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## Impact of Plant Variety Protection on Indian Seed Industry<sup>§</sup>

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### Abstract

This paper has examined the pattern of protection of plant varieties and the early impact of plant variety protection (PVP) on Indian seed industry. The results have shown a positive response by all the actors involved in seed provision, viz. public research institutes, private seed companies, and farmers in terms of participation in protection of varieties. To measure the concentration of private seed companies in PVP, Herfindahl–Hirschman Index was used which revealed that concentration has decreased over the years, with participation of more and more seed companies. The PVP applications for crops have also diversified with time, indicating that PVP is important for a large number of crops. The trends in exchange of germplasm, number of varieties released, breeder and quality seeds produced, and number of public-private partnerships, indicate the growth of Indian seed industry and its confidence in the PVP mechanism.

**Key words:** Plant variety protection, seed industry, India

**JEL Classification:** O31, O34, Q18

### Introduction

Indian agriculture is dominated by marginal and small farmers, and therefore, development of improved varieties that are scale-neutral would help increase their farm income. On the other hand, these plant varieties are protected under intellectual property rights (IPRs), and their implications could be different because of two reasons. First, many studies have reported that IPRs provide incentives to innovators to invest in R&D which result in development of new varieties and increased availability of improved varieties to farmers (Penna, 1994; Gould and Gruben, 1996; Diez, 2002; Kanwar and Evenson, 2003; Srinivasan, 2004; Naseem *et al.*, 2005; Kolady and Lesser, 2009).

The IPRs also facilitate the flow of genetic material and new varieties across the countries as licensing and royalty agreements are widespread world over (Wijk, 1996). However, the enhanced access to improved varieties is often associated with added cost which is a disadvantage to the poor farmers.

Second, it is believed that IPRs have not played any role in stimulating R&D investment and development of new varieties (Leger, 2005; Drew, 2010; Alston and Venner, 2002); and the stronger protection may even cut the global rate of innovation (Grossman and Helpman, 1991). The introduction of IPRs in developing countries has not provided the expected results, especially in the transfer of technologies from developed countries, because weak R&D infrastructure in developing countries hinders the adoption of new technologies (CIPR, 2002; Correa, 2001). The case of India is somewhat different, in the sense that it has a well-developed scientific infrastructure and a diversified seed industry. India had enacted the Protection of Plant Varieties and Farmers

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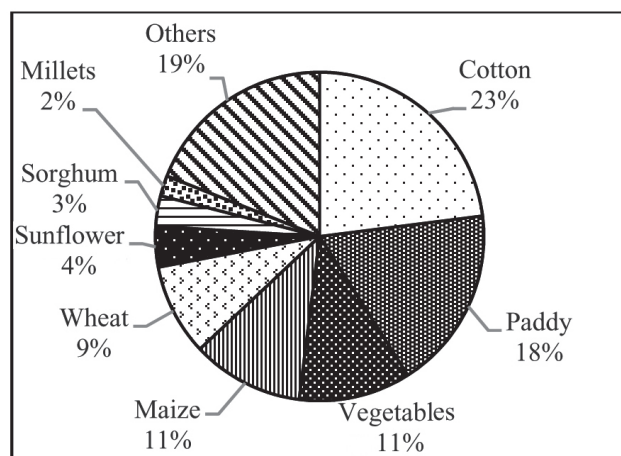
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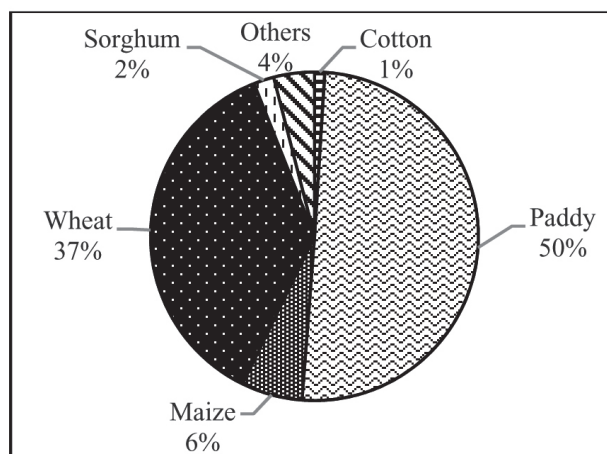
Rights (PPVFR) Act in 2001 and subsequently, established the PPVFR Authority in 2005 for the protection of plant varieties. Therefore, it would be useful to study the progress in implementation of PPVFR Act and the response of seed industry to it. In particular, it would be interesting to know the response of both public and private sectors. Has there been an increase in the development of plant varieties and their delivery to farmers after the new IPRs regime? Which organizations and crops are witnessing more protection activities? This paper has specifically examined some of these issues by analyzing trends in the development and protection, exchange of germplasm and changes in the commercial seed market.

