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# SWOT Analysis on Breeding R&D of Tropical Crops in China in the Context of Implementing UPOV Convention 1991 Act

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**Abstract** This paper firstly reviewed development process of UPOV Conventions and briefly introduced current situation of protection of new tropical crop varieties in China. Using SWOT approach, it analyzed internal strengths, weaknesses, external opportunities and threats of breeding R&D of tropical crops if implementing UPOV Convention 1991 Act in China. Internal strengths include rich resources, strategic significance of tropical crops, solid crop breeding foundation, and broad market prospect. Internal weaknesses include insufficient reserve of germplasm resources, weak R&D and protection of new varieties, low market level of breeding R&D entities, unreasonable structure, low input in breeding R&D, and weak protection awareness. Opportunities include bringing into play strengths of rich tropical plant resources, stimulating enthusiasm for new variety R&D and awareness for variety protection, promoting structural optimization of breeding input entities, raising technology level of breeding R&D, and promoting international cooperation of new variety protection. Threats include more strict restriction of intellectual property right, impact to weak fields of new variety R&D, and difficulty in implementing limitation of farmer privileges. Finally, it came up with four recommendations for breeding R&D of tropical crops in China in the contest of implementing UPOV Convention 1991 Act.

**Key words** SWOT analysis, UPOV Convention 1991 Act, Tropical crops, Breeding, New variety protection, Development strategies

UPOV Conventions are important international agreements on protection of breeders' rights. Since signed in Paris in 1961 and took effect in 1968, UPOV Conventions have been revised in 1972, 1978 and 1991. By December 5, 2012, members of UPOV Conventions have reached 71. At present, most members implement UPOV 1978 Act and UPOV 1991 Act. According to latest statistics of UPOV website, 19 countries are implementing UPOV 1978 Act, 51 countries are implementing UPOV 1991 Act, and only Belgium implements UPOV 1961 Act (supplemented and revised in 1972). China joined the UPOV Convention in 1999, implemented 1978 Act and became the 39th member of UPOV. Since then, China's new plant variety protection stepped onto the international road and rapid development lane. At present, 22 tropical countries joined UPOV Conventions, 13 countries implementing 1978 Act (Argentina, Bolivia, Brazil, Chile, China, Colombia, Ecuador, Kenya, Mexico, Nicaragua, Paraguay, South Africa, and Trinidad and Tobago), 9 countries implementing 1991 Act (Australia, Costa Rica, Dominican Republic, Oman, Panama, Peru, Singapore, United States, Vietnam)<sup>[1]</sup>. Implementing UPOV 1991 Act has become development trend of new plant variety protection. According to provisions of UPOV Conventions, new applicants have to choose UPOV 1991 Act and members implementing other act of conventions should gradually change to UPOV 1991 Act. China is a largest agricultural country in the world. After implementing UPOV 1978 Act, application quantity of variety right is rapidly increasing, and the number of plant variety protec-

ted is gradually increasing. With development of agricultural international trade and agricultural scientific research international exchange, the upgrade to UPOV 1991 Act is imperative. For tropical crops with rich domestic breeding material source, powerful breeding technology strength, and many breeding achievements, joining UPOV 1991 Act will bring excellent opportunity; for tropical crops with insufficient breeding materials, low breeding technology, and few breeding achievements, breeding R&D will face tough challenges.

## 1 Current situation of protection of new tropical varieties in China

China is rich in tropical crop variety resources, but new variety protection is relatively backward. Few species and genera are included into protection list. New variety right is few and takes little portion in the total quantity. According to relevant announcements of Office for the Protection of New Varieties of Plants of Ministry of Agriculture (MOA), by April 11, 2013, MOA has announced 9 batches of protection lists for new varieties of plants, 93 species and genera get protected, including 7 species and genera tropical crops, namely, banana, litchi, longan, mango, *Stylosanthes* spp., rubber tree, and cassava, accounting for 6.45% of the total quantity (listed in Table 1).

