Status and Challenges of Intellectual Property Rights in Agriculture Innovation in India

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The present study is an attempt to analyse the overview and impact of intellectual property rights (IPRs) on agricultural innovation in India. This paper examines the patenting activity to identify current innovations in crop farming in India. In the case of granted patents, majority of the patents belong to the area of plant growth. It explores the specificities of patent portfolios and its scope of future innovations in the agriculture engineering sector. But there are still unanswered questions about whether emerging and evolving IPR regimes in developing countries will contribute to enhance agricultural productivity. This paper attempts to answer some of these questions by tracing the effects of IPRs on private investment in crop genetic improvement and in turn, on agricultural productivity. However, the research looks at the prospect of India as a developing country to boost its current intellectual property (IP) framework and legislation in order to develop its agricultural technology. Hence, it focuses on whether there is a single system as a model of IP regime to enhance agriculture production in India. The research is based on secondary data.

Keywords: Agricultural innovation, intellectual property rights, research and development, patent, technology

Scientific advances in plant breeding led to the Green Revolution, which is regarded as one of the most important achievements to feed the country from 1960's up till now. Mostly staple cereal crops, particularly wheat and rice, were targeted by the Green Revolution. There has been a revolution in science in agriculture over the last ten years, primarily in the area of seed technology especially for rice-wheat. At the same time there have been substantial changes in the application of intellectual property rights (IPR) to scientific discovery in the life sciences. The extension of IPRs to cereal crop is of special significance because rice-wheat and food security are closely interlinked. In other words, the introduction of IPRs in cereal crop is directly linked to the realization of basic food needs. Intellectual property rights are assuming increasing importance, especially for innovative firms.[1] In this sense, the interaction between IPR and agriculture can be seen in two phases. First, adaptation of intellectual property protection (i.e. plant breeders' rights) by developed countries is derived from the patent model. Second, the introduction of patents over life forms which lead to growth of agro-biotechnology.

In this context, it is a debatable point that plants and agricultural biotechnological inventions (i.e. plants, transgenic plants and plant varieties) can be the subject of patent protection, or as an alternative to the protection afforded by plant variety rights. With this notion, the proprietors have argued that plant variety has a limited scope of protection. There are a number of justifications that have been offered for the introduction of IPRs with a view to foster food security in developing countries. Many authors[2,3] argued that IPRs are used create revenue, to defend the firm's competitive position, and to signal competitiveness. However, the private sector gets more benefits through the legal protection offered by IPRs (i.e. the most important incentives for private sector involvement in agro-biotechnology)[4]. IPR is thus prerequisite to participation of the private sector in the development of improved plant varieties. The biotechnology research and development (R&D) helped to enhance yielding capacity by allowing plants to absorb more photosynthetic energy into grain rather than stem or leaf. The enhanced varieties of crops provide nutritional value in grain for instance, the case of the pro-vitamin-A rice[5] which also fulfils the concern of food security. On the other hand, it is sometimes suggested that the introduction of IPRs in developing countries would lead to increase foreign direct investment, increased technology transfers and R&D by foreign companies while at the same time giving

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domestic sectors incentives to be more innovative. However, the question that remains to be tackled is whether IPR helps to increase agriculture productivity in developing countries like India.

With the following introduction, the paper has been categorised in different sectors. First part of paper provides the overview of IPRs which lead to types of intellectual property. The second section deals with the interaction of IPR in agriculture. Third section analyses the impact of IPRs on agriculture which provides some data on crop patenting and shows the emerging trend. The fourth section emphasizes, the issues and challenges of IPRs related to agriculture. The fifth section concludes the argument.

Intellectual Property Rights (IPRs)

IPR can be defined as legal rights established on creative work (or ideas) thereby inventive ideas. Such legal rights generally allow right holders to exclude the unauthorized commercial use of their creations/inventions by third persons. Thus, in the last two decades IP has become a significant factor in agricultural technology where IPRs provide a basic incentive for the development of the private sector in this area. There are two broad categories of IPRs: one, industrial property covering IPRs such as patents, trademarks, geographical indications and industrial designs, and the other is copyright and related rights covering artistic and literary works, performances, broadcasts and so on. IPRs that do not fall under classical division are termed as *sui generis*, meaning one-of-its-kind. Such *sui generis* rights include those covering lay-out designs of semiconductor chips and plant breeders' rights. The types of IPRs are shown in Table 1.

