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The roles of public sector versus private sector in R&D and technology generation: the case of maize in Asia

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Abstract

This paper reports the findings of a study whose objectives were to compare and contrast the public and private sectors in Asia in terms of their (1) estimated level of investment in maize breeding research; (2) germplasm outputs; and (3) nature and extent of roles played in the maize seed industry. Since the 1960s, yield gains, rather than area expansion, have fuelled increases in maize production in Asia. Yield gains, in turn, have been due to the shift in maize cultivation from mostly open-pollinated varieties (OPVs) to mostly hybrids. This transition also shifted the locus of modern maize breeding research from government research organisations to private national and multinational seed companies. In countries where both the public and private sectors participated in maize research, private sector research investment far exceeded that of the public sector. With more aggressive marketing programmes, the private sector captured 89% of the Asian maize seed market in the late 1990s. National public seed research agencies (including universities and cooperatives) developed and produced more maize OPVs than hybrids, mass-produced and distributed seed cheaply, addressed location-specific production problems, and provided agricultural extension services. The private seed companies developed, produced, sold and promoted their own proprietary hybrids. The reluctance of the private sector, however, to address the needs of marginal maize farmers should encourage the public sector to continue playing an active role in maize research and development (R&D), seed production and modern maize technology dissemination, especially with adequate support from appropriate government policies.

Keywords: Maize; Asia; Research; Impact

1. Introduction

In developing economies, maize production ranks first among cereals in Latin America and Africa, but only third in Asia after rice and wheat (FAO, 2001). This production comes from about 97 million hectares planted to maize (69% of global maize area) in 1997–1999 (CIMMYT, 2001). In the same period, around 160 million tons of maize grain (27% of world production) were harvested in Asian countries from 43 million hectares (31% of global maize area).

IFPRI (2003) projected that global maize demand will increase by 58% from 585 million tons in 1997 to 927 million tons by 2025, surpassing both wheat and rice demand. In developing countries, particularly in East and Southeast Asia, rising incomes and the consequent growth in meat and poultry consumption have rapidly increased livestock feed maize demand. Unabated population growth and persistent poverty

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have also kept food maize demand high in poor countries, as in some parts of South Asia.

To serve the growing maize requirement, Asian farmers are gradually shifting to higher yielding maize varieties and more modern production technologies. In response, maize research and development (R&D) agencies are aligning their research strategies to better serve the changing production and market requirements. The expanding opportunities for maize production challenge Asia's maize seed industries, however, such that it is important to understand: (1) how the maize R&D system is organised; (2) what roles the public and private sectors play in the system; (3) how the public and private sectors serve the varying needs of Asian maize farmers; and (4) what technological and policy issues, related to maize R&D, concern players in the seed industry.

2. Maize research and technology development in Asia

This paper provides a synthesis of public and private maize breeding research in Asia. Researchers from the International Maize and Wheat Improvement Center (CIMMYT) interviewed 179 national public agencies, private seed companies and non-governmental organisations (NGOs) in China, India, Indonesia, Nepal, Philippines, Thailand and Vietnam, which together account for 93% of Asia's maize area. In 1997, these organisations collectively sold about 167,000 t of maize seed, or 73% of the formal maize seed market in the region.

2.1. Organisation of maize research

The improved open-pollinated varieties (OPVs) and hybrids that farmers plant are products of an international maize breeding system that includes CIMMYT; hundreds of national, regional, state, or district level public breeding programmes; and thousands of private national and international seed companies. The history, organisation and performance of this international maize research system are described elsewhere (see Morris et al., 1992; López-Pereira and Filipello, 1994; López-Pereira and Morris, 1994; Dowswell et al., 1996), so this paper focuses on maize R&D systems in Asia.

In 1997/1998, the reference year for this study, about 700 national public agencies (including universities and cooperatives), and 290 private companies and NGOs were conducting maize breeding research and/or producing and distributing maize seed in Asia.

2.1.1. Role of the public sector

When national research systems are initially formed, state-sponsored organisations almost always play a dominant role in developing improved technology and disseminating it to farmers (Morris, 1998). Over time, however, the role of the public sector typically declines, and private companies gradually take over their functions. In Asia today, only China and India retain sizeable public agricultural research and extension systems. Excluding these two countries, only 75 of 216 total maize seed organisations (35%) are public, as compared to 707 of 997 (71%) when they were included. The decline in public maize breeding research has been particularly pronounced in Southeast Asia, where today it is carried out by only two or three organisations per country.