### Indian Seed Industry

The value of seed business in India was around ₹ 65 billion in 2010. Across different crops, the highest share in this business was of cotton (₹ 14.95 billion), followed by paddy (₹ 11.7 billion) (Figure 1). Cotton and paddy together dominated the seed market with 41 per cent share in the total seed business in the country. Vegetables and maize jointly occupied third position with a share of ₹ 7.15 billion each and wheat occupied fourth position with a share of ₹ 5.85 billion. Sunflower was the only oilseed crop which figured in seed business and its share was of about ₹ 2.6 billion. Seed business in pulse crops was negligible. In terms of volume, paddy accounted for a share of 50 per cent and along with wheat, it covered around 90 per cent of the seed business (Figure 2). Cotton and vegetables were the major crops in terms



**Figure 1. Crop-wise percentage share in the value of seed business: 2010-11**



**Figure 2. Crop-wise percentage share in the volume of seed business: 2010-11**

of value, whereas in terms of volume, they contributed merely about one per cent to the total seed business. It was mainly because of the low seed rate requirement of these crops compared to those of cereals and pulses. Further, hybrids and high-yielding varieties of cotton and vegetables were sold at a very high price in the market and therefore, private seed companies have shown keen interest in high-value and low-volume seeds.

### Results and Discussion

#### Pattern of Protection of Plant Varieties

This section deals with various aspects of protection pattern of plant varieties. The profile of the private seed companies, which are involved in PVP activities, crops focussed by public and private sectors, state-wise farmers' variety applications in PVP and the crop and seed companies' concentration in PVP are discussed in this section.

#### Participation of Private Seed Companies in PVP

Data on the number of companies working on different crops were compiled from the *National Seeds Directory*, published by the National Seed Association of India (NSAI, 2011a). The concentration of private seed companies on different crops in 2010 is depicted in Table 1. Most of the companies handled two or more crops. The crop-wise analysis indicated that the private seed companies focused more on cotton and rice. A similar pattern was observed in terms of value of seed

**Table 1. Crop-wise focus of private companies in 2010**

Crop	No. of private seed companies	Crop-group	No. of private seed companies
Cotton	107	Cereals	363
Rice	100	Oilseeds	184
Wheat	74	Vegetables	136
Maize	74	Pulses	23
Pearl millet	69	Flowers	10
Musturd	53		
Sunflower	41		
Sorghum	37		
Castor	32		
Sesamum	13		
Groundnut	11		

Source: Compiled by authors from *National Seeds Directory*, (2011a)

business. A few seed companies were working on mustard also, but their share was small in the seed business in terms of both value and volume.

The private seed companies concentrated more on the cross-pollinated crops than self-pollinated crops. It could be correlated with the value of seed business, wherein self-pollinated crops have a lower share than of cross-pollinated crops, except rice, because hybrids require seed replacement every year. The crop-wise analysis showed that the number of seed companies working on cereals was highest, followed by oilseeds, and vegetables. As a single crop, cotton has attracted the maximum number of seed companies. It was also observed that crops like pulses received less attention of the private seed companies, and therefore, these crops require special focus in the form of incentives like subsidy or effective variety protection to attract more seedsmen for R&D. It may be noted that the emerging commercial crops like flowers have also attracted a considerable number of private seed companies.

At the commencement of PPVFR Authority, 13 private seed companies had applied for PVP in 2007 and this participation gradually increased to 32 in 2010. In total, 52 companies have participated in PVP during the past five years. However, given the size of Indian seed industry (approximately 500 seed companies), the participation in PVP is very low (10%).

A sample of 21 companies was selected from the companies participating in PVP to study their profile

and protection pattern of plant varieties. The data for each company regarding establishment, annual turnover, infrastructure and products, number of breeders or scientific staff, total number of products developed, number of varieties protected, etc. were collected. The selected private seed companies, mostly in Hyderabad were surveyed, and the collected information was supplemented by data from the secondary sources like their annual reports, product catalogues and official websites. These seed companies were broadly classified into three groups based on their annual turnover: more than ₹ 5 billion as large companies, ₹ 1-5 billion as medium companies, and less than ₹ 1 billion as small companies. The profile of these companies is given in Table 2. It was observed that the distribution of PVP companies was high in small companies. The companies which were in seed business for a considerably longer period (25 years) had participated in PVP, because these companies had established R&D activities and readily had varieties and hybrids for PVP. The average turnover of PVP applied companies varied from ₹ 0.25 billion to ₹ 8.1 billion and their scientific staff strength ranged from 25 to 117. The large companies had huge area for conducting experiments and seed production. Also, the number of seed growers working with them was large as compared to with other categories of companies. However, it would be difficult to make some assessment about small and medium companies as their future course of action would largely depend upon the behaviour of seed industry as a whole and the ease in implementation of PVP mechanism.

