Chronicles of Young Scientists 1(2) 2010

Available online at www.opubs.com/cys

Chron Young Scientist

Review Article

Intellectual Properties Rights-A strong determinant of economic growth in agriculture

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Received 28 January 2010; accepted 25 February 2010

Abstract In the past few decades the subject of intellectual property rights (IPRs) has occupied center stage in debates about globalization, economic development and poverty elimination. This study concerns the strengthening of IPRs in the plant breeding industry and its effect on agriculture in India. In India, most of the population relies on agriculture for its livelihood. India is self-sufficient in wheat and paddy, but deficient in other agricultural products. Patents are good indicators of research and development output. Patent analysis makes it possible to map out the trend of technological change and life cycle of a technology – growth, development, maturity and decline. Patent information and patent statistical analysis have been used for examining present, technological status and to forecast future trends. One can determine the directions of corporate R&D and market interests by analyzing patent data. The present study is an attempt to analyze patents granted in India in the field of agriculture and importance of biotechnology-based innovations in agriculture

Keywords: Intellectual property rights, patents, agriculture

Introduction

Agriculture in developing economies is rural based with a majority of poor people dependent on it. Hence, any new technology that would result in improving the crop yield or reducing the cost will be highly useful. Particularly, biotechnology innovations have several useful applications in agriculture and are useful for developing countries. However, when such new technologies are protected by intellectual property the implications are different. The plant protection system available in India enables the farmer to save, use, sow, resow, exchange, or share the seeds of protected variety, besides offering protection on farmers' variety, extant variety and essentially derived variety. Such a system has scope for adoption of new technology as well as diffusion of the same. Whereas plant protection could boost research in the area of plant biotechnology by both public and private bodies, it could also result in higher prices for seeds, thus naturally excluding the small and marginal farmers from accessing such new technology. In this paper, an attempt is made to discuss the options available in providing IPRs in agriculture, and importance of biotechnology-based innovations in agriculture

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Origin of Indian legislation

According to the Indian Patent Act 1970 and subsequent Patent (Amendment) Act, 1999 and 2002, patents could be applied mainly for agricultural tools and machinery or the processes for the development of agricultural chemicals [1]. However, methods in agriculture or horticulture, life forms of other micro-organisms like plant varieties, strain/breeds of animals, fish or birds as well as products derived from chemical/biochemical processes, and any processes for medicinal, surgical, curative, prophylactic or other treatments of animals or plants to render them free of diseases or to increase their economic value or that of their products as such, did not constitute the patentable subject matter under the previous patent regime. Till 2004, for inventions relating to substances prepared or produced by 'chemical processes' (including alloys, optical glass, semiconductors and inter-metallic compounds)and substances intended for use or capable of being used as drug and food, no patent was granted in respect of claims for the substances themselves, but claims for the method or processes of manufacture were patented. 'Chemical process' includes biochemical, biotechnological and microbiological process. Now the inventions related with agrochemicals as products can be patented according to the Patent (Amendments) Act, 2005. Earlier, India did not have any legislation to protect plant varieties and no immediate need was felt. However, after becoming a signatory to Trade Related aspects of Intellectual Property Rights (TRIPS) agreement, such legislation was necessitated. TRIPS provide protection for plant varieties by mandating their protection by patents or by an effective sui generis system or by any combination thereof. The sui generis system for protection of plant varieties was developed integrating the rights of breeders, farmers and village communities. Sui generis enables the design of one's own system of protection for plant varieties as an alternative or addition to a patent system for protecting plants.

IPR options in agriculture

Under the Trade Related Intellectual Property Rights System (TRIPS), developing countries can choose to provide patents or develop a sui generis system to protect innovations in agriculture. They also have a third option of joining the Union International Pour la Protection Des Abstentions Vegetables (UPOV). UPOV has been an obvious choice for many countries between the tough standards of patents and the task of developing a sui generis system as it provides an off-the-shelf solution to developing such legislation. India has chosen to develop a sui generis system, which is known as the 'Protection of Plant Varieties and Farmers' Rights Bill 2001' (referred to as Indian Plant Act in this paper). These are discussed in the following paragraphs.