In Asia, most public agencies that are actively involved in maize R&D concentrate on developing and evaluating varieties. Many also move upstream in the germplasm development process, concentrating on genetic resource conservation and pre-breeding activities to produce basic germplasm that can be used as source material by commercial breeding programmes. A few public agencies produce and distribute maize seed, along with extension services, especially to resource-poor farmers, whom profit-orientated private companies tend to ignore. (Public agencies also work in favourable areas, although here they face more competition from the private sector.) More commonly, however, public R&D agencies no longer participate directly in seed production and distribution, ceding that role to the private sector. In Indonesia, for example, the Research Institute for Maize and Other Cereals (RIMOC) sells parent seed of improved maize varieties, for seed multiplication and marketing, to public parastatals and private seed companies. Similar partnerships have also emerged in Thailand, Philippines and India. However, Chinese law prohibits private companies from producing maize seed, so the maize seed industry is composed almost entirely of state-owned enterprises (Pray et al., 1998).

2.1.2. Role of the private sector

Private sector participation in maize R&D in Asia has grown steadily since the early 1990s, when a wave of policy reforms broke up state monopolies on the seed industry. In 1997/1998, about 230 national maize seed companies and about 30 multinational companies were operating in Asia. Across countries, however, these numbers varied enormously. India's huge maize economy alone was being supported by about 230 private national and multinational seed companies, of which 30 had in-house breeding programmes (Singh et al., 1995). In contrast, Nepal had no private companies with in-house breeding programmes, and seed distributors marketed maize seed imported from India.

Private sector research activities in Asia typically depend on company size and volume of seed sold. In general, larger companies establish their own breeding programme. Many smaller seed companies, lacking any in-house research capacity, contract with public research programmes and even large private companies to multiply and distribute maize seed developed by others. Another 75–100 companies develop their own proprietary cultivars using conventional breeding methods. A much smaller number—probably less than 15, mostly multinationals—are large enough to venture into biotechnology research.

2.2. Public and private sector maize R&D investments

2.2.1. Numbers of maize researchers

The CIMMYT survey identified 116 national public organisations and 44 private companies operating in Asia in 1997/1998 with some level of maize breeding capacity. Collectively, they employed 670 scientists in maize genetic improvement (Table 1). In terms of the number of scientists per 100,000 ha of maize area planted or per 100,000 t of maize produced, public investment in maize research in Asia appears to be much higher than private investment (Table 1). Private seed companies tend to target a much smaller maize area than public breeding programmes, however, so the intensity of research investment may not be very different.

2.2.2. Level of maize research expenditure

On average, including annual operating budgets, a public–sector senior maize breeder in Asia in 1997/1998 receives a total support level of about US$ 16,000 per year (US$ 3000 in salary and benefits and US$ 3000 in operating funds). In contrast, a private sector senior maize breeder receives a total support level of about US$ 30,000 per year (US$ 20,000 per year in salary and benefits, and US$ 10,000 in operating funds).

The private sector increased its investment in maize breeding research in Asia for two main reasons. First, Asia represents an enormous potential market for seed and complementary material inputs (fertiliser, crop chemicals and machinery) because many farmers still use traditional production practices. Second, farmer disenchantment with poor-performing public input-supply organisations encouraged increased private sector participation. Also, to address longstanding problems of public seed production agencies—inadequate and unreliable funding, shortages of

Table 1
Public and private sector maize research indicators, Asia, 1990 and 1997/1998

	Number of agencies engaged in maize breeding	Number of scientists engaged in maize breeding (FTE)[a]	Scientists per 100,000 ha of total maize area		Scientists per 100,000 t of maize produced	
			1990	1997/1999	1990	1997/1998
Public sector						
Asia	116	505	2.7	2.6	0.8	1.1
Asia (excluding China)	51	235	2.3	1.5	1.4	0.8
Private sector						
Asia	44	166	0.6	0.8	0.2	0.4
Asia (excluding China)	43	166	0.5	0.8	0.9	0.4

Source: CIMMYT Asia Maize Impact Survey 1998–1999; CIMMYT (1992).
[a] FTE: full-time equivalent.

well-trained employees, and lack of efficient infrastructure and facilities—many Asian countries have introduced policy reforms that transfer responsibility for agricultural input supply to the private sector.

2.3. Public–private sector linkages

2.3.1. International germplasm exchanges

Prior to 1960, no formal system existed to provide plant breeders with access to germplasm developed outside their home countries (Traxler and Pingali, 1999). Movement of germplasm occurred informally as breeders exchanged promising materials with friends and professional colleagues. The establishment of the Consultative Group on International Agricultural Research (CGIAR) in the 1960s provided a mechanism for the global breeding community to access research products from public institutions. In Asia, CIMMYT coordinates an international maize germplasm distribution and exchange network, from which promising experimental materials, provided free of charge, may be requested and used by public and private sector breeding programmes.

