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

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CIMMYT MR

Chapter 6

The Impact of Public and Private Sector Maize Research in the Philippines

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Maize provided a seemingly minor contribution of 5.6% of gross value added (GVA) of the agricultural, forestry and fishery (AF&F) sector in the Philippines in 1997. The contribution of the maize sector becomes significant, however, when seen in relation to the livestock and poultry industries. These industries have been the fastest growing sectors in agriculture in the past decade, contributing 22.4% of GVA in the AF&F sector. The feed requirements of poultry and livestock are close to 60% of domestic maize output (BAS 1998). In standard hog and poultry feed formulations, maize constitutes 50-60% of the ingredients on the basis of weight and 40-50% on the basis of cost (Costales 1990). In addition, maize production occupies one-fifth (2.7 m ha) of the country's agricultural area, provides a major source of livelihood to about 30% of Filipino farmers (Costales *et al*. 1999) and supplies part of the staple food of about 20% of the population (Tagle 1997).

The question to be asked is: Should so many land resources continue to be devoted to a sector that contributes relatively little to GVA? The maize sector deserves special attention because its current performance indicates substantial potential for improving productivity and efficiency through technological transformation of maize production systems, especially in areas where yields are still very low (usually barely 1.0 t/ha). Improved maize technology could significantly increase total maize output with the same land area under maize. A substantial increase in the productivity of large tracts of maize land would also relieve pressure to cultivate maize in extremely marginal lands where other economic activities could be more profitable.

This paper reports the major findings of the CIMMYT-sponsored survey of public and private sector maize seed companies to document the impact of their R&D on maize production in the Philippines.

Maize Demand and Supply

Maize demand mainly comes from two sources: white maize milled into corn grits for direct human consumption and yellow maize used in producing livestock feed.

White Maize

Currently, there are only soft estimates of the aggregate demand for white maize used as food. Food consumption surveys conducted every five years by the Philippine Food and Nutrition Research Institute (FNRI) estimate that the per capita consumption of food maize was 9 kg in 1987 and 13 kg in 1993 (FNRI 1995). Projected at the 1995 population, the 13 kg per capita would translate to around 892,000 t of white maize or about 18% of total maize demand. The Bureau of Agricultural Statistics (BAS) estimated the 1995 per capita food consumption of white maize at about 10.6 kg, aggregating to 735,000 t or about 15% of total maize demand (BAS 1998).

Over the last decade, white maize production has exceeded its consumption as food, which ranged between 39% and 48% of the 1995-97 average output. Since white maize is an inferior good in the Philippines, with an estimated income elasticity of –0.15 (Rosegrant *et al*. 1999), future increases in per capita income will reduce demand, with only population growth increasing it. A relatively small portion of white maize is industrially processed, mainly into starch and starch products (Costales 1994). The rest is fed to livestock in a trade policy environment where users of white maize for livestock feed cannot readily import yellow maize as demand increases. (White maize can readily substitute for yellow maize, particularly in hog feed mixes, where grain color is not very important.)

Yellow Maize

Even with consistent surpluses in food maize, there is a chronic shortage of maize in the aggregate. Maize is a major feed input into the hog and broiler chicken industries, and maize imports, mainly of yellow maize for livestock feed, increased rapidly from 174,000 t in 1992 to 1.1 m t in 1997 (Figure 1), and the share of imports in total maize supply increased from 3.5% to 21%.

There are no robust estimates of demand for maize used for livestock feed. Using the livestock inventory approach, Costales (1996) estimated the 1995 feed maize demand at 3.4 m t. For the same year, a deficit of about 982,000 t was estimated, but actual imports of yellow maize were around 851,000 t (Table 1) or 87% of the deficit. The gap is commonly covered by imports of low-quality wheat.[1]

[1] To take advantage of lower tariffs on wheat as food compared to that on maize, feed wheat is imported with the generic name "wheat" (Mangabat 1998).

Future Prospects

Rapid growth of the livestock and poultry sectors and declining maize area and output will lead to higher domestic deficits over the next two decades, especially in the absence of significant measures to increase yield. Compared to 4% per year during 1984-90, maize yields grew at 3.2% per year during 1990-97, with an average yield of only 1.59 t/ha in the last year. Maize area decreased by 4.7% per year during 1990-97, so that aggregate maize output declined by 1.6% per year.

