An Analysis of the Patents concerning *Hevea brasiliensis*

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Abstract This paper mainly analyzes the application data of patents concerning *Hevea brasiliensis* in the world and China from the perspectives of time, research field, and the geographical distribution of applicants. It also interprets the patents for invention in China from time, research field, and types of applicants. Based on the study, it shows that although the patent applications fluctuate, the general trend is rising. And the patents are mostly concentrated in plant protection, and agricultural biotechnology. The Chinese applicants of patents for invention largely work in the research institutes, and most of these patents focus on the field of plant protection, agricultural biotechnology, and agro-processing. However, the foreign applicants mainly work in companies, and most of these patents only focus on plant protection. These findings will provide a reference for formulating development policies about natural rubber industry in China.

Key words Natural rubber, *Hevea brasiliensis*, Patent analysis

1 Introduction

Hevea brasiliensis (hereinafter referred to as the rubber tree) sharing a tree, or, most commonly, the rubber tree, is a tree belonging to the family *Euphorbiaceae*. It is the most economically important member of the genus *Hevea*. It is of major economic importance because the milky latex extracted from the tree is the primary source of natural rubber. It is currently the only rubber-producing plant of commercial production value. Since the introduction of wild *Hevea brasiliensis* in 1876, the cause of world rubber cultivation has spanned nearly 133 years. China began the introduction of *Hevea brasiliensis* in 1904, and now it has a cultivation history of 110 years[1]. Natural rubber has characteristics of strong elasticity, good insulation, plasticity and abrasion resistance, so it is widely used in industry, national defense, transportation, medical and health fields and daily life[2]. After nearly 60 years of development, China's rubber industry has gained rapid development and China becomes the world's fifth rubber producer. It has made a series of achievements in terms of variety introduction and cultivation, breeding and selection, tapping technological innovation and early product processing, and won a number of national science and technology awards. In 2013, China's rubber planting area reached 1.195 million ha and the yield was about 0.86 million t.

A patent is a set of exclusive rights granted by a sovereign state to an inventor or assignee for a limited period of time in exchange for detailed public disclosure of an invention. An invention is a solution to a specific technological problem and is a product or a process. Patents are a form of intellectual property. Through the patent statistical analysis, we can identify the research capabilities, technical strength and innovation level in different countries and regions, track the evolution path of scientific research, and forecast the technology development trend. Patent statistical analysis is being increasingly valued by researchers and business decision makers[3-5]. The crops for patent analysis mainly include soybeans, corn, transgenic rice, pumpkin, bitter gourd and other temperate crops[6-15], and the patent analysis is not reported on tropical rubber tree. From the perspective of patent analysis, this paper performs a quantitative and qualitative analysis of patent literature concerning global and China's rubber tree, to reveal the application, patent type, geographical distribution and applicants over the past two decades. On this basis, this paper makes recommendations for the development of rubber industry from the perspective of protection of intellectual property.

2 Research data

In May 2014, we retrieved data in China State Intellectual Property Office database, the European Patent Office database, and Derwent patent database. The retrieval model is as follows: (i) (rubber tree or *Hevea* OR *Hevea brasiliensis*)/TI OR (rubber tree or *Hevea* OR *Hevea brasiliensis*)/AB OR (rubber tree or *Hevea* OR *Hevea brasiliensis*)/CLM) AND (19920101 TO 20140430)/PD; (ii) (*Hevea brasiliensis* or rubber)/CLM or (*Hevea brasiliensis* or rubber)/FT. Retrieval time is from January 1, 1992 to April 30, 2014. A total of 1629 global patent applications about rubber tree were retrieved, including 765 domestic applications and 864 foreign applications. The target data after the screening for analysis are classified mainly based on IPC (International Patent Classification), supplemented by manual interpretation. The patents involved in this paper include patent of invention and patent for utility models, and design patents are not included.