**Table 1 Application and grant of tropical crop varieties in 1999 – 2013**

Crop species	Quantity of applications	Quantity of grants
Banana	4	0
Litchi	1	1
Longan	0	0
Mango	0	0
<i>Stylosanthes</i> spp.	1	0
Rubber tree	2	0
Cassava	0	0
Total	8	1

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## 2 SWOT analysis on breeding R&D of tropical crops in China in the context of implementing UPOV Convention 1991 Act

### 2.1 Internal strengths of breeding R&D of tropical crops in China

**2.1.1 Rich resources.** China has broad tropical areas and the climate in these areas is tropical monsoon climate. Various terrain and diverse climate brings diverse tropical crops. Space-time difference of rain and heat also brings diverse tropical crops. China's tropical crops and southern subtropical crops account for 1/3 of whole plant species in China<sup>[2]</sup>. With in-depth survey and collection of germplasm resources, more wild species, wild relatives, farm cultivars, and local variety germplasm resources of tropical plants will be incorporated into the germplasm bank. According to UPOV 1991 Act, each member bound by the Act of 1961/1972 or the Act of 1978 shall apply the provisions of this Convention, at the latest by the expiration of a period of five years after the said date, to all plant genera and species; each member is not bound by the Act of 1961/1972 or the Act of 1978 shall apply the provisions of this Convention, at the latest by the expiration of a period of 10 years from the said date, to all plant genera and species. This means joining UPOV 1991 Act will include more tropical crops species and genera into protection list of new plant varieties. China can take rich tropical plant resources as original materials to make new variety R&D with Chinese characteristics and independent intellectual property right, which is favorable for grabbing the opportunity for new variety R&D of tropical crops.

**2.1.2 Great strategic significance.** Tropical crops are important resources for raw materials of rubber industry, biological fuel industry, food industry, and biopharmaceutical industry, play an irreplaceable role in ensuring national economic security, and are economic resources with strategic significance. With advance of industrialization and urbanization in China, tropical agricultural land resource is gradually reducing, imposing higher demands for high quality and high yield varieties, so it is urgent to strengthen breeding R&D of tropical crops. Since the end of 1970s, China attached great importance to protection and utilization of tropical germplasm resources. Especially since the 1990s, the Ministry of Science and Technology and Ministry of Agriculture took research of characteristic tropical crop germplasm resources as support object, such as national sci-tech fundamental platform construction project, 948 Project, agricultural biological resource protection and utilization project, and Southern Asia project, etc<sup>[3]</sup>.

**2.1.3 Solid breeding foundation.** China has certain scientific research foundation for breeding of tropical crops and has bred certain quantity of new varieties. For tropical cash crops, China has bred excellent natural rubber varieties (7-33-97 and PR107), cassava varieties like South China series, tropical forage grass varieties such as *Stylosanthes guianensis* cv. Reyan No. 2. and *Penisetum purpureum* × *P. americanum* cv. Reyan No. 4, hybrid coconut and short-plant coconut; for tropical fruit varieties, China has bred banana 8818-1 with ability of resisting Panama disease,

sweet mango, seedless litchi, Jizui litchi. In 2007, fine seed coverage of major tropical crops reached 70% and fine seed coverage of banana reached 100% in Hainan<sup>[4]</sup>.

**2.1.4 Broad market prospect.** According to data of China's Agricultural Information website, tropical zone of China includes Guangdong, Guangxi, Yunnan, Fujian, southern Hunan, river valley area in southern Sichuan and Guizhou, and whole area of Taiwan, the total area is about 0.48 million km<sup>2</sup> (not including Taiwan), and the total population is 160 million (not including Taiwan), and agricultural population is 116 million. In 2010, planting area of characteristic tropical crops reached 0.4356 million hectares, total yield was up to 2.7083 million tons, and gross output value up to 13.201 billion yuan<sup>[3]</sup>.