Under Article 27.3 (b) of the TRIPS Agreement, members of the World Trade Organisation (WTO) may exclude from patentability 'plants and animals other than microorganisms and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes [2]. However, members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof. Under this provision, all plants and animal varieties produced by asexual methods of production become eligible for patent protection or sui generis protection or both. This stipulation extends IPR protection to advances made in plant genetic engineering and plant biotechnology. Accordingly, a plant or a part of the plant can be protected under patents or plant variety protection or plant breeders' rights (PBRs). Not all the countries have protected their plant varieties. While the US believes that anything under the sun made by man is patentable, there is a considerable amount of resistance in the European Union. After a decade of discussion in the various policy bodies, the European Union passed a new directive on the Legal Protection of Biotechnological Inventions in July 1998. The European directive states that an element isolated from the human body or otherwise produced by means of a technical process including the sequence or partial sequence of a gene may constitute a patentable innovation. Although plant and animal varieties are still excluded, farmers' privilege to reuse patented plants or animals has been allowed. Denmark, Finland and Ireland have accepted this definition, and patent protection is available in these countries. While Germany required more amendments to go for patents in this area, Italy and Netherlands have objected to this concept. Austria and France have decided to wait for the time being. Canada and Norway exclude plant and animals per se from patentability, including their varieties and even define microorganisms narrowly. Developing countries, such as Argentina, Brazil and the Andean Group, that have implemented TRIPS, so far, only allow patents for microorganisms and microbiological processes excluding plants, animals, genes and other biological material even if isolated by technical processes. These countries have also allowed for compulsory licenses and research exemptions in their patent laws Watal, 2001 and Biotech International, 2001.

A plant or plant variety becomes eligible for protection if it satisfies the criteria of stability, novelty, non-obviousness, uniformity and being distinct, which, however, creates conflicts and differences in defining the criterion of protection. Most developed countries now recognize that novelty is met if the claimed biotechnological product or process does not exist in the prior art. Since non-obviousness is difficult to establish in plant varieties, a lower standard is used, which requires that plants or varieties for which protection is sought must be distinct, i.e., must possess a combination of characteristics distinct from earlier plant varieties and should not have been commercialized before. Thus, more discoveries on the plants grown in the wild may be protected provided other criteria are met. It may be difficult to technically replicate or establish the industrial applicability of the biotechnological inventions in the same way as chemical or mechanical inventions. While replicability is a criterion for patent grants of biotechnological inventions, uniformity and stability are requirements under the law governing plant variety protection. Further fulfillment of disclosure requirements of patent law is difficult in the case of biological materials, where, in addition to a detailed written description, a sample of the protected material is deposited with the depositories, particularly where this is necessary to replicate the process or product claimed.

Patents are the strongest form of intellectual property protection in the sense that they allow the rights holder to exert the greatest control over the use of patented material by limiting the rights of farmers to sell, or reuse seed they have grown or other breeders to use the seed (or patented intermediate technologies) for further research and breeding purposes. One of the concerns in providing patent protection to biotechnology-based research is that it could lead to patenting of research tools or the grant of broad patents that could potentially block further useful research. Under TRIPS, developing countries can choose to provide patents or develop a sui generis system. Countries also have a third option of joining UPOV. UPOV has been an obvious choice for many countries between the tough standards of patents and the task of developing a sui generis system as it provides an off-the-shelf solution to developing such legislation. UPOV appeared as an international agreement in 1961 for administering the rules on plant variety protection and gave a new thrust to the recognition of plant breeders' rights in many countries. The main advantage of the 1961 UPOV Convention, as revised in 1978 and 1991, is the reciprocal national treatment or the same treatment to foreign right holders as accorded to nationals for the protection of new plant varieties from member countries. Unlike other subjects under TRIPS, there is no mention of adherence to UPOV in TRIPS, perhaps due to the fact that there was no agreement among industrialized countries regarding the details of an effective system of protection for plant varieties.

Although TRIPS only specifies that there should be a patents/sui generis regime, or both, pressure has been exerted on various countries to join UPOV in the context of bilateral trade agreements. The purpose of the UPOV Convention is to ensure that the member states acknowledge the achievements of breeders of new plant varieties, by making available to them exclusive property rights, on the basis of a set of uniform and clearly defined principles. The minimum period of protection increased to 20 years (25 years for vines and trees) in the 1991 version (from 15 and 20 years previously). The 1978 Act allowed breeders to use protected varieties as a source for new varieties, which could then be protected and marketed themselves. The 1991 Act has preserved the breeder's exception but the right of the breeder extends to varieties, which are 'essentially derived' from the protected variety, that cannot be marketed without the permission of the holder of the original variety.