3 Global patent application

3.1 Application time distribution As can be seen from Fig. 1(a), the number of patent applications related to rubber tree fluctuated greatly during 1991 -2013, but it showed a rising trend

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on the whole. Due to the impact of the 1998 Asian financial crisis and the 2008 global financial crisis, the number of patent applications related to rubber tree underwent two fluctuations, but it fluctuated at a high level. Due to the lag of patent application publication, the number of patent applications decreased in 2013. As can be seen from the recent surge in the number of patent applications, the relevant scientific research on rubber tree has become even more active in the context of a high demand for natural rubber globally every year.

3.2 Study field distribution of patent applications As can be seen from Fig. 1(b), the fields that patent application involves mainly include germplasm, crop genetics and breeding, crop cultivation and farming, plant protection, agricultural biotechnology, agricultural machinery, agro-processing, quality and safety of agricultural products, and natural product chemistry. The applications are most in plant protection, followed by agricultural biotechnology and crop cultivation and farming, and these patent applications account for 66%. This shows that these three areas are the hot spot of research related to rubber tree.

3.3 Distribution of patent application acceptance countries The patent application is accepted mainly in 50 countries or organizations. China, the United States, Japan and Europe are most active in carrying out the research related to rubber tree, and they are also the main regions where applicants seek patent protection. The patent applications filed to these regions account for 87.17% of total global patent applications related to rubber tree. China's patent applications account for 53.35% of total patent applications in these four target regions, showing that China has occupied the leading position in the patent application related to rubber tree, and patent applications of the United States, Japan and Europe account for 9.97%, 8.93% and 8.93%, respectively, as shown in Fig. 1(c). It can be found that there are 399 patent applications in the United States, Japan and Europe as non-traditional rubber planting regions, accounting for 27.83% of total applications, suggesting that they have a high degree of concern for the rubber industry.

