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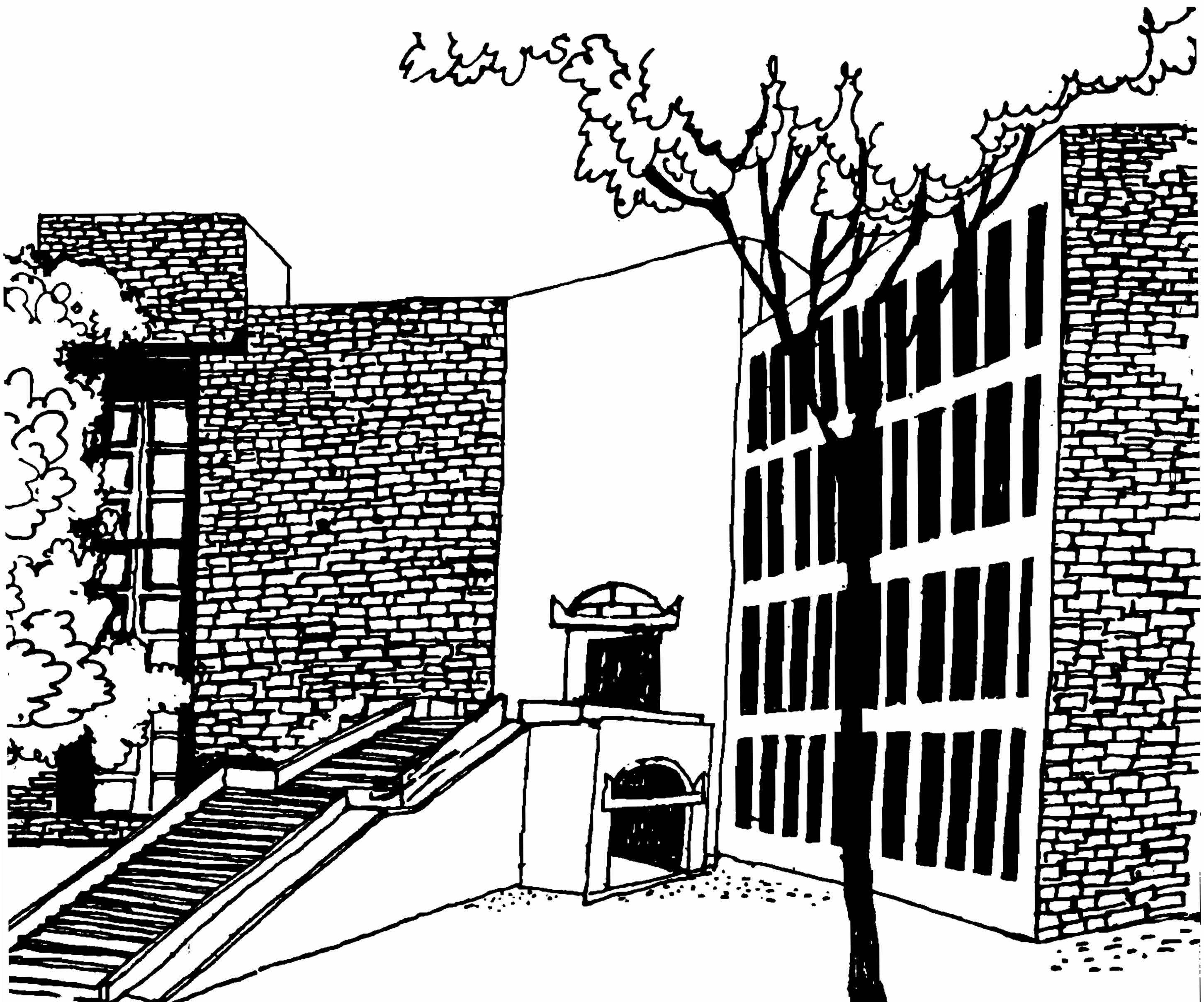

TRADE RELATED INTELLECTUAL PROPERTY RIGHTS AND SEED INDUSTRY IN INDIA: A REVIEW OF ISSUES AND EVIDENCE

By

Rakesh Basant

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INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

Trade Related Intellectual Property Rights and Seed Industry In India: A Review of Issues and Evidence

Rakesh Basant
Indian Institute of Management
Ahmedabad

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Abstract

Any analysis of the Intellectual Property Rights relating to the seed industry in India needs to take cognizance of three inter-related issues: (a) that the current debate on IPRs is part of a larger debate on issues relating to GATT; (b) that the options on IPRs are intricately linked to the New Economic Policy and the accompanying liberalisation process; and (c) that the IPRs relating to plant varieties need to be seen in a broader framework of the seed policy pursued by the government. In this background, this paper reviews the available literature and data to explore the impact of IPRs on the seed industry in India. The paper begins with a description of technological, structural and policy contexts of the seed industry in India. Given these characteristics and evidence from other countries, the likely impact of the seed industry related IPRs is explored. Finally, some policy options available to developing countries like India in the emerging world order are briefly discussed.

Trade Related Intellectual Property Rights and Seed Industry in India: A Review of Issues and Evidence

Rakesh Basant

The GATT-1994 Agreement, which covers a wide variety of issues relating to economic policy, will affect the socio-economic processes in India in many ways. Trade Related Intellectual Property Rights (TRIPS) have probably been some of the most widely debated aspects of the GATT accord. Intellectual Property Protection or Rights (IPP/IPRs) relating to plant varieties and seeds constitute an important dimension of TRIPS. The GATT agreement also allows the contracting parties some flexibility regarding the plant variety legislation they wish to adopt. The Government of India is in the process of framing such a legislation. It is in this context that this paper reviews the available literature and data to explore the impact of such IPRs on the seed industry in India. While most issues relate to the seed industry as a whole, the paper specifically focuses on the small and medium enterprises engaged in the production and processing of seeds. Enterprises engaged in seed storage and distribution are not directly covered.

Any discussion on IPRs and seed industry or plant varieties needs to take cognizance of three inter-related issues: (a) that the current debate on IPRs is part of a larger debate on issues relating to GATT; (b) that in the Indian context, the options on IPRs are intricately linked to the New Economic Policy and the accompanying liberalisation process; and (c) that the IPRs relating to plant varieties need to be seen in a broader framework of the seed policy pursued by the Indian Government.

The paper is divided into four parts. Section 1 summarises the various options available to India for protecting intellectual property embodied in seeds and plants. Section 2 focuses on the technological, structural and the policy contexts of the seed industry. Given the technological characteristics, industrial structure and the policy environment, the third section analyses the likely impact of the seed industry related IPRs. Evidence from other countries is reviewed to explore the impact on a variety of variables which can influence the role of small and medium firms in the seed industry. The final section discusses some policy options which can be used to counteract the likely negative influences of TRIPS on the Indian seed industry.

1. TRIPS and Seed Industry Related IPRS

The GATT-1994 agreement involves significant changes in the intellectual property rights (IPRs) regime in India. Two types of intellectual property protection (IPP), relevant for seeds and plant varieties will have to be introduced.

1. Patent protection for **micro-organisms**[1] and **micro-biological processes**[2]. **Essentially biological**[3] processes for production of plants and animals are exempt from such protection.

2. Protection for plant varieties either by patents or by an effective **sui generis**[4] system or by an combination thereof.

The legal protection of biotechnological inventions has been vigorously debated over the past few years. The GATT-1994 accord has put the seal of 'international consensus' on the patentability of micro-organisms, while the legal protection for live forms (plant, animal, human material) is still being debated. The freedom given to member countries to choose their own **sui-generis** system for plant variety protection recognizes the fact that this debate remains inconclusive. India is yet to evolve such a system. The components of the system which India finally adopts will determine the impact on the seed industry. This section reviews some options which the country has in the area of legislation to protect plant varieties.[5]

Broadly, developing countries can either establish a Plant Breeder Rights (PBR) system similar to the UPOV 1978 or UPOV 1991 acts or combine it with patent protection. The main differences in the implications of the two UPOV-PBR variants and the patent law are summarised in Table 1. It has been argued that IPP of plant material will have an adverse impact on plant breeding through restrictions on the exchange of germplasm and place restrictions on seed saving by farmers. In the context of the three options listed in Table 1, these consequences are briefly discussed below.

Exchange of Germplasm

Plant breeding in most developing countries is predominantly the domain of farmers and public institutions. Over the years the latter have been supported by International institutions. The extent of international exchange of genetic material used in the breeding of improved plant varieties has been considerable. This free international exchange of improved varieties and parental material may become restricted when plants become protected under patent law or under PBRs according to UPOV-1991/ UPOV-1978 acts.