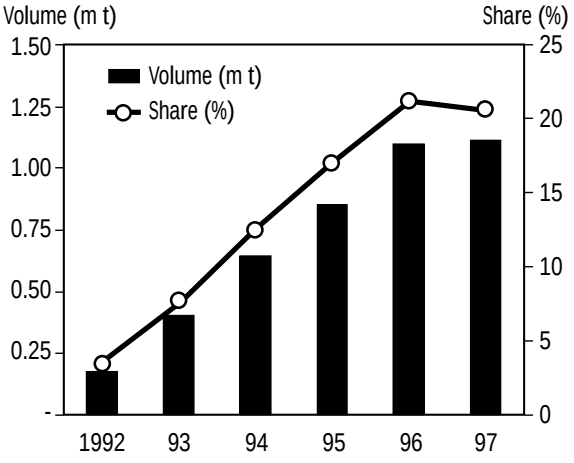

Figure 1. Volume and share of maize imports in total maize supply, Philippines, 1992-97.

Table 1. Estimate of maize deficit with supply and use parameters, Philippines, 1995

Supply / use parameters	Volume (000 t)
Domestic output	**4,129**
Direct food (10.7 kg/cap)	734
Other industrial uses (7.7% of output)	318
Seed (20 kg/ha)	54
Subtotal (non-livestock feed uses)	1,106
Wastage allowance (15% of output)	619
Residual of output	**2,403**
Estimate of livestock feed requirement (Costales 1996)	3,385
Estimate of surplus (deficit)	(982)
Actual maize imports	**851**
Presumed supply shortfall	(131)

The low mean yield indicates the magnitude of the potential to increase maize production, as potential yield from improved cultivars has been shown to be as high as 7-8 t/ha on experiment stations in the Philippines (NSIC 1999).

Maize Area and Seed Market

In 1990, the area planted to hybrid maize was estimated to be only about 9% (347,000 ha) of the total area under maize in the Philippines; improved OPVs occupied another 5% (195,000 ha) (Costales 1993). In 1997, the market for commercial hybrid maize seed consisted of 10,958 t of private sector materials (86% of which was from the multinational firms) and 954 t of public sector hybrids (see Table 2). The total of 11,912 t of hybrid seed sold was equivalent to 595,600 ha or 22% of the total area planted to maize in 1997. Private seed industry sources estimated that 19% of the total maize area in 1997 was under hybrid maize and 4% was under improved OPVs, which suggests that the farmers planted hybrid maize at a higher seeding rate or that not all hybrid seed produced in 1997 was sold.

The size of the Philippine maize seed market was about 14,420 t in 1997 (Table 2). Private-sector hybrid seed accounted for 76% of the market, public-sector improved OPVs accounted for 17% and public-sector hybrids the remaining 7%. This volume of maize seed is equivalent to 26% of the total maize area in 1997 without recycling, or about 36% with recycling. It should be noted that this does not include sales transactions of improved OPVs or traditional varieties that have not been properly recorded.

Public agencies distribute and sell improved OPVs, although these transactions are not well documented. While IPB, the University of Southern Mindanao Agricultural Research Center (USMARC) and BPI-IES reported sales of 34 t, 312.5 t and 6 t of improved OPV seed, respectively, the DA-BAR RIARCs simply reported the area planted to improved OPVs and not actual seed sales. As such, the estimate of 2,154 t of improved OPV seed "sold" through the RIARCs (computed based on the reported planted maize area) would have to be taken with some caution.

In 1989, the maize production subsidy programs of the government included the promotion of certified seed of improved OPVs. Its coverage was estimated at 195,000 ha (Costales 1993), which gives an improved OPV seed market of about 3,900 t. During 1992-98, under the government's Gintong Ani (Golden Harvest) maize program, hybrid maize was vigorously promoted, concomitantly de-emphasizing the use of improved OPVs. This may partly explain the public sector's poor documentation of sales of improved OPV maize seed.

Table 2. Estimated commercial maize seed market, Philippines, 1997

	Reported seed sales (t)	Percent of seed market	Percent maize area covered	
			Without recycling	With recycling
Improved OPVs	2,506	17	4	12
Hybrid maize				
Private hybrid	10,958	76	20	22
Public hybrid	954	7	2	2
Total improved maize	14,418	100	26	36

Source: CIMMYT Maize Impact Survey 1999.
Note: Seed recycling factors used: 1.1 for hybrids and 3 for improved OPVs (Morris *et al*. 1999).