**Table 2. Profile of private seed companies seeking PVP**

Company-size	No. of private companies	Average No. of years in business	Average turnover (in billion ₹)	Average No. of scientists	Average No. of employees	Total field area (acre)	Average No. of seed growers
Large (> ₹5 billion)	5 (24)	31	8.10	117	1542	1200	61250
Medium (₹1-5 billion)	7 (33)	29	2.18	53	582	247	15400
Small (< ₹ 1billion)	9 (43)	27	0.25	25	157	51	N.A

*Note:* Figures within the parentheses indicate percentage to the total

**Table 3. PVP pattern in private seed companies in India**

Company-size	Average No. of crops handled						Hybrids	Open - pollinated varieties	Total	Varieties filed for PVP
	Cereals	Cotton	Pulses	Oilseeds	Vegetables	Total				
Large	4	1	0	2	11	18	893 (91)	83 (9)	976	644 (66)
Medium	5	1	2	2	13	23	440 (79)	114 (21)	554	381 (68)
Small	2	1	0	1	10	14	511 (75)	184 (25)	695	105 (15)
Total							1844 (83)	381 (17)	2225	1160 (52)

*Note:* Figures within the parentheses indicate percentage to total

### PVP Pattern — Sectoral and Crop Focus

The seeds of cereals, cotton, oilseeds and vegetables were being produced by all the companies across different size groups and pulses were the least preferred crops (Table 3). The most preferred crops across these companies were vegetables, followed by cereals, whereas oilseed crops received less attention. In general, the number of crops handled by a company increased with the size of company, but the large companies specialized in a lesser number of crops than the medium companies. The analysis has also highlighted that hybrids were the preferred products vis-a-vis open-pollinated varieties, as about 80 per cent of the products were hybrids. The number of products developed, especially hybrids, increased with the size of company.

As regards application for PVP, as on December 2011, a total of 3569 applications were received by PPVFRA for varietal protection from private seed companies, public sector institutions and farmers. Of

these, about 10 per cent of the varieties were granted titles. From Table 3 it is clear that about 50 per cent of the varieties were filed for protection by the private seed companies. The large companies sought protection for about 66 per cent of their products, whereas small companies sought protection for only about 15 per cent of their products. The survey also indicated that companies which were small in size could not sought protection for most of their products, because of the fee structure and transaction costs involved in the process. Despite cost on variety protection being much lower in India than in other countries, small companies are still concerned about this cost. Therefore, a differential fee structure based on the company-size may be more viable under such a scenario. Another challenge faced by small companies in PVP was technical, legal and administrative costs involved in proving ownership of their product in the case of a dispute. For large companies, the concern was strength of implementation of the protection mechanism under the Act rather than the fee structure.



**Table 4. PVP application pattern in the public sector**

Crops	Notified varieties	Protected varieties	% of varieties protected
Cereals	881	561	64
Pulses	301	202	67
Oilseeds	262	25	10
Vegetables	106	23	22
Cotton	119	101	85
Sugarcane	54	7	13
Total	1723	919	53

### PVP in Public Sector

Details about notified varieties were compiled from the website of Ministry of Agriculture, Government of India and the details about protected varieties were collected from PPVFRA and these data are presented in Table 4. As per ICAR guidelines on IPRs, the ICAR institutes are required to protect their all eligible varieties (ICAR, 2006). The varieties commercialized after 1999 are considered eligible for protection, since at the time of application, a variety should be of less than 13 years of age. In total, about 1700 varieties developed by the ICAR were eligible for registration under PPVFRA, but only about 50 per cent of these varieties were protected. It is almost equal to the private sectors' protection rate. In the public sector also, cotton was the crop which received the highest attention. Pulses, the most neglected crops by the private seed companies, occupied the second position in the public sector in terms of notified and protected varieties. The results confirmed the general notion that the public sector concentrates more on the low-value, high-volume crops. Sugarcane was the least protected crop and the number of its notified varieties was also small in the public sector.

