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

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Chapter 4

Impact of Breeding Research on Maize Production and Distribution in Indonesia

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Agricultural development in Indonesia primarily focuses on increasing the production of food crops, especially rice, maize and soybean, to fulfill domestic demand. The use of high yielding varieties has been recognized as a major factor in attaining this national objective.

Since the early 1970s, Indonesia has been facing difficulties in producing sufficient cereals in general, and maize in particular, to meet its domestic needs. Maize is widely grown for human consumption and for animal feed. At least 2.8 m ha were planted to maize in the 1980s and 3.4 m ha in the 1990s, compared to only about 1.5-2.0 m ha between the 1940s and 1960s (Timmer 1987). Badan Pusat Statistik (BPS), the national statistics bureau, reported that 3.8 m ha were planted to maize in 1998 (BPS 1998). Until the 1990s, maize production remained almost entirely a smallholder enterprise, providing income and staple food for farm households. During the 1970s and 1980s, production techniques were rudimentary, and farmers had been bypassed by the spread of improved plant varieties and cultural practices. Maize farmers used mostly local varieties and simple tools. Labor intensity and capital inputs were low.

Although growing adoption of improved technology led to substantial progress in maize production, the increased production still failed to meet domestic demand, which continued to grow. Demand for maize as feed alone was recently estimated to be growing at 12% per annum (Subandi 1998). Net imports rose from 292,000 t in 1991 to 894,000 t in 1995 and 570,000 t in 1996 (Subandi *et al.* 1998). This trend highlights the need to overcome remaining obstacles to increased domestic maize production (BIMAS 1997).

Some of the obstacles to greater maize productivity included problems related to inputs. For example, agricultural inputs were either unavailable or difficult to obtain because of the inefficient distribution system. Large numbers of farmers were unable to adopt seed of improved maize varieties because it was either unavailable or cost too much. These technological and socioeconomic barriers to increased productivity were reduced to some extent in the 1980s. The large investment in rice production in the 1970s had a positive spillover effect in improving maize production in Indonesia. Farmers became more receptive to using new high yielding varieties (HYVs) of maize, fertilizers, pesticides and other agronomic practices for increasing farm yields. Presently most maize production areas have timely access to vital production inputs, particularly fertilizers and pesticides.

Maize breeders sought to contribute to increased maize production by developing high-yielding open-pollinated varieties (OPVs) and hybrids, but adoption of these materials has varied. Metro, an improved OPV, was released in 1956 but did not increase maize yields significantly because of its susceptibility to downy mildew. The use of hybrids began in 1984 following the release and commercialization of the variety C1 in 1983, but this variety was not used widely because seed was not available. Even so, by the 1990s, some maize farmers had shifted from local varieties to hybrids. Later, some farmers shifted back to local maize because hybrid maize technology could not succeed without better access to seed; hybrid maize was not profitable for small-scale, resource-poor farmers; and seed of open-pollinated maize varieties, like rice seed, was more easily produced and distributed from farmer to farmer.

This paper reviews the impact and potential of R&D on improved maize, especially hybrid maize, on maize seed production and distribution in Indonesia. Data were obtained from a survey of the maize seed industry sponsored by CIMMYT, conducted in early 1999, as well as from published and unpublished government information.

Indonesian Maize Production and Consumption

Production Systems

Maize is produced on *tegalan* (rainfed drylands) and *sawah* (floodable wetlands) in Indonesia. Production systems vary by land type, cropping system and management system. Surveys carried out by the Stanford University-BULOG Project found that low productivity systems prevail over about 69% of the total maize area (Mink *et al.* 1987, cited in Subandi 1998). Farmers in these systems usually plant early, use white or yellow local/traditional varieties, apply a low quantity of fertilizer and use the maize mainly for home consumption. Low productivity systems are generally located in the less developed and relatively remote areas.

A specialized tidal swamp maize production system is found mainly in newly opened land outside Java. On this type of land, maize is grown using the *surjan* system (raised and sunken beds). Rice is commonly grown in standing water in the sunken beds, and maize and/or other *palawija* (perennial) crops are grown on the raised beds. Farmers in these production areas grow maize as one component of the farming system and, depending on market demand, maize may be harvested for grain or as a green crop. No data exist on the extent of the area devoted to this production system, although around 11 million hectares of swamp area are estimated to have good potential for agricultural production (Subandi 1998).

Production Location and Trends

Maize (*jagung*) is Indonesia's second most important food crop after rice. Grown either as a monocrop or as an intercrop with other food crops, about 73% of all maize in Indonesia is planted in rainfed upland and lowland areas with erratic rainfall, and 27% is planted in irrigated upland and lowland areas (Dahlan and Mejaya 1998). Other estimates indicate that 80% of maize is grown in dry upland areas, about 10% in irrigated lowlands and the remaining 10% in rainfed lowlands (Subandi *et al.* 1998). Maize is planted early in the wet season in the uplands and late in the wet season in the lowlands. Two crops of maize are grown in the uplands. The first crop is planted in November/December and harvested in February/March, and it is immediately followed by a shorter duration second crop that is harvested in June. In some lowland areas, especially those close to cities, short-duration maize is planted before the rice crop is harvested and is harvested as fresh corn (Sinring and Talanca 1998).