### 2.2 Internal weaknesses of breeding R&D of tropical crops in China

**2.2.1 Insufficient reserve of germplasm resources.** Although there are rich primitive plant resources in tropical areas of China, tropical crop scientific research institutes have not realized importance of domestic and foreign wild plant resources, the utilization technologies are to be strengthened, and excellent germplasm resources are still insufficient if undergoing collection, identification, screening, and re-innovation. At present, tropical zone scientific education units with Chinese Academy of Tropical Agricultural Sciences (CATAS) as major part have collected about 47000 pieces of domestic and foreign wild species, wild relatives, local species, bred varieties and strains and genetic materials, including 36000 unique resources<sup>[5]</sup>. According to UPOV 1991 Act, it is predominantly derived from the initial variety, or from a variety that is itself predominantly derived from the initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety; it is clearly distinguishable from the initial variety; except for the differences which result from the act of derivation, it conforms to the initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety. Essentially derived varieties may be obtained for example by the selection of a natural or induced mutant, or of a somaclonal variant, the selection of a variant individual from plants of the initial variety, backcrossing, or transformation by genetic engineering. About 70% of major crops of China are innovation of essentially derived varieties<sup>[6]</sup>. At this context, re-innovation through introducing foreign varieties will face the risk of infringing upon rights. Once the infringement is confirmed, it will not only suffer huge sum of claim for compensation, but also be subject to damage to international reputation.

**2.2.2 Weak R&D and protection of new varieties.** New variety R&D of tropical crops are mainly focused on rubber, cassava, tropical forage grass, staple tropical fruits (banana, litchi, longan, mango), but few bred varieties have applied and obtained protection right. Little input is made to excellent and rare crop breeding with special value, and new variety R&D and new variety right protection are nearly blank. Variety R&D remains in inferior

position in competition with tropical agricultural developed countries, such as the United States, Brazil, and Australia. By 2012, United States, Brazil, and Australia have obtained grants of new pineapple and banana varieties. They also obtained grants of mango, litchi, Australian nut, papaya, coffee, cocoa, sisal hemp, and *Stylosanthes* spp. However, China only obtained one grant for litchi, but obtained no grant in new variety of other tropical crops. After China joining UPOV 1991 Act, foreign seed enterprises will enter Chinese market, grab blank area of tropical crop protection with the aid of their advantages, and squeeze space for future tropical crop seed industry.

**2.2.3 Low market level of R&D entities and unreasonable structure.** At present, national scientific research institutions are major forces for new variety breeding of China's tropical crops. Due to limitation of technologies and funds, enterprises are not highly enthusiastic in breeding and the market level of seed industry is low. Firstly, there are few tropical crops with high economic return and good market condition, only including rubber, cassava, oil crops (oil palm, coconut), spices, and some staple tropical fruits, and some crops have small market size. Next, tropical crops have long breeding period, so enterprises have to bear heavy breeding cost, and the return period is long and return risk is high. However, breeding led by scientific research institutions has problems of disconnection between research and market demand, lack of labor division cooperation, and low rate of conversion of achievements. Breeding return is the power source for breeders developing new varieties to a certain extent. Marketization just satisfies such demand. Therefore, market-oriented breeding R&D can effectively promote enthusiasm and input of R&D entities and promote improvement of new variety breeding R&D technologies and application of new variety rights. Weak seed marketization of China's tropical crops restricts new variety R&D and application of variety rights to a certain extent. This will leave certain space for foreign seed giants to apply new variety rights of some crops before China and impose various limitations on China, leading China falling into passive situation.