### PVP Applications by Farmers

A perusal of data on PVP applications filed by the farmers from different states showed that Odisha was the dominant state with 85 per cent of the total applications for protection of farmers' varieties (Table 5). It was also observed that about 98 per cent of the applications were for only rice crop. It may be noted that the applications from farmers are required to be endorsed by the local *Panchayat* or state government officials. The highest share in PVP applications from

**Table 5. State-wise applications for PVP by farmers**

State	Rice	Other crops	Total
Odisha	914	-	914
West Bengal	122	-	122
Uttarakhand	4	6	10
Tamil Nadu	6	-	6
Maharashtra	2	1	3
Punjab	2	1	3
Other states	9	14	23
Total	1059	22	1081

Odisha also indicated greater cooperation among farmers, NGOs and government officials and their active participation in these issues. Odisha is a traditional rice-growing state where a large number of wild rice and cultivars are popular, and therefore an active participation of the farmers is quite possible. Most of the farmers in agriculturally-progressive states did not actively participate in PVP, perhaps because of the dominance of modern varieties in these states. It also shows low and differential level of awareness about PVP among the farmers across the states. Thus, there is a need for organizing awareness generation programmes on PVP.

### Company and Crop Diversification in PVP

The Herfindahl-Hirschman Index (HHI) and four firm concentration ratios (CR-4) were estimated for a better understanding of private seed companies' concentration and competition in PVP. The CR-4 ratio measures the share held by the four largest firms in the industry. It was calculated by adding the share of PVP applications filed by the top four companies. The HHI shows the size of firms in relation to the industry and was estimated as the sum of squared share of each firm in PVP. The HHI ranges from zero to 10000, the HHI value approaches zero when a large number of companies apply for PVP and their shares are relatively of equal sizes. Since HHI takes into account the relative size and distribution of firms, it is considered more comprehensive and a better measure than CR-4 ratio.

The seed companies' concentration in PVP for the past five years (2007-11) is shown in Figure 3. The level of concentration was moderate in the initial years, reached maximum in 2009 and then dropped slowly as more and more companies entered into the PVP.

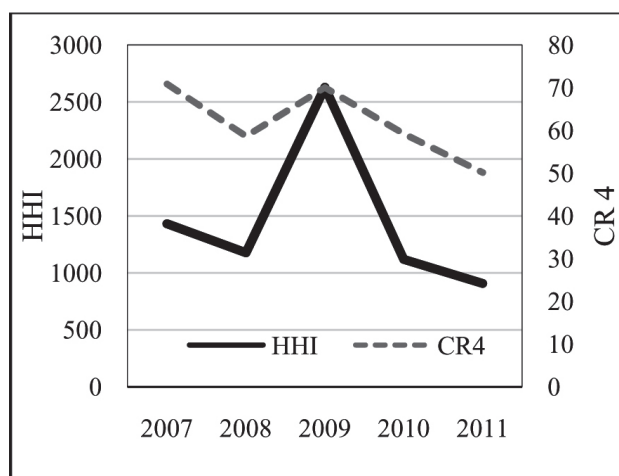


Figure 3. Company diversification in PVP: 2007-11

Although the share of top most company was significantly different in 2007 (22%) and 2009 (48%), the CR-4 ratio remained about 70 per cent for both the years. On the other hand, HHI showed a clear increase in its value in 2009, because, a single company occupied the largest share. Figure 4 displays crop diversification in PVP during 2007-11. In 2007, the level of concentration was very high, it peaked in 2008, and then gradually declined with a marginal increase in 2011. These trends were more noticeable in HHI, the value increased from about 2000 in 2007 to 6500 in 2008. Since, 80 per cent of PVP applications were for one crop (cotton) in 2008, these trends were not uniform. Also, a limited number of crops (12) were allowed for PVP in 2007, which gradually increased to 54 crops in 2011. Cotton consistently remained at the top since the inception of PPV. Apart from cotton,

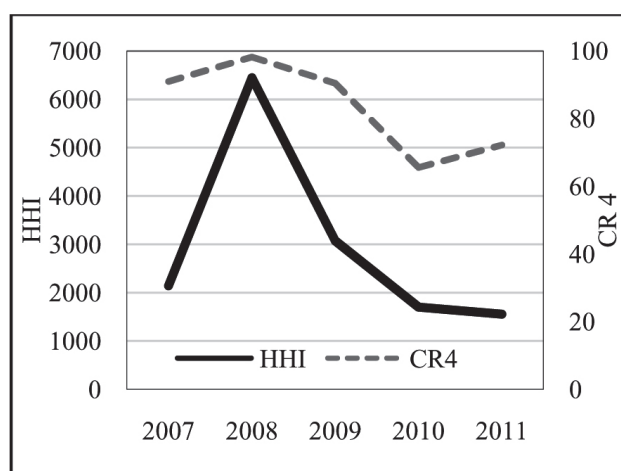


Figure 4. Crop diversification in PVP: 2007-11

rice and maize occupied the top four positions throughout this period. Brinjal, tomato and sunflower were allowed for registration from 2010. Since then they have a considerable share in PVP applications and have replaced pearl millet and sorghum from the top four positions in 2011.