2.3.2. Public–private germplasm transfers

An increased germplasm transfer from public breeding programmes to private seed companies has accompanied the privatisation of many national maize seed industries. Reducing investments in seed production and distribution activities, public breeding programmes have sought new mechanisms for moving their germplasm products into farmers' fields. In many countries, improved germplasm are made available to seed companies, often on a commercial basis. For example, Thailand's Kasetsart University can assure multinational and domestic private companies exclusive use of elite inbred lines if these companies are willing to pay royalties.

2.3.3. Collaborative varietal testing networks

Collaborative varietal evaluation trials allow public breeding programmes and private seed companies to compare promising experimental materials and exchange information. The CIMMYT-managed Tropical Asian Maize Network (TAMNET), funded by the Food and Agriculture Organisation (FAO) of the United Nations, composed of public breeding programmes and private seed companies from Asian countries, was established in 1993 to facilitate and strengthen regional collaboration among member institutions, with the ultimate goal of increasing maize production and productivity (FAO, 1999). It manages a multi-locational varietal evaluation programme; annual field trials are conducted throughout the region, and the resulting data on field performance across countries are synthesised and shared among TAMNET members.

3. Products of maize breeding programmes

The CIMMYT survey identified 360 public sector and 302 private sector maize varieties released in Asia between 1966 and 1997/1998 (Table 2).[1] Nearly 64% of the public sector varieties and 78% of the private sector materials were being marketed at the time of the survey.

3.1. Types of materials

3.1.1. Public sector

Of the 360 public sector maize varieties released between 1966 and 1997/1998, 59% were OPVs and 41% were hybrids, most of which were single-cross hybrids (Table 2). In most Asian countries, the number of OPVs released and the number of hybrids released by the public sector are inversely related. Only in Vietnam have public breeding programmes given roughly equal emphasis to the development of OPVs and hybrids.

Development of OPVs by the public sector was emphasised until the 1990s, when attention shifted to hybrids. The first reason for this was that higher-yielding cultivars were being promoted to farmers across the region, to help meet rapidly increasing maize grain demand. Second, public breeding programmes aimed to provide hybrids cheaper than those available from private seed companies. Third, hybrids offered increased opportunities for public breeding programmes to generate resources for themselves.

[1] In this paper, the term *varieties* is used in a generic sense to mean "improved OPVs and hybrids", whereas the terms *improved OPVs* and *OPVs* are used in a specific sense to mean "improved OPVs developed by a formal breeding program". Unless noted, the varietal counts refer only to field maize varieties. Specialty types, including baby corn, are not included.

Table 2
Characteristics of maize varieties released in Asia[a] by sector (%)[b]

Indicator	Public sector[c]		Private sector[d]	
	Number	%	Number	%
Maize varieties in CIMMYT database (number)	360		302	
Maize varieties sold during late 1990s (number)[e]	232		235	
Type of maize released (%)[b]				
Improved OPVs	211	59		Nil
Hybrids: single cross	77	21	63	21
Double cross	24	7	124	41
Three-way cross	21	6	106	35
Other	27	7	9	3
Maize characteristic (%)				
Ecological adaptation				
Lowland tropical	181	69	284	94
Subtropical/mid-altitude	78	30	18	6
Temperate	4	1	0	0
Grain colour				
White	81	25	30	10
Yellow	246	75	272	90
Grain texture				
Flint	129	44	91	30
Semi-flint	76	26	112	37
Dent	36	12	30	10
Semi-dent	51	18	69	23
Maturity range				
Extra early (<100 days)	78	29	91	30
Early (100–110 days)	91	34	139	46
Intermediate (110–120 days)	52	19	48	16
Late (120–135 days)	28	10	12	4
Extra late (>135 days)	22	8	12	4
Age of varieties				
<10 years	169	47	254	84
11–20 years	126	35	42	14
21–30 years	47	13	6	2
>30 years	18	5	0	0

Source: CIMMYT Asia Maize Impact Survey 1998–1999.

[a] China, India, Indonesia, Nepal, Philippines, Thailand and Vietnam.

[b] Without double-counting cultivars sold by different agencies within a country and/or released in more than one country in Asia.

[c] Released from 1966 to 1997/1998.

[d] Snapshots of 1992 and late 1998/early 1999; not a complete listing of all private sector cultivars released since 1966.

[e] Many older open-pollinated varieties (OPVs) are still being grown from farm-saved seed by the farmers, even though seed is no longer being sold.

