Impact of Public- and Private-Sector Maize Breeding Research in Asia, 1966-1997/98

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Chapter 3

An Interface in Public and Private Maize Research in India

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Maize ranks third in volume among the cereals grown in India. Its contribution to the country's total production of food grain in 1994-97 was about 5% (MOA 1997). Maize has traditionally been grown as a staple food for household consumption. However, the increasing commercial orientation of India's agricultural economy has resulted in a rising demand for maize, especially for feed and industrial use. In addition, policy reforms introduced in the late 1980s to encourage private sector participation in the seed industry stimulated investments in plant breeding research and seed production. Substantial investment in maize research, in particular, has generated a wide range of improved production technologies in response to market demand (Singh and Morris 1997). Private maize seed companies have been established in many important maize-producing states, offering farmers a wide range of improved open-pollinated varieties (OPVs) and hybrids. These companies have captured a significant and continuously expanding share of the national maize seed market. Some analysts note that private seed companies are making a useful contribution, but they also warn that their activities should complement, rather than compete with, the work of government agencies.

The lack of readily accessible information on the maize seed industry, however, makes it difficult for policy makers and research administrators to make decisions on appropriate development strategies. Basic data on research investment, research products and farm-level research impacts are scarce, either because they are difficult to measure or are kept confidential (Singh *et al.* 1995). This chapter summarizes information on investment in and products of public and private maize research and describes policy options for sustainable growth in maize production in India. Data on India's maize seed industry were collected mainly through interviews with 30 public organizations and 23 private (national and multinational) seed companies actively pursuing research and development (R&D) for maize breeding, seed production and sales.

Maize Production and Consumption Trends in India

Maize is grown in a wide range of production environments. The total area under maize in India expanded from 3 m ha in 1951 to 6 m ha in 1970, growing annually at an average rate of 2.9% (Singh *et al.* 1995). In the early 1970s, expansion in area under maize cultivation slowed dramatically, and for three decades the maize area remained virtually unchanged. A significant shift occurred in the 1990s when irrigated winter (*rabi*) maize cultivation expanded rapidly, particularly in the states of Bihar, Andhra Pradesh and Karnataka, where conditions are favorable for maize production (Singh and Morris 1997). Overall, irrigated area increased from 16% in 1970 to 23% of total area under maize in 1997 (Singh 1998). At the same time, maize cultivation moved into marginal areas with relatively low production potential, as farmers reserved more productive areas for more profitable crops like wheat, paddy and sugarcane.

The spread of improved germplasm and crop management practices resulted in a continuous growth in average maize yields from the 1950s onwards (Singh and Morris 1997). Rising yields, coupled with a steady expansion in area, led to growth in maize production of 5.9% and 5.2% per annum in the 1950s and 1960s, respectively (Table 1). After slowing down in the 1970s as the area under cultivation stabilized, growth in maize production, fueled by continuing improvements in yield, averaged about 2.6% per annum in the 1980s and 3.2% per annum in the 1990s. Total maize production exceeded 10 million tons in 1997-98.

Virtually all of India's maize is used domestically for food (70%), feed (15%) and industrial uses (15%) (Singh and Pal 1992). Direct human consumption of maize has declined over time, while feed and industrial uses have increased. Rising household incomes have shifted consumption from maize to other cereals like rice and wheat. They have also led to an increased consumption of meat, particularly of poultry, which has increased the demand for maize as feed. Increased industrial demand for maize comes primarily from the starch industry. Although exports of maize remain negligible, they are expected to increase with improvements in productivity.

Table 1. Annual growth (%) in maize area, yield and production, India, 1950-98

Period	Area	Yield	Production
1950–60	2.85	2.92	5.92
1960–70	3.52	1.67	5.25
1970–80	0.04	1.36	1.15
1980–90	0.07	2.53	2.59
1990–98	1.07	2.08	3.17

Source: MOA (various years).