### Impact of PVP on Seed Industry

Quantifying the impact of PVP on the Indian seed industry is a challenging task. This study has examined the initial impact by assessing the changes that occurred in the seed industry based on four quantitative indicators. First, the export and import of germplasm were estimated to capture the international flow of new varieties. Second, the decadal growth in the number of varieties was worked out to reckon the availability of improved varieties in the market. Third, the trend in breeder seed production and distribution of quality seeds was measured to assess the availability of quality seeds to farmers. Further changes in public and private shares in quality seed distribution and improvement in seed replacement rate (SRR) of selected crops for major states were also studied. Fourth, the number of public-private partnerships (PPP) was studied to analyse the changes in marketing channel in dissemination of new technology and revenue generation by the public sector through PPP.

### Exchange of Germplasm and Growth of Varieties

The changes that occurred in the flow of new technology could be attributed to the new IPR regime. In this study, export and import of seed germplasm were assumed as a proxy for the actual material exchange. The information was compiled from various annual reports of National Bureau of Plant Genetic Resources (NBPGR). The import of germplasm accessions increased from a mere 7,816 in 1995 to 37,018 in 2012 (Figure 5). In the pre-PVP era, the highest number of imports (24,052) was registered in 1999. During 2003-2007, there was some stagnation and then there was an increasing trend. On the other hand, India exported a very small quantity of germplasm and showed a declining trend all these years, barring 2000 and 2002. Here, it may be noted that a change in the exchange of germplasm is also attributed to the enactment of Biodiversity Act (2002) dealing with the export of genetic material.

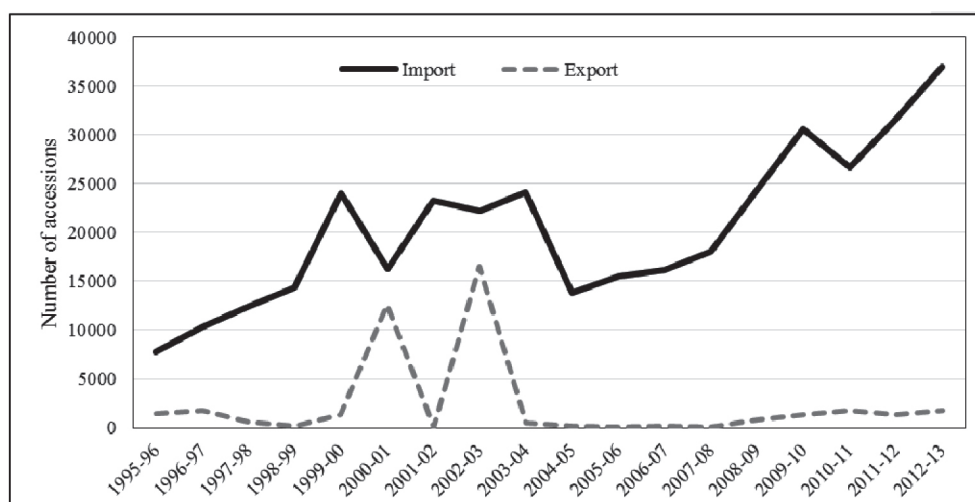


Figure 5. Exchange of germplasm: 1995-2012

The PPVFR Authority was established mainly to encourage the development of new varieties by protecting the rights of the breeders and farmers (PPVFRA, 2012). Therefore, the trend in varietal development in the seed industry could indicate the response of seed industry to the new policy. Table 6 presents the decadal growth in the number of notified varieties and shows a significant increase in the varietal releases of major crops during the recent decade (2000-2010) as compared to the previous two decades (1980-2000). In the case of cereals, major cereals (rice, wheat and maize) recorded a higher growth in the recent decade; however, a sluggish growth was observed in pearl millet and a declining trend in sorghum. It shows that commercially important crops like maize received more attention. The varietal growth in pulses was also higher during the recent decade as compared to the previous decades, except for pigeon pea and black gram. In the major pulse crops such as chick pea, green gram, pigeon pea and french bean, the varietal growth was lower during 1990s than during 1980s. However, in the recent decade (2000s), varietal development picked up for these crops.

The growth of notified varieties in the oilseed sector has been higher in the recent decade than in the previous two decades. The mustard crop has recorded an impressive growth in the recent decade, more than five-time increase in the release of notified varieties as compared to that in the previous decades. Almost all crops, except castor, have registered a higher growth in the recent decade than in the previous decades. A

gradual and steady trend has been found in the case of vegetables, whereas in cotton, it is almost stagnant. It could be due to the fact that cotton and vegetables are mostly dominated by the private sector and all their varieties might have not been notified under the Seed Act.

