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

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CIMMYT^{MR}

Chapter 8

The Maize Industry in Vietnam

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Vietnam has a population of 78 m people (1998), 80% of whom live in rural areas and about 67% of whom are employed in the agricultural sector. Its soil and climatic conditions favor the development of a diverse agriculture. In December 1986, Vietnam started to replace its centrally administered socialist economic system with the free market economic system, known as *doi moi*, that led to a number of economic and policy reforms. Economic structural adjustments began with the de-collectivization of agricultural production, allowing private initiative and ownership of the means of production. Producers became free to decide the kinds and quantity of crops to grow, based on anticipated market demand and input costs. The household became the basic unit of agricultural production, with concomitant rights to use the land and sell its surplus production.

One notable result of *doi moi* has been a dramatic increase in Vietnam's agricultural output. Rice production rose from 17 m t in the mid-1980s to over 25 m t in the mid-1990s. In 1989, from being a net importer, Vietnam became the third largest exporter of rice, after Thailand and the US. In 1997, with 3.6 m t of rice exports, Vietnam was the second largest exporter. *Doi moi* also boosted the diversification of agricultural production. Vietnam slowly shifted from mono-crop, self-sufficient agriculture to more commercialized and profitable enterprises, serving both domestic and

export markets. Now free to sell their produce and purchase their necessities from others, farmers began to venture into growing other crops and practicing animal husbandry and home fisheries.

Food shortages are now considered a thing of the past, but self-sufficiency in food production remains a priority for the Government of Vietnam. The country currently produces around 31 m t of food and aims to produce 32 and 40 m t by 2000 and 2010, respectively (Uy 1998). Although the biggest contributor to food production is rice, since the 1980s maize has become increasingly important in Vietnam's food security and agricultural production objectives. Maize area and production have gradually increased over the last two decades, in contrast to declining trends for other staples, like sweet potato, cassava and potato (Table 1). The rapid development of Vietnam's rice sector has spilled over to the maize industry, as major progress has been made in maize research and agricultural extension. Higher maize yields and total output were achieved with the development of improved OPVs and hybrid maize for marginal environments, improvements in agronomic techniques, establishment and maintenance of demonstration farms, farmer training and expansion of irrigation facilities (Uy 1998).

Table 1. Sown area and gross output of food crops, Vietnam, 1980-98

Year	Sown area (% of total)			Gross output (% of total)		
	Paddy	Maize	Other staples	Paddy	Maize	Other staples
1980	79.4	5.5	15.0	80.8	3.0	16.2
1985	83.5	5.8	10.7	87.2	3.2	9.6
1990	84.8	6.1	9.2	89.5	3.1	7.4
1995	84.9	7.0	8.1	90.5	4.3	5.2
1997	85.5	7.9	6.6	90.5	5.4	4.2
1998	86.2	7.6	6.2	92.1	4.7	3.2

Source: GSO 1995, 1997.

Production Systems

In Vietnam, maize is produced in six major agro-ecological regions or zones: the northern mountainous and midland region; Red River Delta; central coast region; central highland region; southeastern region; and the Mekong River Delta. Each of these regions can be further classified into subsistence (food) or commercial (feed) maize production areas. The northern mountainous and central coast regions support mostly subsistence maize production. The Red River Delta, parts of the northern midlands (e.g., Son La, Hoa Binh and Vinh Phu) and the northern central coast region (such as Thanh Hoa Province) are more commercially oriented, catering to the grain demand of the feed industry. The remaining parts of the central coast region are more subsistence oriented. The central highlands, southeastern region and the Mekong River Delta are mostly under commercial maize production (Annex 1).

In the upland mountainous region (300-1,000 masl), long-duration maize is grown as a subsistence crop from early May to September (Figure 1). Approximately 200,000 ha of maize are cultivated under the upland system, 50% of it in elevations higher than 600 masl.

Local white glutinous maize varieties are most commonly grown as a staple food of ethnic groups in this region. Improved OPVs and some hybrids have also recently been introduced. In 1998, maize yields in the mountainous subsistence system averaged 1.8 t/ha and production was around 307,000 t (Table 2).

