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Indian Seed System Development: Policy and Institutional Options[1]

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Abstract

Developments in the Indian seed industry and their impact on access and use of commercial seed by farmers have been examined. Various types of seed systems such as hybrids, self-pollinated crops, vegetatively propagated crops, crops with high seed volume, etc have been analysed. It has been shown that the commercial seed markets for hybrids are well developed, but these need improving flow of information to farmers and effective regulation of unscrupulous traders, etc. There are significant changes in terms of seed regulations, management of GM crops and protection of intellectual property. Since all these regulations are mutually enforcing, there is a need for developing institutional capacity for their enforcement, as well as flexibility to learn from the experience for future adaptation. There is a lot of scope for strengthening the seed system of 'orphan crops', where there is no participation of the private sector, and the public seed system is facing several resource and institutional constraints. In particular, there is a need for technological backstopping, developing partnerships with private and civil society organisations, and developing capacity at the local level. The results of farm surveys have shown that increasing proportion of farmers use commercial seed for quality considerations. The study has argued that there is a problem with variety selection, particularly of proprietary hybrids, due to lack of information, which has resulted into poor crop performance on several occasions.

Introduction

The Indian seed system has undergone a tremendous change during the past two decades. The system started with public seed corporations in the 1960s, matured over a period of time, ushering the green revolution in the country. These seed corporations ably met the twin objectives of efficiency (delivering seed to commercial farmers) and equity (catering to seed needs of small farmers and marginal areas). However, the situation changed significantly with the expansion of agricultural research system and entry of private seed companies. The State Agricultural Universities (SAUs) and their regional research stations meet the seed needs of a large proportion of farmers, particularly for self-pollinated crops. Private seed companies, on the other hand, are supplying increasing proportion of hybrid seeds. This trend of privatization in the seed system got steamed with the economy-wide reforms introduced by the government during the early-1990s and implementation of the New Seed Policy in the late-1980s. In particular, there is an increasing participation of transnational seed companies. These developments have, no doubt, increased the availability of improved seeds to commercial farmers, but their implications for seed quality and ability to meet seed requirement of small farmers or households in marginal areas are seen with skepticism.

Another significant development has been the shift to a regime of protection of intellectual property. It is feared that the protection of plant varieties would

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further accentuate private activities in the seed system, and transnational seed companies will dominate and exploit the system for their quest for profit. These companies will not only exploit local genetic material for their advantage, but would also charge high prices for seed, restricting the access of resource-poor farmers to improved seed. The problem is further compounded by the introduction of genetically-modified seeds (GMS). There are a number of health and environmental risks associated with the use of GMS. Although one can argue for the nature and extent of these risks, these apprehensions can't be ruled out completely. The question now arises how the seed system can be made more competitive and effective. What should be the mechanism for the regulation of GMS? Who will serve resource-poor farmers in the marginal areas? This paper has addressed all these questions; specifically, the study has suggested policy and institutional (organizational and regulatory) options for developing a sustainable seed system.

Rationale and Methodology

The importance of developing a competitive seed system can't be over-emphasized. The seed turnover rate is very low, and crop production losses are 15-20 per cent due to poor seed health. A host of factors (technical, institutional and policy) constrain performance of the seed system. These factors have been analyzed in a number of studies in the recent past (Jaffee and Srivastava, 1994; Morris, 1998). However, these studies have mainly focused on the activities of private seed companies which primarily deal with hybrid seeds. The results of these crop-specific studies have not been able to present a complete picture of the seed system. Therefore, a systematic study analysing the system for various types of crops and regions was required. Moreover, there was a dearth of studies analysing structure of the system in terms of interface between public-public, public-private and private-private organizations. How these linkages affect the performance of seed system, and what are the conditions promoting these interfaces? How these linkages will change with the protection of plant varieties and use of GMS? What are the institutional mechanisms to ensure seed quality, safeguard interests of farmers and meet seed requirement of marginal areas? The present study has bridged this information gap.