(a) Patent Protection: Under patent law all unauthorized commercial use of patented matter is prohibited. With respect to plants, this implies that the use of patented plant material in breeding programmes may be refused or restricted by the patent holder. If authorised, the royalties will raise the costs of the research programmes. Consequently, the seeds of plants covered by a patent will be more expensive than other locally available seeds.

More importantly, the restricted access to germplasm is not limited to one single generation of a plant. In order to prevent the unauthorized use of next generation which will also incorporate the protected matter, patent protection of specific germplasm is being extended to all subsequent generations of the plant as long as the patent lasts, that is, 17-20 years. Biotechnology patents might constitute absolute worldwide blockades of germplasm exchange, in case a patent is granted which covers a large number of genes.

While India has the option of only providing PBRs for plants (UPOV-1978 or UPOV-1991), it is not entirely clear if patents on micro-organisms and micro-biological processes will not effectively provide patent like protection to plant varieties and seeds. Those in favour of patents for seeds and plants have argued that PBRs provide little protection for bio-engineered genes inserted into seeds and that the broad research exemption to PBRs would allow such genes to be removed from one variety and bred into another. (Lesser, 1990:60).

Patent protection envisaged under the GATT-1994 agreements for micro-organisms and micro-biological processes seems to be another way of providing patent protection to plants. However, enforcement of such legislation may pose serious problems. Lesser (1990:66) argues that 'it is virtually impossible for holders of patents on engineered micro-organisms to prove infringement. The infringer has access to the culture sample, but the inventor has no right to inspect the suspected infringer's production facility to determine whether the patented organism is indeed being improperly used.' Countries like India do not even have adequate infrastructure to ascertain the distinctiveness, uniformity and stability characteristics of plant varieties.

These enforcement related issues are indeed crucial for assessing the impact of patents or PBRs. If Lesser's contention is correct, diffusion (imitation) of the use of patented micro-organisms can be widespread. However, the reversal of the burden of proof under the GATT-1994 agreement puts the 'imitators' in a disadvantageous position. Therefore, the impact of patents on micro-biological processes and micro-organisms remains uncertain.

(b) PBRs under the 1991 UPOV Act: This Act provides protection against commercial use of all material of plant varieties of all genera and species for a minimum period of 20 years. Like patented plants, use of plant varieties protected under this Act for breeding programmes require authorization.

Royalties will also need to be paid if the new bred variety is considered to be **essentially derived** from the initial variety. In many cases costs of seeds will increase along with the costs incurred by breeding institutions.

(c) PBRs under the 1978 UPOV Act: In comparison to the 1991 Act, the protection conferred by the 1978 Act is less stringent. It is limited to varieties of **nationally defined** species and for a minimal period of 15 years. Besides, the PBRs cover only the reproductive material of the variety. The main difference is that the use of protected variety to breed new plant varieties requires neither authorisation nor payment of royalties.

The restrictions on free germplasm exchange imposed by IPRs relating to plants should be contrasted with the advantages of such rights in stimulating foreign breeders to make available their varieties and the associated technology transfer. We shall revert to these issues from the perspective of the small and medium seed firms in section 3.

On Farm Seed Saving

In most developing countries, and some developed countries including the U.S., saving seed for the next crop cycle is a common farmers' practice. In most developing countries almost 80 per cent of total seed requirements were met by saved seed (Wijk and Junne, 1993:61). In India less than 8 percent of total seed planted is commercially purchased. (See Table 2 and subsequent discussion). Plant related IPRs may severely restrict seed saving practices.

Seed saving of patented plants involves the duplication of patented matter. If not for private use, unauthorised saving of patented seeds is an infringement. The use of patented plants consequently raises the overall agricultural input costs and makes farmers more dependent on external seed producers.

PBRs under the 1991 UPOV Act allow the national authorities, to decide about 'farmers' privilege'. Any legislation adopted by India is likely to allow for on farm seed saving. In any case enforcing such restrictions have tremendous transactions costs. Once again, it is not clear if patents on micro-organisms and micro-biological processes will impinge on farmers privilege in any way. For our purposes, the issue is that if on farm saving of seed is restricted in any manner, the market for commercial seed will expand considerably. The seed enterprises will, therefore, face a growing market. The smaller firms will probably do better in such a scenario than under a demand constrained situation where they have to compete with large domestic firms and MNEs.

The Bio-diversity Convention

It has been argued that LDCs are not paid for the bio-diversity developed and conserved by them. But through IPRs of various forms, they pay for using the results of research based on the germplasm embodied in this bio-diversity. It is also suggested that this basic problem can partly be resolved by combining elements of TRIPS and the Rio Bio-Diversity Convention, which most countries have signed.

The Rio Treaty envisages promotion, conservation and utilisation of biological diversity at three levels; eco-system, species and genes. It recognizes Farmers' Rights arising from their past, present and future contributions in conserving improving and making available plant genetic resources. Some of the clauses of the Rio Treaty relevant for our discussion are (Gupta, 1994:17):

Art 15.2: Each Contracting Party shall endeavor to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of this Convention.

Art 15.3: For the purpose of this Convention, the genetic resources being provided by a Contracting Party, as referred to ... are only those that are provided by Contracting Parties that are countries of origin of such resources or by the Parties that have acquired the genetic resources in accordance with this Convention.

Art 16.3: Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that Contracting Parties, in particular those that are developing countries, which provide genetic resources are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights.

Art 8j: Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyle relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and Involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovation and practices.

Unlike the GATT treaty, the Rio treaty is very vague on the implementation of its clauses. In any case, operationalising the 'intentions' embodied in these articles is a difficult task; converting them into legally binding directives is even more difficult. Interpretation of several articles is likely to give rise to disagreement. For example, the Convention stipulates that access and transfer of technology shall be provided on terms that recognise and are consistent with the adequate and effective protection of IPRs. It is not clear how this relates to the above mentioned provisions of Article 16. Furthermore, the Convention has not been signed by all developed countries, including the U.S. (Wijk and Junne, 1993: 63-64). Despite these problems, it needs to be utilized for bargaining purposes. More on this in the last section.

2. Recent Policy Changes and the Emerging Structure of the Seed Industry in India

The seed industry in India has undergone significant changes during the last decade. Many of these changes were either induced by policies or were necessitated by changing technological considerations. This section begins with an outline of the technological characteristics of seed production and processing activities. This is supplemented by a brief description of the recent changes in seed policy and in the structure of the seed industry.

Seed Industry: Certain Technology Related Features

Following Jaffe and Srivastava (1992)[6], we summarise in this sub-section certain techno-economic characteristics of the seed industry. These characteristics are relevant for our purposes insofar as these may influence the participation of the private sector (and of different sized firms within the sector) in the production and processing of seeds. These activities can be broadly grouped into three categories: (a) varietal development; (b) seed production; and (c) seed processing. Varietal development includes germplasm collection, its manipulation for applied plant breeding and varietal testing. This activity culminates in the production and release of breeder seed which is the basic input for the subsequent seed multiplication process. Breeder seed, therefore, is the seed of a newly developed variety that is produced under the supervision of the plant breeder or the owner of the variety. Seed production or multiplication involves the production of foundation and commercial seeds. Foundation (or basic) seed is the progeny of the breeder seed and it consists of the generations of seed between breeder and commercial seed. Commercial seed, which is sometimes called the certified seed, is the seed that is produced to be sold to farmers. Seed processing involves drying, shelling, sizing, removal of inert material and alien seed and various types of treatment (e.g., fumigation or chemical dressing) to protect seed health and combat against fungi, viruses, and bacteria. Processed seed is normally packed for subsequent storage and distribution. In what follows, we discuss some special features of these activities.

(a) Varietal Development: The development of new varieties and hybrids can be a profitable activity for private firms, either specialized R&D firms or firms which also engage in seed production and distribution. However, for several reasons the amount of investment in these activities by the private sector may not reach socially optimal levels. Besides, these factors certainly inhibit the entry of smaller firms in the area of varietal development.

First, private firm entry into plant breeding may be constrained by the high costs and risks, the long gestation periods, and the high technical, capital, and human resource requirements of such work. This may limit the extent of competition in this activity. Second, there are potentially significant externalities associated with effective plant breeding work (and germplasm and varietal maintenance) for which the breeder may capture little or none of the benefits and therefore not take into account when making investment decisions. Third, many outputs from plant breeding R&D have the public good properties of non-exclusivity and non-rivalry as it is often difficult or costly to prevent non-paying farmers or firms from benefitting from the knowledge embodied in new varieties of seed and many such individuals can simultaneously use this knowledge without depleting it.