The main maize-growing provinces in Indonesia are East Java, Central Java and South Sulawesi. East Java accounts for about 34% of all area under maize. In 1994-98, yields in East Java were 6-8% higher than the national average. Before the 1980s, Central Java produced mostly white maize that was used as a supplementary staple to rice. More recently, some farmers have shifted to growing yellow varieties in line with the government's maize production intensification programs aimed at serving the grain requirements of the livestock and poultry industries. South Sulawesi ranks third and has long been a leading producer of food maize in the outer islands.

The average area under maize was around 2.9 m ha in the 1960s, 3.6 m ha in the 1970s and 1980s and reached about 4.7 m ha in the 1990s. Average annual maize yields increased slowly from 1.0 t/ha in the 1960s to 1.7 t/ha in the 1980s and 2.3 t/ha in the 1990s (Table 1). Maize production first exceeded 10 m t in 1992, and the highest production level, 14 m t, was recorded in 1998.

In terms of average annual growth rates, all production parameters declined during the 1960s but posted remarkable recoveries during the 1970s. In the 1980s, area and yield grew at rates similar to those in the earlier decade. The 1990s saw a slowdown in the growth of production parameters, with area and yield increasing at 2.6% and 1.8% per year, respectively, resulting in a 5.0% annual increase in maize production, which is considered high (Table 1).

Table 1. Maize area, yield and production, Indonesia, 1960-98

	Area harvested (ha)	Yield (t/ha)	Production (t)
Annual averages			
1960–69	2,897,059	0.96	2,802,255
1970–79	3,592,169	1.13	4,061,319
1980–89	3,647,699	1.72	6,262,371
1990–98	4,744,308	2.29	10,843,785
Average annual growth rate (%)			
1960–69	-5.6	-1.5	-7.9
1970–79	4.1	4.1	9.0
1980–89	4.0	3.9	10.1
1990–98	2.6	1.8	5.0

Source: Basic data from DGFCH (1998); Timmer (1987); BPS (1998).

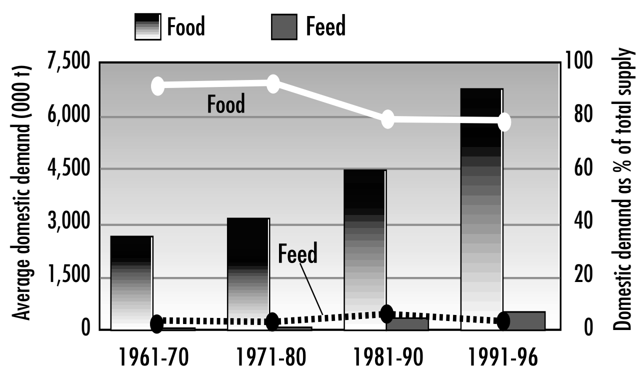

Figure 1. Average domestic food and feed demand for maize in Indonesia, 1961-96.
Source: Basic data from FAOSTAT (March 1999).

Utilization and Imports

A versatile crop, maize is either consumed directly as a secondary staple food or used as raw material for the food and animal feed industries. Figure 1 and Table 2 show that the volume of maize grain used in these industries has increased over time. Unfortunately, no reliable data on direct human consumption could be obtained. FAOSTAT (1999) indicates that maize used as food constituted the bulk of domestic demand, averaging about 2.4 m t annually in the 1960s and 6.3 m t in the 1990s. Feed use of maize was almost 57,000 t annually in the 1960s, 318,600 t in the 1980s and 480,000 t in the 1990s (Figure 1). The proportion of maize utilized as food decreased from 91% in the 1960s and 1970s to about 78% in the 1990s. The proportion used as animal feed increased from 2% in the 1970s to almost 6% in the 1990s.

Table 2. Maize utilization and imports, Indonesia, 1960s to 1990s

Period	Average annual domestic demand (000 t) Food industry	Feed industry	Total utilization	Average volume of imports (000 t)
1961-70	2,453.0	56.6	2,685.6	3.0
1971-80	2,924.2	78.4	3,210.6	28.6
1981-90	4,187.4	318.6	5,316.3	68.7
1991-96	6,311.4	480.3	8,079.7	628.9
	As proportion of total supply			
1961-70	91.3	2.1	nc	nc
1971-80	91.2	2.3	nc	nc
1981-90	78.8	5.9	nc	nc
1991-96	78.0	5.9	nc	nc

Source: Basic data from FAOSTAT (March 1999).
Note: nc = not computed.

Maize Seed Research and Production

Currently three public agencies, four private national and three private multinational seed companies, work on maize R&D, seed production and/or seed distribution in Indonesia. All were interviewed for this study (Table 3).