**2.2.4 Low R&D input.** In China, rice, wheat, soybean, corn and cotton take up the leading position in agricultural production, while tropical crops take up a little portion in entire agricultural production. Therefore, the input in breeding R&D of tropical crops is much lower than staple crops. At the same time, China is still not realizing the importance and strategic significance of tropical crops, leading to relatively low input of public resources to tropical crops. According to data in 2007, average sci-tech investment intensity of 8 provinces in tropical areas was 0.72%, 1.42% lower than the national level, much lower than developed countries (2.6% in the United States, 2.87% in Japan and 2.58% in Germany), and the proportion in tropical agriculture is much more little<sup>[4]</sup>. In some countries implementing UPOV 1991 Act, such as Costa Rica and Republica Dominicana, cassava is one of the most important grain crops; in Vietnam, cassava is the one of the most cash crops; in most tropical countries, tropical

crops are most important cash crops and essential sources for foreign exchange; in developed countries such as the United States and Australia, tropical crops also take up high strategic position and they have established perfect tropical crop variety breeding input chain consisting of government, non-government organizations, scientific research institutions, large seed enterprises, and individuals. Due to lack of input, there is still a certain gap of China's tropical crop breeding technology and variety right owning quantity with developed countries. At present, most new varieties of China's tropical crops are developed through selection, mutant single plant cultivation and breeding. Thus, it is easy to exceed the red line of "essentially derived varieties" in UPOV 1991 Act.

**2.2.5 Weak protection awareness.** In China, the protection awareness is weak for protection of variety rights. Tropical crop breeders have not realized importance of new variety right protection, quantity of new variety right application is far less than the United States, Brazil, and Australia. By 2012, China only had 8 new variety right applications for typical tropical crops and only one was granted. However, in the same period, the figure was 23 in the United States (17 were granted), 20 in Brazil (14 were granted), 34 in Australia (13 were granted)<sup>[7]</sup>. American breeders always value protection of variety rights. Apart from applying legal protection, they also take some technological means to protect their variety rights. For example, Monsanto Company made molecular marker for their materials<sup>[8]</sup>. By contrast, few China breeders protect their new varieties through technological means.

## **2.3 External opportunities for breeding R&D of tropical crops in China**

**2.3.1 Bringing into play advantages of rich tropical plant resources.** The UPOV 1991 Act expands rights of breeders to essentially derived varieties, which constitutes a great limitation to China researching and developing new varieties through introducing foreign varieties and making gene modification. However, China has rich tropical plant resource reserve, can increase output efficiency of new variety innovation with independent intellectual property right, increase new varieties with independent intellectual property right, establish breeding advantages, and maintain safety of China's tropical agricultural production.

**2.3.2 Stimulating enthusiasm of new variety R&D and variety protection awareness.** Since the implementation of *Regulations of the People's Republic of China on Protection of New Varieties of Plants formulated on the basis of UPOV 1978 Act*, various breeding R&D entities are highly enthusiastic in innovation and UPOV 1978 Act has brought huge institutional effect in breeding field of tropical crops. UPOV 1991 Act strengthens protection for breeders' rights, which brings higher profit for protection of crop variety right, greatly stimulates input of breeders in variety innovation, raises awareness of breeders for protecting intellectual property right, so as to increase quantity and quality of new varieties of tropical crops, and promote rapid and sound development of tropical agriculture.

**2.3.3 Promoting structural optimization of breeding input enti-**

ties. New variety protection system provides solid guarantee for market economic benefits for breeders and stimulates enthusiasm of enterprises and individuals for breeding R&D input. UPOV 1991 Act increases protection for breeders' rights, guarantees rapid and reasonable return of breeding entities. Thus, it is not only favorable for widely attracting social entities to invest in tropical crop breeding R&D, promoting technological upgrade and equipment update of tropical crops, but also favorable for inputting manpower, material and financial resources to rare tropical crops with huge exploration potential, filling the gap of tropical crop breeding field, and resisting foreign seed enterprises to nibble weak breeding fields of China's tropical crops.

**2.3.4 Improving breeding R&D technological level.** Joining UPOV 1991 Act means all new plant varieties developed by foreign breeders will get strict protection and more foreign high quality varieties will enter production field of China's tropical crops. China can make higher variety innovation based on introducing foreign excellent varieties. At the same time, under the protection of essentially derived varieties in UPOV 1991 Act, China's tropical crop breeding technology will get greatly improved and tropical crop breeding industry will enter a benign cycle.