The significance of these factors varies across different types of crops. In the case of hybrids, plant breeding work is technically demanding, very costly, and a long-term venture, generating considerable technical and financial barriers to entry. However, for those private firms able to marshall the requisite resources, plant breeding of hybrids can be commercially attractive given the biological protection which plant breeders obtain over their R&D output by maintaining control over the inbred lines. In contrast, varietal development work for self-pollinated varieties (e.g. of rice and wheat) is rather conventional (presenting less significant entry barriers), yet the scope for the breeder to appropriate the benefits from such R&D may be very limited since its output can be easily exploited by others. Besides, recent developments in biotechnological techniques for fingerprinting plant varieties, including hybrids, may allow 'reverse engineering' of these varieties and replicate it. Such replication may or may not involve the knowledge of the parent lines (Ihnen, 1989: 110). In the absence of plant protection (and enforcement), private investment in such activity is usually very limited and public sector financing or direct performance of this function will normally be required.

The introduction of PBRs will reduce technology spillovers and allow the breeder to appropriate a larger share of the benefits associated with plant breeding activity, especially in the area of self pollinated crops. However, entry barriers associated with high risks, high costs and long gestation periods will continue to inhibit the participation of smaller firms in R&D activity.

(b) Seed Production: The production and processing of seed also features externalities, risks, significant skill requirements, and public good characteristics, although their magnitude is considerably less than in the case of varietal development work. The economic and technical barriers to entry for the private sector in these activities are thus far lower than for varietal development. Over a wide range of production and processing activities there is ample scope for private suppliers to appropriate a sufficient proportion of the benefits to make such investments profitable.

Where market demand for commercial seed is developing, as is the case in India, opportunities for profitable production of hybrids and multiplication (and processing) of improved open-pollinated varieties (e.g. maize), and of seeds of specialty, high value crops (e.g. horticultural crops) may be significant. In all such cases, it is very difficult and /or costly for farmers to produce and save high quality seed on their own. Due to the moderate to rapid loss in genetic and/or physical purity, use of farmer-saved seed for such crops will result in yield losses. Potential profit margins are comparatively much lower for the multiplication and processing of seeds for self-pollinated crops, since specialized producers will have to 'compete' with farmer seed retention. **Only firms which carry very low overhead costs and yet are able to produce seeds of consistently high quality (relatively small**

firms with a good technical base ?) might be expected to profit from such activities. To achieve this, such seed multipliers would need to acquire improved varieties from public or private breeders at relatively low cost.

Direct public sector production of seed can be justified in the case of foundation seed for self-pollinated crops as this is generally unprofitable and is associated with significant externalities. As the foundation seed will be planted over a potentially wide area to produce commercial seed, the loss of genetic or physical purity in the foundation seed will have adverse effects on the subsequent production of commercial seed, on seed marketing efforts, and on farm-level productivity. Once foundation seed is available, the private sector can take responsibility for the production of commercial or certified seed.

(c) Seed Processing: This component of the seed production distribution process frequently requires the largest capital investment. This is so because some seed drying, cleaning, chemical treatment and packaging activities either require or are more efficiently performed with mechanized equipment. This does not mean that large scale processing facilities are required, only that some minimum scale should be attained for maximum efficiency. The technical difficulty of seed processing varies among crops, being relatively easy for most field crops and considerably more difficult for most vegetable, oilseed and forage crops.

Therefore, participation of relatively smaller seed enterprises in seed processing activity, especially for vegetable, oilseeds and forage crops is likely to be limited. In fact, while all public sector corporations in India and some large firms have their own processing facilities, small seed enterprises and cooperatives get their seeds processed on a contract basis (Singh, Asokan and Asopa, 1990:14).

Recent Policy Initiatives and Implications for the Industrial Structure

The Indian seed industry has been dominated by a large number of small and medium firms. Till 1987, this industry was not included in the Appendix I industries and consequently the foreign companies and monopoly houses were not allowed to invest in the seed sector. The changes in the industrial licensing policies in 1987 have allowed large Indian firms and foreign owned enterprises to participate in the seed industry. The new seed (import) policy (NSP) of 1988 initiated major liberalization of seed imports and exports. The import of seeds of vegetables flowers and fruits has been put under open general license (OGL). The import of seeds of oilseeds, pulses and coarse cereals is allowed initially for two years by companies which have collaborative agreements, provided that the foreign supplier agrees to supply parent lines/nuclear or breeder seeds/seed technology to its Indian client. Import of seeds of wheat and paddy are not allowed under the NSP. Among other incentives, import duty on seeds and equipment used for seed production was significantly reduced and income tax rebate was given for R&D expenditure.

India's commercial seed industry expanded considerably during the late 1980's and early 1990's, both in the private and the public sectors. The private sector boom was induced by the policy initiatives outlined above. Much of the growth in this sector has stemmed from either foreign investments or from spin offs from previous companies, with technical and marketing personnel branching off to start their own seed companies. One firm alone, Maharashtra Hybrid (MAHYCO), has given birth to at least eight additional private companies. Several of the branch-off companies have sold their original company's hybrid varieties under a new name, undermining the latter's appropriability of benefits from their R&D effort. (Jaffe and Srivastava, 1992: 84; Pray and Rebeiro, 1990:36-38).

The evidence on the structure of the seed industry in India is extremely limited. In fact, no robust estimate of the number of firms engaged in the production and processing of seeds is available. Available estimates range from 70 (Pray et.al, 1991) to 500 (Pandey, 1994). One way to reconcile these two estimates is to assume that most of the growth in the number of firms occurred during 1989 (year to which Pray et. al.'s estimates refer) and 1994. We have not been able to check this out. It is indicated earlier, activities relating to seed industry can be broadly classified into three groups (a) seed or varietal development; (b) seed production and processing; and (c) seed distribution. It is not entirely clear which of these activities are performed by firms included in the estimates mentioned above. It is possible that Pandey (1994) has also included firms that are primarily engaged in seed-distribution.

Prior to 1987, large firms and multinational corporations were not allowed to enter the seed industry. Consequently public sector units and small and medium private sector firms constituted the industry. During the late 1980's and early 1990s the seed industry has undergone significant changes with the entry of large and foreign firms. The data base on these changes is very limited. Broadly, going by the information provided in Pray et. al.(1991), it is clear that the private sector is comprised of a diverse mix of enterprises of varying sizes, ownership characteristics and operational specialization. Almost all of the MNC subsidiaries have emerged after the announcement of the New Seed Policy in 1988. According to some estimates, among the Indian owned firms, there were about six large seed and agri-business enterprises combining research, production and processing with seed turnovers exceeding Rs 50 million. Another dozen or so firms are medium-scale with annual seed sales of Rs 10-50 million. These companies have very limited research programmes and focus on multiplying and distributing public bred varieties. An additional 40-50 smaller seed companies organize seed multiplication schemes and perform wholesale, storage and transport functions.

As Chart 1 and Table 3 show, the interface between public and private sectors in the seed industry is significant. Much of the genetic material, self and open pollinated varieties and the inbred lines used by the private firms is obtained from the Indian public sector research institutions, or the International Agricultural Research Centers (IARCS). A sample survey of 24 private seed enterprises (see also Table 4) showed that 16 firms obtained germplasm for pearl millet from ICRISAT and 6 firms obtained germplasm for the same crop form Indian public universities. Nineteen of the sample firms obtained pearl millet breeder seed from ICRISAT, while ten obtained sorghum breeder seed from the same source. Only the MNC subsidiaries obtained much of their germplasm from private sources (eg. parent companies or subsidiaries in other countries), although such material may also have originally derived from public research. (Pray et.al. 1991: 322-3).

The results of the sample survey are significant because the sample was biased towards the largest and most R&D intensive companies. In fact, the sample includes all enterprises that have research programmes for major field crops in India (Pray et.al, 1991: 317). Obviously, the dependence of smaller, less R&D intensive firms on external (mainly public) sources for germplasm and other breeding material will be significantly more than the sample firms referred to above.

The private sector has focused its plant breeding work on sorghum, pearl millet, maize, cotton, sunflower, and selected oilseed crops and vegetables. (See for some estimates, Pray and Rebeiro, 1990: 44-45). For each of these crops, there is scope for successful hybridization, thus providing firms with some degrees of natural protection against competition as well as higher margins on their sales. The former is important since the plant varieties listed above are not legally protected in India but will come under the purview of the proposed changes in the IPRs. Interestingly, for crops mentioned above, the applied research expenditures for the public and private sectors have reached similar levels in recent years. However, the majority of privately bred hybrids are based on germplasm or other materials obtained from public sources (Pray et.al.1991: 317-18).

While there is growing involvement by the private sector in plant breeding, most varietal development work on self and open pollinated crops in undertaken by the public sector and the vast majority of HYV and hybrid varieties of wheat, rice, maize, coarse grains and oilseeds have derived from the central government research institutions and the State Agricultural Universities (SAUs). Public sector institutions have also been very active in developing hybrid varieties of major cereals, forage crops and cotton. Over the past fifteen years, more than 2000 varieties have been released by public sector institutions (Table 5).