Table 1 mentioned about different typology of IPRs. Among them several of the IPRs are relevant to the agricultural sector in that they are used to protect goods or services produced in the agricultural sector. Specifically, IPRs in agriculture is patents, plant breeders' rights, trademarks, geographical indications and trade secrets. For instance, the designs of potato chips or any other chips are functions related to agriculture, but these are assumed to be incorporated in machines produced in the industrial sector. Similarly, scientific papers or television programmes covering ideas related to agriculture are not seen as directly being produced in this sector.

Presently, patent is one of the important tool of IPR for agricultural goods and services by providing strongest protection for patentable plants and animals and biotechnological processes for their production. In nutshell it gives the patentee the right to prevent third parties from making, using or selling the patented product or process. However, patentable products have to meet the criteria of patentability, viz., novelty, non-obviousness, usefulness and applicability and the patent laws are followed by all countries. Nonetheless, not all countries allow the patenting of plants and animals or even microorganisms or biotechnological processes. In this context, IPRs can be seen as assets that provide a policy framework where intangible

Table 1—Types of intellectual property rights

Intellectual property rights	Types of instruments	Subject matter covered	Main fields of application	Major international agreements
Industrial property	Patents	New, Non- obvious, indigenous application inventions	Manufacturing	Paris Convention Patent Cooperation Treaty, Budapest
	Utility models	Functional designs		Treaty Strasbourg Agreement
	Industrial designs	Ornamental designs		Hague Agreement
	Trademark	Signs or symbols to identify goods and services		Nice Agreement
	Geographical Indications			Lisbon Agreement
Literary and Artistic Property	Copyrights and neighbouring rights	Original works of authorships	Printing, entertainment, audio, video, etc.	Berne Convention Rome Convention Geneva Convention Brussels Convention
Sui Generis Protection	Breeders' right	New, stable homogenous, distinguishable varieties	Agriculture and food security	Union for Protection of Plant varieties (UPOV)
Trade Secrets	Integrated circuits	Original layout designs Secret business knowledge	Micro electronic industry All industries	Washington Treaty

Source: WIPO, 1995

resources are to be transformed into sustainable development through the protection and promotion of creativity and innovation. But, there is still doubt on how far; strong IPRs can lead us towards sustainable development. For instance, R&D is increasingly conducted in countries where IPR protection is still weak.[6] Similarly, patents, copyrights and trade secrets are of critical importance to research partnerships and projects.[7] The other authors[8] note that, the open-innovation paradigm is shaking up the conventional understanding of IP protection. With this context, IPR issues are complex and multifaceted which involve a variety of different rights such as patents, copyrights, trademarks, industrial designs, geographical indications and trade secrets, and the legislation varies from country to country. Thus, there is need to understand the importance of IPR on both the micro and the macro level and are subject to analysis on the regional, industrial or firm level.

Intellectual Property Rights and Agriculture Technology

Since very long period, machines have been seen as a kind of invention or artistic creations and were protected by the intellectual property rights. But, the assignment of IPRs to living things is of relatively recent origin in developed countries. In 1930, the first vegetable propagated plants were made patentable in the US[9] During the second half of the 20th century a new form of intellectual property, namely plant breeders rights (PBRs), for the protection of plant varieties emerged[10]. According to Indian law, IPRs related to innovation in crops and planting are covered by the Protection of Plant Varieties and Farmers' Rights Act of 2001.[11] This act is for the betterment of protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants. However, the period of protection of registered varieties is based on the types of crops. For instance, for trees and vines, the protection is eighteen years, for other crops it is fifteen years and for extant varieties the protection is fifteen years from the date of notification.

Hence, in one way we can say that the system for the protection of plants is likely to scale up economic benefits in the developed countries. This type of system attracts private breeders in protecting their intellectual property. For instance, patents or PBRs normally impose restrictions on farmers' ability to sell grown seed (and in some cases to reuse it) thereby enhance the market for the breeder's seed. However, even in the developed countries reuse of seeds remain quite common although for many crops annual purchase is now the rule. Contrary to this, in developing countries farmers have traditionally replanted, exchanged or sold seed from the previous years' crop. In developing countries the majority of farmers reuse, exchange or sell informally to neighbours, and annual purchase of new seed is relatively rare in most countries. Obviously, breeders have difficulty in recouping the investments made in improved varieties through repeat sales that put farmers and breeders in contrasting footage.