Overall, a higher decadal growth in the number of varieties for the majority of crops was recorded in the post-PPVFRA period. The overall growth in varietal development in the public sector, was mainly due to the strengthening of plant breeding capacity through varietal development programmes like All India Coordinated Research Project (AICRP) for various crops (ICAR, 2008), and in the case of private seed companies, it was due to the increase in their plant breeding intensity. Further, advances in S&T such as better identification methods, increased availability of genetic materials (germplasm, inbred lines) and provision of incentives for varietal development to the scientists are the other factors which might have played a crucial role in the higher varietal growth in the recent decade. This finding is in consonance with the study of Naseem *et al.* (2005), who have reported that PVP has led to the development of more varieties of cotton in the USA. Similar findings were reported by Diez (2002) and Srinivasan (2004). They have argued that plant breeders' rights in the Europe have increased the incentives for private firms to develop new crop varieties. Kolady and Lesser (2009) have also found that implementation of PVP attracted private investment in wheat in the USA and provided high-



**Table 6. Crop-wise decadal growth in the number of notified varieties: 1980-2010**

Crop	1981-1990	1991-2000	2001-2010
<b>Cereals</b>			
Paddy	206	197	282
Wheat	75	68	103
Maize	46	61	111
Sorghum	61	50	46
Pearl millet	41	42	48
<b>Pulses</b>			
Chick pea	42	37	62
Green gram	37	32	44
Pigeon pea	38	27	30
Black gram	18	27	26
Field pea	15	17	25
Lentil	10	13	19
French bean	6	5	9
<b>Oilseeds</b>			
Groundnut	42	39	60
Mustard	9	6	53
Soybean	26	24	32
Sesame	24	15	26
Sunflower	10	20	28
Linseed	19	7	20
Castor	11	14	12
<b>Vegetables</b>			
Bhendi	6	7	13
Brinjal	20	25	22
Cauliflower	3	6	9
Onion	7	4	10
Potato	3	8	13
Tomato	15	13	28
<b>Cotton</b>	76	81	85

Source: Compiled by authors from <http://seednet.gov.in>

yielding varieties of these crops in higher numbers from both public and private sectors.

### Production of Breeder and Quality Seeds

In India, the breeder seeds are produced by different ICAR institutes and state agricultural universities (SAUs). The seed indents are submitted by the public sector institutes and private seed companies across the country, and each breeding centre is allocated the production targets. It is assumed that

the changes in breeder seed production may indicate the response of seed industry to the policy changes in the country. Data compiled from the annual reports of the AICRP-National Seed Project (NSP) are presented in Table 7. The production of breeder seeds has consistently increased for all the crops, except cotton. The trend analysis has also indicated that there was a tremendous increase in seed production of cereals and oilseeds after 2002. Surprisingly, the breeder seed production in cotton declined after 2003. It may be due to the introduction of *Bt* cotton in the country during this period. After the introduction of *Bt* cotton, the cotton seed sector is mainly dominated by the private seed companies.

The pattern of distribution of quality seeds has also shown a considerable change. During 1995-96 to 2011-12, it has increased by about two-times for cereals and by about four-times for pulses and oilseeds. The pulses seed distribution hovered around 5 lakh quintals during 1995-2001, but after that it got momentum and reached a maximum of about 21 lakh quintals in 2010-11. The study has also found that there was no impact on the fibre crops (cotton) and seed production remained stagnated at around 2.5 lakh quintals throughout this period. It could be because it reached a high seed replacement rate (SRR) in as early as 2000. It may be mentioned here that the ICAR had launched a seed project in 2005-06 with a financial outlay of ₹1.99 billion, covering 86 centres throughout the country, which increased the capacity for quality seed production of crops and played a major role in changing the seed production scenario in the country (Prasad *et al.*, 2011).

### Share of Public and Private Sectors in Quality Seed Production

It is clear from Table 8 that quality seed production has increased more than two-times during 2003-04 to 2009-10. The increase in quality seed production was moderate till 2005-06, but afterwards, it accelerated. Although an overall increase in quality seed production was observed, the share of private sector declined from 47.5 per cent in 2003-04 to 38.9 per cent in 2009-10. The state-wise data indicated that the private sector had played an active role in quality seed production and secured more than 50 per cent share in top five states. In Tamil Nadu and Gujarat, more than 70 per cent of the seed was being supplied by the private