Further, most of the scientists presently employed by the private enterprises in India received their training from and frequently worked at the public universities and research stations or at ICRISAT. However, while private firms have hired scientist from the public institutions, there are still only about one hundred Ph.D. or M.Sc. scientists working for private seed companies compared with over 10,000 such scientists at the public institutions. (Jaffe and Srivastava,1992:80).

Overall, the participation of private and public sector in the seed industry overlap, particularly after the stage of varietal development (Table 3). The linkages of the private firms with the public sector are significant. The private sector dominates only in the distribution of vegetables and in the import of maize and vegetable seeds. These patterns may alter significantly after the introduction of plant variety and seed related IPRS. Some possible shifts are discussed in the next section.

To conclude this section, a categorization of seed firms operating in India may be useful. Following Chopra (1989), firms in the Indian seed industry can be classified into six broad categories.

(i) Seed Firms without R&D: Private seed enterprises which only multiply certified or "truthfully labelled" seed of superior hybrids/varieties developed by public sector R&D system. These firms usually purchase their foundation seed supplies from the recognized government foundation seed agencies. (eg. National Seeds Corporation or State Universities). Many of these seed companies have created necessary infrastructure (facilities, manpower etc.) and have been recognized to produce foundation seed for their own certified seed production programmes. Most of these enterprises are likely to be relatively small.

(ii) Seed Firms with R&D: Private seed enterprises which have initiated plant breeding research to involve superior hybrids through their own R&D programmes, while still primarily engaged in the multiplication of seeds developed by the public sector. They employ trained plant breeders, have invested in research stations and labs. Their inhouse R&D units are recongnised by the Government of India (Ministry of Sciences and Technology). These units obtain the basic breeding material from public plant breeding stations, state agricultural universities, international agricultural research centers (eg. ICRISAT), private seed companies and state sponsored research stations in other countries. Many of these seed companies are already marketing hybrids bred by themselves. The parental lines of these hybrids are not disclosed resulting into the enterprise's monopoly over their scale.

(iii) Seed Firms with Foreign Collaboration: Private seed enterprises who have created linkages (collaboration, royalty etc.) with transnational companies and obtained production and marketing rights of their adaptable hybrids. They maintain parent materials, produce and market hybrid seeds typically such enterprises also have R&D facility and are relatively large.

(iv) MNC Subsidiaries: Subsidiaries of multinational seed, chemical and food companies which obtain breeding material from their parent companies, isolate adaptable lines, make crosses and develop superior hybrids, without disclosing their pedigree. They multiply their foundation seeds and either sell the same to seed farmers at fairly high prices or produce and market their commercial seed. These are also generally large firms.

(v) Joint Sector Firms: Seed enterprises involving both private and public capital. These firms multiply seeds of only publicly bred hybrids/varieties. (Under the National Seeds Project System, each state will eventually have one such state seed corporation).

(vi) Public Sector Firms: Government seed enterprises which primarily play the role of developing seed trade, maintain foundation seed stocks for sale and inter-state marketing. They also engage into seed production, processing and marketing of HYV seeds.

Unfortunately, we do not have robust estimates of the existing number of firms in the various categories enumerated above. We also do not have information about the possible overlap among different categories of private sector firms (especially types (ii) and (iii) defined above). However, most of the small and medium seed enterprises are expected to belong to category (i). Despite the data gaps, the categorization is conceptually relevant because the changes in the IPRs might have differential impact on firms in different categories. Besides, these categories may undergo significant changes with liberalized trade in seeds and IPP protection of plant varieties. For example, for survival, firms without R&D facilities may either have to develop these facilities or develop linkages with domestic and/or foreign companies that are technologically dynamic.

3. Implications of TRIPS for the Indian Seed Industry

Restrictions on germplasm exchange resulting from IPP of plant varieties would probably inhibit plant breeding activities by small and medium enterprises. As mentioned earlier, international germplasm exchange has played a vital role for developing improved varieties of food and other crops in less developed countries. It is now feared that new technologies in conventional plant breeding and in bio-technology will not be available to these countries or that they will have to pay excessive charges to get access to it.

These fears get accentuated by some recent developments. First, multinationals all over the world have been taking over many of the smaller seed companies. In effect, recognition of the potential of bio-technology has resulted in the consolidation of the seed industry as large chemical, pharmaceutical and food enterprises in the U.S. and the European Community purchase seed companies (Pray and Ramaswami, 1991:31; Menon and Sadananda, 1989:38). Second, IPRs are being strengthened in the developed countries, especially in the area of living organisms and plant varieties. Third, in the more developed countries, the private sector share of bio-technology research is higher than its share of conventional plant breeding research. And finally, universities in the U.S., which were traditionally important sources of agricultural technology for developing countries, are patenting their products of bio-technology.

Given these fears and other features of the seed industry and policy discussed earlier, the impact of IPP of plant varieties will depend on (a) what changes take place in the role of public sector in seed production and processing; (b) how private sector firms respond in terms of R&D, foreign collaborations etc; (c) what trends emerge in the area of seed imports; and (d) what changes take place in the policies relevant for the seed sector e.g. subsidies etc. In what follows, we discuss some of the probable developments in these areas.

Role of the Public Sector

From the point of view of the small and medium seed firms, two inter related questions regarding the role of the public sector will be extremely relevant:

(a) How will the nature and quantum of public sector R&D change? Whether the public sector will continue to be their source of new technologies embodied in germplasm and other breeding material. If yes, under what terms and conditions?

(b) Will the public sector withdraw from the activity of commercial seed production? Whether PBRs will provide enough protection to induce the large private sector firms to initiate R&D on self pollinating crops and gradually deplace the public sector? In what follows we discuss some probable answers to these questions.

The role of the public sector in the technological developments of the seed industry in India has already been highlighted. Even in the United States, the entrance of private firms into seed breeding had generated considerable concern within the public sector research system. These concerns included (see Lesser, 1990:62-63): (i) the growing influence of the private sector on the scope of research, with the risk of shifting public research to background breeding, a phenomenon that may remove the public sector as a force in the commercial seed market; (ii) Loss of public confidence in the impartiality of the public sector researchers; (iii) inhibition of the free flow of information and germplasm between and among private and public sector researchers; (iv) lower allocation of government research funds; and (v) conflicts of interest for researchers working simultaneously at universities and private sector firms. These concerns are pertinent for India as well.

There is no evidence from any country that the introduction of PBRs have resulted in a significant shift in the scope of the public sector research. However, it has been argued that public research policy should de-emphasize public breeding of commercial hybrids which compete with private hybrids and concentrate instead on more basic aspects of breeding that are not or can not be addressed by private firms, on providing germplasm useful for breeding hybrids, and on the breeding of varieties (Pray et.al., 1991; Jaffe and Srivastava, 1992). In fact, in recent years, the share of the public sector in the commercial seed supply has declined vis-a-vis the share of the private sector (Table 6).

If the policy for restricting commercial seed production by the public sector is adopted explicitly, the private sector will face a growing market. It is expected that the reduction in the size of public seed supply will stimulate demand for private hybrids, thereby making private research more profitable. However, the positive impact of such a policy should be weighted against the negative impact of less public sector R&D.

The ability of the seed companies to realise technological opportunities depends on the availability of genetic material suitable for their breeding programmes and the state of their plant breeding technologies and knowledge. In India, as shown earlier, the public sector has been the most important source of advances in knowledge and technology of plant breeding. Private breeding would not grow without this indirect support (Pray et.al, 1991:322). The firms most adversely affected will be the smaller ones with limited access to plant breeding material and technology.

As indicated earlier, because breeders depend on the availability of novel germplasm, the economic value imparted by PBRs may chill the current free exchange of protected material and thereby threaten future research. At present, UPOV-1978 is applicable in most countries which grants free access to protected varieties for research use and allows commercialisation of derived new varieties. This free access applies to varieties that have already been marketed. For varieties that have been protected but not yet marketed, access is less clear. The derived variety must be distinct so as not to violate the right of the holder of PBR. This will change once UPOV-1991 becomes the norm. (Lesser, 1990:63). However, access to the basic collection of germplasm for major crops is generally free, as these collections are for the most part publicly held. Access to germplasm for minor crops is potentially more problematic. These crops have not attracted much private sector research so far. (Lesser, 1990; 63-64).