3.1.2. Private sector

During the late 1990s, multinational companies developed most private sector varieties being sold in Asia; only in India had national companies developed the majority of private sector varieties. No private national seed companies were engaged in maize R&D in Indonesia, Nepal or Vietnam. In Indonesia and Vietnam, private sector maize R&D was being carried out only by multinationals. In China, virtually no private sector maize R&D of any description was being carried out.

Among all the maize varieties developed by the private sector and marketed in Asia during the late 1990s, double-cross hybrids predominated (41%), followed by three-way cross hybrids (35%) and single-cross hybrids (21%) (Table 2). Double-cross and three-way cross hybrids were marketed both by national seed companies and multinationals; single-cross hybrids were marketed much more frequently by multinationals. Only one private company had developed an OPV—PT BISI of Indonesia, a multinational. Contrasting sharply with the public sector's emphasis on OPVs, the private sector's emphasis on hybrids was based on commercial considerations: hybrid maize farmers are often commercial growers who require and purchase significant quantities of fresh seed every year. Also, hybrid seed commands higher prices than OPV seed does, thus providing increased profit opportunities for seed companies.

Hybrid seed is expensive to produce and must be sold at premium prices to recoup production costs, but private companies in Asia have difficulty implementing full cost recovery. While direct seed price controls are no longer common in Asia (except in China), the ability of private companies to set remunerative prices is affected indirectly by policies that favour public seed agencies. In Vietnam, for example, several private company respondents observed that they are forced to compete with government seed agencies that receive subsidies and favourable regulatory treatment.

Without enforceable intellectual property rights and plant variety protection regulations, private companies may be reluctant to release their best hybrids, especially single-cross and three-way-cross hybrids, since it may be extremely difficult to protect the inbred lines used to produce these types of hybrids. Fear of losing their valuable inbred lines to unscrupulous competitors has discouraged several multinationals

from marketing their best hybrids in several Asian countries.

3.2. Ecological adaptation

Sixty-nine percent of the public sector maize varieties released in Asia during 1966–1997/1998 have been adapted to lowland tropical environments. As expected, only in China, India and Nepal have public breeding programmes released varieties adapted to subtropical/mid-altitude environments. Similarly, 94% of all private sector maize varieties available in Asia during the late 1990s were adapted to lowland tropical environments (Table 2). Only 6% were adapted to subtropical/mid-altitude environments. With the notable exception of northern China (which was not included in the CIMMYT survey), none of the available private sector maize varieties was adapted to temperate environments.

3.3. Grain characteristics

3.3.1. Public sector

The majority of the public sector maize varieties released in Asia during 1966–1997/1998 were yellow (75%), hard-grained flint or semi-flint (70%), and extra early- and early-maturing (63%) materials (Table 2). In countries such as Philippines, where considerable quantities of maize are still consumed directly as food, especially by subsistence farmers, relatively more white-grained maize varieties were released. In countries such as Thailand, where maize is grown mainly for use in livestock feed industries, yellow-grained varieties predominated. Flint and semi-flint materials are emphasised because of their greater suitability for use as livestock feed and added advantage of storing well. Only China's public breeding programmes focused more on dent and semi-dent materials, reflecting a preference among Chinese consumers for easy to process, soft-grained food maize. Short-duration varieties are emphasised because they are easily accommodated into intensive cropping patterns, where two or more crops are grown annually. They enable the maize crop to escape drought in areas where the rainfall period is too brief to support late-maturing varieties. They shorten the 'hungry season' by providing a source of food well before other food sources become available. Compared to full-season varieties, however, short-duration varieties tend to be lower yielding, more susceptible to diseases and more vulnerable to insect damage.

3.3.2. Private sector

Similar to the public sector releases, most private sector maize varieties being sold in Asia during the late 1990s were yellow and hard grained (flint or semi-flint) materials (Table 2), suggesting that private companies also aim to meet the large and increasing demand for livestock feed grains that are more resistant to fungi and insects, and are less likely to spoil during shipping and storage (Dowswell et al., 1996). The latter characteristic is particularly important in less-developed countries, where transporting maize grain from production zones to processing points in the larger cities often takes longer.

The private seed companies in India, Indonesia and Philippines developed and sold more short-duration varieties (extra-early and early) during the late 1990s, whereas medium-duration varieties (intermediate) featured more heavily in Thailand and Vietnam. As cropping intensity increases in the region's more favoured production environments, the demand for high-yielding short-duration varieties can be expected to increase.