Only one public agency, the national Research Institute for Maize and Other Cereals (RIMOC), and one private multinational company, P.T. Benihinti Suburintani (BISI), affiliated with Charoen Pokphand Seeds Company of Thailand, pursue maize breeding research on improved OPVs as well as hybrids (Table 4). The government has established two national companies, P.T. Sang Hyang Seri and P.T. Pertani, for mass seed production and distribution. These companies, together with the National Seed Board (NSB) and 15 regional Seed Certification and Control Services (SCCS), are primarily responsible for ensuring an adequate supply of quality seed, supporting the growing seed industry and assisting in the distribution of quality seed to maize farmers. The NSB mainly is responsible for approving the release of new maize varieties based on recommendations from RIMOC.

Table 3. Type and number of maize seed organizations in Indonesia, 1998

Type of organization	Number
Public seed agency with breeding program	
National focus	1
Province, state, district	0
Public seed company with no local breeding program that produces and sells seed locally (can also import seed)	2
Private national seed company	
With local breeding and seed production program	0
With no local breeding or seed production program (only imports seed for sale)	0
With no local breeding program, but produces and sells seed locally (can also import seed)	4
Multinational seed company	
With local breeding and seed production program	1
With no local breeding or seed production program (only imports seed for sale)	1
With no local breeding program, but produces and sells seed locally (can also import seed)	1
University, cooperative with breeding program	0
Non-profit organization that produces and sells seed	0
Individual seed producer (farmer)	0

Source: CIMMYT Maize Impact Survey 1999.

Table 4. Number of maize seed organizations by sector and activity, Indonesia, 1998

Activity	Public sector	Private sector
Population improvement, development of OPVs	1	1
Inbreeding, development of hybrids	1	1
Biotechnology research (e.g., transgenics, marker-assisted selection)	0	1
Agronomy research (e.g., fertilizer trials, pesticide trials)	1	2
Seed production (OPVs)	2	4
Seed production (hybrids)	2	4
Seed sale (OPVs)	3	4
Seed sale (hybrids)	3	5

Source: CIMMYT Maize Impact Survey 1999.

Role of the Public Sector

Located in Maros, South Sulawesi, RIMOC (or BALITJAS - Balai Penelitian Tanaman Jagung dan Serealia Lain*)* is a technical working unit of the Central Research Institute for Food Crops (CRIFC). In general, CRIFC is charged with conducting research on the country's primary staple food crops, including rice, maize, legumes and root crops, for which respective specialized research institutes have been established. Its range of research includes plant breeding, agronomic studies, pest and disease management and biotechnology. The scope of work is influenced by the diverse crop-growing conditions found in Indonesia (AARD 1997).

Public agencies involved in maize R&D mainly are responsible for developing and producing high-yielding maize cultivars and for mass seed production and distribution. RIMOC is mandated to undertake varietal and agronomic research on improved maize OPVs and hybrids. Aside from actively testing new cultivars prior to release, RIMOC is responsible for producing the parent stocks of improved maize cultivars for sale to public seed production entities as well as private seed companies. Resource constraints limit the quantity of parent stocks that RIMOC can produce. On average, RIMOC needs about Rp 8-10 million/ ha (about US$ 1,150-1,400/kg) to produce 100-200 kg/ha of male and 400-500 kg/ha of female parents on its 20 ha research farm. Government funding is usually inadequate and often delayed, hindering the timely production of much-needed parent stocks.

As noted, the two big public corporations P.T. Sang Hyang Seri and P.T. Pertani mass-produce improved OPV and hybrid maize seed for distribution to maize farmers around the country through their respective marketing networks. Both entities also handle seed of rice, soybeans and other vegetables. Maize seed is produced either on company land or through numerous farmer-cooperators, using parent stocks obtained from RIMOC. Both companies also have hybrid maize seed production and/or seed distribution contracts with multinational companies such as P.T. BISI, P.T. Pioneer and Cargill. P.T. Sang Hyang Seri, for example, has had two five-year seed production and distribution contracts with Cargill. From its inception until 1998, P.T. Pertani acted only as a local distributor of maize seed produced by P.T. BISI and P.T. Pioneer. Contract arrangements specify that P.T. Sang Hyang Seri and P.T. Pertani receive a mutually agreed percentage of the market price. While seed production and distribution are currently their main tasks, both public entities foresee going into maize R&D in the future.

Role of the Private Sector

Only one private multinational company, P.T. BISI, among the seven private companies operating in Indonesia, maintains its own maize R&D program, including some biotechnology research. Most private companies concentrate on maize seed production and distribution. Unlike the multinationals, which produce and distribute their own proprietary materials, local private seed companies handle improved OPVs and hybrids produced by RIMOC. These small, usually familyowned, corporations work exclusively on maize and operate only within a province or region, unlike the multinationals, which operate in several regions or countrywide and also sell seed of crops other than maize (rice, soybeans and vegetables).

Both the private national and multinational companies produce maize seed through farmer-cooperators that are provided the parent materials, fertilizers and pesticides. Assistance for mechanizing selected farm operations is also provided if needed. The companies buy seed produced by the farmer-cooperators at a premium over the market grain price. The premium can be up to 40% higher, depending on how well the seed satisfies pre-set quality standards.

The newest participant in Indonesia's maize seed market is the multinational Monsanto, which arrived in July 1998. Monsanto currently imports F1 seed from the Philippines, India and Thailand and plans to establish its own maize seed R&D and production facilities in Indonesia, which Monsanto officials reported to have the lowest seed production costs in Asia.