The available evidence does not suggest a clear pattern of effects on exchange. However, in the U.S., PBRs seem to have slowed down the flow of scientific knowledge and materials from private breeders to universities but not from universities to breeders. But the nature of these exchanges have undergone a change. It is increasingly common for U.S. breeders to sign agreements for the use of germplasm, agreements that can involve the payment of royalties if a new variety is marketed. Lesser (1990) refers to a U.S. survey in which 41 of 48 respondents felt that "plant patents" would adversely affect free exchange of germplasm among public and private breeders. Unfortunately, the term "plant patents", which can have several interpretations and may include or exclude PBRs, was not defined. But in general consensus seems to be that exchange restrictions are going to be more severe for breeders in non-UPOV member countries (Lesser 1990:64). Whether the patents of genes will further inhibit the free exchange of germplasm is not quite clear. Examples have not yet been documented. It has been argued the effect will depend on the protection requirements of national laws and the responses of germplasm rich countries (Lesser, 1990). More on this in the last section.

Whatever little information there is on the impact of PBRs in developing countries comes from Chile and Argentina, two developing countries that have adopted some form of PBR without signing UPOV. Apparently in Chile, PBRs induced universities and perhaps the government research institutions to invest more on plant breeding research. In both countries, PBRs facilitated joint ventures between public sector research institutes and private cooperatives and firms under which the private concerns have financed government performed research in return for rights to multiply and sell varieties owned by the government. These joint ventures have allowed the Argentine government to perform research and through increased salaries, to retain its scientists. (Lesser, 1990:61-62). This should be contrasted with the experience of Turkey where most restrictions on foreign participation and seed imports have been eliminated in the seed industry. Many multinational seed companies have reportedly hired almost all of the government plant breeders leaving the government research system very weak.

While the experiences of Chile and Argentina are interesting, two points need to be highlighted. One, the agro-climatic conditions in these countries are such that many of the temperate zone plants and seeds can be adopted without (or with limited) local adaptation. Therefore, the risks involved in the collaborative research in these two countries are presumably not very significant. Second, even if collaborative research is induced by PBRs, smaller firms are unlikely to be partners in such efforts, because of limited actions of technical and financial resources.

However, given India's technological capability in breeding technology, PBRs will provide an incentive for the Indian scientists to develop new varieties, provided they have the resources and get a share of the benefits which the employing institutions receive from their innovations.

Private Sector R&D

If PBR legislation has the expected incentive effect, private R&D expenditure on self-pollinated crops like wheat, rice, barley and soyabeans should increase as enforcement grows stronger. But even in the absence of PBRs many private seed firms undertake R&D. As indicated earlier a number of large firms entered the seed industry after the licensing restrictions were removed in 1987. Most of these firms have established R&D facilities for plant breeding or extended research programmes that they have in other industries. Interestingly, the estimated private research expenditure for sorghum and millet was of the same order of magnitude as the research expenditure on these crops by the public sector (Pray et.al,1991:317,323). However, this research was significantly dependent on public sector research. Besides, the linkages among private sector firms for germplasm exchange etc. were fairly limited. Therefore, if R&D expenditure of the private sector increase significantly due to the introduction of PBRs , the smaller non-R&D firms may not benefit from this research unless exchange and other linkages are developed. It is very difficult to predict how and if such linkages will emerge.

The Indian private seed companies spend about 4 per cent of their sales on R&D. This compares well with the estimates for the U.S. (3-4 per cent) and Argentina (5 per cent). (Pray and Ramaswami, 1991:16). According to an earlier estimate, the private companies in India have developed about 122 varieties/hybrids: 55 in vegetables; 39 in millets; 13 in cotton; 9 in oilseeds; 4 in fodder crops; and 2 in pulses.

As the market for seed grows, opportunities for profitable multiplication and processing of hybrid varieties, improved open-pollinated varieties, and seeds of specialty crops may be significant. Profit margins, especially in the absence of PBRs, are much lower for the multiplication and processing of seeds of self-pollinated crops, since specialised producers have to compete with low-cost farmer production and retention.

Available evidence on seed company margins for sorghum and millet hybrids shows that they are considerably higher for hybrids bred by the private sector than they are for the hybrids bred by the public sector. Distributors margins are also higher for private hybrids than for public hybrids, but distributors margin for private hybrids are much lower than seed company margins. (Pray et.al, 1991:319). Therefore, both seed companies and distributors gain from private hybrids, but the relative gains are higher for the seed companies than for the distributors. The same pattern may emerge for open pollinated crops once PBRs are introduced. Despite this incentive, enforcement problems may not encourage the private sector to undertake breeding of open-pollinated crops in any significant manner. Consequently, the role of the public sector in the breeding of open-pollinated crops would continue to remain important, at least in the short run.

Introduction of PBRs in India is unlikely to result in any restrictions on the retention of seeds by farmers for resowing. In any case enforcing such protection policies are almost impossible. Under such circumstances the private sector will undertake varietal development and breeding of open pollinated crops only if they can charge a high price from seed distributors and if their research product can be adequately protected from other seed companies. The adequacy of enforcement will be crucial here as well.

Countries that have private sector breeding programmes in self pollinating crops like wheat and soyabeans - the U.S., countries in the European community, Argentina and Chile also have PBRs studies of the U.S. seed industry have shown that private breeding of wheat and soyabeans increased around 1970 when the Plant Variety Protection Act was passed. The number of soyabean and wheat varieties also increased sharply during the 1970s. (Pray and Ramaswami, 1991:27; Lesser, 1990:60). There is also some evidence, albeit weak, that privately developed varieties are more productive than publicly bred ones (Lesser, 1990:60). Overall, however, no study has been able to isolate PBRs as the cause of private breeding, because changes in technologies and prices were taking in the U.S. at the same time as the introduction of the PBRs (Pray and Ramaswami, 1991:27).

In 1989, officials interviewed from Pioneer, DeKalb, Northrup-King, Cargill, Morgan and several smaller Argentine companies reported that there were no increases in private research on self-pollinated crops or on hybrids, owing to the 1973 PBR legislation (Pray, 1991). However, some other studies suggest that PBRs had a small positive effect on private plant breeding in Argentina, especially of wheat and soyabeans. PBRs in Chile also appear to have improved access to fruit varieties from the United States and New Zealand, and indirectly increased seed exports. (Lesser, 1990:61). New Zealand had similar experience with PBRs when transfer of fruit technology took place (Wijk and Junne, 1993:61). A survey of Indian seed companies in 1988 showed that they are overwhelmingly in favour of PBRs, to benefit more from their R&D effort (Agarwal, 1989: 78). However, the nature of PBRs preferred by them was not probed. Such a response is understandable given the poaching of hybrids and varieties by unscrupulous firms. They usually lure the contract farmers to reveal the parent lines. (See, Barwale, 1989 for some examples;pp. 70-71).

Pray(1991), after reviewing the evidence on the impact of PBRs on private research has the following conclusions to draw: (1) Some type of property rights, either legal or technical (hybrids), does seem necessary, but not sufficient, condition for private research on self-pollinated crops; (2) Without enforcement mechanisms such as plant royalty bureaux, an efficient court system and companies which are willing to take PBR violators to court, PBRs provide only a limited amount of protection to breeders; (3) Even if PBR legislation does effectively protect breeder's rights, markets have to be sufficiently large to justify private investment in research; and (4) PBRs may stimulate the transfer of technology.

It is interesting to note in this context of transfer of technology from abroad that one of the most significant impact of the seed policy was an increase in collaboration agreements between domestic and foreign companies aiming at import of technology and parental material. So far about 20 seed companies have been involved in collaborations (Table 7.) Most of the collaborations seem to involve hybrid seeds for vegetables, oilseeds (mainly sunflower) and ornamental plants and flowers. The details of these collaborations are not readily available.

Although no information is available about the size of the domestic firms involved in such collaborations but most of them are likely to be large. With the introduction of PBRs, such collaborations are likely to grow and mainly large domestic firms with R&D facilities will be able to gain access to foreign technologies through such arrangements. In the time to come, firms with R&D facilities will enter into foreign collaborations and firms with collaborations will spend more on R&D facilities. Consequently, these two sets of firms will consolidate their position along with MNC subsidiaries. Interestingly, the meagre available evidence on the U.S. experience does not suggest that plant variety protection led to mergers or monopolisation in the seed industry (Ihnen, 1989: 113). Nonetheless, the danger of smaller firms getting marginalised is real.

On balance, according to some studies, PBRs in the U.S. have produced modest private and public benefits at modest private and public costs. However, this conclusion is contingent upon the existence of a significant public breeding effort as a counterbalance to possible monopolisation by the private sector. (Lesser, 1990:61). India will also have to evolve policies whereby the public sector is not marginalised.