Essentially, UPOV 1991 permits farmers to reuse their own crop for seed purposes on their own holdings but does not allow for formal sale. In contrast, TRIPS only requires that there should be some form of IP protection for plant varieties and does not define in any way the exceptions that may be provided to the rights of owners of protected varieties. Because of the restrictive rights of farmers in UPOV 1991, although some of the Asian countries allowed patenting of microorganisms and microbiological processes even before this was a TRIPS requirement, not all of them became members of UPOV other than China until mid-2000. Given the ambiguity in defining the term 'effective', and the leverage available in UPOV 1978, following UPOV 1978 would be a preferred option for many, although presently, membership to UPOV 1991 alone is open.

Apart from the use of patents and plant varieties protection, intellectual property in plants can also be appropriated by technological means. For instance, crops such as commercial hybrid of maize cannot be reused if hybrid yield and vigour are to be maintained. This characteristic of some 'hybrids confers a natural form of protection by which seed companies can more readily capture a return on their investment through repeat seed sales' (Report of the Commission on Intellectual Property Rights (RIIPRDP), 2002). These are the types of IPR options available in plant protection. In the following paragraphs, we discuss the sui generis system as adopted in India

Growth of patenting activity in agriculture

Analysis of the data indicates that agriculture patents constitute ~ 2% of the total Indian patents (Table 1). The growth of patenting activity during 1995–2004 is shown in Figure 1. It can be concluded that there is a gradual increase in the number of patents. The number of patents reached a maximum during 2001–2002, while it declined during 2003–04. [3]

Country-wise distribution of patents

Data from the country of the applicants were analysed in order to ascertain the countries of the research group active in R&D in agriculture. Data on the number of patents granted to different countries indicate that 113 Indian applicants obtained 288 (64%) patents and the rest 161 (36%) patents were granted to 98 foreign applicants. Applicants from the United States, United Kingdom and Japan are on the top three foreign countries in terms of the number of patents granted in India [4, 5]. Majority of applicants that accounted for total patents granted in India are American Cyanamid Co, USA (17), Zeneca Ltd, UK (11) Sumitomo Chemical Co, Ltd, Japan (6), CSIR (58), United Phosphorous Ltd, (12), Sulphur Ltd, (11), Montari Industries Ltd (7), Rallis India Ltd (7) are the major players. Among foreign countries, USA topped the list with 66 patents followed by UK 23, Japan 21, Australia 9, Germany and Israel, 7 each. The remaining 28 patents were granted to countries such as Brazil, Canada, Denmark, France, Italy, Korea, Luxembourg, Malaysia, Mauritius, Norway, South Africa, Spain, Sweden, Switzerland and USSR. It may be concluded that maximum number of patents was granted to the home country. USA received patents for cotton harvester; cultivation of fungi; watering arrangements for growing plants; cheese making apparatus; fast-cooling container for milk; milk protease production; feeder apparatus for birds; device for egg-collection; insect-killing device; preservative composition for animals; pesticidal ; herbicidal and fungicidal composition and biocides containing halogenated hydrocarbon, acyclic compounds, organic nitrogen compound or heterocyclic compounds [6]. Patenting activities in UK were focused on preservative composition for plant; antimicrobial material containing micro-organisms; biocides containing inorganic compounds, organic nitrogen compounds or nitrogen carbon, and devices for storing farm produce [7]. In Japan, the main focus of patenting activity was on preparing bactericide containing inorganic compounds; herbicides; vapor or smoke emitting composition; biocides containing acyclic compounds or organic nitrogen compounds; mushroom cultivation; container for marine animals; beehive device and device for catching insects. Further analysis of data indicates that majority of the Indian applicants were individuals (47%), while 41% was industries and the rest R&D institutions. Patenting activity in the ICAR (six patents) was low, while CSIR (58 patents) played a significant role. However, in case of foreign applicants, 82% belonged to industry, 13% individuals and the rest 5% R&D institutions. Like the number of patents, the number of applicants also was highest for USA (33) followed by Japan (13), UK (12), and Australia (8). (Table 2)

Table 1: Total output of Indian patents in agriculture

Block year	Total no. of granted	Total no. of patents	Block year patents in agriculture Percentage
1995–96	2780	47	1.69
1997–98	4780	100	2.09
1999–2000	3250	91	2.8
2001–02	3820	109	2.85
2003–04	5930	102	1.78
10 yrs	20, 560	449	2.18

Discipline-wise classification of patents in agriculture

Discipline-wise analysis and classification of patents in agriculture according to the total number of patents granted, has been categorized into ten classes of IPC. The subclass number covering medicinal preparation containing materials from plants has been clubbed with subclass biocides and plant growth regulators. Analysis of data presented in Table 3 indicates that maximum patents have been granted in the field of biocides, plant growth regulators, pest repellants or attractants, while processing of harvested produce and devices for storing accounted for the minimum. Patenting activities in these IPC classes have been discussed in detail.