**Table 7. Trends in breeder seed production and quality seed distribution in India: 1995-2011**

Year	Breeder seed production (in tonnes)				Quality seed distribution (in '000 quintals)			
	Cereals	Pulses	Oilseeds	Fibres	Cereals	Pulses	Oilseeds	Fibres
1995-96	2645	339	992	19	4400	360	1260	260
1998-99	1874	416	595	25	5730	410	1380	290
2001-02	2154	579	1234	39	6560	470	1210	290
2004-05	3189	870	1927	33	8140	740	2340	280
2008-09	4833	1505	2676	20	14740	1450	3990	260
2009-10	5959	1995	3511	22	16520	1970	5070	270
2010-11	6167	1562	3729	80	18260	2080	5060	260
2011-12	6282	1428	3871	51	18450	1920	5840	340

Source: Compiled by authors from annual reports of AICRP-NSP (Crops) for different years and from [www.indiastat.com](http://www.indiastat.com)

**Table 8. Share of public and private sectors in quality seed production: 2003-04 to 2009-10**

Year	Total quality seed production (in lakh quintals)	Private sector share (%)	Public sector share (%)
<b>All India</b>			
2003-04	132.3	47.5	52.5
2004-05	140.5	45.0	55.0
2005-06	148.2	46.8	53.2
2006-07	194.3	41.0	59.0
2008-09	250.4	39.8	60.2
2009-10	279.7	38.9	61.1
<b>States ( 2009-10)</b>			
Tamil Nadu	14.5	73.9	26.1
Gujarat	9.2	71.6	28.4
Punjab	15.3	61.9	38.1
Madhya Pradesh	25.6	53.9	46.1
West Bengal	16.6	50.4	49.6
Andhra Pradesh	44.0	47.5	52.5
Karnataka	11.9	38.8	61.2
Bihar	12.7	31.8	68.2
Uttar Pradesh	43.1	20.5	79.5
Maharashtra	26.8	18.2	81.8

Source: Compiled from <http://seednet.gov.in> and [www.indiastat.com](http://www.indiastat.com)

sector. Surprisingly, in the major seed hubs of India like Andhra Pradesh (47.5%) and Maharashtra (18%), seed supply by the private sectors was less than the public sector.

### Seed Replacement Rate

The SRR for the selected crops in the major states of India is shown in Table 9. It is evident that SRR has increased for all the crops over the years, particularly after 2005. In rice, a higher SRR was achieved by Tamil Nadu and Andhra Pradesh than the other states. In the case of maize, all the states, except UP and Rajasthan, had more than 90 per cent SRR in 2011. In cotton, Karnataka, Gujarat and Maharashtra had achieved 100 per cent SRR in as early as 2001, and other states also attained the maximum SRR in 2011. Across different crops, the SRR for pigeon pea was very low. Except Andhra Pradesh, all the states were hovering around 20 per cent in 2011. The figure for rapeseed and mustard has shown a promising trend and in 2011, except Bihar, all the states achieved more than 60 per cent SRR.

### Public-Private Partnership

The data on PPP related to commercialization of new varieties or new seed technologies were compiled from the *NSAI Magazine* (NSAI, 2011b) and some public research institutes having a special cell like Institute Technology Management Unit (ITMU). It is evident from Figure 6 that a noticeable change in PPPs occurred after 2006. The number of PPPs was around 5 per year till 2005 and it increased to about 30 per year and the highest of (42 per year) was noticed in 2011. A total of 174 Memoranda of Agreement (MoAs) were signed between the public institutes and private companies during 2003-2011, which involved 75 private companies, 28 public institutes (ICAR and SAUs) and 4 institutes of Consultative Group on International Agricultural Research (CGIAR).

**Table 9. State-wise seed replacement rate for major crops in India**

Year	Tamil Nadu	Andhra Pradesh	Karnataka	Gujarat	Maharashtra	Rajasthan	Uttar Pradesh	Punjab	Bihar	All-India
<b>Paddy</b>										
2001	17	42	22	18	18	4	14	11	6	19
2005	55	61	29	21	19	5	20	19	12	21
2011	68	87	41	38	46	7	32	53	38	40
<b>Maize</b>										
2001	8	48	100	100	53	2	7	42	21	21
2005	2	84	100	100	60	18	12	69	40	35
2011	98	100	100	100	93	53	31	99	100	57
<b>Cotton</b>										
2001	15	48	100	100	100	61	70	-	-	21
2005	14	84	100	100	100	51	64	-	-	22
2011	100	100	100	100	100	100	73	-	-	100
<b>Pigeon pea</b>										
2001	6	13	8	10	13	14	12	-	-	8
2005	3	33	14	15	13	9	18	-	-	10
2011	12	78	13	31	31	22	25	-	-	22
<b>Rapeseed and mustard</b>										
2001	-	-	-	71	-	69	27	26	29	49
2005	-	-	-	100	-	48	52	21	30	55
2011	-	-	-	100	-	85	64	64	47	79