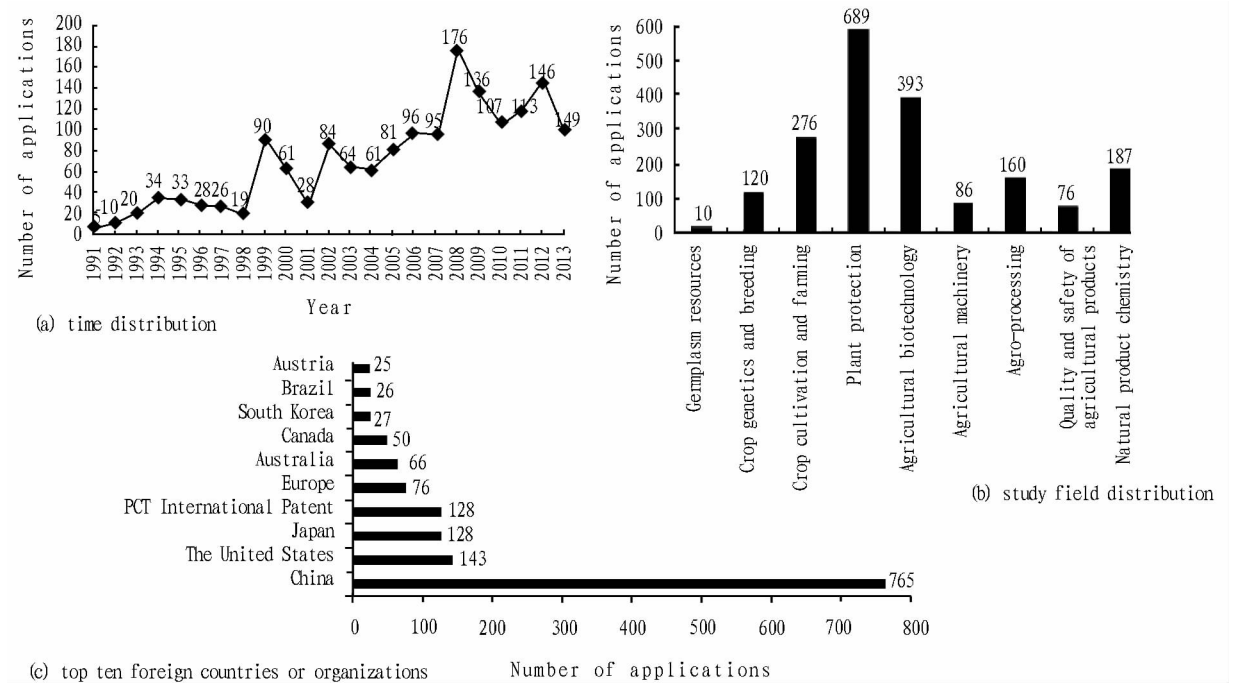

Fig. 1 Global patent application

4 China's patent application

4.1 Application time distribution As can be seen from Fig. 2(a), before 2004, China's patent applications related to rubber tree were maintained at a relatively low level, not more than 20 per year. Since 2005, there has been a rapid increase in patent applications in China, and it was affected by the global financial crisis, but the impact was limited due to National Intellectual Property Strategy introduced by the Chinese government and some supporting documents related to the rubber industry. A large number of research institutions, universities and businesses throw themselves into the rubber industry research, and the awareness of IPR protection has been significantly improved, resulting in soaring patent applications in China. By comparing Fig. 1(a) and Fig. 2(a), it can be found that the patent applications related to rubber tree at home and abroad show a similar trend especially after 2005. This proves that China's patent applications have been increasingly dominant in the field of study of rubber tree, and more foreign applicants choose China as the important patent application acceptance country to protect their own technology. Obviously, foreign applicants have attached great importance to China's natural rubber market. This is closely related to the development trend of China's tire industry in recent years[16].

4.2 Study field distribution of patent applications As can be seen from Fig. 2(b), most of the patent applications are about

plant protection, followed by crop cultivation and farming, and agricultural biotechnology and agro-processing. These patent applications account for more than 77.98%. By comparing Fig. 1(b) and Fig. 2(b), it can be found that the hot areas of research in rubber tree at home and abroad are basically identical, which shows that China's rubber tree research leads the global development.

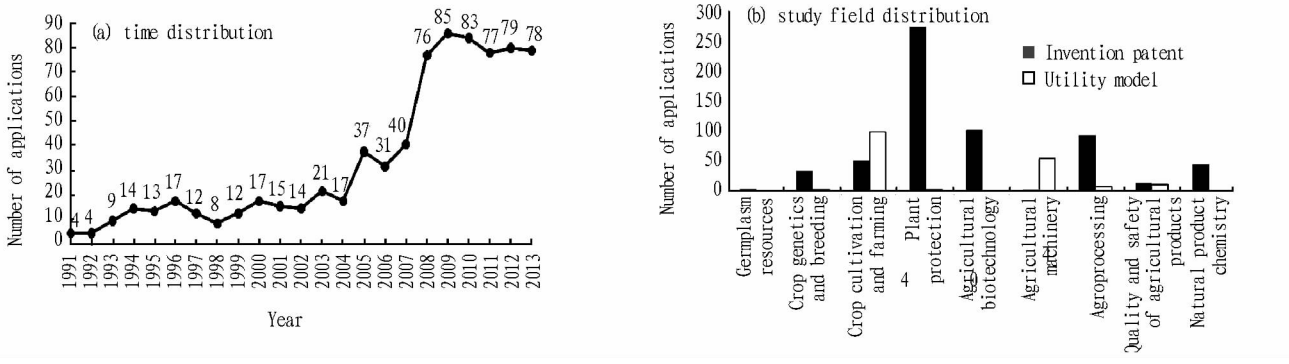

Fig. 2 China's patent application

4.3 Applicant distribution Table 1 lists the applicants on China's rubber tree patents. As can be seen from the table, the applicants are mainly research institutions and enterprises. Most of domestic applicants are research institutions while most of foreign applicants are enterprises. This shows that in recent years, the level of industrialization of China's rubber patent technology is low, and production is not closely linked with research.