Organization of Maize Research

Public and Private R&D

In 1997, 6 public institutions and 11 private seed companies were involved in maize R&D in the Philippines (Annex 1). The public agencies include the Department of Agriculture–Bureau of Plant Industry (DA-BPI) experiment stations, which develop maize varieties and undertake seed testing, as well as the Bureau of Agricultural Research (BAR) and its 15 Regional Integrated Agricultural Research Centers (RIARCs), which conduct maize R&D and extension activities in regions where maize is an important crop. Among the public organizations, only the Institute of Plant Breeding (IPB), a research institute of the University of the Philippines Los Baños, conducts maize R&D with a national focus. The other universities and government agencies operate at a regional level (Table 3).

The majority of the private maize seed companies (four multinationals and six nationals) have local breeding programs. Two of the multinationals do not have local maize breeding programs but have commercial tie-ups with local companies: Novartis (Thailand) with Cornworld and DeKalb with Ayala.

Table 3. Maize seed organizations in the Philippines, 1997

Type	Number	Number with breeding programs	Name	Estimated maize seed sales in 1997 (t)			
				Public OPVs	Public hybrids	Private hybrids	Total
Public or parastatal seed company (national)	1	1	IPB	34	720	–	754
Public or parastatal seed company (province, region)	1	1	DA-BPI (IES, LB-Economic Garden, LG-NRDC)	6	6.5	–	12.5
Universities, cooperatives, etc., with breeding program	3	3	USMARC, CMU, ViSCA	312.5	0	–	312.5
Private national seed company with breeding program (also produce and sell seed)	7	7	Ayala Genetics Research, Inc.; Cornworld Breeding Systems; Dow AgroSciences B.V.; Far East Hybrid Research, Inc.; Asian Hybrid Philippines, Inc.; PlanTek, Inc.; Tropical Hybrid Seed Genetics, Inc.	–	–	1,537	1,537
Multinational seed company with local breeding program	3	3	Bioseed Research, Phils.; Pioneer Hi-Bred; Cargill Phils.	–	–	9,421	9,421
Private national seed company with no breeding program (only produce and sell or import seed)	–	–	–	–	–	–	–
Multinational seed company with no local breeding or seed production program (only import seed for sale)	1	–	Novartis (Thailand), Ltd.	–	–	(Not available)	–
Multinational seed company with no local breeding program but produce and sell seed locally	–	–	–	–	–	–	–
Universities, government agencies, cooperatives with no breeding program	1	–	DA-BAR (RIARCs)	2,153.9	227.1	–	2,381.0
Individual seed producer (farmer), produce and sell seed	–	–	–	–	–	–	–
Total	–	–	–	2,506.4	953.6	10,958	14,418.0
Percentage share in 1997 seed market	–	–	–	17.4	6.5	76.0	100.0

Source: CIMMYT Maize Impact Survey 1999.

Initially, IPB was concerned with the development of superior OPVs, also called composites. In the 1980s, IPB began a modest program for breeding hybrids. Some of the released cultivars are sold and used in areas covered by the government's integrated maize production program. The other five public institutions were established in the 1980s, their main focus being to generate and promote improved OPVs. Private seed companies have always focused on hybrid maize R&D and commercialization.

Human Resources and Level of Investment

Only six of the ten private seed companies provided information on the deployment of personnel and investment in maize R&D. In the public sector, most respondents reported that investment expenditure on R&D also included activities commonly classified as "extension." The figures should therefore be interpreted with qualifications.

Staff Deployment

The private companies responding to the survey (excluding the multinationals) reported a total of 264 personnel working on maize. Forty-four percent of the personnel were involved in R&D, about 31% in marketing and administration and 25% in seed production (Table 4). On average, each company employed about 44 staff members for its maize program, most of them being skilled technicians and support personnel (54%). The public sector had fewer maize program personnel, totaling 139. Most of these were deployed in R&D (61%). On average, each public institution has 17 personnel, most of them skilled technicians and support staff (Table 4).

The private sector employs more human resources for maize activities than the public sector. Also, the private sector's (excluding multinationals') proportion of personnel working on marketing and administration is higher than the public sector's, which has most of its maize personnel working on R&D. This reflects the business side of maize R&D for the private sector and the research thrust of the public agencies.

