

Patents and China's research and development in agricultural biotechnology

Ruifa Hu, Xiaobing Wang, Jikun Huang & Jinyang Cai

A study assesses Chinese scientists' knowledge of patents and the relationship between scientists' patent-using behaviors and their organizations' mandates.

Previous studies have shown that despite the increasing prevalence of patents that impede the use of inventions by other researchers¹⁻⁴, public-sector scientists often disregard patents and adopt 'working solutions' that allow their research to proceed^{5,6}. This finding is not surprising, given that such scientists' research focuses on basic science in the service of the public good. However, when a public research program has as its mandate both the furtherance of the public good and the commercialization of their technologies, how have scientists responded to the patents? Specifically, do they know and care about the research tools and materials used in their research but patented by others? How have they actually used patented materials in their research activities? Though these issues arise frequently in agricultural research and development (R&D) in large developing countries where public research programs actively engage in commercial agricultural R&D activities, they have not been examined in the literature.

The survey

To address these questions, we surveyed China's R&D in genetically modified (GM) crops.

China has a strong public GM agricultural technology program^{7,8}, and its GM crops have been widely adopted by millions of farmers⁹⁻¹². This study uses 2010 data from a survey conducted by the authors and supported by the government. The survey covered 378 research teams from 75 universities and 72 public research institutes that engaged in China's recent GM Special Program (GMSP). Research teams were selected on the basis of their involvement in the GMSP because it is the largest agricultural R&D program in China, run by the public sector with an overall goal of generating GM varieties for commercial uses. During the survey, all teams were informed that the results would be used only for research purposes and that in the final dataset their affiliations and names would be eliminated, with their survey information identified only with the aid of a confidential identifier code. As a result of this anonymity, together with the government's support, the response rate was 100%. To ensure high quality of data, phone calls were made to the head of the research management division of each university or institute and the research team leader to clarify missing information or inconsistent data.

GM crop R&D, we addressed the following points. First, information on personnel working on GM crop intellectual property rights (IPRs) was collected from 147 universities or research institutes. Interestingly, no single person worked specifically on GM crop IPRs. Second, for research teams engaged in upstream and midstream GM crop R&D, we asked scientists about the research tools and materials used in their studies. The research tools and materials were divided into two groups based on their origin: self-innovated or externally sourced. For each of the external tools and materials, we asked the following question: "Do you know whether or not it has been under patent protection?" If the answer was "Yes," we asked whether the scientist had decided to circumvent the patents legally (e.g., making some changes or modifications so that the use of the modified tools or materials could avoid apparent patent infringement) or reach an agreement with the patent owners. A "No" answer suggested an infringement of IPRs.

Our survey results concluded that, unlike those in the public R&D system in the United States^{6,13}, many Chinese scientists are aware of the patent status of research tools and materials used in their R&D activities. On average, each research team applied 3.1 research tools and materials in their current studies, of which

Chinese scientists' knowledge of patents

To understand the patents used in China's

Ruifa Hu and Jinyang Cai are at the School of Management and Economics, Beijing Institute of Technology, Beijing, China and the Center for Chinese Agricultural Policy, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China; Xiaobing Wang and Jikun Huang are at the Center for Chinese Agricultural Policy, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.
e-mail: jkuang.ccap@igsrr.ac.cn

Table 1 Scientists' awareness of the patent status of research tools and materials

	Total	Self-innovated	External source		
			Know it has been patented	Know it has not been patented	Do not know
Number per team	3.1	0.61	0.69	0.79	1.01
Percentage	100	19.7	22.1 (27.5)	25.5 (31.8)	32.7 (40.7)

Shown are the average numbers of self-innovated and external sources of research tools and materials used per research team and scientists' knowledge about patent status of external tools and materials. The numbers in parentheses refer to the percentages of the externally sourced items.

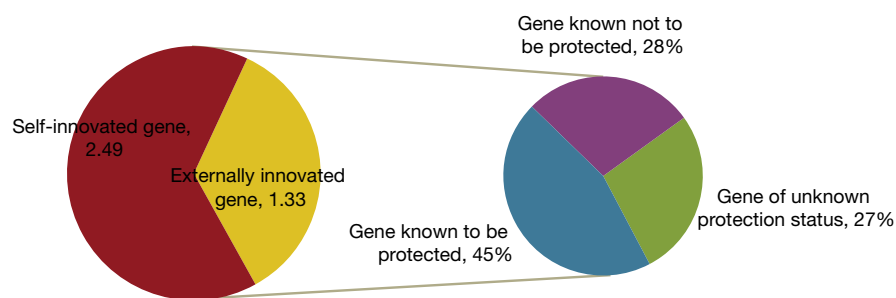


Figure 1 Average number of genes used for transformation in midstream research and scientists' knowledge of patent status of externally sourced genes.