Another angle to be seen is the interaction between agriculture and IPR. This can be broadly divided into three parts[12] (Fig. 1), a) Technology development facilitated by IPRs (incentives for present efforts), b) Technology development driven by IPRs (requirements of the IPR regime) and c) Technologies that influence IPRs. It is interwoven with each other. The development of plant varieties depend on the nature of the IPR regime and the magnitude of investment, the kind of technology, and the pace of technology development and transfer. In other words, IPR regime will be one of the main drivers to act in plant protection or other kind of activities related to crop cultivation. Different kinds of IPRs will govern various technologies. In order to visualize the likely scenario in the agricultural R&D, gaining more insights into the IPRs and related aspects is inevitable. The interaction of IPR regime and the process of technology development and transfer would have multiple impacts on the farmers, researchers and organizations involved in the agribusiness.

The prescribed Fig. 1 demonstrates the relation between IPRs and agriculture which shows the dynamics of interaction in three ways which help the R&D and Policy framework. The Indian Patent Act in 1970 and involvement of GATT in 1987 brings IPR regime in the form of various amendments and bills (i.e. Patents (Amendment) Act, 1994, Geographical Appellation Bill, 1999, Patents Bill, 1999, PVP and Farmers Rights Bill, 1999 etc.). Presently, the world trade organization (WTO) members accept the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) which gives a number of specific minimum levels of protection.[13] The implication of technology can be seen on social, economic and ecological system. For instance, the fair trade cotton which enhanced quality of society through high value of fair trade cotton in global market and also

its effect on soil fertility because of use of organic fertilizer. Thus, the interaction of IPRs with agriculture has been dilated below.

Technological Development Facilitated by IPRs: Incentives for Present Efforts[12]

IPRs can help to increase investment pathways in R&D in two scenarios. In the first scenario, plant breeding efforts to produce hybrids is likely to spread to newer crops. The second scenario is guaranteed protection so that new investments can be attracted. A case in point is the HYV seeds –here public investment is bound to take off especially in food grain crops in India. Besides, investment in technology development and transfer in inputs like feed, vaccines, and pesticides will witness increased activity. While the public sector will concentrate on basic research, the private sector will focus on applied aspects in India.

Technological Development Driven by IPRs: Compulsion of IPRs Regime[12]

IPRs can influence investment behaviour and this can happen either in the public or in the private sector. The following example illustrates changes in investment decisions in the public sector. A new regime necessitates a mechanism for regulation, monitoring and dispute settlement. Therefore, a class of technologies will emerge. A good example is the growing awareness and expanded investment in the DNA finger printing technology. The IPRs make influence to investment in two ways. First, private firms will be compelled to increase outlays for research, which may lead to innovations. Second, increased technology transfer through joint ventures (read equity participation) and/or mergers and acquisitions between domestic and foreign firms may lead to the innovation.