Investments in R&D

In 1997, the investment in maize R&D by private seed companies ranged from PhP 1.5 to 6.0 million (US$ 39,500 to 157,900) per year (Table 5). The five private seed companies that responded spent PhP

Table 4. Distribution of personnel in the private and public sectors, Philippines, 1997

	Private sector		Public sector	
Function / level	**Number**	**Percent**	**Number**	**Percent**
Respondents	6	–	8	–
Personnel				
R&D	116	44	85	62
Seed production	65	25	27	19
Marketing and administration	83	31	27	19
Total	264	100	139	100
Hierarchy of position (average per firm)				
Senior level	5	10	3	18
Intermediate level	8	17	3	18
Technical and other support	24	54	8	46
Laborers	8	19	3	18
Total	44	100	17	100

Source: CIMMYT Maize Impact Survey 1999.

14.8 million (US$ 390,000) on maize R&D, an average of PhP 3 million per firm (US$ 78,000). This figure underestimates the total investment in private maize R&D because data from the large multinationals were not available.

In the public sector, seven respondents had a maize R&D expenditure ranging from PhP 12,400 to 4.6 million (US$ 326 to 121,100) per year (Table 5). A total of PhP 8.63 million (US$ 230,000) was spent on maize R&D in 1997, averaging PhP 1.23 million (US$ 32,440) per public institution. The IPB, which has a national maize R&D focus, was allotted more than half of the public aggregate expenditures. If IPB is excluded from the calculations, the average expenditure on maize R&D by a public agency declines to about PhP 672,000 (US$ 18,000), which is less than one-quarter of R&D investments made by a relatively small private seed firm. The public expenditure also includes non-R&D activities like extension.

Table 5. Average annual investment in maize R&D by sector, Philippines, 1997-98

	Private sector (n=5)		Public sector (n=7)	
	PhP	US$	PhP	US$
Low level	1,500,000	39,500	12,400	326
High level	6,000,000	157,900	4,600,000	121,053
Total across companies	14,750,000	388,158	8,629,216	227,085
Average per firm	2,950,000	77,632	1,232,745	32,440
Average w/o IPB	—	—	671,536	17,672

Source: CIMMYT Maize Impact Survey 1999.

Products of Maize R&D

Varietal Releases, 1966-99

Information on the products of the maize R&D system was obtained from the National Seed Industry Council (NSIC, formerly the Philippine Seed Board). Between 1966 and 1999, a total of 180 maize cultivars, including 168 field maize cultivars, were approved for release. Of the field maize cultivars, 105 were hybrids developed by the private sector and 55 were improved OPVs developed by public R&D institutions (Table 6). The public sector also released 8 hybrids for commercial use, all of which were developed by IPB.

Among the public regional institutions, USMARC, the center for improved OPV development, accounted for 16 (30%) of all improved OPVs released as of 1999. The Ilagan Experiment Station in northern Luzon released 11 improved OPVs (20% of the total). The IPB released 18 improved OPVs, 4 of which were still available in the market in 1999.

Consistent with the relative magnitude of resources invested in maize R&D, the outputs showed the increasing dominance of the private sector in the Philippine maize seed industry, as it released 62% of all maize cultivars (Table 6). Table 6 also reflects the emphasis of the private sector on the higher value hybrids that provide higher returns both to the private sector and the maize farmers.

Table 6. Field maize cultivars released by private and public seed institutions, Philippines, 1966-99

	Private sector		Public sector		Both sectors	
Type of cultivar	Number	Percent	Number	Percent	Number	Percent
Hybrids	105	100	8	13	113	67
Improved OPVs	0	0	55	87	55	33
Total	105	100	63	100	168	100
Sector share		62		38		100

Sources: CIMMYT Maize Impact Survey 1999; NSIC 1999.

Seed Characteristics and Prices

Table 7 summarizes the characteristics of the 31 public and private maize cultivars available in the market in 1997. Most of the cultivars were hybrids (65%, mostly three-way crosses), yellow (71%), flint (32%), maturing in less than 100 days (45% being extra-early), and all were adapted to lowland tropical conditions. Five single-cross hybrids were available, four from private companies and one from IPB, but no data on the actual volume of seed sales were made available to this study.

Table 7. Characteristics of public and private sector cultivars of field maize available in the Philippine market, 1997

Characteristic	Number of cultivars	Proportion
Type of maize	31	100
Improved OPV	11	35
Hybrid	20	65
Single-cross hybrid	0	0
Double-cross hybrid	1	3
Three-way-cross hybrid	13	42
Top-cross hybrid	0	0
Grain color		
White	9	29
Yellow	22	71
Grain texture		
Flint	10	32
Semi-flint	5	16
Dent	0	0
Semi-dent	1	3
Ecological adaptation		
Lowland tropical	31	100
Subtropical/mid-altitude	0	0
Highland	0	0
Maturity class		
Extra-early (<100 days)	14	45
Early (100-110 days)	8	26
Intermediate (110-120 days)	0	0
Late (120-135 days)	0	0
Extra-late (>135 days)	5	16

Source: CIMMYT Maize Impact Survey 1999.
Note: Sums may not total to 100% because some cultivar descriptions were missing.