**2.3.5 Promoting international cooperation in new variety protection.** Joining UPOV 1991 Act will strengthen international cooperation in protection of new tropical crop varieties, such as in information exchange, data communication, variety exchange, variety test, and variety description specifications. Also, it will be easier to introduce more excellent foreign new varieties, to promote development of China's tropical crop breeding industry.

## **2.4 External threats for breeding R&D of tropical crops in China**

### **2.4.1 More strict restriction of intellectual property right.**

(i) The problem of essentially derived varieties. Firstly, according to present condition, for China's tropical crops, especially rubber, cassava, and coconut, most breeding materials are introduced from abroad and most bred varieties are highly connected with foreign germplasm. In the context of implementing UPOV 1991 Act, a lot of excellent germplasm resources in foreign countries, especially developed countries, have obtained protection of plant variety rights. Since breeding using foreign germplasm resources is using original materials, according to definition of essentially derived varieties in UPOV 1991 Act, new varieties bred with granted germplasm resources as original materials may be taken as essentially derived varieties and consequently subject to restriction of rights. Next, R&D of China's new tropical crop varieties mainly adopt induced mutation, somatic asexual mutation, primitive variety mutation, backcross, and genetic engineering breeding. New varieties bred through these approached will possibly be defined as essentially derived varieties. (ii) Taking various protection methods will restrict breeding of China's tropical crops. UPOV 1991 Act breaks the limitation the only taking one protection method to protect variety right or patent right for the same plant species and genus. This means that new variety protection

can adopt two methods legally accepted in local countries. As a result, after joining UPOV 1991 Act, the probability of materials adopted for breeding getting protection of intellectual property right will be greatly increased. (iii) The extension of variety right protection period will restrict China's tropical crop breeding. Compared with UPOV 1978 Act, UPOV 1991 Act extends protection period of variety rights. This means the limitation period for China making innovation through using varieties or resources with expired protection period will be longer. Joining UPOV 1991 Act, China will have to pay higher costs for introducing, absorbing or re-innovating foreign valuable varieties or resources, or delay the utilization time. Also, countries with more variety rights will control China's variety market using their protected varieties, leading to great gap of China with foreign countries in variety innovation and competition, science and technology weakness, economic weakness and market share<sup>[9]</sup>.

**2.4.2 Weak field new variety R&D facing challenges.** According to quantity of applications and grants issued by UPOV for new varieties, China has advantage in litchi and longan, while China is weak in rubber, cassava, coconut, banana, and tropical forage grass. Compared with international situation, breeding resources and achievements of China in pineapple, mango, Australian nut, papaya, coffee, cocoa, and sisal hemp fall behind the United States, Brazil, Ecuador, South Africa, and Chile. Joining UPOV 1991 Act, weak field new variety R&D of China's tropical crops will face challenges. Firstly, limited to provisions of essentially derived varieties, China's quantity of new variety protection rights is far less than other countries, so tropical crops with weak breeding resources will suffer great attack. Besides, longer period of new variety protection means that foreign superior varieties will occupy share of new variety protection of tropical crops for a longer time. Weak crops of China, such as pineapple, mango, papaya, coffee, cocoa, and sisal hemp, will be subject to attach to a certain extent. If foreign new varieties with variety right of these crops enter China, it may lead to constant shrinkage of breeding research of these crops and finally result in industrial development being under control of foreign countries.

**2.4.3 Implementing farmers' privilege in new variety R&D facing difficulties.** China's tropical agricultural production is mainly commercialized production and most products are produced for sales, and producers are mainly farmers, medium and small sized farms. UPOV 1991 Act expands breeders' rights to harvested materials and processed products of granted varieties. In respect of harvested material, including entire plants and parts of plants, obtained through the unauthorized use of propagating material of the protected variety shall require the authorization of the breeder, unless the breeder has had reasonable opportunity to exercise his right in relation to the said propagating material. Farmers generally are weak in awareness of intellectual property right. Besides, it is easy for farmers to breed new varieties through asexual reproduction technology and then expand planting. This will inevitably lead to infringement dispute. In addition to lack of intellectual