Public and Private Sector Research Investment

Table 5 shows the average level of annual investments devoted by the public and private sectors to maize research in Indonesia. While the public sector has three and the private sector has four maize research programs, only one in each sector is engaged in breeding and development activities. The rest are involved only in agronomic research.

The public sector has 23 researchers working on maize (in full-time equivalents, FTEs), which is equivalent to having 6 maize scientists per million hectares of maize area and 2 scientists per million tons of maize produced (Table 5). These numbers are lower than those registered in 1990, when the public sector had a total of 37 FTE maize researchers or 12 scientists per million hectares of maize area (CIMMYT 1992). The private sector currently has 46 FTE scientists engaged in maize research, equivalent to 12 maize scientists per million hectares of maize area and almost 5 scientists per million tons of maize produced—twice the human resources of the public sector for maize R&D. In 1990, the private sector had only 7 FTE maize scientists or 2 full-time maize researchers per million hectares of land planted to maize (CIMMYT 1992). These numbers indicate that, while government investment in human resources for maize research declined over the last decade, private-sector investment increased significantly.

Table 5. Public- and private-sector investment in maize research, Indonesia, 1998

Research indicator	Public sector	Private sector
Total number of maize research programs	3	4
Number of programs with maize breeding activities	1	1
Total number of maize researchers (FTEs)	23	46
Number of maize scientists		
Per m ha of maize area	6	12
Per m t of maize produced	2.3	4.6
Percentage of researchers engaged in maize breeding and/or crop management research	21	nd
Number of cultivars developed (1960 to 1997/98)		
Improved OPVs	22	1
Hybrids	13	31
Total	35	32

Source: CIMMYT Maize Impact Survey 1999.
Note: nd = not determined.

Public-Private Sector Linkages

The roles of the public and private sectors in the maize seed industry are linked through several activities: knowledge and information dissemination; cooperative trials for yield potential, pest and disease resistance and overall seed quality;

releases of new hybrids; and human resource development via training programs, workshops and collaborative research (Suherman 1997).

In the future, both the public and private agencies involved in maize R&D will benefit from strong and active collaboration in developing a more efficient system of varietal registration, certification and release; establishing and enforcing intellectual property rights and plant variety protection laws; transferring and disseminating biotechnology techniques; and promoting public awareness of biotechnology issues, including biosafety and environmental impacts (as per Undang-Undang Budidaya Tanaman or Government Decree No. 12/1996).

Products of Maize Breeding Programs

Cultivars Released

From 1960 to the time of this study, 67 improved OPVs and hybrids were released and commercialized in Indonesia (Annex 1). Public research agencies released 22 improved OPVs and 13 hybrids while the private sector released one improved OPV and 31 hybrids. The public sector released its first improved OPV, Gajah Warangan, before 1945 and its first hybrid, IPB-4 (a single-cross variety), in 1985. The private sector released its first maize hybrid (C1, developed by Cargill) in 1983. In general, maize cultivars released and commercialized in Indonesia are flint to semi-flint, yellow, mature in less than 100 days and are adapted to the tropical lowlands (Table 6).

Table 6 also reveals each sector's maize research priorities. Public agencies emphasize R&D for improved OPVs, whereas private companies give priority to hybrid maize research. In terms of product characteristics, both sectors work towards developing improved cultivars with higher yields, better pest and disease resistance and better abiotic stress tolerance.

Seed Production

Most of the quality maize seed is produced in East Java and supplied to other islands, particularly Sumatra, Java, Kalimantan, Sulawesi, Nusa Tenggara and Irian Jaya. Some maize seed is also produced in Central Java, Lampung in Sumatra and Sulawesi, but production in these areas is not sufficient for local requirements (Suherman 1997). To alleviate the problem of inadequate maize seed supply, the government uses provincial

Table 6. Characteristics of maize cultivars released by the public and private sectors, Indonesia, 1960-98

Characteristic	Public sector	Private sector	Both sectors
Number of releases			
1960-69	5	0	5
1970-79	1	0	1
1980-89	10	5	15
1990-98/99	19	27	46
Type of material (%)			
Improved OPV	63	3	34
Hybrid			
Single cross	3	25	13
Double cross	0	3	1
Three-way cross	26	63	43
Top cross	0	6	3
Grain color			
White	9	13	10
Yellow	77	87	82
Other	14	0	8
Grain texture			
Flint	31	19	25
Semi-flint	54	81	67
Dent	11	0	7
Semi-dent	3	0	1
Maturity class			
<100 days	66	53	60
100-110 days	17	34	25
110-120 days	0	0	0
120-135 days	3	0	1
>135 days	3	0	1

Source: CIMMYT Maize Impact Survey 1999.
Note: All (100%) cultivars adapted to the lowland tropics. Some proportions will not total to 100% because of incomplete varietal descriptions.

institutions, such as the Agricultural Extension Service, to multiply foundation seed, stock seed and parent stock seed. Among the country's 27 provinces, 14 are equipped with seed multiplication facilities.