The institutional economics framework was applied to assess the structure and performance of the seed system. This framework examines the organizations, activities, regulations and contracting arrangements for all elements of the seed system, viz. plant breeding, source seed, seed multiplication and conditioning, marketing, quality control, and consumer protection. In the first phase, structure of seed system, seed policies and regulatory issues were studied. It was followed by the case studies of seed system for commercial crops in developed region (cotton), high-value crops in marginal or hill region (vegetables), vegetatively propagated crop (potato), crop with high seed rate (groundnut), self-pollinated crops in developed region (paddy), etc. In terms of research issues, the case studies focused on the diversity of the seed system, institutional linkages, seed quality, information flow, etc. Farm surveys were conducted in 2003-04 and 2004-05 to assess the performance of the seed system in terms of delivery of improved seed, varieties and information to farmers. The details of farm surveys have been given in Table 1.

Seed Industry: Evolution and Contemporary Developments

The origin of Indian seed industry could be traced back to the establishment of national and state seed corporations during the 1960s, which continued to expand both in terms of their number and business during the 1970s. The industry underwent structural changes with the entry of private seed companies, mostly family-owned, during the 1980s and this trend continued in the 1990s also. The private seed companies focused mainly on hybrid seeds and a few large companies diversified into research and development (R&D) to increase their share in the seed market. The new seed policy of 1988 and the economy-wide reforms of 1991 attracted the multinational companies (MNCs) to India in a major way. Most of them entered through partnership with the national companies, and only a few established their independent seed business in the country. The industry was mainly governed by the Seeds Act

Table 1. Details of farm survey conducted

Crop	State	Districts	Number of farmers
Paddy	Haryana	Karnal	60
Cotton	Maharashtra	Yavatmal and Jalgaon	96
Potato	Uttar Pradesh	Firozabad and Barabanki	96
Vegetables	Himachal Pradesh	Solan and Mandi	96
Groundnut	Andhra Pradesh	Anantapur	72

(1966) and thrived largely on the material bred by the public plant breeding programmes of the institutes under the Indian Council of Agricultural Research (ICAR) and SAUs. This is a typical development path followed by seed industries even in the developed countries (Morris, 1998).

The private seed sector has witnessed tremendous growth and now it supplies most of the hybrid seeds in the country. For example, as seen from Figure 1, the private sector is a dominant player in major cotton-growing states and public sector accounts only for 10-30 per cent of commercial seed supply. Even in self-pollinated crops like paddy, the share of public sector is nominal and the private sector supplies 60-80 per cent of commercial seed in the states of Haryana and Andhra Pradesh. Low marginal cost and risk in producing paddy seed and potential lucrative market for hybrid rice could explain greater private sector's participation in rice seed in the favourable production environments. In the case of inaccessible hilly areas also, the private sector supplies a significant proportion of commercial maize and vegetable seeds. All these signs point towards consolidation of this trend in future. Only in the case of high-volume seed crops like potato and groundnut, there is less participation of the private sector and the aggregate statistics do not reveal private sector's participation, if any. Entire potato seed in Uttar Pradesh (UP) and Himachal Pradesh (HP) is supplied by the government, although there are some private seed producers mostly in Punjab and Western UP, but there share is negligible. In the case of groundnut, besides state seeds corporations and government department, there are some producers' organisations and oil trading public agencies who supply seed to farmers and their role becomes significant in the year of seed scarcity. Wherever there is support of research stations and

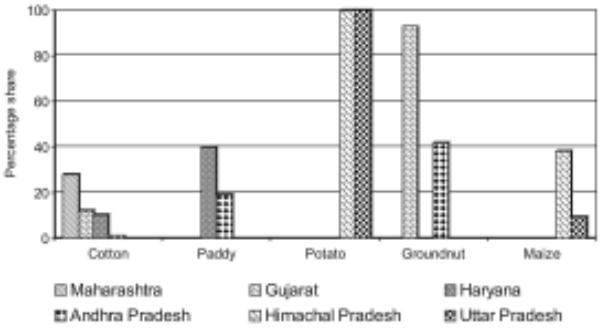

Fig. 1. Share of public sector in supply of commercial seed: 2002

opportunities for seed supply, there are local seed producers, often progressive farmers, and their role is likely to increase whenever there are efforts to strengthen decentralized seed system. Thus, there are increasing trends towards the use of commercial seed and the private sector is playing a larger role in the seed supply.