In the central highlands, north midlands and southeastern region, two rainfed maize crops are grown every year. The first crop is seeded in late April/early May and harvested in July, whereas the second crop is sown in late July/early August and harvested in October/early November (Figure 1). To maintain soil fertility, farmers either intermittently replace the second maize crop by, or intercrop it with, a legume, usually soybean or

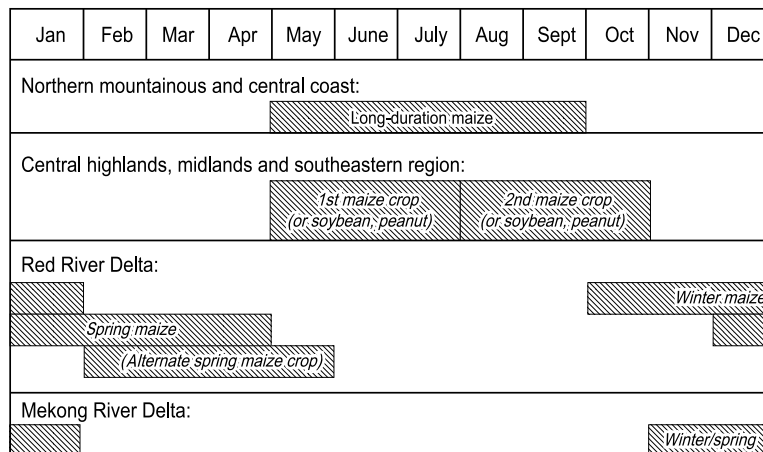


Figure 1. Crop calendar for maize in selected agro-ecological zones, Vietnam.

Note: Text in italics indicates commercial maize production systems.

Table 2. Maize area, yield, and production, Vietnam, 1990 and 1998

Production system	Area (000 ha)		Yield (t/ha)		Production (000 t)	
	1990	1998	1990	1998	1990	1998
Subsistence systems						
Northern mountainous	139.0	169.7	1.2	1.8	172.1	307.0
Central coast	32.4	46.2	1.0	2.0	33.7	91.8
Subtotal	171.4	215.9	1.2	1.9	205.8	398.9
Commercial systems						
Central highlands and midlands	90.7	176.7	1.8	2.6	165.9	453.9
Red River Delta	110.0	150.2	1.8	2.7	202.0	408.1
Southeastern region	48.5	89.8	1.5	3.1	71.7	278.9
Mekong River Delta	11.2	17.1	2.3	3.3	25.6	56.0
Subtotal	260.4	433.8	1.8	2.8	465.2	1,196.9
Total	431.8	649.7	1.6	2.5	671.0	1,595.7

Source: GSO 1996, 1997; Agricultural, Forestry and Fishery Statistics 1985-1995.

groundnut. Soybean is grown either from July / August to October / November (the most popular practice) or during the summer months of May to July. Although commercial crops such as coffee, tea, or sugarcane are heavy competitors for agricultural land, maize (mostly hybrid maize) is planted to about 230,000 ha in this region.

In the lowland areas (usually along riverbanks), one maize and one upland or vegetable crop are grown. In the Red River Delta, two maize crops are grown per year: winter maize¹ sown between two rice crops, and spring maize sown as the main crop along with a second cash crop. Common cropping patterns include spring rice-main rice-winter maize (the most widely practiced system); spring maize-main rice-vegetable or upland crop; spring maize-main rice; groundnut-main rice; and groundnut-main rice-winter maize. About 140,000-150,000 ha are planted to winter maize and another 80,000 ha to spring maize (usually intercropped with groundnut). Winter maize is grown from late September to January and spring maize is usually grown from December to April / May (some

farmers also grow it from February to May / June). In the Mekong River Delta, the principal maize crop (mainly hybrids) is winter / spring maize grown from November to January (in An Giang Province). Irrigated maize is grown on about 30,000 ha, but a small area is also planted to local glutinous maize varieties on alluvium soil along riverbanks during summer or winter / spring seasons.

The central highlands, midlands, southeastern and lowland regions (all specialized maize areas) are the most important areas for commercial maize production in Vietnam. Cultivated maize area in these regions totaled around 430,000 ha in 1998 (Table 2). Upland farmers, whose hilly lands are less suitable for rice production, traditionally grew most of the maize in Vietnam as a single rainfed crop. Because none or minimal chemical fertilizer is applied, maize yields are low at about 1-1.5 t/ha (Ha 1993). In the lowland areas, irrigated maize production using higher-yielding maize varieties and chemical fertilizers and pesticides has been introduced in response to increasing market demand for maize as animal feed and industrial raw material.