Single-cross hybrids were the most expensive, selling for PhP 72-105/kg (US$ 1.90–2.76/kg) for private sector material. The IPB sold its single-cross hybrid for PhP 65/kg (US$ 1.71/kg) (Table 8). Seed of three-way-cross hybrids ranged from PhP 56 to PhP 94/kg (US$ 1.47-2.47/kg) and seed of improved OPVs was PhP 25-33.33 (US$ 0.66-0.88)/kg. Excluding the public-sector single-cross, the average market price for seed of single-cross hybrids was three times higher than the price of improved OPV seed and 19% higher than the price of seed of three-way crosses. Seed of three-way crosses was priced 2.5 times higher than seed of improved OPVs (Table 8).

At a farm-gate maize grain price of PhP 5/kg in 1997, the seed-to-grain price ratios for single crosses were 14.4-21.0 for private-sector seed, and 13.0 for the public seed (Table 8). For three-way crosses, the ratio ranged at 11.2-18.8 and for improved OPVs seed it was 5.0-6.7. Farm-gate grain prices are artificially inflated by very high tariffs (100% in 1995, gradually declining to 50% by 2004) on maize imports in excess of the minimum access volumes (MAV) of the Philippine commitments to the World Trade Organization (WTO). Even within the MAV, tariffs are relatively high (35%).

Table 8. Seed prices and seed-to-grain price ratios, Philippines, 1997 (grain price = PhP 5.00/kg)

	Seed price (PhP/kg)				Seed-to-grain price ratio			
	Private sector		Public sector		Private sector		Public sector	
Type of seed	Low	High	Low	High	Low	High	Low	High
Single-cross hybrid	72.00	105.00	65.00	—	14.4	21.0	13.0	—
Three-way-cross hybrid	56.00	94.00	—	—	11.2	18.8	—	—
Improved OPV	33.00	—	25.00	33.33	6.6	—	5.0	6.7

Source: CIMMYT Maize Impact Survey 1999.

Adoption and Impacts

Private seed industry sources estimated the hybrid maize area in 1990 to be about 347,000 ha, a mere 9% of the total area planted to maize. For the same period, BAS estimated the area under improved OPVs at 195,000 ha, or about 5% of the total maize area. This study found that, while the total area planted to maize declined, the area under hybrids had increased to around 595,600 ha, or 22% of maize area, by 1997. With seed recycling, this is about 24% of all area planted to maize. Recent unofficial industry estimates, however, estimate the area under commercial maize hybrids at only about 18.9% of maize area in 1997 (Table 9).

Relying on reported sales of public maize R&D institutions and area under the coverage of relevant RIARCs, this study estimates the area under improved OPVs to have been about 108,000 ha, or 4% of total maize area in 1997 (12% with seed recycling). Both the absolute and relative figures are lower than the 1990 levels reported by BAS. The extremely small value obtained for area planted to improved OPVs may simply be the result of poor documentation of the disposal of improved OPV seed by public institutions.

Based on the recent industry and CIMMYT survey estimates, hybrid maize area increased by 91% between 1990/91 and 1997, but this was still only a fourth of the total maize area in 1997. Most hybrids in the market had yellow grain, indicating that farmers had adopted mostly yellow hybrids. Total area under yellow-grained maize was 1.03 m ha in 1997, and the area under hybrids was 64% of this area. Very few white-grained hybrids were present in the market. Seed industry sources estimated that seed of white-grained hybrids constituted only about 3-6% of total seed sales in 1997, covering at most 24,000 ha or only about 1.4% of the 1.7 m ha planted to white maize.

The difference in hybrid seed technology adoption has also resulted in different mean yields for yellow maize and white maize production systems, or food and feed production systems, or subsistence and commercial maize production systems. During 1995-97, yellow maize areas yielded an average of 2.3 t/ha and white maize areas yielded only 1.1 t/ha. Furthermore, while yellow maize yields steadily improved from 1987 to 1997, those of white maize barely changed (Figure 2).