Maize seed is also produced by government seed farms and national seed companies (P.T. Sang Hyang Seri and P.T. Pertani). High quality breeder and foundation seed are produced at RIMOC and at the Directorate General for Food Crops (DGFC). For hybrids, four levels of seed are produced: (1) breeder seed, which comes directly from research programs and is used to produce (2) foundation seed; (3) stock seed, produced *en masse* from foundation seed; and (4) extension (or commercial) seed produced from stock seed. Breeder seed has the highest quality and is the most expensive to produce. Extension seed is the relatively lower-quality, cheaper seed.

Although RIMOC is mandated to develop, release, produce and sell breeder seed, it can do so only in small amounts primarily because of human, physical and financial resource limitations. RIMOC has an effective area of only 20 ha devoted to producing parent seed stock. The area yields about 400-800 kg/ha of improved OPV breeder seed. RIMOC produces about 100-200 kg/ha of male parents and 400-500 kg/ha of female parents for hybrids, at an average cost of Rp 8-10 million/ha (US$ 1,150-1,400/ha). When government funds are lacking or delayed, the area under parent stock production is reduced. Such constraints limit the quantity and sometimes quality of maize seed available for distribution to public and private seed agencies. In addition, maize seed yields of government facilities in Indonesia have often been very low, especially when compared to the US standard for single-cross hybrids of a minimum of 1 t/ha of parent stock (D. Beck, personal communication).

Foundation seed is multiplied by the provincial seed centers BBI (Balai Benih Induk, or central seed farm); stock seed by the regional seed producers BBU (Balai Benih Pembantu, main seed farm); and extension seed by the seed multipliers and farmer cooperatives KUDs (Koperasi Unit Desa). The BBIs and BBUs are located in various cities across the 27 provinces of Indonesia. The BBIs receive breeder seed; BBUs receive foundation seed from BBIs; and seed multipliers receive the stock seed from BBUs. All seed needs to pass multilocational testing and be certified and registered prior to commercialization. The SCCS conducts these multilocational tests in ten locations for two seasons with RIMOC and implements the seed certification and registration process.

Seed Prices, Sales and Adoption

Seed Prices

Table 7 shows the range of maize seed prices in Indonesia and the seed-to-grain price ratios. As expected, seed of single-cross hybrids is the most expensive, ranging from a low of Rp 10,000/kg (US$ 1.43/kg) to a high of Rp 23,000/kg (US$ 3.29/kg). Single-cross hybrids are more expensive to produce because of lower seed yields, but farmers are willing to pay more for seed of single crosses because of their higher grain yields. Seed of improved OPVs is the cheapest, at Rp 3,000-7,000/kg (US$ 0.43-1.00/kg). The price of improved OPV seed from the public and private sectors is similar, primarily because the private companies handling improved OPVs produce and market them for the public agencies. Three-way hybrids marketed by the public sector are slightly more expensive than those sold by the private sector, indicating that either the public agencies are less efficient than the private ones or that public three-way crosses perform better in the field and can be sold at higher prices. In terms of seed-to-grain price ratios, single-cross hybrids from the private sector cost 10-23 times more than maize grain, and three-way crosses cost 6-12 times more. Seed of improved OPVs costs only 3-7 times the price of maize grain.

Table 7. Maize seed prices and seed-to-grain price ratios by maize type, Indonesia, 1997/98 (grain price = Rp 1,000/kg)

	Private sector		Public sector	
	Low	High	Low	High
Seed price (Rp/kg)				
Single-cross hybrid	10,000	23,000	–	–
Three-way-cross hybrid	6,000	12,500	7,000	15,000
Improved OPV	3,500	7,000	3,000	7,000
Seed price (US$/kg)				
Single-cross hybrid	1.43	3.29	–	–
Three-way-cross hybrid	0.86	1.79	1.00	2.14
Improved OPV	0.50	1.00	0.43	1.00
Seed-to-grain price ratio				
Single-cross hybrid	10.0	23.0	–	–
Three-way-cross hybrid	6.0	12.5	7.0	15.0
Improved OPV	3.5	7.0	3.0	7.0

Source: CIMMYT Maize Impact Survey 1999.

The volume of sales of all seed types have been increasing since 1990, which indicates that farmers demand improved seed even at higher prices because higher yield and better field performance more than compensate for the higher seed cost.

Seed Sales

Reliable and consistent data on seed production and sales by sector have been difficult to collect for this study, especially since official published sources report conflicting figures. Maize seed companies were surveyed directly, and the seed sales figures declared by public and private agencies during these interviews are used in this study. It should be noted that respondents might have provided sales figures lower or higher than the actual sale figure for tax or other reasons.