The Maize Seed Industry

The 1966 Central Seed Act laid the legal foundation for India's seed industry. This legislation was designed to govern the production, certification and distribution of all seed in India, prescribe seed certification standards, and assign the responsibility for enforcing the standards to state governments. In line with the national objective of attaining food self-sufficiency, the Act assigned responsibility of commodity research and seed production to public organizations. Maize research and seed production activities thus remained firmly in the public domain (Pal *et al.* 1998).

The emergence of a vibrant commercial farming sector during the late 1970s and early 1980s (attributable in part to the green revolution in wheat and rice) created incentives for private-sector participation in the seed industry. The result was increased involvement of private companies in research, seed multiplication and distribution activities. As the Indian market was still relatively closed, most of these seed companies were Indian owned. Many did not establish their own research programs but specialized in multiplying seed of public OPVs and hybrids.

The implementation of the New Policy for Seed Development in 1988 opened the doors to foreign participation in the seed industry (Morris *et al*. 1998). Today both the public and private sectors play an active role in the maize seed industry. Public organizations continue to engage in research, development, seed production and seed distribution. Their efforts are now strongly complemented, however, by an increasingly active private seed industry.

Investments in Maize Research

Public Sector Investments

India's national maize research program has several components. In 1957, the Directorate of Maize Research (DMR, formerly the All-India Coordinated Maize Improvement Project) was established by the Indian Council of Agricultural

Research (ICAR) to promote and coordinate basic and applied research on maize in India. The DMR maintains more than two dozen research centers in different parts of the country, covering a wide range of agro-climatic conditions. In addition, it interacts through ICAR with other national and international research organizations. A network of state agricultural universities (SAUs) that, in addition to their teaching functions, are responsible for addressing specific research problems supports the DMR. Government departments, research organizations, and non-agricultural universities also undertake research directly or indirectly related to maize (Pal *et al.* 1998).

Since detailed expenditure data are not available for several research cost categories, the level of public investment in maize research cannot be determined precisely. Even so, the level of investment can be estimated indirectly by using measurable indicators such as numbers of scientists (Pal *et al*. 1998). In 1997, 102 full-time equivalent (FTE) scientists were employed in 30 DMR and SAU research centers with an annual budget of Rs 42.3 million (US$ 1.1 million) for maize research (Table 2). This is equivalent to 17 FTE scientists for every million hectares of maize planted in India, quite low by global standards (CIMMYT 1994). The level of training of these scientists is impressive. Of the 102 FTE maize scientists, 33 were senior scientists with Ph.D. or M.Sc. degrees, and 69 were intermediate- and junior-level scientists.

Scientists involved in germplasm improvement (including plant breeders and those providing direct support to plant breeding efforts) dominate the public research system. Seventy-eight percent of all maize researchers are involved in germplasm improvement, 17% are engaged in crop agronomy and only 2% in social science research (including economics and statistics) and extension. All public breeding programs screen and evaluate materials and perform basic population maintenance and improvement work, but only the larger and better equipped breeding programs generate and test cross inbred lines.

Private Sector Investments

As noted earlier, policy reforms introduced in the late 1980s removed many obstacles to private (foreign) participation in maize research in India. Currently, 18 national companies and 5 multinational companies engage in maize breeding. They are usually connected to seed production operations. Private breeding programs

Table 2. Maize research personnel and expenditure in the public and private sectors, India, 1997

		Private sector		
Indicator	Public sector	National companies	Multinational companies	All companies
Number of respondents	30	18	5	23
Maize research personnel	342	295	40	336
Senior-level scientists	33	42	8.5	50.5
Intermediate-level scientists	69	29	7.5	36.5
Technical staff	240	225	24	249
Scientists per million ha under maize	16.5	–	–	14.1
Annual budget (Rs million)	42.3	27.1	37.5	64.6
Annual budget (US$ million)	1.1	0.71	0.98	1.7

Source: IARI-CIMMYT Survey, 1998-99.
Note: Rs 38.5 = US$1.

are thus the first step to a vertically integrated industry combining research, seed production and seed distribution functions.