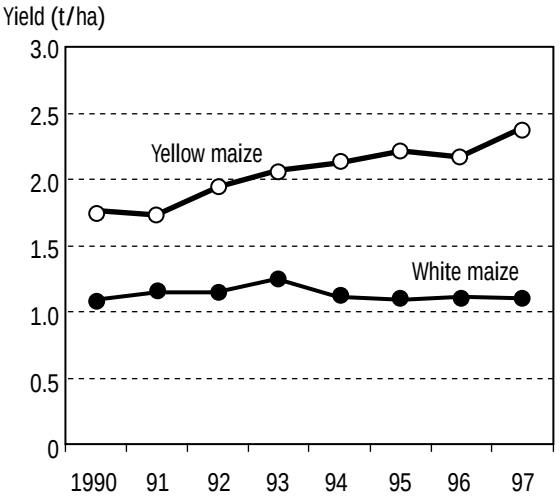

Figure 2. Actual mean yield of yellow and white maize in the Philippines, 1987-97.

Table 9. Estimated adoption of improved maize seed (without recycling), Philippines, 1990/91 and 1997

	1990/91				1997			
	Area (000 ha)		Proportion (%)		Area (000 ha)		Proportion (%)	
Source of information	Hybrids	OPVs	Hybrids	OPVs	Hybrids	OPVs	Hybrids	OPVs
BAS 1999	—	196	—	5.2	681	566	25.0	20.8
CIMMYT Maize Impact Survey 1999	—	—	—	—	596	135	21.9	4.9
Recent seed industry sources, 1999	347	—	9.1	—	515	—	18.9	—
Total maize harvested	3,745	—	—	—	2,725	—	—	—

Key Issues

Plant Variety Protection

The Philippines has not yet instituted any plant variety protection (PVP) law, although as a signatory to the WTO, the country was committed to having one in place by the end of 1999. As of July 2000, the Lower House of Congress (House Bill No. 10654; 2000) and the Senate had already passed the final reading of their respective versions of the PVP bill. Both versions are close to the provisions of the International Convention for the Protection of New Varieties of Plants (UPOV Convention) of 1991. The maize seed company respondents agree that some form of PVP should be enforced. They differ on the degree of strictness on what should constitute an infringement of intellectual property rights, particularly on the use of material already in the market or in farmers' fields. The more established companies with strong crop R&D programs prefer a more stringent PVP law patterned after the 1991 UPOV Convention. Smaller seed companies that are still establishing their own niche in the seed market prefer a less stringent form that will allow them access to a relatively wide range of genetic material. Local breeders currently operate with a "gentleman's agreement" based on professional and personal ethical norms. While no blatant violations of this sort of arrangement have been documented, isolated instances of what local breeders term "flashlight breeding" have occurred, but so far they are not considered serious. Several respondents emphasized the need for a credible and enforceable PVP law because the resulting incentive to invest will be more vital to the seed industry than the financial incentives (e.g., tax deductions or holidays) currently offered under the Seed Industry Development Act (SIDA) of 1992.

Government Programs, Policies and Regulations

Hybrid Seed Promotion

During 1992-98, the Gintong Ani hybrid maize seed promotion program distributed seed to farmers at 50% of cost together with a specialized credit scheme. The national government allocated seed quotas for public and private seed companies. These companies also offered further bulk purchase discounts. Small and new seed companies noted that this scheme allowed them to introduce their materials into the market as a starting point for brand name recognition. Some companies doubted that the program significantly spurred the adoption of hybrid maize technology, as it mainly covered areas where hybrids were already in use or where farmers were about to switch from OPVs to hybrids even without special intervention.

The Gintong Ani program has continued as the Makamasa (Pro-Masses) maize program. Under the current scheme, the allocation of quotas to seed companies is delegated to local government officials. The seed companies see this scheme as distorting the market because local officials choosing seed of favored companies have replaced farmers choosing the seed themselves.

Hybrid Seed Imports

Historically, imports of hybrid maize seed into the Philippines have been regulated, subject to only a 3% tariff when allowed. The statutory 10% value-added tax (VAT) has also been waived for seed imports. These actions reflect the tendency towards greater liberalization of the seed industry, but unless the policy commitment becomes a firm one, opponents to the liberalization of maize seed imports may appeal to Section 15 of SIDA 1992, which expressly prohibits "the importation in commercial quantities of species of seeds that are

being produced locally…only exempted of which are seeds that are not produced in sufficient quantities" (R.A. 7308, SIDA 1992).