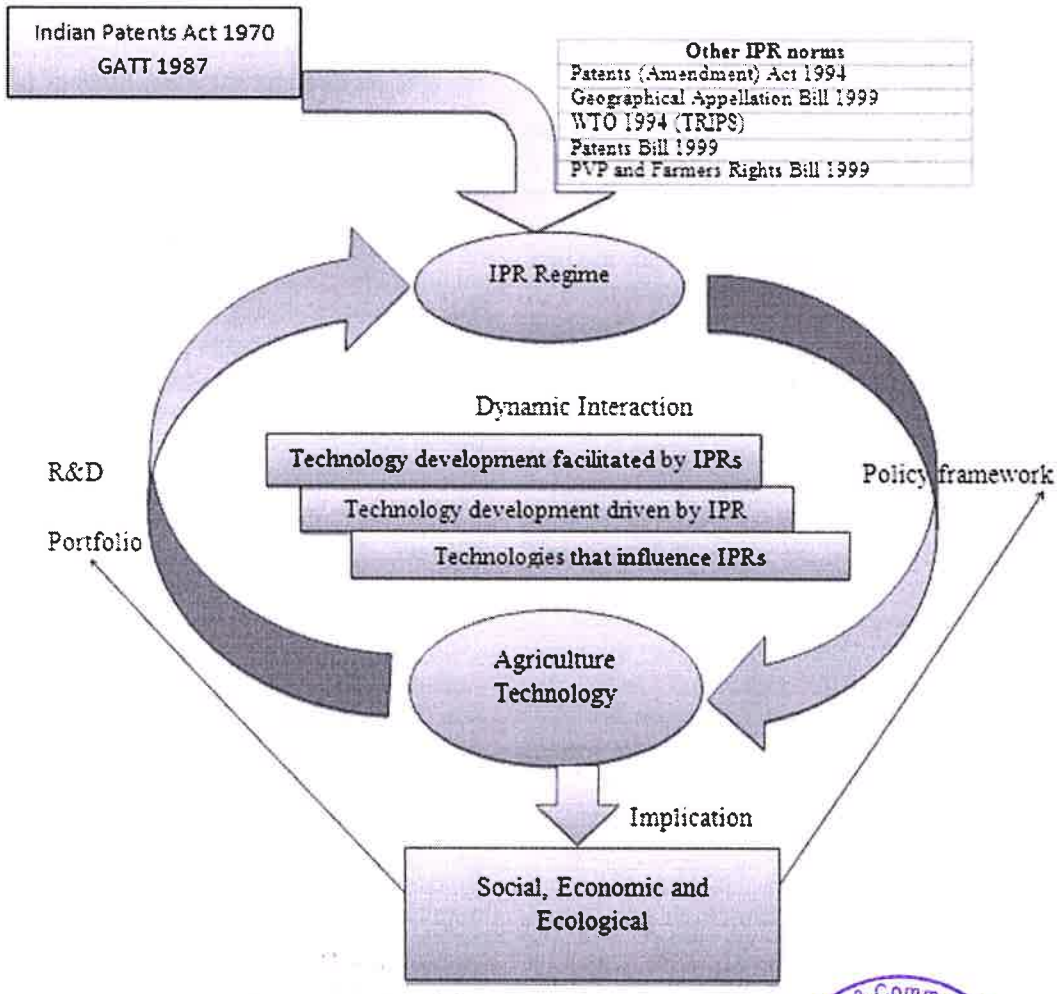

Fig. 1–IPR regime and technological processes in agriculture
Source: Ravishankar and Archak, 2000

compete with the market. However, in the broad area of agriculture research the international cooperation model is being replaced by private proprietary models as biotechnology plays an increasingly vital role in the development of new plant varieties. Thus, the impact can be seen in terms of either increment or decrement in pesticides, seeds, and biotech.

Trends in Seed Crop

The given table present trends in notified varieties of major field crops in various crops since last three decades. It can be observed from given Table 3, from 1980-1989 to 1990-1999, there was no change in terms of number notified varieties and hybrids but during last decade, namely 2000-2010, witnessed significant increment.

Table 3 demonstrates notified varieties of major crop fields. The decade variation among 1980 to 2010 suggests fluctuation that was initially increased but next decade followed up with decline. For instance, in 1980-1989 it was 198 and in 1990-1999 was 188 and in 2000-2010 was 303. A similar kind of trend can be seen in wheat crop also. Perhaps one of the reasons can be grown strum towards food security government or manufactures pay more attention on these two crops. Although, in terms of cash crop which is cotton shows positive increase. For example, in 1980-1989 it was 72 which has lifted up-to 95 in 2000-2010.

Table 3—Trends in notified varieties of major field crops from 1980-2010

Number of notified varieties and hybrids by decade

Crop	1980-1989	1900-1999	2000-2010
Rice	198	188	303
Wheat	84	66	112
Maize	43	64	113
Pearl millet	38	45	51
Sorghum	55	49	55
Cotton	72	78	95
Total	490	490	729

Source: Pray; Nagarajan 2012

Registrations of Pesticides

Pesticide registrations have increased rapidly since the 1980s shown in figure 2, the growth in terms of number has increased twice in the period of 2000-2010.[17] Perhaps, the reason behind the increase in pesticides is that many private companies were involved during the post liberalization period and the government introduction of horticulture mission.