In 1997, 23 private companies reported employing 336 FTE workers (Table 2), most of whom were involved in seed production and distribution. These workers included 87 FTE junior or senior maize scientists, with an annual research budget of about Rs 64.6 million (US$ 1.7 million). This represents a significant change from earlier years, when virtually all maize research was carried out by the publicly funded programs of ICAR and the SAUs. In contrast to the public sector, maize research in the private sector is totally confined to developing and marketing proprietary, branded hybrids. No private company works on developing commercial OPVs or on crop agronomy.

Products of Public and Private Research Programs

The germplasm products of public breeding programs and private seed companies show the differences in their research priorities. Of the 256 improved maize materials developed by public and private breeding programs for commercial cultivation in India between 1961 and 1997, about 31% were improved OPVs and 65% comprised various types of hybrids (Table 3). Seventy-seven percent of all hybrids released came from the private sector and the rest from public breeding programs. All improved OPVs developed since 1961 have originated from the public sector and 50% of all public improved OPVs were released in the 1980s. The public sector had more releases than the private sector until 1989. Among all public-sector materials released between 1960 and 1999, 79% were released in the 1990s. Among all private-sector materials released over the same period, 33% were released during the 1990s (Figure 1).

Public agencies concentrate their research efforts on developing improved OPVs. Private companies meanwhile emphasize double-cross and three-way cross hybrids; the production of single-cross hybrids is unattractive owing to the difficulty of protecting parental lines (parent materials can easily go astray once provided to contract seed growers). In 1990-99, the private sector released only 11 single-cross hybrids compared to a total of 83 double- and three-way crosses (Figure 2).

About 75% of the improved OPVs and hybrids developed by the public programs and private companies since 1961 have had yellow grain, serving the preference for yellow grain in some regions. Public breeding programs have produced mainly flinty materials. Private companies put greater emphasis on semi-flints and semi-dents and a moderate emphasis on dent maize, reflecting their greater reliance on exotic germplasm based mainly on North American materials (Singh *et al.* 1995).

Most of the improved OPVs and hybrids developed in India are suitable for favorable production conditions. Although public breeding programs have produced a somewhat broader range of materials than private companies, neither sector has placed any emphasis on developing materials for marginal production environments with highly unfavorable agro-climatic conditions (e.g., drought or waterlogging, extreme heat or cold, severely nutrient-deficient or imbalanced soils) (Pal *et al.* 1998).

Of the 256 materials released since 1961, about 33 improved OPVs and 88 hybrids were still available in the Indian maize seed market in 1997. These consisted of 33 improved OPVs and 12 hybrids released by the public sector and 76 hybrids released by private companies. Most of the hybrid seed sold by public agencies and private companies is seed of double-cross hybrids. No improved OPV seed sold as of 1997 was developed by the private sector.

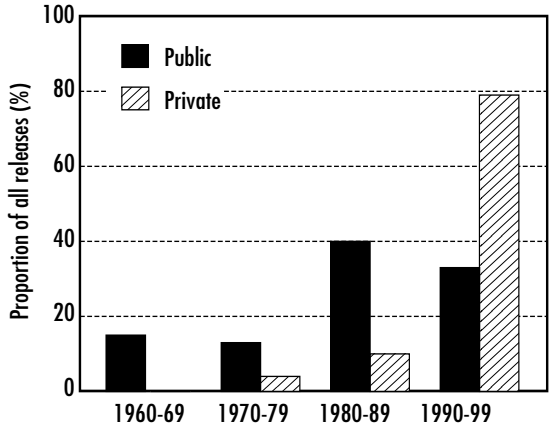

Figure 1. Proportion of maize releases by sector, India, 1960-99.

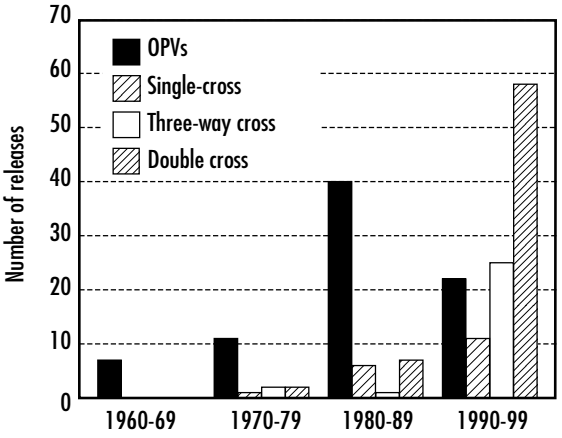

Figure 2. Number of public improved OPVs and private-sector hybrids, India, 1960-99.