It is valid to restrict imports of seed that does not meet the commonly accepted sanitary and phyto-sanitary standards. Apart from that, seed quality, suitability and performance in local conditions should be the field within which competition takes place. The country should not deprive itself of better quality seed, regardless of where it is produced.

The National Food Authority

The National Food Authority (NFA) is mainly responsible for stabilizing grain prices (by setting price support levels) and procuring and importing grain to maintain buffer stocks. As a result of NFA's regulatory functions, domestic maize prices may not reflect the movement of international prices, preventing efficient adjustments in the domestic market. The NFA also participates in the grain market, but it fulfills its stabilization function at the cost of large and chronic financial losses (Clarete 1999). It has been suggested that NFA focus its intervention (price support and buffer stocking) on white maize, relegating the trade in yellow maize to market forces. On equity grounds, the idea of supporting white maize farming households sounds appealing. However, the welfare consequences of possible economic distortions (e.g., a shift from yellow to white maize production) may exacerbate existing inefficiencies, especially in the absence of significant technological improvements in white maize production. Such a move may reduce NFA's financial losses and save it from possible WTO sanctions, but it may also support the inefficiency of white maize production systems.

Regardless of the policy changes the NFA undertakes, the interests of efficiency and equity would be served by splitting the regulatory and commercial trading functions of NFA into two separate bodies. Each one should concentrate on the pursuit of its respective objectives: (1) keeping domestic prices "attuned" to world price movements and (2) maintaining a buffer stock of maize as a secondary staple.

Equity Issues

Government intervention is based on the goal of protecting the interests of maize farmers, who are usually the poorest households in the agriculture sector. In practice, however, the hybrid seed promotion and subsidy program essentially favors yellow maize producers, the more progressive farmers in the maize sector. The high tariff on maize also favors yellow maize, as practically no white maize is imported. The current NFA price support at PhP 6.00/kg (US$ 0.16/kg) also benefits mainly yellow maize, since white maize is consistently priced higher than yellow maize.

For white maize, production technology has stagnated, mean yields are significantly lower and cropped area coverage is larger than for yellow maize. Given that farmers who grow white maize are generally poorer than those who grow yellow maize, a technological intervention to increase the productivity and lower the production cost of white maize will have positive welfare effects on farm households. All things equal, lower costs and higher yields will translate into higher net benefits, whether output is sold in the market or consumed at home. Increased white maize production may however simply reduce imports, with the maize price remaining unchanged at the import parity level, or increased production may result in lower market prices of white maize, dampening the welfare gains to producers if all the output is marketed. For farmers who are also consumers of white maize as a food staple, welfare losses from lower prices in production are simply recaptured as gains in consumption, if output is constant. But

all welfare effects from output expansion are net efficiency gains in production and consumption. For pure consumers, the increase in output and lowering of price will be an unambiguous welfare gain. At the aggregate level, the net welfare gain from increased efficiency in white maize production would be positive.

Environmental Issues

One of the main environmental concerns in maize production systems in the Philippines pertains to land degradation in hilly uplands and marginal environments. Monzalud (1999) investigated the productivity and environmental effects of maize production in selected marginal environments in the Philippines and found that the more marginal the environment, the faster the rate of soil degradation and the lower the yields of maize and net income. Shively and Corcolon (1999) proposed soil conservation technologies in production systems in selected upland environments in the Philippines. Soil conservation technologies were shown to have positive net returns in the long run but required significant land investments that would result in negative net incomes for farmers in the short run. Thus, special intervention would be necessary to encourage investments in land conservation and to bridge short run losses. The alternative is to remove distortions caused by economic incentives to agricultural products, e.g., protection to maize, which may lead to a natural exit from unsustainable production systems.

The full extent of maize production in marginal environments in the Philippines is not yet known. What is known is that total area planted to white maize declined from 2.7 m ha in 1990 to 1.7 m ha in 1997, while yellow maize area has remained fairly stable. It was not clear where the reduction in white maize area occurred (i.e., whether it was in marginal lands) and what cropping systems have replaced it.

Health Issues

Health issues in maize production systems relate to the level of aflatoxin (caused by a pathogen that has toxic side effects when contaminated grain is consumed) in grain maize. Aflatoxin results from inadequate post-harvest facilities and rural road infrastructure. Grain traders attributed inadequate private investment in large grain drying and storage facilities to NFA's heavy involvement in grain trading and to the high capital costs.