The Fig. 2 demonstrates the pesticide registrations. If, one can see it decade wise, it shows a positive increase, decade by decade. For instance, in the period of 1970-79, there were 105 registrations following a slight decrease in 1980-89 (104) and after than it continues to increase.

Extant Varieties of Crop

A sizeable number of applications for the protection of plant varieties in the country have been recorded by the plant variety. The data suggests that, as on March 2011 there were 216 extant varieties registered by the public, private and farmers shown in table 4. The large extant varieties registered by the public institution followed by private and farmers. The higher number of extant varieties registered by the ICAR may be one of the reasons that, it is a large agriculture research university in India where various funding sources are available through collaboration at national and/or international level.

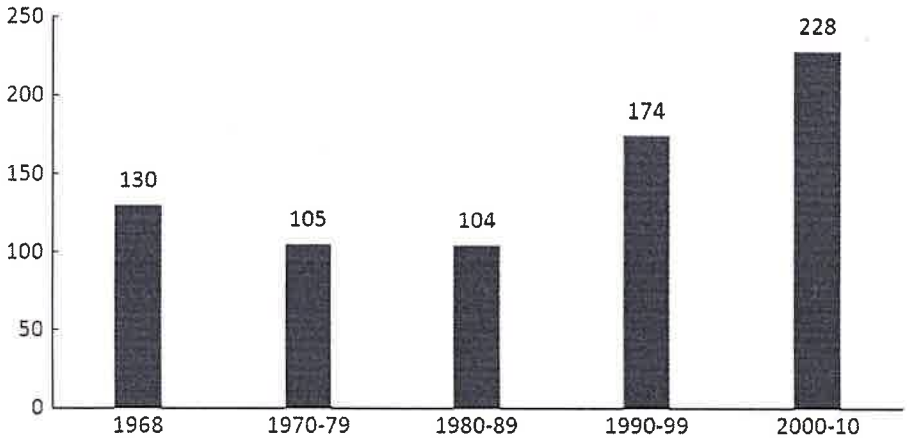

Fig. 2–New pesticide registrations by decade, 1968–2010

Source: Pray; Nagarajan 2012

Technologies that Influence IPRs[12]

It is in fact improvement in crop varieties that contributes maximum growth in productivity and other technologies that revolve around this. Considering the enormous investment that goes into variety development, innovators are developing technologies that help overcome operational difficulties in seeking protection for their novel varieties with or without operational regime. Such technologies are collectively called as Genetic Use Restriction Technologies (GURTs). A number of patents have already been issued for such technologies. Products of GURTs are crop varieties with traits whose expression is under the external chemical control. The traits may be germination viability of seeds, flowering, nutritional and flavour qualities, resistance to diseases, pests and herbicides, sterility and fertility restoration (for hybrid production), etc. Seeds in possession of the farmers will be useless, if they do not buy the prescribed chemicals and use in an appropriate time, thus producing their seeds every year on their own but compelled to buy the chemical season after season. The underlying desire of a private innovator is not to force farmers to buy seeds every year, but to force farmers to pay for their seeds for subsequent use. Hence, their grouping according to nature of protection is relevant to understand and appreciate probable stake-holders and the plausible impact. Here, agricultural technologies are grouped under different heads, *viz*, crop improvement, crop protection, knowledge based, natural resources management, machinery based and technologies concerning livestock.

Impact of IPR in Agriculture

In India, there are 50 public research institutions which are involved in modern biotechnology and among them 10 are engaged in plant genetic engineering especially with rice, chickpea, oilseeds, cotton and various horticulture plants.[14] More or less, most of the crop is developed outside India. Therefore, with the paying license fee Indian manufacturers are back crossing the local hybrids with transgenic seeds to develop commercially viable hybrids that can be grown in various agro climatic regions of the country. If it is successful in field trail then they register their 'essentially derived varieties' under the Indian Plant Act. For instance, to introduce transgenic or *Bt* cotton in India, Monsanto of the United States has been obtained by the Maharashtra-based MAHYCO (Indian collaborator of Monsanto) on payment of license fee.