Table 1 Main patent applicants

Applicant	Number of applications
Rubber Research Institute, CATAS	136.91
BASF SE (Germany)	102.00
Syngenta (Switzerland)	39.00
Institute of Food Science and Technology, CATAS	35.50
Bayer (Germany)	35.00
Institue of Tropical Bioscience and Biotechnology, CATAS	14.00
Sumitomo Corporation (Japan)	10.50
Yunnan Institute of Tropical Crops	10.00
Sanofi-Aventis (France)	9.00
Bridgestone Corporation (Japan)	8.50
Environment and Plant Protection Institute, CATAS	8.49
Hill Reis, Inc. (USA)	8.00
Analysis and Testing Center, CATAS	7.00
Guangxi Tianyuan Biochemistry Co., Ltd.	7.00
Shanghai Institutes for Biological Sciences, CAS	6.00
Hainan University	5.33
Janssen Pharmaceutical Co., Ltd. (Belgium)	5.00
Hainan Zhengye Zhongnong High-tech Stock Co., Ltd.	5.00
Japan Pesticide Co., Ltd.	4.00
South Subtropical Crops Research Institute	4.00
The DOW Chemical Company (USA)	4.00
NYSE: NVS (Switzerland)	4.00

Note: For the joint application, the number of applications is averaged in accordance with the number of applicants.

5 China's invention patent application

Now there are a total of 587 patent invention applications related to rubber tree in China, accounting for 93.47% of total applications. The domestic applicants account for 50.6% while the foreign applicants account for 49.4%. From the time distribution, foreign applicants' applicants fluctuated, and peaked in 2008; before 2006, domestic applicants' applications were at a very low level, less than five per year, but after 2007, it achieved rapid growth. It reached the highest value of 49 in 2011 and 2012, as shown in Fig. 3(a). Due to the lag of patent application publication, the patent application data decreased in 2013. From the field of study, the domestic applicants are scattered, and the application is mainly about agro-processing, plant protection, agricultural biotechnology, and crop genetics and breeding. Foreign applicants' applications are mostly about plant protection, accounting for more than 68% of total applications, as shown in Fig. 3(b). From the type of applicants, enterprises are in a dominant position in the application. As for the domestic applicants, the proportion of teaching and research institutes is largest (59.76%). The applicants in each profession vary. Teaching and research institutes are prominent in the area of agricultural biotechnology and agro-processing while enterprises and individuals hold a dominant position in the area of plant protection, as shown in Fig. 3(c). As for the foreign applicants, enterprises account for 89.49% of total applicants, and there are less other three kinds of applicants, as shown in Fig. 3(d). Through the analysis, it can be found that different from the fact that major foreign applicants are enterprises, China's major applicants are research institutions or universities and individuals, which indicates that China's rubber tree patent technology stays at the research stage, far from reaching industrialization.

6 Conclusions and recommendations

6.1 Conclusions Over the past 20 years, the global rubber patent application has showed an overall upward trend, confirming the rapid development of global natural rubber industry. From a global perspective, the applicants are mainly enterprises and research institutions, and the field of study is concentrated in plant

protection, agricultural biotechnology, crop farming and cultivation. From a domestic perspective, rubber is a national strategic material, and China has attached importance to the natural rubber research in recent years, so that the research staff significantly increase awareness of intellectual property rights, and are aware that intellectual property is an effective means to protect scientific research results. During the Eleventh Five-Year Plan period, the average annual growth rate of rubber invention patent application in China reached 22.94%, and the average annual growth rate of applications of research institutes or universities reached 77.83%. Research institute has become an important part of China's natural rubber patent application, leading the global rubber tree research via its obvious advantage in plant protection, crop cultivation and farming and agro-processing. But we should clearly realize that from a global perspective, China's rubber industry still lags behind. China's patent application involves a number of research areas, and several areas are at the leading level, but from a global perspective, technology still lacks market competitiveness, and it does not form patent layout. China's rubber tree research is very active, but the patent applicants are mainly concentrated in research institutes or universities, and there are few enterprise applicants.