Today, the Indian seed industry is heading towards a maturity phase with three major undergoing changes. First, private seed companies consider research and development (R&D) as an important mechanism to differentiate their product and enhance their market power. This tendency is likely to intensify further. The second major change is arising from the process of globalization and liberalization. The resource-rich MNCs with well-established R&D programmes overseas are expanding their activities through mergers and acquisitions and the national companies may find it difficult to compete with them. Third, the industry is going to be governed by multiple regulations, and protection of intellectual property rights (IPRs) is emerging as an important factor to shape its growth and performance. India has put in place all the necessary legislations and institutions to strengthen

the IPRs regime to comply with the World Trade Organization (WTO). Concomitantly, other regulations like those dealing with development and commercialization of genetically-engineered (GE) crop varieties and access to and use of genetic resources have become important for the seed industry. How will these mutually-reinforcing developments affect the structure and performance of the seed industry? The following section deals with these issues.

Policy Issues

The contemporary issues in public plant breeding mainly relate to sustainability of funding and management of intellectual property in the context of modern science. The sustainability of funding requires attracting additional resources from both public and private sectors. The public resources could be mobilised through improving effectiveness and efficiency of the programmes with greater accountability in utilization of these resources. This requires a number of organizational and management reforms to rationalize allocation of resources, facilitation of knowledge-flow in the system, management of intellectual property, regulation of private R&D, human resource development, etc. (for details, *see* Pal and Byerlee, 2006; Jha, 2001). Private research resources would largely depend on the research infrastructure, including strength of public breeding programmes, research cost, size of the market for new technologies (e.g. commercial seed), protection of intellectual property for appropriation of research benefits, regulatory policies, etc. (Byerlee and Echeverria, 2002; Pray and Umali-Deininger, 1998). India is well placed in terms of availability of research infrastructure, scientific manpower and a vast market for improved technologies. Fiscal incentives like tax concessions for R&D expenditure, lower duty rates on import of R&D equipment, sales tax exemption (on seed), etc. are also conducive for attracting private investment. However, protection of intellectual property and regulatory policies for private research, especially on development and use of genetically modified organisms (GMOs) are evolving, and therefore these have been discussed in this paper.

The Protection of Plant Varieties and Farmers' Rights (PPVFR) Act, 2001 and the amendments of the Patents Act provide incentives to the private sector by bringing the domestic IPRs regime at par with the international regime envisaged under the WTO. The evidence indicates that there is increasing tendency to protect intellectual property and the number of patents filed by research organizations is increasing rapidly (Ramanna, 2002). The Seeds Act, 1966 is also under revision to provide a greater operational flexibility to seed industry and entrust it with the responsibility of ensuring seed quality. These developments are expected to further accelerate privatization of seed research in the country. In fact, private seed companies are finding it more attractive to develop and sell proprietary material to capture a significant proportion of the seed market. The effective implementation of the PPVFR Act is expected to promote private plant breeding in the country in the long-run. The immediate effect could be in terms of increased access to seeds developed by transnational seed companies. These companies may sell seed on their own or tie up with the national companies for multiplication and marketing of their material. It is also likely that transnational seed companies establish joint research ventures with the national companies, such as that between Monsanto and Mahyco. Whatever may be the path, Indian farmers may have multiple choice and access to improved seed, which can have positive effect on crop productivity. At the same time, this could create some degree of concentration in seed market because of substantial investments made by some of the transnational seed companies.

The provision of compulsory licensing and presence of a strong public breeding programme for developing varieties which can be delivered by public and private seed agencies, are useful options to control the monopolistic tendencies. The provisions of mandatory registration of plant varieties, farmers' right to sell unbranded seed, and disclosure of information on parents of hybrids are being discussed by the private seed industry and these may significantly influence relations among seed entities. Nevertheless, the issues like protection of genetic resources—a provision under the Convention on Biological Diversity—and to encourage free flow of seed among farmers are quite important from the

system perspective. It is extremely important for the crops where traditional seed systems are dominant. Public ownership of genetic resources could also be used to bargain for access to proprietary technology to promote a competitive seed industry (Fischer and Byerlee, 2002).