¹ The planting of winter maize always uses the transplanting technique, in which maize seedlings are grown in beds, then balled using banana leaves or sheaths and transplanted to the paddy fields. This permits the use of only 14-15 kg of seed per hectare. Depending on soil type and varietal characteristics, transplanting maize results in stand densities of about 53,300-67,000 plants/ha. Transplanting is also used to overcome unfavorable conditions during planting time, such as low soil temperature and cold winds (Do Hai Dien 1997).

The Maize Economy of Vietnam

UTILIZATION AND TRADE

Vietnam is predominantly a rice-consuming country, although maize constitutes a major portion of people’s diets (especially in the rural areas and mountainous regions) and is used as a substitute staple when rice shortages occur. Maize is also the primary source of feed for Vietnam’s poultry and livestock industries. FAO indicates that maize consumption as food increased four-fold from 266,000 t in 1961 to about 920,000 t in 1996 (FAOSTAT 1999). Maize utilization for animal feed also grew more than ten-fold from 20,000 t in 1961 to 250,000 t in 1996. Local experts believe that the quantity of maize used as feed in 1996 was actually much higher, since feed demand from the livestock sector alone was estimated at around 500,000 t. The Ministry of Agriculture and Rural Development (MARD) estimated the 1997 demand for feed maize at around 560,000 t. This increase is attributed mainly to the expansion of Vietnam’s livestock and poultry industries as a result of growing household demand for livestock products.

Time-series data show that the proportion of total maize supply (domestic production and imports) used as human food has been decreasing gradually over the last three decades, while the proportion used as animal feed has been increasing. In the 1960s, 83% of the total maize supply was used as human food, while barely 11% was used as animal feed. In the 1990s, 66% of the total maize supply was consumed as food, while feed use increased to about 27% (Figure 2). The proportion of the maize supply used as seed appears to have remained at around 1.8-2%. Domestic consumption of maize as food, feed, seed and raw material (including wastage) has accounted for 92% of total domestic production in the 1990s.

From 1961 to 1997, Vietnam imported an average of 43,000 t of maize grain and exported around 38,000 t of maize products a year, mostly to neighboring Asian countries (FAOSTAT 1999). Net imports (in maize grain equivalent) for the same period averaged 4,620 t (Figure 3). In the 1990s, imports of maize grain and exports of maize and maize products grew at a rate of 20% annually. Over the last three decades, the increase in maize exports was more dramatic than the decrease in maize imports. Maize grain imports declined by more than 50%, dropping from 56,000 t in the 1960s to 20,000 t in the 1990s, whereas exports of

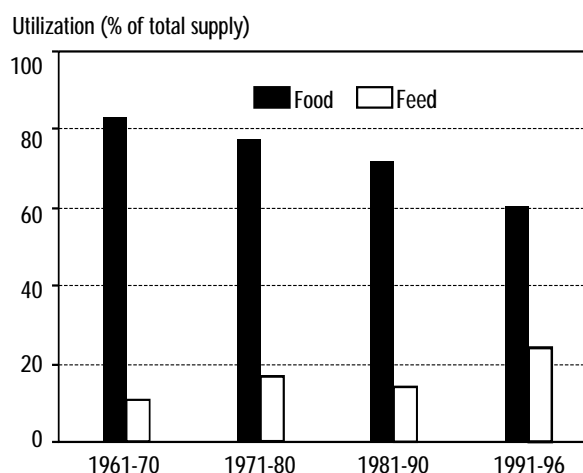


Figure 2. Average maize utilization as proportion of total supply, Vietnam, 1960s-1990s.