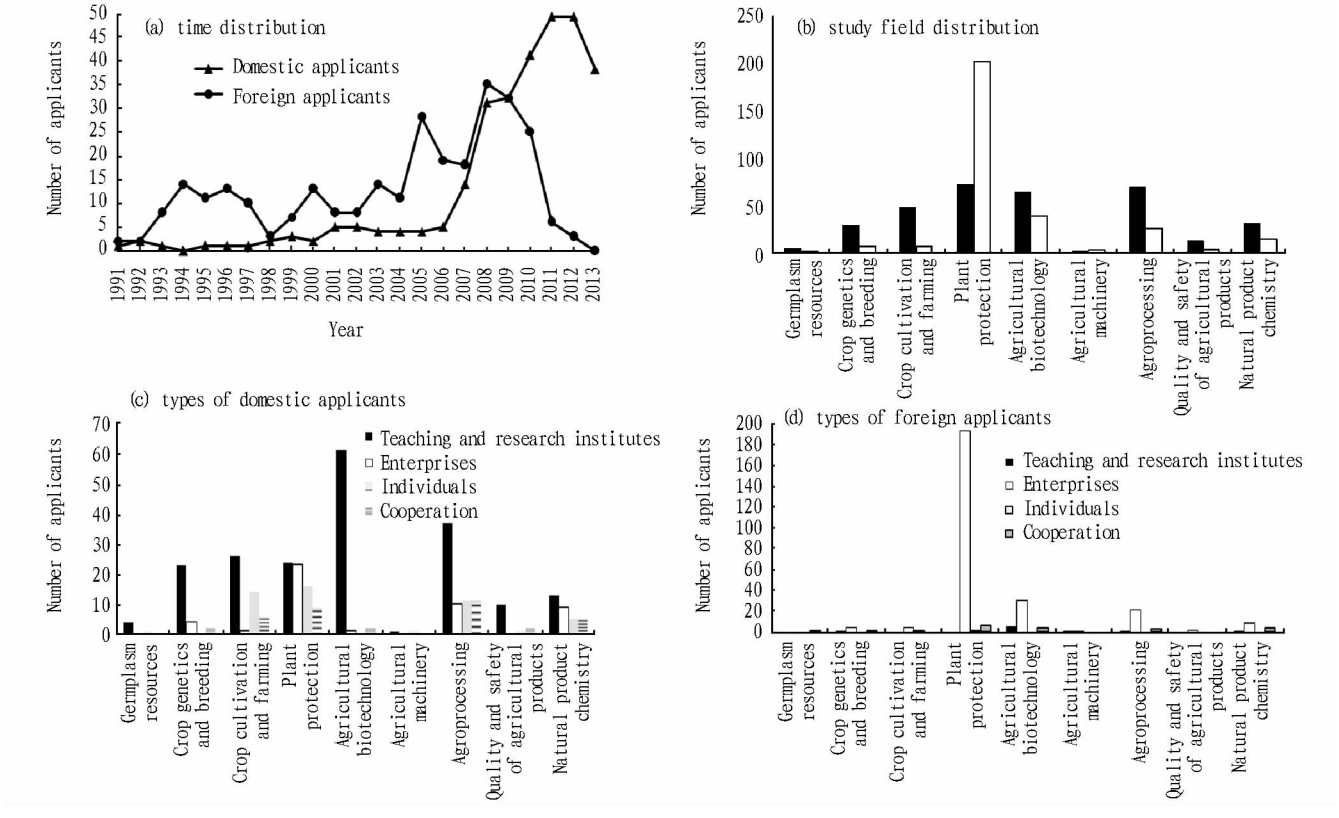

Fig. 3 China's invention patent application

6.2 Recommendations

6.2.1 Increasing investment in science and technology to promote the technological innovation in the rubber area. China should strengthen the technology research in the areas of rubber breeding, cultivation, processing and machinery. Based on National Modern Agricultural Industry Technology System for Natural Rubber, it is necessary to focus on joint scientific and technological research to solve key technical problems, and strengthen innovation and protection of intellectual property rights to enhance competitive strength.