Source: Compiled from <http://seednet.gov.in>

The analysis of crop-wise concentration of PPPs indicated that at the top of the PPPs list were cereals (105), followed by vegetables (50), while pulses and oilseeds had a very small number of PPPs (Table 10). Conventionally, R&D on pulses and oilseeds is undertaken mainly by the public sector and a similar situation prevailed in the case of PPPs also. It could be due to low market demand for seeds of these crops, which would adversely affect profitability of the private seed firms. The major crops in the country had a higher number of PPPs, indicating that the size of market and volume of business are the major determinants for the private firms to enter into a PPP. Although a significant number of MoAs were signed in wheat, it occurred for a single variety with many firms. This shows that the market potential of a variety was the major factor for a PPP.

Information on revenue generation from commercialization of technology was compiled from the NSAI report for two major research institutes in the country. One institute had received about ₹ 20

million over the past four years from commercialization of technology, while the other received a revenue of about ₹ 7 million from licensing of a single rice variety. The revenue generation indicated the quantity of quality seeds reaching the farmers through private seed companies. A substantial quantity of improved seeds reached the farmers through PPPs which is a good signal for both seed industry and farmers. Thus, a noticeable impact has been found in the technology dissemination channel in the seed industry through PPPs.

## Summary and Conclusions

The pattern of PVP applications by the private seed companies, public institutes and farmers has been analysed. Though the participation in PVP has been found across different sizes of private seed companies, the proportion of varieties protected is lower for small companies as compared to large companies. The well-established companies (more than 25 years in seed business) have been found to participate actively in

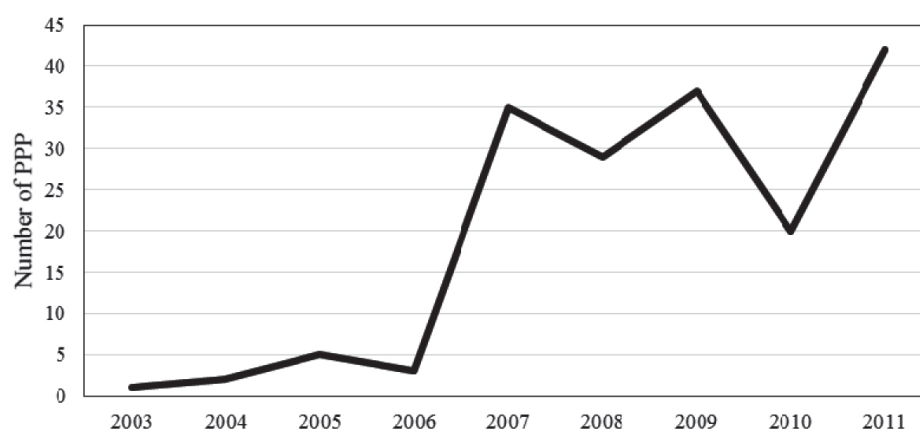


Figure 6. Trend in public-private partnerships (PPPs) in seed sector: 2003-2011

Table 10. Concentration of public-private partnerships in seed sector: 2003-2011

Particulars	No. of MoAs	No. of private companies	No. of public sector institutes	No. of CGIAR institutes
<b>Crop-groups</b>				
Cereals	105	69	22	2
Vegetables	50	46	18	4
Cotton	11	3	9	-
Oilseeds	5	5	5	-
Pulses	3	3	2	1
Total	174			
<b>Crop</b>				
Rice	63	32	17	-
Wheat	28	25	1	-
Maize	12	10	3	1
Brinjal	12	10	2	1
Cotton	11	3	9	
Others	48			
Total	174			

PVP vis-a-vis to the newly-established companies. In the case of public sector, about 50 per cent of the eligible varieties have been protected under PPVFRA. The level of concentration of PVP applications by the private seed companies has gradually declined, and crop diversification in PVP has increased over time. As far as farmers' varieties are concerned, the state of Odisha had the largest share (85%) in PVP applications and rice figured in almost all of them, because of good cooperation among farmers, government agencies and NGOs in the state.

There has been an increasing trend in the import of germplasm in the country which indicates high

access to international genetic material. It has also been observed that growth in the number of notified varieties in the recent decade (2001-2010) has increased for most of the crops. An increase has also been found in breeder seed production and distribution of quality seed in the country. The SRR has increased almost three-times for the major crops in most of the states. A discernible increase in public-private partnerships has been recorded after 2006. Therefore, the evidence suggests that initial response of the industry to PVP is optimistic. However, there is a need to monitor these trends in the seed industry, and as more data accumulate over the years, a better understanding of the impact of PVP on the seed industry can be established.

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