The Impact of Import Liberalisation

As argued earlier, the role of PBRs need to be seen along with the new economic policy and the seed policy of 1988 both of which favor liberalised imports. According to Pandey (1994), of the 500 seed companies, about 133 companies have applied for import of seeds of cereals, pulses and oilseeds. Table 8 reports the import and export of seeds of major crops in recent years. For vegetables, there has been a significant increase in imports of seeds over the past few years. The export of vegetable seeds seems to have tapered off in the late 1980s. Overall, the import and export of seeds has increased with significant fluctuations across crops. However, the exports of seed, fodder seed and ornamental plants/fruits have increased considerably.

There are limitations to the inroads seed imports can make in the domestic market. It is profitable to import seed if it gives higher yields, improves the quality of the crop or is less expensive than the local seeds. Agro-climatic conditions, tastes in local markets and local costs of seed production can be important barriers to trade. Most crop varieties do not transfer well into new agro-climatic conditions. They must usually be modified to fit local climate, day length, soils, pests and deceases. Many quality characteristics that are rewarded with high market prices in one country are not acceptable in others. Finally countries like India with low labour costs can frequently produce seeds more cheaply than high income countries. Therefore, Pray (1990) argues that imported seed will probably not gain a large share of the total seed sown in any crop in India. He cites the example of Thailand where conditions are similar to India.

It is clear, therefore, that differences in agro-climatic conditions of tropical and temperate regions mean that imports cannot substitute for local research. If research is to be localised, even the MNCs which are operative in India will have to undertake some research here. In most countries MNCs concentrate on hybrid seeds of major field crops and on hybrid vegetable seeds. They also export commercial seed to developing countries. Most large MNCs prefer, however, to grow part of their commercial seed in the country where it is sold and to import part. The Pioneer seed company, for example, prefers to grow 70 per cent of its seed locally and to import 30 per cent . This strategy saves transportation costs, takes advantage of inexpensive labour to produce labour intensive seeds and diversifies production risk. The MNCs may sell the parent seed in return for a royalty on the commercial sales. Alternatively, they may decide to invest in a local partnership or a wholly owned subsidiary. Prima facie, arms length licensing will not be preferred under the new economic policy and the MNCs would probably opt for equity participation. It is not entirely clear which of these arrangements will dominate in the post PBR era. However, the smaller seed companies with almost non-existent research infrastructure are unlikely to be part of such arrangements.

Anecdotal evidence suggests that vegetable seed prices declined in India when import restrictions were lifted. (Pray and Ramaswami, 1991:31). This decline in prices could have been due to a large excess demand for hybrid vegetable seeds which domestic production could not fulfill (see, Agarwal, 1988: 33). Some studies also suggest that the location of a multinational corporation's research programme in a country is associated with higher yields of maize in tropical regions. But so far no empirical study has examined the impact of a liberal import policy combined with MNC participation on the price of seed and the availability of technology (Pray and Ramaswami, 1991:31).

In a survey of Indian public and private seed companies conducted in 1988, the majority view was that the MNCs will enter India gradually (Agarwal, 1988:19). But any legislation on PBRs was not on the cards at that point in time. Interestingly, most of the institutions (88 per cent), both public and private, thought it desirable to increase MNC participation through collaborative work on biotechnology in plant breeding. The major reasons cited for such collaborations were: need to develop a bio-technology programme for pulses; to get access to advanced technology; for training of scientists; to compete in the international seed market; to breed better disease and pest resistant hybrids/ varieties; and to facilitate recombining characters in non- sexually propagated crops and multiplication of identified genotypes with less variability (Agarwal, 1988:20). Therefore, the domestic industry does not seem to question the desirability of the participation of foreign seed companies ; the conditions of such participation are being debated.

Other Policies Relating to Seed Industry

The Indian government has provided subsidized credit to private seed companies for capital investments. The growth of the public sector seed production has also involved huge government subsidies. Seed certification in India has been voluntary so far, and many private firms sell labelled seeds. Theoretically, lack of certification may reduce the demand for private varieties because farmers will be reluctant to buy them and the government extension agents will be unable to promote them. The government in India sets the price of the seed sold by public institutions and allows the private sector to set prices as it wishes. The public sector prices are fixed on cost plus basis, and since this sector is not very efficient, their prices are usually higher than those at which private companies could produce seed. The prices set by the state, therefore, act as floor prices. If yield differences are large, farmers are prepared to pay as much as 30 per cent more for private varieties, as compared to the public varieties (Pray and Ramaswami, 1991:29).

There has also been a considerable duplication in investments and activities of state and national seed corporations. While the public seed corporations have concentrated most of their activities on the production and sale of self-pollinated crops, some such corporations have also been active in the market for hybrid varieties, partly to subsidize their losses from other seeds. (Jaffe and Srivastava, 1992:56).

All these policies may undergo a change with the implementation of GATT-1994 and the NEP. Reduction in subsidies may inhibit public sector research programmes, especially in the field of self-pollinated crops. Smaller private enterprises, which have focused on multiplying and distributing public varieties of these crops will probably suffer the most in such a scenario.

Certification may entail bureaucratization but may become necessary if a large variety of new seeds/varieties are imported from abroad. Since quarantine facilities are limited, seed certification can be another level at which possibilities of disease and pests can be checked. In fact, in the absence of registration there have been instances where unstable and unadapted varieties have been sold under high pressure of publicity (Gill, 1989: 63). In this sense certification may be desirable. With or without certification requirements, the marketing skills and resources are likely to play a major role in the seed market in the near future. The smaller seed companies again will be at a loss unless they have linkages with large or multinational seed enterprises.

Given the concerns regarding increases in the prices of seeds, the state may have to evolve a new price policy. It is difficult to ascertain with certainty the relative performance of the smaller seed companies in a situation of price competition. Most likely, they will be at a disadvantage. Since research is crop and region-specific, smaller firms will probably survive by breeding for market niches, not large enough to be attractive to larger firms. This strategy will also work only if public research systems continue to provide them with germplasm and other breeding material.

4. Policy Options for Developing Countries

One policy that is justified by all historical evidence is to increase public support for technology transfers by investing in strong government research programmes and in international centres, research of which will be accessible to developing countries. The empirical research confirms the social profitability of public research. Many studies have shown very high rates of return to different types of public plant breeding research (Evenson and Westphal, 1994). In fact, public R&D in both pre-technology science and applied fields has significant potential benefits. Estimated rates of return on public ore-technology research have been in the range of 74 and 83 per cent. Similar estimates for bio-technology research relating rice were in the range of 23 and 50 per cent. Similarly, estimated returns on all agricultural research in the public domain have ranged from 50 to 155 per cent. (Pray and Ramaswamy, 1994).

We have already discussed at length, the role played by the public sector research in the growth of the private sector firms in the seed industry in India. Given such high benefits, it needs to be re-emphasized that public research, whose results are available to small firms as improved germplasm or inbred lines, is an important mechanism for neutralizing the technological edge of large firms. Besides, one major problem of relying exclusively on foreign bio-technology research is that the priorities of foreign research laboratories may be different from India's. It has been argued that these priorities might change with the introduction of PBRs. But given the tenuous link between PBRs and private research, this may only remain a hope.

What policies will facilitate inflow of technology? This is important even for the continuance of the public sector research systems as major sources of new seed technology. One should probably start with the adoption of PBRs conforming to the UPOV-1978 Act. PBRs under this act have proven to be an effective system in the industrialized countries and will provide sufficient protection for breeders in a country like India. Such a system leaves room for free exchange of plant varieties and for on farm seed saving practices, while it has shown to be adequate in encouraging foreign breeders to make available their proprietary varieties (Wijk and Junne, 1993:62).