It is observed that, overall, forty-three patent applications were filed but one international and three national patents were granted during the year of 2011.[15] Over 200 extant varieties were registered and granted protection and 436 applications were brought out in the Plant Variety Journal. Six copyrights were registered by ICAR institutes to protect developed software. 'Weather Cock' software package, capable of agro-meteorological analysis to understand possible impacts of climate change on crop performance, was developed and registered. Trademark 'IISR' was granted to the Indian Institute for Spices Research, Kozhikode. The Indian Agricultural Research Institute (ICAR) now has a corporate platform, 'Agrinnovate India' for technology commercialization and consultancy at home and abroad.

The premise Table 2, demonstrates the categorisation of Granted Indian Patents on transgenic plants as on March 2011.[16] From the Indian perspective, there are three universities (i.e. ICAR, Bose Institute, and Tamil Nadu Agriculture University) that hold the command for transgenic plant and

Table 2—Granted Indian patents for transgenic plants categorised by patentees as on March 2011

Foreign companies	Crop design NV, Monsanto Technologies LLC, Syngenta Participations Ag, Pioneer Hi-Bred International Inc, BASF Plant Science, Bayer Bioscience, Centocor Inc, Japan Tobacco Inc, Meristen Therapeutics, Senesco Technologies Inc, Agrivida Inc, Avestha Gengraine Technologies Pvt Ltd, Chromagenics BV, Dow Agroscience LLC, EI Du Pont De Nemours & Co, Fraunhofer-Gesellchaft ZurForderung Der Angewandten Forschung EV, Kweek-EnResearch bedrijf Agrico BV, LTA Resource Management Maxygen INc, Nippon Paper Industries Co Ltd, Protalix Ltd, Warner-Lambert Company LLC
Foreign universities/institutes	Auburm University, Bar Ilan University, Texas Tech University, The University of Chicago, University of Central Florida, The Hebrew University of Jerusalem, Leibniz-Institute of Plant Genetics and Crop Plant Research (IPK), Max-Planck Gesellschaft
Indian universities/institutes	Indian Agricultural Research Institute (ICAR), Bose Institute, Tamil Nadu Agriculture University
Foreign individuals	Raab R Michael, YehShyi-Dong

Source: S Kochar, 2011

Table 4—Extant varieties granted in India as on March 2011

Grantee		Number of plant variety titles granted
Public Sector		
	Indian Council of Agricultural Research	186
	Orissa University of Agricultural & Technology	7
	Birsa Agriculturtal University	2
	Dr. Panjabrao Deshmukh Krishi Vidyapeeth	3
Private Seed Companies		
	New Nandi Seeds Crop	7
	JK Agri genetics	4
	Maharashtra Hybrid Seeds Co Ltd.	2
	Ajeet Seeds Ltd.	2
	Vikram Seeds Ltd	1
Farmers		
	Individuals	3
Total		217

Source: S Kochar, 2011

Table 4 indicates the number of plant variety titles granted in India. If one can calculate sector wise, then the number of granted plant variety are 198, 16 and 3 by Public sector, Private sector and farmers respectively.

Issues Related to Intellectual Property Rights in Agriculture

The process of technology development and transfer would have multiple impacts on the farmers, researchers and organizations involved in the agribusiness where the multiple sectors and networks work together. This also brings some issues of ethics in diffusion of technology and food safety and security concern.

Ethics of Human Well-Being

One of the main issues is whether IP and research should relate with agriculture, because more than 60 percent people are involved in agricultural activities. The fact that human well-being depends on food, and some of the critical questions in this area are: Does IP protection truly stimulate research investment in agriculture? Does publishing play a key role in the public domain? Issues must be addressed by policy makers at the international, national and institutional levels. In the case of plants, there are further complications to this characterization of public goods. To begin with, the heritability of genetic characteristics differs across species, where for example natural out-crossing in cross-pollinated species leading to loss of genetic purity. Further, genetic information is only economically useful to the extent that the technological mix of complementary inputs is also available.

Lack of focus on Poor Farmers

On the other hand plant breeders are keen to generate profit from their research investment. Breeders are not able to recoup their investment because of the high rate of HYVs, farmers are not easily adopting these technologies in context of India. IPRs (Patents and PBRs) normally impose restrictions on farmers' ability to replant exchange or sell seed. Most of the crops have been developed elsewhere and Indian government manufacturers are only back-crossing the local hybrids with transgenic seeds to develop commercially viable hybrids that can be grown in different agro-climatic regions of the state, by paying a license fee. Since the growing concentration in the seed industry, public sector research on agriculture, and its international component, should be strengthened and better funded. The objective could be to ensure that research is oriented to the needs of poor farmers that public sector varieties are available to provide competition for private sector varieties; and that the world's plant genetic resource heritage is maintained. In addition, this is an area in which nations should consider the use of competition law to respond to the high level of concentration in the private sector.