Table 3. Maize cultivars developed in India, 1961-97

Cultivar types and characteristics	Public agencies	Private companies		All seed companies
		National	Multinational	
Cultivar type (number)				
Improved OPV	80	0	0	80
Hybrid	40	91	36	167
All improved material	120	97	39	256
Cultivar type (%)				
Improved OPV	67	0	0	31
Hybrid	32	94	92	65
Top cross	1	0	0	<1
Double top cross	7	0	10	5
Three-way cross	4	22	18	14
Double cross	13	56	59	36
Single cross	7	16	5	10
Unspecified hybrid	0	6	3	9
Grain color				
Yellow	81	82	69	74
White	18	7	26	13
Other	0	10	3	13
Grain texture				
Flint	65	24	23	48
Semi-flint	10	33	38	17
Dent	8	12	21	20
Semi-dent	13	31	18	15
Maturity				
Extra early	19	34	23	25
Early	30	40	33	39
Intermediate	7	16	21	13
Late	4	3	15	23

Source: Data from IARI-CIMMYT Survey 1998-99.
Note: Some proportions will not total 100% because of incomplete varietal descriptions.

Seed Production and Sales

Organization of Seed Production in the Public and Private Sector

The central government and various state governments are involved in maize seed production and distribution. The National Seeds Corporation (NSC) administered by the central government produces and distributes significant quantities of maize seed, as do some state seed corporations (SSCs) (Pal *et al.* 1998). In addition, a number of state agricultural departments, research institutes and SAUs supply small quantities of maize seed directly to farmers, often to promote new releases. Many of these public seed agencies work with contract growers for seed production.

Maize seed production in the private sector is concentrated in the states of Andhra Pradesh, Karnataka and Maharasthra. All private seed companies are engaged in production and distribution of maize seed. They do not produce seed commercially using their own land and labor but rather employ contract growers to produce the seed. The contract growers are provided with seed and, in some cases, other material inputs and services on credit (Pal *et al.* 1998). A few family-run seed enterprises are operated by commercial grain farmers. With modest levels of processing, these farmers try to sell their maize produce as seed rather than as ordinary grain in the hope of capturing an attractive price premium. The private companies interviewed in 1998-99 estimated the share of such seed at 10-15% of the total volume of maize seed marketed annually.

Seed Sales by the Public and Private Sector

Sales of maize seed are difficult to estimate with precision. Data on seed sales of private companies are difficult to collect. Both public seed agencies and private seed companies have cause to misrepresent their sales figures (Pal *et al.* 1998). Nevertheless, partial data compiled from public and private sources reveal some interesting trends.

First, maize seed sales of all public agencies and private seed companies grew seven-fold, from only around 4,500 t in 1981-85 to around 33,000 t in 1995-97 (Table 4). Across all maize materials, the market share of public agencies declined over the last 15 years from 90% in 1981-85 to barely 15% in 1995-97, while that of private seed companies rose from 10% to 85% (Table 4). The private sector now dominates the market for improved maize seed. It must be noted that public seed agencies handle many unprofitable crops and are required to operate in marginal production environments where demand for seed is low and distribution costs are high. In contrast, in areas where public seed agencies and private companies both operate, private companies appear to provide better service in producing seed and delivering it to farmers.

Second, the volume of hybrid seed sold by private companies has grown much more rapidly than that of public OPV seed sales, raising serious questions about whether or not OPV seed will continue to be available in the future. Similarly, the volume of proprietary hybrid seed sold by private companies has grown more rapidly than that of public hybrids, confirming that private companies are more effective than public agencies at delivering their materials to the farmers (particularly in more favorable production environments) (Pal *et al.* 1998).