4. Status and performance in the maize seed industry

4.1. Commercial maize seed sales and market shares

The farm-level impacts of maize breeding programmes in Asia can be estimated by examining evidence on varietal adoption, which are in turn estimated by data on commercial maize seed sales collected from public seed agencies and private seed companies. While it was not possible to collect information about all of the commercial maize seed sold during the reference year (1996/1997), information was collected for well over two-thirds of total estimated 1996/1997 commercial maize seed sales in Asia. Assuming that the seed that was not included in the survey was similar to the seed included by the survey, it is possible to draw conclusions that are valid for the entire commercial maize seed market.

The 179 public and private seed-agency respondents reported selling just over 167,000 t of improved maize seed in 1996/1997, of which 5000 t (3%) were OPV seed and 162,000 t (97%) were hybrid seed. China had by far the largest commercial maize seed market in Asia; in 1996/1997, Chinese seed organisations (all public companies) sold 87,600 t of hybrid maize seed, equivalent to 52% of all commercial maize seed sold throughout Asia. Nepal, having sold only 1500 t or slightly less than 1% of the Asian market, had the region's smallest commercial maize seed market.

Because of China's large, and predominantly public, maize seed market, public sector seed sales exceed private sector seed sales in Asia. Including China, 58% of all commercial maize seed sold in Asia during 1996/1997 was public sector seed. When China is excluded from the analysis, however, the picture changes dramatically: excluding China, private seed companies dominate the Asian maize seed industry, accounting for 89% of all commercial maize seed sales during 1996/1997 (Table 3).

Outside China, why do private sector hybrids dominate? First, many private sector hybrids are simply of better quality and performance than public sector hybrids, reflecting the longstanding concentration of private seed companies on hybrid breeding, as well as more focused targeting of production environments. Second, private companies emphasise seed quality assurance, since their economic survival depends on the reputation that they establish among farmers. Third, private seed companies have much more effective marketing strategies using aggressive advertising and promotion campaigns, and extensive production and distribution networks that allow efficient delivery of seed to the end users. In contrast, public seed agencies usually have little incentive to look after seed quality and tended to distribute their seed through centralised distribution facilities that frequently are inaccessible to farmers.

4.2. Evolution of commercial maize seed sales

Commercial maize seed sales in Asia rose from about 91,000 t in 1990 to just over 167,000 t in 1997 before decreasing to 144,000 t in 1998 (Fig. 1). This decline was a direct result of the severe Asian financial crisis, which among other things dramatically increased the real cost of seed and other purchased inputs.

In the 1990–1998 period, OPV seed sales declined at an average rate of 4% per year, while hybrid sales increased at an average rate of 8% per year. Looking more closely, public sector seed sales grew at an average rate of 2% per year, while private sector seed sales grew at a much higher average rate of 24% per year. Seed sales of OPVs drove the relatively sluggish growth in public sector sales, whereas increased hybrid seed sales fuelled the explosive growth in private sector sales. The divergent rates of seed sales growth between the public and private sectors led to the increasing dominance of the private sector alluded to previously.

4.3. Seed prices

As expected, seed of single-cross hybrids across Asia commanded the highest prices, averaging US$ 2.07 kg^{-1}, followed by seed of three-way cross hybrids at US$ 1.51 kg^{-1}. Seed of OPVs was cheapest at an average of US$ 0.59 kg^{-1}. These differences in retail selling prices correlate closely to differences in production costs.

Table 3
Sales of maize seed (t) from the public and private sector, by type of organisation, Asia, 1997

	Maize seed sales (t)		Maize seed sales (%)	
	Asia	Asia (excluding China)	Asia	Asia (excluding China)
Public seed agencies	96150	8550	57.5	10.7
Private national companies	18650	18650	11.2	23.4
Multinational companies	52450	52450	31.4	65.9
Total	167250	79650	100.0	100.0

Source: CIMMYT Asia Maize Impact Survey 1998–1999.