Another fear is that a private-sector dominated seed industry may not serve resource-poor farmers in marginal areas, and may also raise seed prices beyond the reach of small farmers. The available evidences support this trend (Pal *et al.*, 2007). Therefore, the government should closely monitor the seed sector and intervene using an appropriate mix of the measures like laws, fiscal incentives and direct seed supply to farmers. It may be noted here that seed prices of hybrids have risen much faster because of greater participation of private seed companies and their quest to make profit. It is desirable that seed prices should be kept within the reach of farmers, particularly small farmers, and these should not rise beyond a limit not justified by the yield or economic advantage.

As regards the policy on biotechnology, India has approved commercial cultivation of first GM crop (Bt cotton) and taken a number of other initiatives. There are still a number of challenges to be addressed— development of research capacity, biosafety and management of public dialogue on controversial issues. Establishment of biotechnology capacity is relatively capital- and human resource-intensive. Both the public and private sectors will have to play an important role, and there is much potential for forging public-private linkages to enhance overall impact. These linkages could be further useful as advances in biotechnology have blurred the differences between pure science and agricultural science, requiring close linkages with general science and technology providers. It is more so when a major responsibility for promotion of biotechnology in India rests with the Department of Biotechnology in the Ministry of Science and Technology. These public-private linkages can be fostered by setting appropriate mechanisms for the sharing of cost and benefits, establishing joint ventures, and management and ownership of intellectual property.

Given the current debate on biotechnology in India and elsewhere, effective biosafety regulations must be in place that are credible, cost-effective and properly coordinated. There is no easy solution to resolve these issues. Ethical issues relating to alteration of biological system, protection of genetic resources, and biosafety and health effects are really critical. We need to take a collective judgement on these issues, which is possible only when adequate scientific evidence is passed on to all the concerned and a healthy debate is encouraged. Lack of information and debate breeds confusion, and delay in decision-making.

A dimension often neglected in the regulation is coherence between various acts governing an industry or sector. For instance, biotech research in India is governed by a number of acts, notably the Seeds Act, Environment (Protection) Act, PVPFR Act, and Biological Diversity Act. It is important that there is coherence between these acts; otherwise some of the positive aspects of these provisions could be neutralized, hampering the growth of private sector research. Finally, there is inadequate flow of information about new technologies to farmers. Since much of this information is a public good, public institutions and government will have to take the major responsibility of disseminating information and educating farmer consumers.

Public-Private Partnership

A number of theoretical concepts are applied to study the public-private partnerships. The new institutional economics literature sees the partnership as a strategy to minimize transaction costs associated with developing and enforcing contractual relations in provision of a good or service. The transaction costs are mainly determined by the frequency and uncertainty of a transaction, limit to rational behaviour of economic agents, and asset specificity of the transaction (Williamson, 1975). For example, a private seed company has to transact with public plant breeding programs for new varieties and source seed. A high transaction cost with high asset-specificity of establishing a plant breeding program may help develop partnership with public plant breeding programs (*see* ICRISAT model). On the other hand, a low transaction cost will favour market-

based transactions, while low asset-specificity can lead to vertical integration, bringing seed production and plant breeding under a hierarchical structure. The second important conceptual framework used is the recent developments in the theory of organisational behaviour. The analysis blurs the classical difference between public and private sectors, and underlines the need for partnerships for efficient provision of a good or service with equitable social benefits, whilst maintaining higher flexibility, and accountability of the private sector and social interest of the public sector (O'Looney, 1992). Other approaches focus on the traditional welfare analysis in use of scarce resources, development of networks of innovations for the given social and economic institutions, and incentives and relationships that shape the flow of knowledge and information (for details, *see* Spielman and Grebmer, 2004).