6.2.2 Strengthening the patent layout. In the new development situation, China's applicants need to follow the development of the rubber industry to develop reasonable intellectual property strategy, and form a perfect system of patent protection.

6.2.3 Raising awareness of international patent application. China's researchers should intensify international patent application, to seize the technological high ground and expand the scope of patent protection.

6.2.4 Strengthening Industry-Academia-Research. Domestic enterprises can strengthen cooperation with universities or research institutions to give full play to the role of Industry-Academia-Research, to jointly promote the industrialization of patented technologies. It is necessary to establish the modern industrial technology innovation system which combines industry, academia and research to promote industrial development and industrial upgrading.

References

[1] QI QL, WANG XQ, ZHANG ZY, *et al.* Current situation of Chinese natural rubber industry and development suggestions[J]. Chinese Journal of Tropical Agriculture, 2013, 33(2):79-87. (in Chinese).

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ry, the national forest area was 208 million hectare, the forest coverage was 21.63%, the forest area and forest stock separately ranking the fifth and sixth place in the world[11]. Also, per capita labor cost of China is relatively low, so China's carbon sink projects have considerable advantages in costs.

Secondly, with support of Bio-Carbon Fund of the World Bank, the global first carbon sink project was launched in Guangxi on January 17, 2007. In this project, more than 4000 hectare shelter forests were taken as pilot forests of carbon sink research and transaction. It accumulated certain experience for carbon sink market of China. The Bio-Carbon Fund is proposed according to the provision in *Kyoto Protocol* that CO_2 emission goal must come from transaction of emission reduction right. At this background, many developed countries have set up various carbon funds, to increase carbon stock, reduce risk of carbon sink market, and support development of carbon sink market, which plays an important role in implementing carbon sink projects in developing countries.

Thirdly, the establishment of carbon sink market will inevitably change existing economic structure. Using market economic rules to make adjustment of urban ecological pattern is favorable for forming green economic system with coexistence of ecology and economy. In carbon sink mode, the establishment of benign system will bring about a series of advantageous effects, limiting carbon emission and rebuilding ecological urban pattern will form chain and comprehensively improve global ecological environment.

In sum, carbon sink mode can promote water cycle, change wind force and regulate global climate, clean the air, so as to reduce haze concentration through reducing relative temperature and humidity, and reduce particulate matters and microorganisms in air. Its operation mechanism is scientific and feasible. Besides, China has huge potential and advantages in implementing carbon sink projects in China. The Doppler effect of carbon sink project will bring considerable positive effect on operating systems of the entire system, forming benign cycle of operation mechanism of the entire society.

References

[1] China Environmental State Bulletin in 2013[J]. Environmental Protection, 2014(11):42. (in Chinese).

[2] LIU AM, YANG L, WU YL, *et al*. Research on the health effects of atmospheric particulates in city region[J]. Environmental Monitoring in China, 2012,28(5):19-23. (in Chinese).

[3] HE YB, ZHAO XL, QIAN YL, *et al*. Effect of autumn climate of 2011 on agricultural production[J]. Chinese Journal of Agrometeorology, 2012, 33(1):156-158. (in Chinese).

[4] CHEN XL, FENG YR, WANG AY, *et al*. Numerical experiment research on air pollutants during atmospheric haze over the multi-cities of Pearl River Delta Region[J]. Acta Scientiarum Naturalium Universitatis Sunyatseni, 2007,46(4):103-107. (in Chinese).

[5] Solomon S, D Qin, M Manning, *et al*. Technical summary in climate change 2007: The physical science basis[M]. Cambridge University Press, 2007.

[6] Birgitta S, Hans-christen H, Alfred W, *et al*. Hygroscopic growth of aerosol particles and its influence on nucleation scavenging in cloud: experimental results from Kleiner Feldberg[J]. Journal of Atmospheric Chemistry, 1994(19): 129-152.

[7] GU WD. Study on the special formation mechanism of China haze[J]. Macroeconomics,2014(6):3-7, 123. (in Chinese).