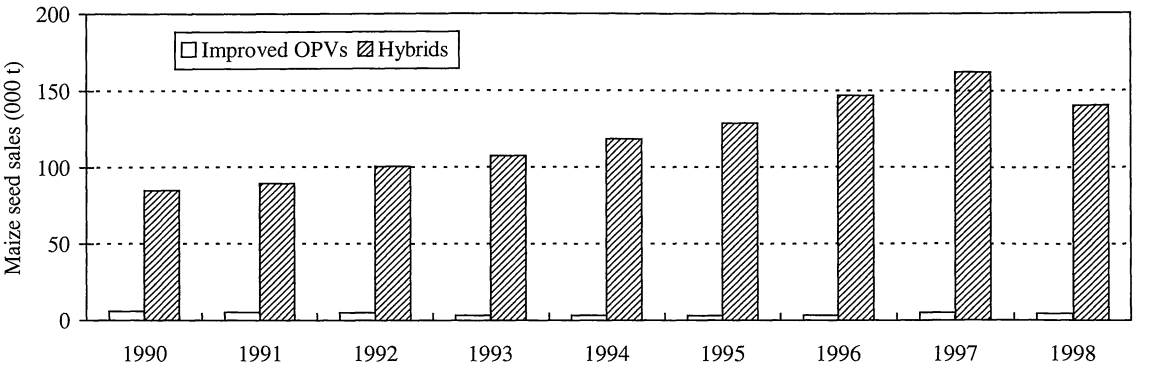

Fig. 1. Evolution of maize seed sales by type of cultivar, Asia, 1990–98. Source: CIMMYT Asia Maize Impact Survey 1998–99.

Furthermore, seed sold by multinational companies was the most expensive (US$ 1.85 kg^{-1}), followed by seed sold by public agencies (US$ 1.15 kg^{-1}) and by seed sold by private national companies (US$ 1.09 kg^{-1}). Contrary to expectations, in many instances public sector seed was sold at prices higher than those of private sector seed. For one, public agencies may be less efficient at producing seed than private companies, and they may be passing along higher seed production costs in the form of higher prices. It is also possible that the public sector varieties simply are not priced competitively. Alternatively, varieties marketed by public agencies may perform better, such that their seed can be sold at higher prices.

4.4. Composition of maize seed prices

To gain insight into the production cost structure of commercial maize seed, survey respondents were asked to break down the retail price of one kilogram of double-cross hybrid seed (a common seed type sold in the seven survey countries) into five major components: (1) R&D costs, (2) seed multiplication costs, (3) marketing and distribution costs, (4) overheads, and (5) gross margins.

On average, public seed agencies in Asia reported relatively high R&D costs and relatively low seed multiplication costs compared to private seed companies (Fig. 2). Marketing and distribution costs and overheads as proportions of seed retail price were comparable between public agencies and private companies. Subtracting the total of the first four categories from the seed retail price, private companies earn higher gross margins (15% on average) than public seed agencies (8% on average).

4.5. Adoption of modern maize varieties

The number of modern maize varieties developed and released by public and private breeding programmes in Asia has increased steadily during the last 30 years. During the same period, commercial maize seed sales have risen sharply. Has the development, release and sale of increased numbers of modern maize varieties been reflected in greater adoption by Asian farmers?

4.5.1. Area planted to improved germplasm[2]

For this study, the area planted to modern maize varieties in each Asian country was estimated based on 'expert opinion' estimates made by senior scientists working in national maize programmes and by representatives of private seed companies. In each country, these knowledgeable informants were asked to estimate the percentage of the national maize area planted to local varieties, OPVs and hybrids. These estimated

[2] It was difficult to estimate the area planted to improved maize varieties for at least two reasons. First, maize in Asia is grown in a wide range of environments and as a component of many different cropping systems, many of which are poorly monitored by government crop reporting services. Second, because maize is an open-pollinating species, it is often very difficult to distinguish between 'local' or 'traditional' varieties and improved maize varieties in the field, especially when the latter have been grown from farm-saved seed that has been recycled many times. These considerations should be kept in mind when interpreting the adoption estimates presented in this section.

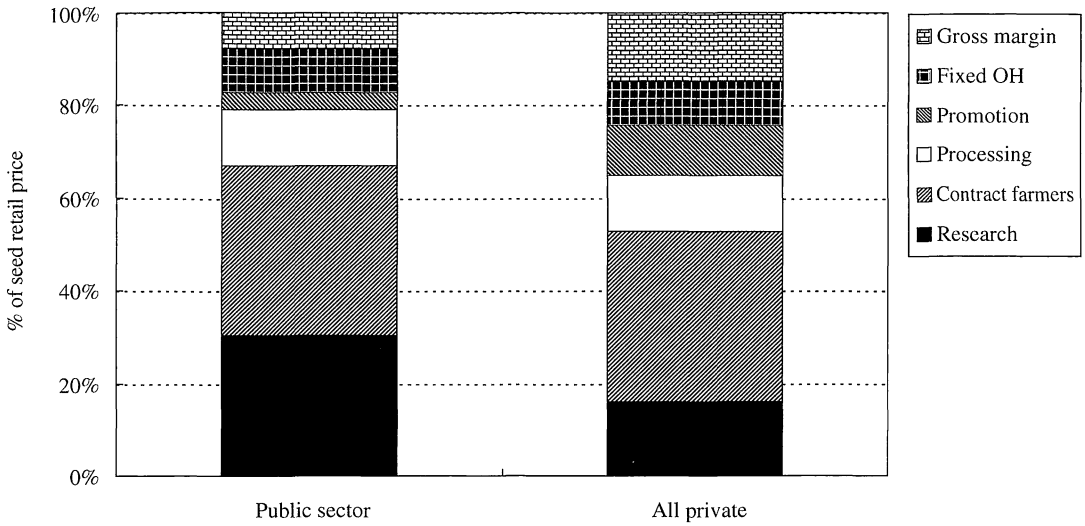

Fig. 2. Composition of maize seed prices by type of seed organisation, Asia, 1997/98. Source: CIMMYT Asia Maize Impact Survey 1998–99.

percentages were then applied to the total national maize area for 1997 to derive estimates of the number of hectares planted to each type of material.