More recently, health concerns have been raised in regard to *Bt* (*Bacillus thuringiensis*) maize. *Bt* maize contains a naturally occurring toxin that is fatal to certain insect pests. Several international and national NGOs are vigorously campaigning for the government to prohibit field testing and commercialization of *Bt* maize in the Philippines. Public discussion has taken place in academic and local community settings, and opinions on the subject differ. A community in Laguna Province did not favor approving *Bt* maize (UPLB Perspective 1999), for example, but farmers in General Santos City, South Cotabato were more receptive to field testing of *Bt* maize, because the corn borer problem has been quite severe in this area (The Philippine Star 1999). After several rounds of consultation and discussion, the National Biosafety Commission recently approved field testing of *Bt* maize. Utilization and consumption of *Bt* maize output will certainly generate further public debate.

Summary and Conclusions

Historically, the average yield of maize in the Philippines has been low (1.6 t/ha), and improvements in yield have been quite slow. The yellow maize sector has been performing better than the white maize sector, partly because modern seed technology, particularly hybrid maize technology, has focused almost solely on the development of yellow hybrids. In addition,

although public agencies have commercialized several high-yielding improved OPVs of white maize, the infrastructure required to produce and distribute them efficiently has been grossly neglected. India has established systems to channel publicly developed seed to farmers, and in the Philippines such channels need to be established in areas where white maize is produced to experience significant gains in productivity.

At around 2.4 t/ha, the average yield of yellow maize in the Philippines is still low compared to yields in other Asian countries. This yield level may perhaps result from slow adoption of more modern technology, especially during the first half of the 1990s when the hybrid maize seed industry was small. In the later half of 1990s, the more liberal government policy allowed new companies to enter the seed industry, promoting more dynamic private sector participation. Industry players perceive that there are still seed market niches to explore, especially with maize farmers who are shifting from another crop (usually rice) to maize and, in the process, exploring the potential of hybrid seed technology. The industry estimates that the hybrid seed market is potentially about 80% of the 1 million hectares devoted to yellow maize production, implying an additional 250,000-300,000 ha over the area already planted to hybrids.

However, seed industry representatives also perceive several challenges facing the industry. Foremost is the need for a PVP law. The more established seed companies see the implementation of PVP as the government's role in accelerating the generation and transfer of modern maize technology from the private sector to the farmers. While the established companies would prefer a simple yet strict PVP law, new entrants feel that a strict law might restrict their opportunities to develop hybrids for commercial use.

Another concern is related to the government's role in promoting hybrid seed among farmers. Seed allocation programs in key maize producing areas have allegedly led to unfair allocations among seed companies. Uncertainties about allocations and unscrupulous deals have made some firms cautious about joining government crop production programs. In the beginning, small companies appreciated the program, which assured a ready market for their products. More recently they have indicated that local politics has become decisive in seed allocation and that it would be better if there were no program at all and farmers were simply allowed to choose the best hybrids based on field performance and seed price. For the seed and maize industries to advance in the Philippines, these concerns need to be addressed, keeping in mind that farming households and communities should be the final beneficiaries of modern technology.

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Annex 1

MAIZE SEED COMPANIES OPERATING IN THE PHILIPPINES, 1999

Private companies

1. Ayala Genetics Research Inc.
2. Asian Hybrid Philippines Inc.
3. Bioseed Research Philippines
4. Cargill Philippines Inc.
5. Cornworld Breeding Systems Corporation
6. Dow AgroSciences B.V. Philippines
7. Far East Hybrid Research Inc.
8. Novartis (Thailand) Ltd.
9. Pioneer Hi-Bred Agricultural Technologies Inc.
10. PlanTek Incorporated
11. Tropical Hybrid Seed Genetics Inc.

Public organizations

1. Institute of Plant Breeding, University of Philippines, Los Baños
2. University of Southern Mindanao Agricultural Research Center (USMARC), North Cotabato
3. Central Mindanao University (CMU), Musuan, Bukidnon
4. Visayas State College of Agriculture (VISCA), Baybay, Leyte
5. Department of Agriculture, Bureau of Plant Industry (DA-BPI) Experimental Stations: Ilagan Experimental Station (IES), Isabela; Los Baños Economic Garden, Los Baños, Laguna; La Granja-National Research and Development Center (LG-NRDC), La Granja, Negros Occidental]
6. Department of Agriculture-Bureau of Agricultural Research (DA-BAR) with its Regional Integrated Agricultural Research Centers (RIARCs)