In the IPC class A01B (soil working in agriculture or forestry agricultural machines or implements), all the patents were granted to Indian applicants for developing agricultural and gardening tools set, seed-cum-fertilizer drill, human-propelled tiller, ploughing-cum-sowing implement, mattock cultivator, rotary tilling device, shaft-driven timing system for internal combustion engines, improved plough with a mounted adaptor, adaptor for plough and improved process for manufacturing tractor discs [8]. In the IPC class A01C (planting, sowing and fertilizing), out of 15 patents Indian applicants received 10 for developing portal digital soil salinity tester, air screen cleaner machine, preparing in situ compost, machine for cleaning and grading of seeds, preparation of synergistic fertilizer composition from agricultural compost and agricultural waste, groundnut planter, animal-driven agricultural apparatus, manufacturing a slow-release urea fertilizer by nitrification inhibition, sowing device and composition for increasing herbage and essential oil yield in Palmarosa. Switzerland was granted a patent for the process for preparing seeds having prolonged shelf life, Sweden for surge arrester, Australia for harvesting apparatus, and Norway for improved agricultural composition. In the IPC class A01D (harvesting and mowing), out of 22 patents 14 were granted to India, while 5 to Australia, one to Germany, Israel and USA respectively, for harvester, harvesting apparatus and harvesting machine. Indian applicants received patents for self-driven crop-orienting two-wheeler and three-wheeler harvester; machine for harvesting sugarcane; trimmer; sugarcane-harvesting knife, harvester for harvesting crops; lawnmower and machine for separating out cotton from cotton pods. In the IPC class A01F (processing of harvested produce, devices for storing agricultural or horticultural produce), four patents were granted to India for multi-crop thresher, novel container for storing plant products, storage pot and improved process for the preparation of a pseudobactin useful for storing agricultural/horticultural produce; while one patent to Australia for method of making rice straw silage, Brazil for silo for vegetable grains, Germany for cleaning method and UK for liquid composition for preserving farm produce. In the IPC class A01G (horticulture, cultivation and forestry), out 33 patents 22 were granted to India, 4 to USA, 2 to the Netherlands, and 1 to France, Israel, Italy, Japan and Mauritius respectively. Indian applicants received patents for khurpa for gardening and sowing, automatic device for soil irrigation for shallow rooted agricultural farms/ gardens, underground subsoil irrigation, automatic drip irrigation system, improved dripper, tractor for use in horticulture operations, rain guard for a latex yielding tree, implements for gardening and sowing, device for supporting latex collection receptacle, cutting and gripping device, secateurs, water candle for automatic watering of plant and apparatus for irrigating plants. Foreign applicants received patents for preparing a substrate for culture of fungi, composition for promoting mycelial growth, medium for mushroom bed cultivation, reservoir container assembly, drip irrigation tape and emitter, irrigator, fluid distributing system and plant protection device.