One may infer that incentives, problems and risks associated with incentives, contextual realities and nature of goods or services are important for developing and enforcing partnerships. Since plant breeding is a risky activity with high asset-specificity, contractual relations that shape the flow of knowledge and material are critical for establishing research partnerships. Macro-economic policies and social and economic institutions further influence the attitudes and pace of research partnerships. For example, a greater reliance on market forces and the enabling institutions like IPRs may facilitate research partnerships, while public and private sector will continue to maintain a negative perception in an inward looking economic environment.

The ICAR, as an apex agricultural R&D organisation of the country, has initiated dialogues with private R&D organisations, NGOs and other stakeholders to develop partnerships. A number of policy decisions have been taken through a consultative process. These decisions underscored continuity of dialogue, sharing of resources, expertise and cost and benefits of technologies in a transparent manner, capacity building, and developing a culture of mutual confidence and trust. Although these initiatives are quite comprehensive and path breaking in several ways, there are only a few examples of successful partnerships. In the case of hybrid rice, ICAR, SAUs, IRRI and national private seed companies collaborated for development of male sterile lines, development of hybrids and refinement of seed multiplication technologies. The partnership upscaled the hybrid rice technology and intensified plant breeding and seed multiplication activities in the private sector. The technology has been commercialized and being adopted even in marginal areas of eastern India because of significant yield advantage.

In spite of the above-mentioned successes, there are certain constraints and rigidities which need to be addressed. The private sector would appreciate and value a timely response from the public organisations which is possible only in a decentralised system. Delay and uncertainty in establishing a partnership may enhance transaction cost. In order to avoid this, the private sector would prefer to enter into some kind of agreement with other private companies, or an international organisation. Perhaps the ICRISAT's consortium of private seed companies reflects this concern. A group of private seed companies, both national and international, has formed a consortium to fund the plant breeding program of ICRISAT for pearlmillet and sorghum. The member companies pay annual fee and have access to advanced breeding material. The material is available to the public plant breeding programs, but not to non-member seed companies. Private seed companies benefit from advanced breeding material and minimize their research cost, while ICRISAT is able to generate resources to fund its breeding programs for the crops. The National Botanical Research Institute, Lucknow, has taken lead in this direction for Bt cotton, but their initiative is constrained by the lack of freedom to operate. In addition to addressing technical issues like freedom to operate in an era of IPRs, development of mutual confidence and trust among the partners is a major issue which shall build over a period of time. However, it requires transparent procedures and commitment to honour the contract and confidentiality of information. While all these issues are important for working in a partnership mode, there are other modes of partnerships which are largely governed by markets. The markets for technologies provide ample opportunities to work independently, but complement each other's

activities through market-based contracts. For example, public sector can develop inbred lines or semi-finished breeding material, which can be taken by the private seed companies on agreed conditions for development of a finished product. This can be further licensed to another private seed company for multiplication and distribution of seed. The government should play a facilitating role in such cases.

The examples discussed above demonstrate that some forms of public-private partnerships can be of mutual benefit and can serve the farming community in a more effective manner. There is a need to promote such partnerships in provision of improved seed to marginal and isolated agricultural production environments. One successful example of this has been the public delivery of private seed, mostly of vegetables, in inaccessible regions of Himachal Pradesh, where the government procures seeds from the private seed companies through open tender and the line department distributes them to farmers.

Seed Acquisition and Management by Farmers

Positive developments in the seed system should be reflected in the acquisition, management and replacement of seed by farmers. It is likely that easy access to quality seed and information would help farmers make informed-decisions regarding selection of variety, procurement of seed from a reliable source and replacement of seed frequently. This section deals with these issues. The discussion is based on the farm survey data conducted in the sample states. Here, it may be noted that these surveys were designed to capture different farm situations representing degree of commercialisation of agriculture and seed system, and therefore, may not necessarily be used for a wider generalisation of the results.