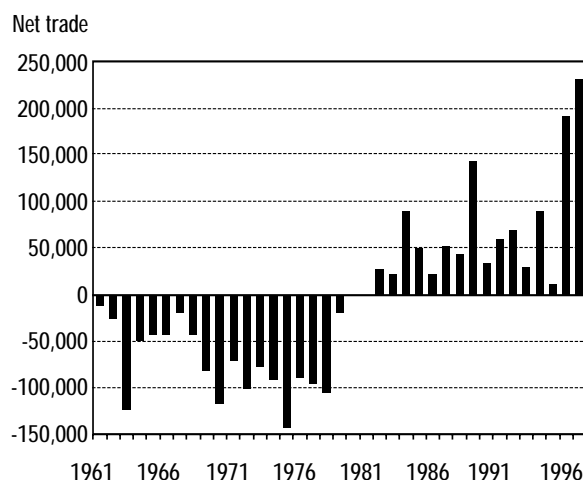


Figure 3. Net trade (export less import) of maize grain (t) in Vietnam, 1961-97.

maize and maize products rose from a mere 473 t in the 1960s to more than 118,000 t in the 1990s. In 1997 exports exceeded imports by about 230,000 t. The growing domestic market and the promising export potential, in tandem with strong government support, provided farmers with a strong incentive to increase maize production.

PRODUCTION

In 1961, Vietnam planted 260,000 ha to maize, yielding an average of 1.1 t/ha for a total production of 292,200 t. In 1980, area under maize had increased to almost 390,000 ha and production to 429,000 t, but average yields remained at 1.1 t/

ha. In 1990, Vietnam planted 432,000 ha to maize and, at an average yield of 1.5 t/ha, produced 671,000 t of maize grain. Maize production declined by almost 2% per annum in the 1960s but increased by 6.5% annually in the 1970s (Table 3). This increase occurred because of expanded area under maize, as yields continued to decline by almost 1% per year. In the 1980s, yield increased at 4% per year while area planted to maize grew at about 3% per year. From 1990 to 1997, production grew twice as rapidly as during the 1980s. This growth usually is attributed to the development and vigorous promotion of hybrid maize, supported by improvements in the production infrastructure.

Table 3. Annual growth in maize production, Vietnam (%/yr)

Period	Area	Yield	Production	Seed
1961–70	-1.55	-0.23	-1.78	-1.77
1971–80	7.20	-0.72	6.47	6.76
1981–90	2.86	4.08	6.94	2.73
1991–97	6.36	9.38	15.74	5.97
1961–97	2.68	1.94	4.62	2.82

Source: FAOSTAT April 1999.

The Maize Seed Market

As recently as ten years ago, maize farmers planted mostly improved OPVs and some local/traditional varieties. Use of hybrid maize was negligible. Hybrid maize R&D, actively pursued by the public sector, contributed to the rapid expansion of area planted to hybrid maize (Table 4). From almost nothing in 1990, by 1994 hybrid maize area had expanded to about 135,000 ha or

Table 4. Area planted to hybrids, Vietnam, 1990-97

	Northern provinces		Southern provinces		All Vietnam		Estimated seed requirement (t) ^a
	000 ha	% total	000 ha	% total	000 ha	% total	
1990	na	na	na	na	nil	nil	na
1991	na	na	na	na	0.5	0.1	25
1992	na	na	na	na	12.8	3	640
1993	40.0	11	20.0	14	60.0	12	3,000
1994	70.5	19	64.5	38	135.0	25	6,750
1995	84.9	22	78.1	43	163.0	29	8,150
1996	119.1	31	110.9	59	230.0	37	11,500
1997	159.0	34	141.0	61	300.0	43	15,000
1998	na	na	na	na	340.0	50	17,000
1999	na	na	na	na	650.0	65	32,500
2000	na	na	na	na	700.0	70	35,000

Source: Department of Agricultural and Forestry Extension 1999.

Note: na= not available.

^a Estimated based on an average seeding rate of 20 kg/ha.

25% of total maize area, and by 1997, hybrid maize occupied 300,000 ha or 43% of the 690,000 ha of total maize area. Of this, 61% was in the southern provinces, particularly in Dong Nai (GSO 1997). During 1992-97, the area planted to hybrids grew at 57% per year.

The government planned to expand the area devoted to maize to 1 m ha by 2000 and to plant 65-70% of this area to hybrids (Department of Agricultural and Forestry Extension, 1999, personal communication). The additional 310,000 ha of land for expanding maize production would be mainly in the Red River Delta, north midland and eastern region and the central highlands. The expansion of maize area in the Mekong Delta would depend on the price of maize relative to the price of paddy.