Adoption of Improved Germplasm

Official production statistics indicate that about 56% and 60% of the total area under maize was planted to improved materials in 1995 and 1997, respectively (FAI 1998). In 1995, Singh and Morris (1997) surveyed 864 maize growers located in the six most important maize-growing states and reported that approximately 51% of the maize area in these locations was planted to improved materials (Table 5). Approximately 22% of the area was planted to improved OPVs and 29% to hybrids (Pal *et al.* 1998).

Table 4. Maize seed sales (t) by public agencies and private companies in India, 1981-97

	1981–85	1986–90	1991–94	1995-97
Public seed agencies				
Improved OPVs	278	817	479	388
Hybrids	3,659	2,598	3,622	4,382
Private seed companies				
Improved OPVs	0	332	434	653
Hybrids	427	2,063	14,494	27,130
All public and private sales				
Improved OPVs	278	1,150	914	1,040
Hybrids	4,087	4,661	18,116	31,512
All materials	4,365	5,811	19,030	32,553
Market share of private sector (%)				
Improved OPVs	0	29	48	63
Hybrids	10	44	80	86
All materials	10	41	78	85

Source: Data from IARI-CIMMYT Surveys 1992 and 1998-99.

The use of improved germplasm, however, varies considerably by state. The adoption of improved maize varieties is very high (at 81-98%) in the commercial maize-growing areas of Karnataka, Andhra Pradesh and Bihar (Table 5) (Singh and Morris 1997). Hybrid maize adoption is also very high (at 55-86%) in these states, where agro-climatic conditions are generally favorable for the production of two maize crops annually and where private seed companies are particularly active. In contrast, the use of local materials continues to dominate in the semi-subsistence maize areas of Uttar Pradesh, Rajasthan and Madhya Pradesh, where production conditions are generally less favorable and where private seed companies have been less active. In these areas, the use of improved germplasm is much less extensive and hybrid maize adoption levels have not yet reached 10% (Singh 1998). In cases where farmers have adopted improved materials, improved OPVs are more popular than hybrids. This pattern is attributable to the fact that farmers in the latter three states prefer short duration materials with good eating quality, and few improved materials meet these criteria.

Farmers who grow OPVs generally do not replace their seed frequently. In areas where hybrid use is extensive, most maize farmers replace their seed at the beginning of each cropping cycle, but approximately 10% of the area planted to hybrids is planted with recycled F2 seed (Singh 1998). Although the market for hybrid maize seed in India is growing rapidly, knowledge of specific maize hybrids remains very limited. Most farmers select hybrid seed based on the reputations of the seed companies, rather than on detailed information on the performance of the seed in the field.

Table 5. Percentage of maize area under improved germplasm in selected states, India, 1995

State	Improved varieties			Local varieties	All varieties
	Improved OPVs	Hybrids	All improved		
Andhra Pradesh	15	79	94	6	100
Bihar	26	55	81	19	100
Karnataka	12	86	98	2	100
Madhya Pradesh	23	15	38	62	100
Rajasthan	18	8	26	74	100
Uttar Pradesh	31	8	39	71	100
Total[a]	22	29	51	49	100

Source: Singh and Morris (1997).
Note: These six states accounted for 70% of total area under maize in 1995.

Conclusion and Policy Options

Public and Private Participation in the Seed Industry

India's earlier policy of entrusting the public sector with maize research, seed multiplication and distribution generally had positive results, particularly during the early stage when farmers were still learning about the benefits of improved production technologies (Pal *et al.* 1998). The national maize program was quite successful in developing improved OPVs and hybrids, and the public seed agencies proved to be reasonably effective in delivering seed to millions of small-scale maize growers.

Policy reforms introduced during the late 1980s opened up the maize seed industry to private sector participation, including foreign multinational companies. Over time, the private sector became increasingly active not only in maize research to develop improved germplasm but also in producing and distributing seed (Singh *et al.* 1995). This development benefited many farmers as adoption of improved OPVs and hybrids increased.