Use of Commercial Seeds

Of the total seeds of cotton, tomato and pea used in the case study states, more than 90 per cent were procured from the commercial sources. Even in the case of paddy, 60 per cent of the seeds used were commercial. Only in potato, farmers mostly used farm-saved seed and in a few cases, the seed was procured from other farmers. The proportion of commercial seed was 20 per cent (Table 2). In the case of groundnut, although the share of seed procured from commercial sources was very high, it was largely produced by progressive farmers and therefore, it was difficult to compare with other crops in terms of quality. This was primarily because of difficulty in supply of source seed caused due to seed-multiplication rate. This problem was solved in potato to some extent because of large-scale source seed production by research institutions and state government departments and seed multiplication done by small seed producers.

The trends in procurement of commercial seed were echoed by the area planted with different types of seeds. Almost entire area under cotton, tomato and pea was planted with commercial seeds. In case of paddy, about half of the area was sown with commercial seed. However, potato growers continued to be served largely by the traditional seed system, where seed saving and exchange was predominant (Table 2).

These trends in the use of seed for various case study crops revealed that development of commercial seed markets in India has increased use of quality seed for most of the crops. This was expected for hybrids where farmers need to replace seed every year. But, increasing trends in the use of quality seeds of pea and paddy were quite encouraging. This showed that wherever there was economic advantage in the use of commercial seed, farmers did acquire fresh seeds from the market. And since there was increasing demand for quality seed, private sector did participate in the provision of seed. This situation exited in groundnut and potato, but low seed multiplication rate and high seed handling costs restricted the private sector's participation. In both the crops, there was no problem of genetic impurity of seeds, but there were other quality considerations like disease control, which deserved immediate attention. Technologies to manage diseases, handling and storage of seed and increasing supply of source seed would go a long way to strengthen the decentralized seed systems for these crops.

Sources of Commercial Seeds

What are the sources and reasons for procuring commercial seeds by farmers? Almost all farmers bought the seed of cotton, tomato and pea from the commercial sources, i.e. a private seed dealer or sale counter of the seed corporation or government department. In a majority of the cases, the seed was bought from private seed dealers, as almost the entire private seed and a significant proportion of public seed was being sold by them. Furthermore, all of these market transactions were in cash and hardly a few farmers bought seed on credit basis even when they were buying from a dealer known to them. The cases of farmers buying seed from other farmers were quite low both for paddy and potato grown in the favourable production environments (Table 2).

It was interesting in the sense that as the supply of commercial seed improved and farmers had a better access to seed markets, importance of the traditional seed system diminished. However, traditional seed systems were found to be very effective in terms of popularisation and seed provision of new varieties. Once a variety was accepted by the farmers, formal seed systems faced little risk in the production and delivery of new variety on a large scale (Pal *et al.*, 2000).

The reasons for farmers acquiring fresh seed were quite revealing. A majority of the farmers bought fresh seed for quality considerations. They felt that fresh seed available in the market was of better quality, and would give a distinct yield advantage. The proportion of such farmers was as high as 90 per cent for tomato and pea, and about 60 per cent for cotton and paddy. In cotton and paddy, a significant proportion of farmers (more than 30%) bought fresh seed to change variety (Figure 2). Only in the case of potato and groundnut, where seed storage and management was rather difficult, farmers also bought seed as they had sold all the stock. It reiterated that there was seed demand for these crops but there were not adequate incentives for the private sector to participate. Perhaps fiscal incentives, coupled with technological developments to reduce the costs and risks would go a long way in attracting the private sector to the seed business of these crops.

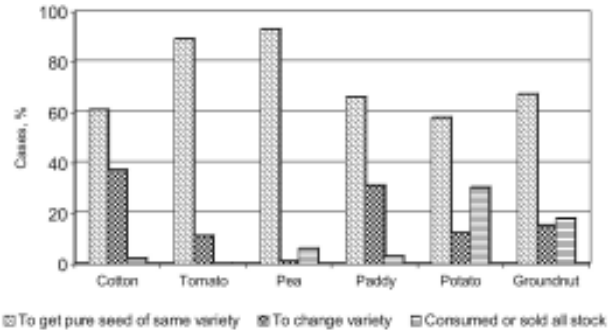

Fig. 2. Reasons for acquiring off-farm seed: 2003-04 and 2004-05

The above results have clearly shown that Indian farmers replace seed frequently for quality