In principle, all seed sold in Indonesia should be certified. However, data on the volume of certified seed does not match the estimated area planted to maize, making it difficult to draw conclusions based on seed certification data. Seed companies using certification data may often project seed demand poorly and over- or under-produce seed. It is also possible that not all seed that is produced is certified and that not all certified seed is sold. Table 8 shows the reported volume of seed certified by the government and the estimated seed sales of the public and private sectors by type of material from 1990 to 1998. Sales of all maize seed increased from about 1,700 t in 1993 to more than 12,500 t in 1998. As per available records, the volume of certified improved OPV and hybrid seed was around 3,800 t in 1993, peaked at 24,000 t in 1996 and declined to 4,500 t in 1998. Between 1993 and 1997, the volume of certified seed recorded has been higher than the volume of seed sold, confirming that not all certified seed is sold. In 1998, the volume of maize seed sold was higher than the volume certified for that year, because excess stocks of seed certified in 1997 were carried over for sale in 1998. Table 8 also shows a steady increase in the amount of hybrid maize seed sold during 1990-98, except for a significant decrease during the Asian economic crisis year of 1997. In contrast, sales of seed of improved OPVs were erratic, though a small increase was posted even during 1997. These trends indicate that in the crisis year of 1997 maize farmers may have shifted from growing the more expensive hybrid maize to growing the cheaper improved OPVs.

Adoption of Improved Germplasm

In 1998-99, public seed agencies and private companies reported total sales of about 12,500 t of improved maize seed, composed of almost 10,000 t of hybrids and 2,500 t of improved OPVs (Table 8). Assuming an average planting rate of 20 kg/ha for hybrids and 25 kg/ha for improved OPVs, and a seed recycling factor of 1.1 for hybrids and 3 for improved OPVs (Morris *et al*. 1999), the amount of seed sold translates to almost 550,000 ha planted to hybrids and 300,000 ha planted to improved OPVs. The total area planted to high yielding improved maize varieties totals about 850,000 ha, or about

Table 8. Seed sold and certified by type of material, Indonesia, 1990-98

Year	Estimated seed sales (t)			Reported volume of certified seed (t)		
	Hybrids	Improved OPVs[a]	Total	Hybrids	Improved OPVs	Total
1990	980	237	1,217	na	na	na
1991	1,097	255	1,352	na	na	na
1992	1,586	277	1,864	na	na	na
1993	1,607	129	1,736	2,731	1,055	3,786
1994	3,636	1,405	5,041	4,410	2,104	6,514
1995	5,084	1,202	6,286	5,672	1,842	7,514
1996	9,442	1,559	11,001	16,792	6,919	23,711
1997	7,941	1,625	9,566	14,479	6,843	21,322
1998	9,972	2,532	12,504	3,440	1,071	4,511

Source: CIMMYT Maize Impact Survey 1999.
Note: na = not available.
a Seed sales data for 1990-93 incomplete.

22% of Indonesian maize area in 1998. The remaining 78% is planted to local/traditional varieties or uncertified seed (Table 9). It is difficult to estimate precisely the area under each type of cultivar, primarily because maize farmers in Indonesia treat hybrids like OPVs and recycle the F2 or F3 seed.

The seed industry data indicate that in 1990 barely 2% of all area under maize in Indonesia was planted to improved OPVs and hybrids and 98% was planted to local/traditional maize varieties. The proportion of area planted to improved cultivars has since gradually increased. The interview respondents estimated that around 8% and 13% of the area was planted to improved OPVs and hybrids in 1997. As these estimates may either over- or under-report area, this study also referred to data from *CIMMYT World Maize Facts and Trends* (Table 9), which reported that in 1985 only 1% of all area under maize in Indonesia was planted to hybrids and 25% to improved OPVs. In 1990, area had increased to 10% and 50%, respectively. By 1997, a mere 6% of Indonesia's maize area was planted to local/traditional varieties and 94% was planted to improved cultivars (of which 23% were hybrids and 71% improved OPVs).

Table 9. Percentage of area under maize by type of cultivar, Indonesia, 1990-98

Year	Hybrids	Improved OPVs	Local / traditional varieties
Estimated from Table 8			
1990	1.7	0.9	97.4
1991	2.1	1.0	96.9
1992	2.4	0.9	96.7
1993	3.0	0.5	96.5
1994	6.4	5.4	88.2
1995	7.7	3.9	88.4
1996	13.9	5.0	81.1
1997	13.0	5.8	81.2
1998	14.3	7.9	77.8
Estimated from CIMMYT *World Maize Facts and Trends* (various issues)			
1985	1	25	74
1988	3	27	70
1992	10	50	40
1997	23	71	6

Local experts believe, however, that the cumulative quantity of improved OPV seed distributed in Indonesia covers a much higher portion of the total area under maize than is indicated by seed sales and other data reported in this study. Today it is difficult to find a true local/traditional maize variety in the field, except in remote villages, because improved OPVs have become very popular. Local experts also expect that hybrids will contribute increasingly to maize production.

Government Programs and Policies

In the last five years, the growing demand for maize grain from Indonesia's livestock and poultry industries has required about 1 m t of maize grain imports annually. For this reason, the government has formulated production programs and support policies to strengthen the domestic maize industry.

Production Programs

In late 1998, a new production intensification program called GEMA PALAGUNG 2001 was launched to attain self-sufficiency in rice, maize and soybean production by the year 2001. The program also aimed to plant 4 m ha with certified improved seed of high-yielding maize varieties. The government targeted a seed replacement rate of 100% over at least 8% of cultivated area to ensure better quality and quantity of grain production. Public and private seed companies were given incentives to produce breeder seed all year round through collaborative seed production, by making hybrid maize technology more accessible to farmers, and by making HYV seed available to farmers at the right time, quantity and price.