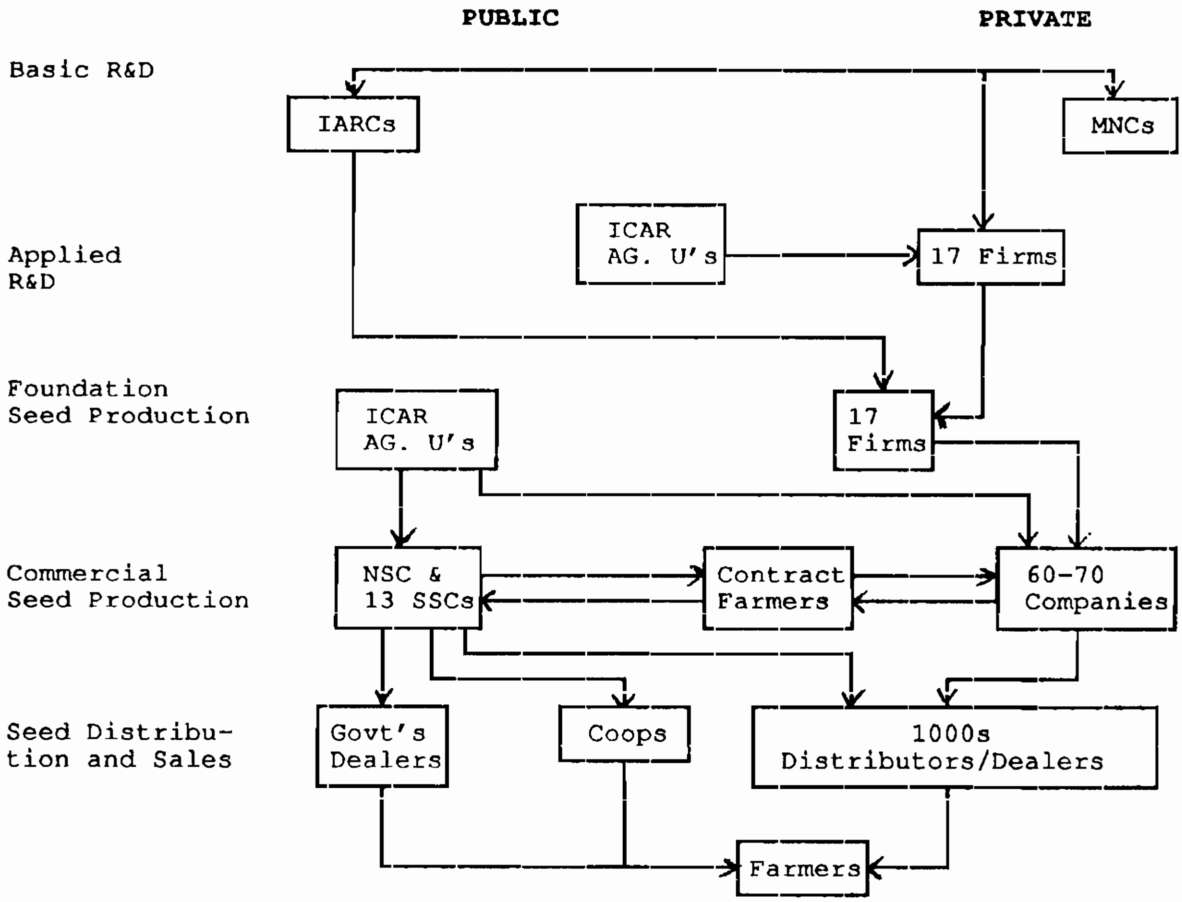
The UPOV 1978 agreement is open for membership till the end of 1995. subsequent applications will have to for the UPOV 1991 agreement, which is more stringent and controversial. Indian breeders have a formidable track record and now need to protect all their inventions. Otherwise, foreigners will use these inventions freely while we will have to pay royalties for foreign inventions. Joining UPOV now will reduce the transactions costs for Indian breeders by enabling them to get protection in all signatory countries with a minimum paper work and expense. Introduction of some sort of legal framework for plant protection will also initiate a learning process regarding the use and implementation of PBRs for plant breeding firms and implementing agencies. Such learning is likely to be extremely useful in the long run when we move towards a more stringent IPR regime.

Mere membership of UPOV, however, is not likely to bring benefits to Indian breeders. A concerted and systemic effort is required to identify technologies and varieties which need to be protected. A lot will therefore, depend on the strategies the breeders and researchers in the public and private sectors adopt to meet the challenges of the emerging world order and utilize the opportunities of appropriating the benefits of their research efforts. India is a major player in bio-technology and should seek to improve its position. In situations of complementary capabilities, collaborative research projects with scientists around the world may be useful in getting access to new technologies and reaping benefits of the technologies generated together. But collaboration is not the only strategic option, in certain research areas where Indian scientists have an advantage, competition may entail more benefits. These choices are difficult and require an enormous information base. Measures to reduce information gaps and to facilitate such choices will be extremely useful.

At the same time, developing countries should look for ways to operationalise the Bio-Diversity Convention. As mentioned earlier, this convention envisages that developing countries cooperate in the conservation of biological diversity in exchange for a share in the benefits arising from the exploitation of genetic resource which are collected in their countries. This share may consist of financial returns and of access to relevant technologies. It is the latter which is particularly relevant. While the wording of the Bio-diversity Convention is ambiguous, the countries rich in bio-diversity should demand the right to use patented plants or bio-technology on preferential terms. In general, the Convention needs to be used vigorously to improve the terms and conditions of exchange of seed related technology. Since UPOV is going to be the major debating forum for future changes in plant breeding and PBRs, India and other developing countries should join UPOV and influence future institutional outcomes, using the Convention as a bargaining tool.

Chart 1

Interaction Between Public and Private Sectors in the Indian Seed Industry



Source: Pray et.al. (1991), p. 316.

MNCs - Multinational Corporations; IARCs - International Agricultural Research Centres; ICAR - Indian Council of Agricultural Research; AG.Us - State Agricultural Universities.

Table 1
Comparison of Main Provisions of PBR Under the UPOV Convention and Patent Law

Provisions	UPOV 1978 Act	UPOV 1991 Act	Patent Law
Protection coverage	Plant varieties of nationally defined species	Plant varieties of all genera and species	Inventions
Requirements	Distinctness Uniformity Stability	Novelty Distinctness Uniformity	Novelty Inventiveness Nonobviousness Industrial application and usefulness
Protection term	Min. 15 years 15-18	Min. 20 years	17-20 years (OECD)
Protection scope	Commercial use of reproductive material of the variety	Commercial use of all material of the variety	Commercial use of protected matter
Breeders' exemption	Yes	Not for essentially derived varieties	No
Farmers' privilege	In practice: yes	Up to national laws	No
Prohibition of double protection	Any species eligible for PBR protection can not be patented	--	--

Source: Wijk and Junne (1993): Table 5.3, p.59.

Table 2
Seed Requirements, Commercial Seed Supply and The Role of the Private Sector in Major Field Crops in India, 1987

(1000 metric tones)

Crop	Total Seed Planted	Commercial Seed	Private Supply
Wheat	2,088	158 (7.6)	53 (33.5)
Paddy	1,025	132 (12.9)	80 (60.6)
Sorghum	992	25 (2.5)	6 (24.0)
Maize	150	13 (8.7)	9 (69.2)
Peare Millet	110	15 (13.6)	9 (60.0)
Pulses	677	23 (3.4)	9 (39.1)
Groundnuts	635	38 (5.9)	24 (63.2)
Other Oilseeds	176	16 (9.1)	7 (43.7)
Total	5,853	420 (7.2)	197 (46.9)

Source: Adapted from Pray and Ramaswami, (1991): Table 7, p.7.

Notes :

1. Figures in parentheses report the percentage share of commercial seed to total seed requirement.
2. Figures in parentheses report the percentage share of the private sector firms in the commercial seed supply.

Table 3
Institutional Mix in India's Seed System

Variety Sourcing, Development			Seed Production, Processing			Seed Marketing, Distribution			
Crops	Direct seed import	Variety Development	Foundation/ Basic Seed	Commercial/ Certified Seed	Seed Processing	Wholesale/ logistics	Promotion	Retail sales	Price determination
Wheat	NA	G	M	CON	M	M + Coop	M	M + Coop	PS
Rice	NA	G	M	CON	M	M	M	M	PS
Maize hybrid	P	M	M	M	M	M	M	M	MD
Potato	NA	G	M	M	M	M	M	M	MD
Vegetables	P	M	M	M	M	P	M	P	MD
Cotton	NA	M	M	M	M	M	M	M	MD
Seedlings	NI	G	M	M	NA	NA	P	M	MD
Forage	NI	G	G	G	G	G	M	M	MD

Source: Jaffe and Srivastava (1992): p.82.
Codes: G - Predominantly Government enterprises and institutes (90% or more); **P** - Predominantly Private enterprises, individuals and institutes (90% or more); **M** - Mixed Government and Private involvement (significant but separate roles for each); **C** - Seed or producer Cooperative; **CON** - Government contracting out to private firms and farmers; **NI** - No information available on existing formal activity; **NA** - No formal activity; **PS** - Partly subsidized; and **MD** - Market determined.

Table 4
Private Companies' Use of Millet and Sorghum Breeding Material from the Public Sector

	Pearl millet	Sorghum
Number of companies breeding material from		
ICRISAT	16	6
AICSIP/AICMIP	6	3
University	6	3
Foreign company	0	2
Other Indian company	4	2
Own collection	7	5
Number of companies receiving different types of material from ICRISAT		
GRU[1] material	8	6
Nurseries	7	4
Breeders seed	19	10
Number of companies commercially producing		
ICRISAT hybrids	11	3
Private hybrids	5	4

Source: Pray et. al. (1991): Table 5, p. 323.
Note:1. GRU is the Genetic Resource Unit.