Table 2. Proportion of seed quantity, source of seed and area planted with commercial seed by sample households: 2003-04 and 2004-05

Particulars	Crops					
	Cotton	Tomato	Pea	Paddy	Potato	Groundnut
I. (a). Proportion of seed quantity procured (%)						
Commercial	91	99	98	60	21	35
Other farmers	8	1	0	12	19	23
Farm saved	1	0	2	28	60	42
(b). Proportion of farmers procuring seed from different sources (%)						
Commercial	98	98	98	61	37	41
Other farmers	1	2	0	14	21	23
Farm saved	1	0	2	25	42	36
II. Proportion of area planted with commercial seed (%)						
	96	99	97	60	24	37

Source: NCAP farm survey.

Table 3. Sources of information about varieties

Crop	Source of information (% of cases)			
	Fellow farmers	Seed dealers	Extension agents	Others
Cotton	70	17	-	13
Paddy	76	14	2	8
Potato	87	7	2	4
Pea	42	28	26	2
Tomato	49	42	3	6
Groundnut	80	-	16	4

Source: NCAP farm survey.

considerations. Increased availability of seed and wider seed distribution networks have improved farmers' access to commercial seed. Discussion with farmers during farm surveys revealed that higher seed prices were not a problem for them if they could realize higher yield or cost reductions due to use of commercial seed. In case seed prices were high and there was germination failure due to adverse weather conditions, farmers found it difficult to arrange additional resources to procure fresh seed. This problem was indicated by some farmers growing cotton and vegetables. It is therefore important that farmers are either compensated by seed companies in case of inferior seed, or crop is insured against crop failures due to adverse climatic conditions.

Sources of Information

Delivery of information about seed of crop varieties on sale, seed agencies, seed and crop management practices are as important as delivery of seeds. Farmer-to-farmer dissemination of information on crop varieties was still dominant for all crops (Table 3). This was not surprising when the present extension methodology under the Training and Visit system emphasized working with a few contact farmers, which in turn, spread messages among their fellow farmers. Seed dealers turned out to be the second important source of information about crop varieties. This source was particularly important for vegetables, where almost entire seed is sold by the private dealers, and for crops like tomato, cauliflower and cabbage where most of the seed is imported. Only pea growers received information from diversified sources (fellow farmers, seed dealers and extension agents) because most of the seed sold in HP was of public varieties and the government department and private seed dealers had significant role in seed sale. Some seeds like Bt cotton required additional information to be delivered to farmers, and during the filed visits it was also found that the concerned seed company printed extension material for distribution along with Bt cotton seed. In some cases, seed dealers were well informed by the seed company about the new seed, who in turn educated the farmers. However, it was rather difficult to establish that to what extent the required guidelines were followed by Bt cotton growers, as there were very few growers in the sample area. Nevertheless, this indicated that seed companies and dealers will have to play a much larger role in educating farmers in the adoption of information-intensive crop varieties and associated management practices.

Conclusions

The study has concluded that the commercial seed markets for hybrids are well developed, but these need improvement in the flow of information to farmers and effective regulation of unscrupulous traders, etc. There are significant changes in terms of seed regulations, management of GM crops and protection of intellectual property. Since all these regulations interact closely, there is a need for developing institutional capacity for their enforcement, as well as flexibility to learn from the experience for future adaptations. There is a lot of scope for strengthening the seed system of 'orphan crops', where there is no participation of the private sector, and public seed system is facing several resource and institutional constraints. In particular,

technological backstopping, developing partnerships with the private and civil society organisations, and developing capacity at the local level deserve special attention. The study has shown that increasing proportion of farmers use commercial seed for quality considerations. However, there are problems with the selection of crop varieties, particularly of proprietary hybrids, due to lack of information. This has resulted into poor crop performance on several occasions. Thus, empowerment of farmers with information about commercial seed market and new varieties and strengthening of the system to protect farmer seed users would go a long way in developing the seed system. In the case of high volume crops, technological empowerment of local seed agencies and farmers should be accorded high priority.

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