exhibition boards, brochures, large-scale equipment manuals, *etc.* to enable more scientific researchers to understand the large-scale equipment and related functions of the sharing center and attract more universities and research institutes in the region to come to use the equipment of the sharing center. Second, promotion can be carried out through multiple channels. Through the holding of large-scale equipment operation and use training courses, function presentations, technical academic exchange seminars, *etc.*, the scope of the sharing services will be further expanded while improving the service ability of sharing center managers and the operation level of users. Third, encouragement should be carried out by multiple measures. By actively sending management personnel of the sharing center out to attend relevant academic conferences and providing incentives to managers and users to jointly apply for related scientific research projects, publish articles, and apply for patents, and encouraging managers to strengthen technical cooperation with relevant external scientific researchers the academic influence of the sharing center will be improved.

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