[8] GAO G. The climatic characteristics and change of haze days over China during 1961-2005[J]. Acta Geographica Sinica, 2008,63(7):761-768. (in Chinese).

[9] HUANG LY, CHEN Q. A study about theoretical basis and status of China forest carbon sinks[A]. Technical and Economic Professional Committee of China Forestry Economic Association, Professional Committee of Chinese Society for the Study of Technical and Economic Forestry Technology and Economy. Low Carbon Economy and Forestry Theory - China Forestry Academic BBS, the 6th edition[C]. Technical and Economic Professional Committee of China Forestry Economic Association, Professional Committee of Chinese Society for the Study of Technical and Economic Forestry Technology and Economy, 2009:12. (in Chinese).

[10] LIU Y. National grassland monitoring report in 2013[J]. China Animal Husbandry Bulletin, 2014(6): 18-33. (in Chinese).

[11] Study on the 8th national forest inventory[J]. Forest Resources Management, 2014(1): 1-2. (in Chinese).

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[2] LI JH, WANG CY, JIANG JS, *et al*. Current situation, problems and countermeasures of comprehensive development and utilization of Hevea brasiliensis[J]. Chinese Journal of Tropical Agriculture, 2013, 33(6):71-74. (in Chinese).

[3] GAO JP, DING K. Comparison on nano — patent of both sides of the Taiwan Strait and their industry development strategy[J]. Science Research Management, 2012, 33(6):100-109. (in Chinese).

[4] LAI YG, ZHU DH, HU WB. The construction of patent strategy for the high-tech enterprise based on the patent intelligence analysis[J]. Science Research Management, 2007, 28(5):156-162. (in Chinese).

[5] YU X, LI W. A study on US biotechnology enterprise patent strategy and its enlightenment[J]. Science Research Management, 2007, 28(4):9-15. (in Chinese).

[6] QIN H, ZHOU SW, DONG B, *et al*. Analysis on patents in soybean of Monsanto[J]. China Invention & Patent, 2011(5):52-56. (in Chinese).

[7] SUN JR. Patent search result and analysis of high yield & resist maize breeding and breeding technique[J]. Chinese Agricultural Science Bulletin, 2011,27(01):471-474. (in Chinese).

[8] SUN JR. Analysis on patents in breeding and breeding technology of special maize[J]. China Agricultural Technology Extension, 2010(8):14-16. (in Chinese).

[9] LIU XX, LI JY. Analysis on patents in industrialization of transgenic rice [J]. Journal of Huazhong Agricultural University (Social Sciences Edition), 2011(1):12-18. (in Chinese).

[10] TANG Y, LAO JD, HUANG LX, *et al*. Analysis of the situation of the related patents on pumpkin in China[J]. Guangxi Journal of Light Industry, 2009(7):3-4. (in Chinese).

[11] MO YQ, LING XC, MENG YC, *et al*. Analysis of the situation of the related patents on momordica charantiap in China[J]. Guangxi Journal of Light Industry, 2008(7):12-13. (in Chinese).

[12] CHEN YH, YUAN JF, WU ZY, *et al*. Analysis of the situation of the related patents on puerarin in China[J]. Modern Agricultural Science and Technology, 2009(14):359-360. (in Chinese).

[13] WANG Y, LI JG, CHEN QB. Analysis of the situation of the related patents on Chrysanthemum in China[J]. Heilonjiang Agricultural Sciences, 2008(5):115-116. (in Chinese).

[14] SHENG Q, LIANG JC. Analysis on the situation of the related patents on Chinese yam in China[J]. Modern Agricultural Science and Technology, 2011(6):11-15. (in Chinese).

[15] FENG PS. Analysis on the situation of the related patents on rhizoma gastrodiae in China[J]. Guizhou Chemical Industry, 2011,36(4):15-16. (in Chinese).

[16] LI HM., GU JY, WANG G, *et al*. Analysis on Chinese patents of invention in tire of business[J]. China Invention & Patent, 2013(4):36-39. (in Chinese).