Support Policies

The Indonesian government has taken a keen interest in supporting the development of improved cultivars, particularly of hybrid maize, in line with its maize production improvement program. It supports public research institutes as well as private seed companies in maize R&D and has encouraged the formation of farmer groups to produce seed for public and private companies.

The government has also established public institutions to ensure adequate seed supply. These include the National Seed Board, two national seed centers (P.T. Sang Hyang Seri and P.T. Pertani), the 15 SCCS offices and other support units. Several food and horticultural crop research institutes have been established, with a mandate for developing improved varieties with higher yields and better disease and pest resistance. In February 1994, the Directorate of Seed Development was established under the Department of Agriculture to help strengthen SCCS work (Suherman 1997).

In 1995, the government formulated a policy to make the best quality seed of improved maize varieties available to farmers to raise maize production for national self-sufficiency and possible export. The policy's main objectives are to: expand research on breeding, development and maintenance of improved maize OPVs and hybrids; multiply quality maize seed and distribute it to farmers in sufficient quantities; develop public and private sector seed enterprises; support seed technology development by providing training and technical support to private seed producers and farmers for producing, processing, storing, and utilizing high quality seed; and control and regulate the quality and quantity of seed distributed within the industry (Suherman 1997).

Constraints

Historically, the production of maize grain in Indonesia has been insufficient to meet demand for human food and animal feed for several reasons.

One major constraint is the distance between maize production areas and major seed production sites. East Java is the major maize seed producing province, but the main grain producing areas are located quite far from East and Central Java, in Lampung and North Sumatera in Sumatra and in Nusa Tenggara Timur and South Sulawesi. Seed prices are always much higher outside East Java because of distribution and transport costs.

Appropriate post-harvest facilities and practices also remain to be established and promoted in the major maize producing areas. Post-harvest facilities for shelling, drying and storage are needed at the farm level. Better institutional support and physical infrastructure are required to improve maize grain marketing.

Many proprietary hybrids have been released within a short time, causing confusion among farmers about the best choice of hybrid for their specific location. In government seed farms, parent stock production is usually low because of lack of money and human resources. Although government policies do support maize research, the resources provided to implement these policies and increase the research capacity of government institutes and seed farms are inadequate (Suherman 1997).

Lastly, R&D activities are limited, especially in the public sector, by resource constraints. RIMOC is primarily mandated to produce inbred lines and new varieties that resist downy mildew and stemborers and tolerate drought and stalk lodging, but it conducts little research in this area because of lack of funds and qualified human resources (Suherman 1997). The private sector has recently offered significant financial and technical support for public maize R&D, including payment of incentives and royalties to maize breeders and researchers, on the condition that the private companies receive exclusive rights to the products of that research. This arrangement conflicts with the mandate of public agencies to serve all beneficiaries, however. The absence of laws on intellectual property rights, plant variety protection and breeders' rights complicates the matter even further. It will be interesting to see how the conflict is resolved as the various participants in the seed industry seek to achieve their various objectives.

References

AARD (Agency for Agricultural Research and Development). 1997. *This is AARD*. Ministry of Agriculture, Jakarta.

BIMAS, BP. 1997. Intensifikasi jagung di Indonesia, Peluang dan Tantangan *(Maize Intensification in Indonesia, Opportunity and Challenge)*. Makalah pada Seminar Nasional Jagung.

BIMAS, BP. 1999. *Program Bimas Intensifikasi Padi, Palawija, dan Hortikultura.* Badan Pengendali Bimas Pusat, Jakarta.

BPS (Badan Pusat Statistik). 1998. National Statistics Bureau, Jakarta.

CIMMYT. 1986; 1992; 1989/90; 1994; 1999. *World Maize Facts and Trends*. Mexico, D.F.

Dahlan, M. and M. Mejaya. 1998. *Maize Production in Indonesia*. Paper presented at the Third Tropical Asian Maize Network (TAMNET) Meeting held in Hanoi, Vietnam, October 27-29.

DGFCH (Directorate General for Food Crops and Horticulture). 1998. *Penyebaran Benih Jagung di Indonesia*. Direktorat Bina Perbenihan, Direktorat Jenderal Tanaman Pangan dan Hortikultura, Departemen Pertanian Jakarta.

FAOSTAT. 1999. FAO Statistical Database. Production Domain, accessed March 1999. Food and Agriculture Organization of the United Nations, Rome.

Mink, S.D., P.A. Dorosh and D.H. Perry. 1987. Corn production systems. In Timmer, C.P. (ed.), *The Corn Economy of Indonesia*, Cornell University Press, Ithaca.

Morris, M.L. 1998. *Maize Seed Industries in Developing Countries*. Lynne Rienner Publishers and CIMMYT, Boulder, Colorado.

Morris, M.L., J. Risopoulos and D. Beck. 1999. Genetic change in farmer-recycled maize seed: A review of the evidence. *CIMMYT Economics Working Paper No. 99-07.* CIMMYT, Mexico, D.F.