In the IPC class A01H (new plants or processes for obtaining them, plant reproduction by tissue culture techniques), 8 patents were granted to India, 2 to UK and 1 to Germany. Patents were granted for nutrient medium composition for enhancing shoot sprouting from bamboo species and excised embryo-axis of cotton, transformation of plant/ tissue, rhizobial preparation for enhancing nodulation activity and grain yield in legumes, cold extruded composition, and synergistic composition as growth medium for fungi and bacteria [9]. In the IPC class A01J (manufacture of dairy products), 4 patents were granted to India, 3 to USA and 1 to Italy and USSR respectively. Indian applicants received patents for continuous production of cheese free from aspartic protease, manufacturing paneer; while foreign applicants for the production of immobilized milk-clotting protease, method of preparing milk, producing shredded cheese, no fat cheese analogue and container for fast cooling used for preservation of milk. In the IPC class A01K (animal husbandry, silk rearing or breeding animals, new breeds), 30 patents were granted, 16 to India, 5 to USA, 3 patents to Canada, 2 each to Israel and Japan, 1 to South Africa and Spain respectively. Indian applicants received patents for composition to attract Apis flora, chick drinker set, device for storing and feeding poultry feeds, dispensing liquid in poultry farming, weighing and testing fat contents of milk, developing fishes in flowing water, killing mosquitoes, a sensor for intrusion detection, plastic beehive box to breed honeybees, degumming of silk with a fungal protease, process for extraction of silk enhancing fraction from aerial parts of the plant Cassia tora, preparing extract of Silene vulgaris used for enhancing silk yield, feed supplement for silkworm to enhance silk production and improved honey-processing device. Foreign applicants received patents for drinking-water dispenser; water-delivery assembly; feeder apparatus; feeder assembly; poultry feeder; apparatus for incubating eggs and holding eggs and collection of eggs, production of honeycombs for beekeeping; fish hook; container for storing/transporting marine animals and constant temperature box for pollinating insects. In the IPC class A01M (catching, trapping apparatus for destruction of noxious animals), 12 patents were granted, 7 to India and 3 to USA and 2 to Japan. Indian applicants received patents for bird deterrent device, catching narcotizing or killing insects by electric means using illumination for attracting trapping and killing flying mosquitoes and mosquito/insect-repellent device. Foreign applicants received patent for dispensing device, insect bait station, electronic device and apparatus for controlling pests.

In the IPC class A01N (biocides, pest-repellants or attractants, plant growth regulators), 298 patents were granted, 192 to India, 50 to USA, 21 to UK, 14 to Japan, 4 to Germany, 3 to Israel and Korea, 2 to Australia and France, 1 to Denmark, Luxemburg, Malaysia, South Africa, Spain, Switzerland and USSR respectively [10, 11]. Indian applicants received patents for process and methods of preparing biocide from the roots of Decalpis hamiltoni; synergistic insecticide, weedicide, herbicide, bactericide, fungicide, disinfectant, rodent repellant, pest-repellant, cockroach-repellant composition; water-based stable micro-emulsion formulation of neem oil; herbal insect repellant; formulation useful for insect-free storage of cereals, modulating plant growth and sensescence, composition for preventing post-harvest deterioration of sugarcane and biocide for rapid action in sugarcane juice. USA received patents for preparing pesticidal, herbicidal, fungicidal, weedicidal, anthropodicidal, germicidal, wood preservative composition. UK received patents for preparing disinfectant composition, antimicrobial material, pesticidal compound, composition for enhancing shelf-life, preserving aquatic and farm produce. Japan received patent for preparing insecticidal mat, bactericide, insect-repellant composition and water soluble anti microbial composition. Rest of the countries received patents for insect- repellant composition, insect-repellant device, synergistic fungicidal mixture, herbicidal, germicidal, disinfecting composition.

Status of biotechnology in India

With the establishment of National Biotechnology Board (NBTB) in 1982, a move was made to develop biotechnology in India [12, 13]. One of NBTB's tasks was to coordinate the biotechnology research done by various agencies like the Department of Science and Technology, Department of Atomic Energy, Council of Scientific Research, Indian council of Agricultural Research, Indian Council of Medical Research and various universities. NBTB's role was to improve research initiatives on BT, develop infrastructure and skills required for R&D in BT and other strategies like bio-safety, regulation, intellectual property rights, etc. In 1986, the Department of Biotechnology (DBT) replaced NBTB. Under this move, infrastructure and research facilities were created; besides the facilities for maintenance of cell lines, acquisition of research biological at a central point and distribution was created. Under DBT's guardianship, financial institutions started encouraging investments in BT commercialization by entrepreneurs. An interface organization called Biotech Consortium of India was established to serve as a link between research organizations and industry located either in India or abroad. A survey of Indian patents in biotechnology during 1972–1988 carried out for the Department of Biotechnology and subsequently updated until 1991 showed that patenting in biotechnology is foreign-dominated with nearly 75% of the patents owned by foreigners. Predominantly, patents related to the pharmaceutical sector covered processes for the preparation of antibiotics, vitamins, enzymes, antibodies and vaccines, although patenting also covers chemicals such as alcohols and polysaccharides. In the agricultural sector, it covers plant growth regulators, veterinary vaccines, plant cells and tissue culture. In the food industry, dairy and fish products, yeast and food additives, starch products, glucose and fructose syrups are covered by the biotechnology patents. However, what is significant is that biotech patents are marked by a shift towards newer areas employing gene manipulation techniques.