The private sector has, however, largely ignored marginal areas where maize production potentials are low, because sales of improved seed to resource-poor farmers are not profitable. Public institutions are responsible for developing improved production technologies, supported with appropriate policies, for the small-scale subsistence farmers in these areas. Public seed agencies in India have not been as effective as private companies in producing high quality maize seed and distributing it to farmers in a timely and cost-effective fashion. The difference in performance is largely attributed to economic factors: profit-driven private companies must pay attention to the bottom line, whereas public agencies continue to receive government directives to maintain relatively low seed prices, which undermines their incentive to operate efficiently.

The policy directives aim to promote innovative new strategies for private seed companies and public seed agencies to share the responsibility of serving the needs of a wide range of end users, especially small-scale maize farmers located in marginal environments. Although the emergence of a flourishing private maize seed industry has relieved some of the pressure on public breeding programs, government administrators must continue to ensure that research resources are allocated to support national policy objectives (Singh 1998).

Regulations and Intellectual Property Rights

There are numerous government regulations to prevent both public seed agencies and private seed companies from indulging in unscrupulous practices that could harm vulnerable groups of producers and consumers. The government safeguards are justified, but some regulations may be unnecessary (Pal *et al.* 1998). The government could simplify the seed quality certification framework and allow private seed companies to operate within broad policy directives. To serve maize producers and consumers more effectively and efficiently, the best strategy is to ensure that seed markets are transparent and competitive.

The absence of legislation protecting intellectual property rights of plant breeders has influenced the strategies pursued by many private seed companies, particularly transnational companies and larger Indian companies that have their own research capacity. Many seed companies have been reluctant to establish full-fledged breeding programs in India because they are uncertain of earning adequate financial returns from their investment in research (Pal *et al.* 1998). Similarly, many companies have been unwilling to introduce single-cross hybrids into the Indian market because they feel they cannot protect the valuable parental lines. As a result, Indian scientists have been denied access to cutting-edge research technologies and Indian farmers have been denied access to some of the best available germplasm. Regulatory measures should promote strong research linkages between public and private research programs, ensuring a free flow of genetic materials.

Economic liberalization can provide new opportunities for exploiting competitive advantage leading to export-led growth in agriculture. On the scientific front, advancement in maize biotechnology can provide new avenues for attaining higher and more stable productivity levels and in reducing research lags. To benefit from these new, complex and capital-intensive developments, the public and private sectors in the maize industry must work together in generating funds and undertaking research to attain the desired levels of research intensity to improve national maize research and production.

References

CIMMYT. 1994. *CIMMYT World Maize Facts and Trend: Maize Seed Industries, Revised: Emerging Role of the Public and Private Sectors*. Mexico, D.F.

FAI (Fertilizer Association of India), 1998. *Fertilizer Statistics*. New Delhi.

MOA (Ministry of Agriculture, Government of India). Various years. *Estimates of Area, Production and Yields of Principal Crops in India*. Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi.

Morris, M. L., R.P. Singh and S. Pal. 1998. India's maize seed industry in transition: changing roles for the public and private sectors. *Food Policy* 23 (1): 55-71.

Pal, S., R.P. Singh and M. Morris. 1998. Country case study: India. In M. Morris (ed.), *Maize Seed Industries in Developing Countries*. Lynne Rienner Publishers and CIMMYT, Boulder, Colorado.

Singh, N.N. 1998. *Maize research in India*. A country report presented at the FAO-sponsored Third Tropical Asian Maize Network (TAMNET) Meeting, Hanoi, Vietnam, October 27-29.

Singh, R.P. and S. Pal. 1992. Technological advancement and the state of maize development in India - an appraisal. *Agricultural Situation of India* 47(4):245-252.

Singh, R.P., S. Pal and M.L. Morris. 1995. Maize research, development and seed production in India: the contribution of the public and private sectors. *CIMMYT Economics Program Working Paper 95-03*. CIMMYT, Mexico, D.F.

Singh, R.P. and M.L. Morris. 1997. Adoption, management and impact of hybrid maize seed in India. *CIMMYT Economics Program Working Paper 97-06*. CIMMYT, Mexico, D.F.