Barrier in the Diffusion of Technology

IPRs reduce the rate of diffusion of Agriculture technology even though it depends upon region. The delay in diffusion relates to uncertainty and risk, and lack of information about the new technology. In such cases, the degree of technical complexity or novelty of an innovation may be an important factor inhibiting diffusion.[18] Applying this to seed technology, one can see that during the period of Green Revolution there was success only in a few states, it did not entirely replace the existing technology of using farm-saved seeds or the traditional cropping pattern. Thus, the moot question is whether the farmers with small and marginal land holdings would adopt the HYVs. In India, most of the farmers are marginal or below the marginal level and farmers have traditionally replanted, exchanged or locally sold seeds from previous seasons because poor farmers do not buy

seed every season. The rate of seed replacement is very low generally in India. There is also a lack of information about the technology; low land holding farmers do not have adequate information about new technology. Adoption of new technology will be easy only if the farmers have adequate information about the new technology. Basically the implementation of technology depends on block level as proper execution of plan to distribute technology can be carried out whether it is technology equipment or HYVs seeds. Such things lead to decrease in the level of development and farmers' livelihood.

Regime and IPRs

The foregoing discussion has only one lesson which is a corollary to the lesson learnt in case of deployment of registered extant varieties through soft and /or cross-licences. The existing strength of the national public research system in the development and commercial use in rice wheat application need to be timely consolidated and further developed. This attempt to dissect issues on IPR in the field of agriculture may give an initial idea to persons having ordinary skill in the art to become more IPR compatible in their research approach. It is quite clear that India, although sufficiently meets the domestic requirement of HYV seeds, has not been on the national or international level map of patenting activity in crop of rice-wheat. Given the importance of agriculture in India's economy, there is need to monitor the functioning of legislations such as the PPV& FR Act. As a pioneer and role model in the protection of farmers' rights, India is duty bound to closely monitor the effectiveness of this regime, especially to ensure benefit of its own large farming community.

Conclusion

Broadly, in agriculture IPRs are now visible in the form of the PBRs and other patent activities. In the present form of IPRs, there is a need to improve the IPR regime in terms of the legislation and implementation of laws. Therefore, public sector involvement might be useful to enhance the creation of a better environment for improving the agricultural innovation in the country. For instance, in the case of biotechnology, the industry will depend on the kind of IPR regime prevalent in India. However, India has enough of its own resources the only need is to monitor proper implementation of available resources. Thus, food safety is a major concern around the world and agriculture and cultivation has become more challenging because of various constraints due to biotic and abiotic factors. New technology has played a major role in mitigating the problems related to biotic and abiotic challenges of agriculture. Transfer of technologies in the field of agriculture biotechnology has captured the attention of many research organizations and funding agencies globally. The study presented in this paper on IP innovation and technology diffusion through the collaboration of different stakeholders from national level to state level, provides a clear picture of development in the agricultural sector in developing nations and the need for support from government and other funding agencies for betterment of agriculture systems and ultimately the common public. Adopting new technologies in different regions through creative collaborations for the purpose of product development, implementation and commercialization is also expected to give a significant boost to the sector.

Public and Private sector both have launched several kinds of techniques/method, farming equipment etc. but to implement there is a need to advertise with the society. With this concern, policy at national, international and local level should concern on how IP protection truly stimulates research investment in agriculture and, if publishing plays a key role in the public domain. The growing concentration of public sector in the seed industry should be strengthened and better funded. The objective should be to ensure that research is oriented to the needs of poor farmers; that public sector varieties are available to provide competition for private sector varieties; and that the world's plant genetic resource heritage is maintained. Adoption of new technology will be easy only if the farmers have adequate information about the new technology. Generally the entire implementation of technology depends on block level because there are proper plans to distribute technology whether it is technology, equipment or HYVs seeds.

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