Table 5
Number of Varieties/Hybrids Released in India by Public Sector Research Centres, 1985

Crops	Varieties/Hybrids
All Cereals	521
Wheat	167
Paddy	322
Millets	307
Maize	66
Sorghum	59
Pearl millet	58
Pulses	307
Oilseeds	299
Fibre crops	138
Cotton	114
Jute	12
Forage Crops	87
Vegetables	344
Flower	1
Total	2004

Source: Agarwal (1989): Table 2, p. 75.

Table 6: Seed Distribution by Public and Private Companies

(Percentage)

Crop Seed	1983-84		1984-85		1985-86		1986-87	
	Pub	Pri	Pub	Pri	Pub	Pri	Pub	Pri
Hy.Jowar	54.2	45.8	54.8	45.2	58.8	41.2	57.4	42.6
	(1,16,595)		(1,27,642)		(1,38,088)		(1,51,323)	
Pearl Millet	63.0	37.0	39.8	60.2	44.5	55.5	47.7	52.3
	(19,514)		(18,437)		(19,671)		(26,662)	
Hy.Cotton	34.0	66.0	41.7	58.3	32.2	67.8	27.3	72.7
	(11,690)		(11,338)		(16,577)		(17,498)	
Paddy	100	0	100	0	100	0	80.0	20.0
Wheat	71.7	28.3	44.8	55.2	65.0	35.0	42.1	57.9
	(77,658)		(49,736)		(1,01,320)		(80,101)	

Source: Agarwal (1989): Table 3, p. 76.
Note: Figures in parentheses report total quantities produced in quintals.

Table 7
Details of Foreign Collaborations in Respect of Seed and Planting Material

Name of Indian Company	Name of Foreign Company	Name of Country	Name of the product/activity	Type	Year
1	2	3	4	5	6
Wimco Ltd.	Swedish Match AB	Swed	Production of seeds & seedlings for agro forestry activities	Fin	1983
Maharashtra Hybrid Seeds Ltd.	Seedtec. International Inc.	USA	Hybrid sun-flower Seeds	Tech	1983
Cargill Seeds India (Pvt.) Ltd.	Cargill Inc.	USA	Hybrid Seeds	Fin	1986
ITC Agrotech Ltd.	Continental Grains	Aust	Hybrid Seeds	Tech	1988
Bejo Sheetal Seeds (P) Ltd.	Bezo Zadan B.V.	Holl	Hybrid Seeds	Fin	1988
PHI Biogene Pvt. Ltd.	Pioneer overseas Corporation	USA	Hybrid Seeds	Fin	1988
Bihar Seeds Corpn.	Pacific Seeds	Aust	Hybrid quality Sunflower Seeds	Tech	1988
Nath Seeds Pvt. Ltd.	Dobi Gon & Co.	USA	Hybrid Sunflower Seeds	Tech	1988
Welcome Seeds Pvt. Ltd.	NRI Cases India/UK	U.K.	Vegetable Seeds	Fin	1989
Bilt Treetech Pvt. Ltd.	Plantex	Aust	Propagating of trees, shrubs ornamental flowers	Tech	1989
Omega Agseed India	Agseeds Pvt. Ltd.	Aust	Improved Variety of seeds	Fin	1990
Bharat Pulverising Mills Ltd.	Nova Seeds	USA	Oil seeds/ Pulses/ Vegetable Seeds	Fin	1990
Bisco Seed Tech. Pvt. Ltd.	Agripro Bio Sciences Inc.	USA	Hybrid Seeds	Tech	1990
Nath Seeds Ltd.	K.Z. Gebroaders	Holl	Vegetable hybrid seeds	Fin	1990
Maharashtra Hybrid Seed Co.Ltd.	Asgrow Seeds Co.	USA	Hybrid Vegetable seeds	Tech	1990
ECL Agrotech	Controco-op	Yugo	Hybrid Seed	Tech	1990
Harrisons Malayalam Ltd.	Agri Saatan Gmbh.	West Germany	Hybrid Seeds HYV of Vegetable	Tech	1991
Sandoz (India) Ltd.	Zaadunio B.V.	Holl	High yielding variety of seed etc	Tech	1987
Sandoz (India) Ltd.	Northrup King Co.	USA	High yielding seeds plantlets	Tech	1987

1	2	3	4	5	6
Harrison Malayalam	Semynio Szatzucht Gmbh	West Ger	Hybrids/HYV seeds of field crops	Tech	1991
Harrison Malayalam Ltd.	Green Tek/cultiss (Yet to be approved by SIA)	Holl	Plant Tissue culture	Tech	
Intercorp Inds. Ltd. N.Delhi	Rustica Semences	France	Hybrid Seeds	Tech	1992
Raunaq International Ltd.	Centrocoop and Instt. of Field and Vegetables Crops Faculty Uni. of Agri. NOVISAT	Yugo	Hybrid seeds	Fin/Tec h	1992
Southern Petro Chemicals Industries Corpn.	Pioneer Overseas Corpn.	USA	Hybrid Seeds	Fin	1993
Proagro-PGS India Ltd. N.Delhi	Plant Genetic Systems International NV	Belgium	Hybrid oilseeds rape and vegetable seeds	Tech/Fi n	1993
Micro Planate Ltd. Bombay	Kemira OY, Finland	Finland	Hybrid and synthetic seeds	Tech	1993
Pioneer Overseas Corpn.	Pioneer Overseas Corpn.	USA	100% owned Research Co. on hybrid seeds		1993

Sources: National Conference On Seeds, 1993. Agenda papers Annexure V. pp 39-41; Pandey, (1994): p. 10.

Table 8
Imports and Exports of Seeds by Crops in Recent Years
(in metric tonnes)

Sr. No.	Crop	1987-88	1988-89	1989-90	1990-91	1991-92
Imports						
1	Maize	0.622	0.361	0.093	0.177	0.949
2	Sorghum	-	0.055	0.031	0.043	2.367
3	Millets	-	0.225	0.001	-	-
4	Sunflower	0.382	0.114	0.137	5.398	373.309
5	Fodder seeds	-	-	0.013	-	0.010
6	Veg.Seed	1.389	8.944	81.538	65.853	26.273
Planting Material (in Nos.) Mainly in Oil Palm		-	-	2,10880	4,65957	3344536
Exports						
1	Wheat	2656.20	200.00	-	419.44	0.005
2	Maize	0.047	-	-	0.352	0.043
3	Sorghum	100.00	-	-	0.209	-
4	Millets	-	0.270	-	357.50	-
5	Sunflower	-	-	-	0.003	-
6	Niger Seed	3565.50	4018.37	9326.24	6441.21	13876.0
7	Fodder	-	17.000	10.00	70.000	68.000
8	Vegetable Seeds	3557.68	2935.25	908.58	1979.84	668.21
9	Seeds of ornamental plants/ fruits/ trees	25.92	3.406	0.526	152.74	5020.67

Source: Proceedings of the national conference on seeds, 1993.

End Notes

1. Micro-organisms are small forms of life such as bacteria, viruses, fungi, algae, small plants and animals. For example, bacterium for cleaning oil spills has already been patented. It is argued by some that genes and cell lines are also micro-organisms. And when these are isolated through micro-biological processes, they should be eligible for patenting. The counter view is that there is no artificial gene. If genes are considered such all transgenic plants and animals can be patented.

2. Micro-biological processes relate to processes for the treatment of animals or plants to render them free of disease or increase the economic value of their products. Most genetic engineering methods for the production of transgenic plants and animals are included in this category. For example, the Harvard mouse with human genes, susceptible to cancer has been patented in the U.S.. Gene splicing technique for genetic engineering is also one such process which has been patented. Some argue now that all products using these processes should be a property of the entity which holds the process patents.

3. Essentially derived variety is a variety derived from the protected variety and retains virtually the entire genetic structure of the protected variety. One major consequence of this kind of protection is that if a breeder inserts a single new disease resistant gene into a PBR protected variety, he/she has to obtain permission from the holder of the original rights before marketing the variety.

4. A **sui generis** system implies a system of protection which is unique or specific to a particular kind of product, plant varieties in this case. Patents have universal application. Plant Breeders' Rights provide such a system. International Union for the Protection of New Varieties of Plants (UPOV) Convention provides the framework for national PBR legislation. In most developed countries patents cannot be granted to plant varieties. The U.S. is an exception such patents have been granted. For example, a patent on plant characteristics was given to an American company for a maize variety with high levels of a particular amino acid. They are now claiming monopoly rights over all maize varieties with this characteristic, irrespective of the process through which it is achieved. This is likely to be contested in courts.

5. The discussion is mainly based on Wijk and Junne, (1993:58-61).

6. In the following paragraphs we have quoted liberally from Jaffe and Srivastava (1992) especially from pages ix-xi.

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