Huge resources are spent on introducing new traits in plants through GMOs, and all over the world, the field of transgenic crops has been expanding ever since such products were introduced in 1996 [14, 15]. It is considered that use of transgenic crops results in sustainable and resource-efficient crop management practices, aside from reducing the use of pesticides in crop production, and thus impact positively on biodiversity. Because of these advantages, the total land area used for transgenic crops increased from 1.7 million ha in 1996 to 58.7 million ha in 2002. In the United States alone, the total land area used for these crops increased from 1.5 to 39 million ha (majority under transgenic cotton), where patents and UPOV 1991 protect innovations in plant varieties. In 2000, a total of 13 countries, 8 industrial and 5 developing countries, grew GM crops. Although plant biotechnology is considered to provide solution to the growing food insecurity among developing countries, lack of appropriate and concrete answers to the concerns raised relating to the environment have induced the developing countries to tread cautiously in the area of transgenic crops. One reason for the slow spread of transgenic crops in developing countries is that governments in many developing countries are withholding approval for the release of GM crops due to their insufficient technical, financial and infrastructure capacities to assess GM crops for biological safety. In some developing countries, even if the technical capacity to regulate for bio-safety is strong, approvals for GM crops have been delayed because of political pressures from local and international anti-GM activist groups and uncertainty regarding consumer acceptance of GM products in international markets. GM crop technologies created by private companies restrict technology transfer to poor farmers in poor countries because of the privately held intellectual property rights. Lack of protection for intellectual property rights in developing countries demotivates the entry of the private sector.

Research in this area is nevertheless expanding. For instance, there are about 50 public research institutions in India, which are engaged in modern biotechnology tools for agriculture. At least 10 of these are engaged in plant genetic engineering with rice, chickpea, oilseeds, cotton and number of horticultural products. Furthermore, there are about 45 private and foreign companies carrying out research in agricultural biotechnology .However, as Table 4 shows, the transgenic lines in advanced stage of development for field trials are in the private sector. Most of the crops have been developed elsewhere and Indian manufacturers are back-crossing the local hybrids with transgenic seeds to develop commercially viable hybrids that can be grown in different agro climatic regions of the country, by paying a license fee. Once they are successful, the Indian manufacturers can register their 'essentially derived varieties' under the Indian Plant Act [16]. Already, such a variety owned by Monsanto of the United States has been obtained by the Maharashtra-based MAHYCO (Indian collaborator of Monsanto) on payment of license fee to introduce transgenic or Bt cotton in India. This has been commercially approved for sale in a few states. As evident from Table 4, much of the research on transgenic cotton is focused on developing plants that are resistant to lepidopteron pests. This is because cotton cultivation utilizes about 9 million ha and accounts for roughly 50% of pesticide consumption in India. Cotton cultivation in India has been plagued with rising costs of cultivation, ineffective pesticides, adulterated seeds and other factors leading to consecutive crop failures and heavy indebtedness have led to suicides by farmers. This explains the large-scale interest of the private sector to introduce transgenic cotton that will be resistant to pests. In simple terminology, *Bacillus thuringiensis*, or popularly known as Bt technology, provides farmers an 'inbuilt pest management system'. Although officially, Bt cotton was released in a few states in India in 2002, unconfirmed reports point that Bt cottonseeds were sold before they were officially released and have already been sold in Punjab where it was not officially released earlier. In another state, farmers continued to use a 'hybrid' variety of a private company, which is said to have similar characteristics of transgenic cotton seeds. These two cases of IPR infringement had already come to surface and in the latter case, a legal decision is pending.

Conclusion

An attempt has been made to analyse the trends of patenting and patented technologies in India in different areas of agriculture also innovations in biotechnology and its several useful applications in agriculture is discussed. The study also interprets innovative activities in the agricultural sector with regard to patent statistics. The result of the study will provide a global scenario of applicants who have obtained patents in India. While patents prevent further research, a sui generis system adopted by India benefits both the farmers and the breeders, and diffusion is possible. Although plant protection rights will check unlawful bio-prospecting, to protect the interests of farmers and breeders, large databases that document the existing varieties need to be undertaken. This paper highlighted some of the issues that emerge from the context of extending protection to extant and essentially derived varieties, and the implications for agricultural research in the context of adopting transgenic technology. While protection may encourage the private sector to go for research in commercial crops, it may also divert the resources of the public sector from investing in research on food crops to regulating and monitoring the research in private sector. Nevertheless, the task that confronts developing countries like India is in focusing on developing the physical and scientific infrastructure to provide plant protection effectively.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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