Of the 19.6 million hectares planted to maize in Asia in 1997, 33% was planted to local varieties, 22% was planted to OPVs and 45% was planted to hybrids (Table 4). The combined 13.0 million hectares planted to OPVs and hybrids represent a significant increase over the 8.2 million hectares estimated to be planted to modern varieties in Asia during the early 1990s (López-Pereira and Morris, 1994). It is also comparable to the 11.1 million hectares and 12.2 million hectares planted to modern maize varieties in sub-Saharan Africa and Latin America, respectively (Morris, 2002).

Table 4
Area planted to maize, by maize type, based on estimates of national public sector researchers,[a] Asia, 1997

Maize type[b]	Area planted to maize	
	000 ha	% of maize area
Farm-saved seed	6595.4	33.2
OPVs	4305.0	21.8
Hybrids	8670.8	44.9
Total modern varieties	12975.8	66.7
Total maize area (adjusted FAO)	19571.3	100.0

Source: CIMMYT Asia Maize Impact Survey 1998–1999.

[a] Adjusted using area data from the Food and Agriculture Organization (FAO) of the United Nations.

[b] OPV: open-pollinated variety.

Adoption rates vary significantly between individual countries. In Thailand and China, virtually the entire national maize area is planted to OPVs and hybrids. At the other extreme, in Philippines only about 36% of the national maize area is planted to OPVs and hybrids.

As in other regions of the developing world (see Morris, 2002), the area planted to hybrids in Asia is now more than twice as large as the area planted to OPVs (Table 4). At the individual country level, only in Nepal and Indonesia is the OPV area still larger than the hybrid area. These findings, which are consistent with the commercial maize seed sales data presented earlier, reflect the active role of the private sector in promoting hybrids in many Asian countries (except for China, where hybrids have been promoted by public seed companies).

5. Summary and conclusions

This paper has presented data on the activities of national maize seed industries in Asia. It has documented the human and financial resources invested over the last three decades in developing and deliver-

ing improved maize seed to Asian farmers, described the products of public and private maize breeding programmes, and estimated the area planted to modern varieties.

5.1. Summary of major findings

The total area planted to OPVs and hybrids in Asia continues to expand rapidly. In 1997/1998, approximately 13.5 million hectares were planted to OPVs and hybrids in the seven countries surveyed by CIMMYT, equivalent to 67% of these countries' total maize area and representing a significant increase from the estimated 8.2 million hectares planted in 1992. Meanwhile, the area planted to farm-saved seed declined from around 11 million hectares in 1990 to only 6.6 million hectares in 1997/1998.

The area planted to hybrids now significantly exceeds the area planted to OPVs. In 1990, 5.8 million hectares in Asia (71% of total maize area) were planted to OPVs, and 2.4 million hectares (29% of total maize area) were planted to hybrids. By 1997/1998, this trend reversed: OPVs were being grown on 4.3 million hectares and hybrids were being grown on 8.7 million hectares.

With the significant exception of China, the primary locus of maize breeding research in Asia has shifted from the public sector to the private sector. In countries where both public research organisations and private seed companies conduct maize breeding research, the private sector investment significantly exceeds that of the public sector, because of the greater levels of support provided to private sector scientists (salary, benefits, operating budgets). Although the number of scientists working in public breeding programmes is larger than in the private sector, the latter group generally is remunerated better.

Outside China, the private sector dominates the commercial maize seed market in Asia. In 1997/1998, approximately 56% of the commercial maize seed sold in Asia was public hybrid seed, 41% was private hybrid seed and 3% was OPV seed (mostly developed by public breeding programmes, but the seed was multiplied and sold by private companies). Excluding China, the market share controlled by private companies rises to 89% (85% hybrids and 4% OPVs). Across Asia, multinational seed companies control a larger market share than national seed companies. In some countries, the market share of the multinationals is extremely high: in Indonesia, the Philippines and Thailand, multinationals hold more than 80% of the commercial maize seed market.