Sinring, R.A. and A. H. Talanca. 1998. Maize post-harvest practices, marketing and utilization in Indonesia. In Baldos, D.P. (ed.) *Maize Post-Harvest Practices in Asia and Researches in Crop Management*. Report of the 4th Regional Training Course on Maize Agronomy and Production, Asian Maize Training Center, Suwan Farm, Pak Chong, Thailand.

Subandi. 1998. Corn varietal improvement in Indonesia: progress and future strategies. *IARD Journal* 20 (1).

Subandi, I.G. Ismail and Hermanto.1998. Jagung, Teknologi Produksi dan Pasca Panen *(Maize, Production Technology and Post Harvest).* Puslitbang, Bogor, Indonesia

Sudaryanto,T., S. Ahmad and Erwidodo.1998. Penawaran, Permintaan dan Konsumsi Jagung (*Maize Supply, Demand and Consumption in Indonesia*).

Suherman, O. 1997. Maize Seed Production and Processing in Indonesia. In *Seed Production of Maize in Asia and Researches in Crop Management.* Asian Maize Training Center, Suwan Farm Pak Chong, Thailand.

Timmer, C. P. 1987. *Corn Economy of Indonesia.* Cornell University Press, Ithaca and London.

Annex 1

Improved Open-Pollinated and Hybrid Maize Cultivars Released in Indonesia

Maize type and cultivar name	Year of release	Days to maturity	Dry grain yield (t / ha)	Resistance to downy mildew	Resistance to rust
Improved OPVs					
1. Metro	1956	110	3.2	S	–
2. Malin	1951-60	100	3.0	S	–
3. Kania Putih	1951-60	150	3.3	–	–
4. Baster Kuning	1951-60	130	3.3	S	–
5. Harapan	1964	105	3.3	S	–
6. Permadi	1966	96	3.3	S	–
7. Pandu	1966	130	3.7	–	–
8. Bima	1966	140	3.7	–	–
9. Bogor Composite-2	1969	105	3.6	S	–
10. Harapan Baru	1978	105	3.6	R	MR
11. Arjuna	1980	90	4.3	R	MR
12. Bromo	1980	90	3.8	R	MR
13. Parikesit	1981	105	3.8	R	MR
14. Abimanyu	1983	80	3.3	R	–
15. Nakula	1983	85	3.6	R	MR
16. Sadewa	1983	86	3.7	MR	–
17. Kalingga	1985	96	5.4	R	–
18. Wiyasa	1985	96	5.3	R	–
19. Rama	1989	100	5.0	R	R
20. Bayu	1991	87	4.0	R	–
21. Antasena	1992	98	5.0	MR	–
22. Bisma	1995	96	5.7	R	R
23. Wisanggeni	1995	90	5.3	R	–
24. Surya	1997	98	6.0	R	–
25. Lagaligo	1997	90	5.3	R	R
26. Arjuna Bisi	1998	85			
Hybrids (public and private)					
27. C1	1983	100	5.8	MR	–
28. Pioneer-1	1985	100	5.0	MR	–
29. CPI-1	1985	100	6.2	MR	–
30. IPB-4	1985	100	5.6	R	–
31. Pioneer-2	1986	100	5.9	MR	–
32. C2	1989	93	6.3	R	–
33. C3	1992	95	6.4	–	R
34. Semar-1	1992	100	5.3	R	R
35. Semar-2	1992	90	5.0	R	R
36. CPI 2	1992	97	6.2	R	R
37. Pioneer-3	1992	98	6.4	S	S
38. Pioneer-4	1993	100	6.9	–	S
39. Pioneer-5	1993	99	6.8	S	S
40. Bisi-1	1995	92	7.0	R	R
41. Bisi-2	1995	103	8.9	R	R
42. Semar-3	1996	94	6.3	R	–
43. P6	1996	96	9.0	R	R
44. P7	1996	100	8.7	R	–
45. P8	1996	100	8.8	R	R
46. P9	1996	100	9.0	R	R
47. Bisi-3	1996	94	6.6	R	R
48. Bisi-4	1996	98	6.9	R	R
49. C4	1997	103	7.5	R	R
50. C5	1997	100	8.1	MR	R
51. C6	1997	104	7.9	MR	MR
52. C7	1997	100	8.0	MR	MR
53. Bisi-5	1998	97	8.3	R	R
54. Bisi-6	1998	100	7.7	R	R
55. Bisi-7	1998	97	8.3	R	R
56. Bisi-8	1998	97	8.0	R	R
57. P10	1999	105	7.7	MR	R
58. P11	1999	110	8.1	–	MR
59. P12	1999	106	8.1	–	R
60. P13	1999	103	8.0	MR	–
61. P14	1999	101	7.6	MR	–
62. Semar-4	1999	90	5.9	R	R
63. Semar-5	1999	98	6.8	R	R
64. Semar-6	1999	98	6.9	R	R
65. Semar-7	1999	98	6.8	R	R
66. Semar-8	1999	94	6.9	MR	R
67. Semar-9	1999	95	6.6	MR	R

Note: R = resistant; MR = moderately resistant; S = susceptible.