19.7% were self-innovated and the rest from external sources (Table 1). Among the externally derived research tools and materials, scientists indicate that to their knowledge, 27.5% were patented whereas 31.8% were definitely not; the remaining 40.7% had unknown patent status. Overall, when using external research tools and materials in their GM R&D process, Chinese scientists were aware of nearly 60% (27.5% + 31.8%) of their patents' status.

The scientists' understanding of patents was also observed in the use of cloned genes in midstream research (Fig. 1). The survey results show that, on average, each team used 3.82 genes in transformation, with 2.49 genes (65%) being self-innovated or cloned genes and 1.33 genes (35%) being invented by others. Among the externally innovated genes, the scientists indicated that 45% were patented, 28% were not patented, and the remaining 27% were of unknown patent status.

Use of external research tools, materials and genes

More than two-thirds of the external research tools and materials used by the scientists were sanctioned (Table 2). For the 259 external research tools and materials used, 38% of patents were circumvented, 11% were used with agreement and 19% were derived from patents freely shared by international institutes. The

remaining 31% were used without licensing.

Further analysis reveals that scientists' approaches to using external research tools and materials were closely related to their organizations' mandates. To elucidate this relationship, we divided research organizations into two groups: group I included universities and research institutes with both a strong mandate of generating GM crops for commercialization and biosafety certificate(s) for the production of their GM crops before our survey was conducted, such as the Chinese Academy of Sciences, Chinese Academy of Agricultural Science, Huazhong Agricultural University and Fujian Academy of Agricultural Science; and group II included all other universities and research institutes surveyed. In total, group I comprised 42 research teams and group II comprised 336 research teams. The results demonstrate that 90% of external research tools and materials were used legally by members of group I, but only 66% in group II. Group I's use of external research tools and materials without licensing was only 10%, whereas group II's was 34%. Note that in US public research institutes, the proportion of illegally used patented techniques is roughly 25% (ref. 6), which falls between those of China's groups I and II.

The usage pattern of patented genes differs from that of patented research tools and materials. Among the patented genes from external

sources, 88% were used with a gene transfer agreement, of which 44% were free of charge, 11% were subject to some charge and 45% were used under a 'research only' condition. These results indicate that scientists in China are very careful in using patented genes and that a majority of Chinese scientists tend to use patented genes legally.

Conclusions

Our survey results suggest that scientists' knowledge and behavior related to IPRs in public agricultural R&D reflect their research mandates. Chinese scientists in the public sector are more familiar with IPRs, which is not surprising because China's public agricultural R&D system functions for both furthering the public good and commercializing technologies, as noted earlier. Further, within the public sector, scientists at institutions with a greater mandate to engage in commercialization or business are more careful about the patent status of external technologies they use and are more likely to use them legally.

However, the results of our survey also suggest that, for IPR issues, China's public R&D program still faces challenges. Although we demonstrate that most Chinese public-sector scientists have relevant patent knowledge, can use technologies in the R&D process legally and exhibit behavior consistent with the mandates of their organizations, infringements of IPRs do occur. Products developed using unlicensed technologies risk IPR disputes when applying for commercialization approval. Further, as indicated earlier, no single division or person worked on IPR issues related to GM crops at any of the 378 universities and research institutes we surveyed.

The Chinese government has recently taken several measures to manage the challenges of IPRs issues in the GMSP. First, the Ministry of Agriculture (MOA) has organized and offered lectures and workshops on IPRs to all research teams engaged in GMSP, making the participation of team leaders compulsory. Second, the MOA has initiated the creation of a patent pool or internal patent exchange platform to better use the outputs funded by the GMSP. Thus, we may optimistically predict that China's GM crop IPR management will improve, and that China's IPR management will likewise be modified to meet current international standards.

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COMPETING FINANCIAL INTERESTS

The authors declare no competing financial interests.

Table 2 Approaches to using external research tools and materials by researcher category

	Total	Group I: received biosafety certificate for production of GM crops (42)	Group II: did not receive biosafety certificate for production of GM crops (336)
Total	100	100	100
Legal use	69	90	66
Circumvent	38	13	42
Licensing	11	6	12
Free shared from CGIAR and other international institutes	19	71	12
No licensing	31	10	34

The numbers in parentheses are the number of research teams in each group. CGIAR: Consultative Group for International Agricultural Research

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