Adoption of modern maize varieties has been uneven from one Asian country to another. Adoption of modern maize varieties has increased for Asia as a whole, but the level of adoption varies from country to country. As in Latin America and Africa, the use of modern maize varieties in Asia is concentrated in countries (and regions within countries) where maize is a commercial crop. Meanwhile, limited adoption is found in countries where maize is grown mainly as a subsistence crop intended for home consumption. Thailand and the Philippines represent two extreme cases. Virtually all maize area in Thailand in 1997/1998 was planted to OPVs and hybrids; only about one-third of the maize area in Philippines was planted to modern maize varieties.

Maize R&D efforts by the public and private sectors are complementary, and links between them appear to be expanding. In recent years, governments throughout Asia have had to confront two major challenges: (1) increasing demand for improved maize production technologies, and (2) a stagnant or declining resource base that has constrained the ability of public research organisations to develop and disseminate improved production technology. In response to these challenges, Asian policy makers have enacted measures to encourage more active private sector participation in the maize seed industry.

Private seed companies have responded to the policy reforms by increasing their maize R&D investment. Except in China, the emergence of a private seed industry has been accompanied by increasing specialisation in both the public and private sectors. To avoid wasteful competition with the private sector, public breeding programmes have concentrated on activities that are unlikely to attract profit-orientated firms, for example, genetic resource conservation, pre-breeding, population improvement, development of special trait materials, and OPV development. Private seed companies, meanwhile, have emphasised inbreeding, hybrid development, hybrid seed production and distribution. Despite this increasing specialisation, however, public and private maize seed organisations in Asia continue to be linked through international germplasm exchanges, public–private

germplasm transfers and collaborative varietal testing networks.

5.2. *Looking to the future*

How will the relationship between public organisations and private seed companies evolve in the future? Convened by CIMMYT, a group of experts (scientists from the public and private sectors, development agency officials, NGO representatives, media specialists and farmers) met in Tlaxcala, Mexico, to discuss the conditions necessary for productive and harmonious collaboration between the public and private sectors with respect to R&D for maize, wheat and rice, and agreed upon the following points (CIMMYT, 1999):

- Public organisations can and should continue to play an active role in maize research and seed production; public-sector involvement will help to reduce R&D costs for private firms (e.g. by generating improved germplasm that can be used as inputs into commercial breeding programmes and by training researchers).
- Where conditions permit the existence of competitive seed markets, the public sector should complement and support rather than compete with the private sector in providing improved seed and related technology to farmers.
- The public sector has a particularly important role to play in supporting local private seed companies, which can enhance competition in seed markets.
- Where technical, economic or institutional conditions discourage private companies from providing improved seed technology to farmers, public agencies may be called upon to assume responsibility for meeting farmers' needs.
- Even where international research organisations and private seed companies are active, strong national public research programmes will often be needed to adapt privately and internationally developed research products to local conditions.

Successful public–private sector collaborations in Asia are especially evident in India and Thailand, where strong public breeding programmes have encouraged and supported the development of extremely successful and competitive private seed industries.

The lack of enforceable and effective plant varietal protection laws in Asia, however, makes the private sector (especially the large multinational seed companies) sceptical about sharing its materials with the public sector. This possibly discourages many private seed companies from introducing their very best materials into the market, in turn restricting the range of better production technologies available to farmers.

How might the public sector roles and responsibilities develop in the future to accommodate the needs of millions of subsistence farmers who, until now, have attracted limited attention from private seed companies? The anticipated increase in maize demand in Asia will lead to the intensification and commercialisation of existing production systems, as well as expansion into less favourable maize production environments. The public sector can work on identifying principal technological constraints to increasing maize productivity in these areas, designing crop and resource management technologies to alleviate the principal constraints and support sustainable practices in the fragile environments, and develop technology dissemination plans and more effective agricultural extension strategies.

The strong likelihood that the private sector will be reluctant to address the needs of farmers in marginal areas should encourage the public sector, including international agricultural research centres like CIMMYT, to continue their active role in maize R&D and seed production, particularly for improved OPVs. Within each country, the public sector should assume a more complementary and supportive role to the private sector by developing policies that facilitate private sector operations.

Finally, it is important to recognise that improved maize seed is not the only key to increasing maize productivity and uplifting the conditions of resource-poor maize farmers in Asia. No amount of advanced public or private sector maize research will help the most disadvantaged farmers unless substantial parallel investments are made in infrastructure, agricultural extension, input production and distribution systems, grain harvest and post-harvest facilities, and grain marketing. In the end, the role and impact of appropriate government policies—from those on input and grain prices to those on intellectual property rights—should certainly not be overlooked.

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