property right knowledge, it will increase the difficulty in settling disputes. Furthermore, farmers' random infringement will increase costs for safeguarding rights of breeders. Strictly enforcing provisions of UPOV 1991 Act will increase farmers' burden to a certain extent, bring impact to production enthusiasm of farmers, and exert influence on constant increase of farmers in short term. In breeding of tropical crops such as cassava and tropical forage grass, there is research of farmers' participation. Breeding researchers provide breeding materials and make experiment directly in farmers' farmland. Through participation of farmers and in-field knowledge, researchers select strains suitable for farmland environment. Sometimes, farmers will combine their farm varieties with materials provided by researchers. Such breeding R&D method will also face the problem of safeguarding rights and need attention of breeders.

### 3 Recommendations for breeding R&D of tropical crops in China in the context of implementing UPOV Convention 1991 Act

**3.1 Strength-opportunity recommendations** It is recommended to implement go-out strategy for protection of new varieties. Based on strengths and external opportunities of tropical crop breeding R&D in China after joining UPOV 1991 Act, it is recommended to increase input in tropical crop breeding R&D, consolidate and strengthen existing breeding strengths. Next, it is recommended to implement go-out strategy for protection of new varieties, and actively apply new variety right of tropical crops.

#### 3.2 Weakness-opportunity recommendations

**3.2.1** Increasing reserves for tropical crop germplasm resources with independent property right. It is recommended to continue advancing survey, collection, storage, evaluation, and utilization of original germplasm resources of China's tropical crops. Besides, it is recommended to continue introducing foreign excellent germplasm resources and avoid problem of intellectual property right.

**3.2.2** Increasing quantity of rights of new tropical crop varieties. Firstly, it is recommended to actively utilize existing germplasm resource reserve to research and develop new varieties and apply for new variety protection right. Secondly, it is recommended to actively declare the protection right for existing new tropical crop varieties. Thirdly, it is recommended to strengthen R&D of new tropical crop varieties and enhance protection of rare tropical crop varieties with Chinese characteristics.

**3.2.3** Improving related laws and regulations. It is recommended to establish and improve related laws and regulations to combine UPOV 1991 Act, practically safeguard rights of breeders, establish and improve incentive mechanism for new variety R&D, realize rapid and reasonable return of breeding R&D, and stimulate enthusiasm of breeders for R&D input, and promote marketization of tropical crop breeding industry.

#### 3.3 Strength-opportunity recommendations

**3.3.1** Making breeding R&D of new varieties using self intellectual property right. It is recommended to make innovation in

new varieties using existing self intellectual property right of China's tropical plant resources, to effectively evade infringement problem involved in UPOV 1991 Act.

**3.3.2** Increasing input in tropical crop breeding R&D. For valuable tropical crop germplasm resources, China should allocate funds for protection; for R&D of advanced breeding technologies, it is recommended to provide project arrangement and fund support.

**3.3.3** Strengthening publicity of laws. It is recommended to enhance awareness of breeders, farmers, scientific research institutions, and enterprises in tropical areas for intellectual property right.

**3.4 Weaknesses-threat recommendations** It is recommended to strengthen researches on UPOV 1991 Act, innovate upon institutional design, and coordinate conflicts between protection of rights of breeders and farmers' privileges.

### 4 Conclusions

SWOT analysis approach is a commonly used strategic planning tool. Using this approach, it is able to make comprehensive, systematic and accurate researches on research objects, so as to formulate proper development strategies, plans and measures on the basis of research results. At present, there have been reports about seed industry development of rice, vegetable, buckwheat and cotton using SWOT approach in both domestic and foreign countries. There are also researches about opportunities and threats for staple crops after China implementing UPOV 1991 Act, but there is still no specific research about tropical crops using this method. Therefore, our research is expected to explore strategic measures for China's tropical crop seed industry development in the context of UPOV 1991 Act, so as to raise China's competitive power of tropical crop seed industry.

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