Assuming an average seeding rate of 20 kg/ha, Vietnam is estimated to have required around 25 t of hybrid maize seed in 1991 (Table 4). This requirement had risen to 3,000 t in 1993 and to

15,000 t in 1997 (which included about 1,700 t of imported maize seed). During 1992-97, hybrid maize seed sales totaled only about 12% of the entire quantity required each year. In 1997/98, the hybrid seed market was estimated to be around 5,000-6,000 t, or only about 36% of the total requirement, which indicates that a large proportion of the hybrid maize area may have been planted with recycled hybrid seed. Should the government devote an additional 310,000 ha to hybrid maize by 2000, about 32,500-35,000 t of F1 hybrid seed will be required, or about seven times the current marketed volume of seed—a very large potential business for both national and multinational seed companies dealing in hybrid maize. Expanded operations by seed companies or the entry of new companies will depend not only on the total seed production capacity of these companies, but also on how open or competitive the maize seed market is in Vietnam.

Summary information on the maize industry in Vietnam is given in Table 5.

Table 5. Summary information on the maize industry of Vietnam

Total area planted to maize, 1997/98 (000 ha)	690
Traditional varieties and improved OPVs	390
Hybrids	300
Total maize production, 1997/98 (000 t)	1,641
Average maize yields, 1997/98 (t/ha)	2.39
Traditional varieties and improved OPVs	1.70
Hybrids	3.50
Estimated potential area for maize production (000 ha)	310
Year hybrids were introduced	1990
Estimated hybrid maize seed market, 1997/98 (t)	5,000
Average maize seed price per kg, 1997/98	VND 13,000 (US\$ 0.96)
Improved OPVs	VND 3,000 (US\$ 0.22)
Hybrids	VND 20,000 (US\$ 1.48)
Average annual maize seed imports, 1990s (t)	1,700
Average maize grain price per kg, 1997/98	VND 1,900 (US\$ 0.14)
Average annual grain maize imports, 1990s (t)	17,756
Proportion of total demand used as human food (1997/98)	68%
Proportion of total demand used as animal feed (1997/98)	26%
Average exchange rate (Vietnam dong per US\$)	VND 13,500

Source: CIMMYT Maize Impact Survey 1998/99.

Organization of Research and Seed Production

Table 6 summarizes the types of maize seed organizations operating in Vietnam. Of these, four public and three private companies were interviewed for this study. Only the public seed companies deal with development, research, seed production and sales of OPVs. The private sector concentrates on hybrid maize (Table 7). Only one private seed company maintains its own hybrid maize breeding research and seed production

facilities in Vietnam (Tables 6 and 7). The other private companies, all multinationals, import their seed from the mother company, after the cultivars pass seasons of agronomic and adaptation trials in Vietnam (Annex 2). None of the seed companies in Vietnam is involved in maize biotechnology research, although the National Maize Research Institute (NMRI), a public research agency, is currently exploring possible collaboration with Carnegie Mellon University in the US and a Swiss research organization in research, human resource development and upgrading facilities and equipment.

Table 6. Number of maize seed organizations in Vietnam, 1998

Type of organization	Number
Public seed company with breeding program	
National	3
Provincial, state, district	54
Private national seed company with breeding program (engaged in maize breeding, production and sales)	1
Multinational seed company	
With local breeding and seed production program	1
With no local breeding or seed production program (only imports seed for sale)	3
With no local breeding program, but produces and sells seed locally (can also import seed)	2
University, cooperative with breeding program	0
Non-profit organization that produces and sells seed	0
Individual seed producer (farmer)	0
Total number of maize seed organizations	64

Source: CIMMYT Maize Impact Survey 1998/99.

Table 7. Maize-related activities of seed organizations, by sector

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

Source: CIMMYT Maize Impact Survey 1998/99.

ROLE OF THE PUBLIC SECTOR

Two public research agencies carry out most of the maize research in Vietnam: the NMRI, located near Hanoi and founded in 1988 under the Ministry of Agriculture and Rural Development, and the Institute for Agricultural Sciences (IAS), located in Ho Chi Minh City. The NMRI is responsible for the “formulation of maize research and production strategies for Vietnam; development of new maize germplasm and varieties, especially hybrids; evaluation of various agro-ecological systems for maize cultivation; development and evaluation of different maize post-harvest and processing technologies; as well as the lead in improving Vietnam’s human resources on maize research and development through increased national and international collaboration” (NMRI 1998). The IAS, which also has a small program on legumes, maintains five research stations, a 10 ha research farm, and a 150 ha farm devoted to maize research and seed production. It maintains its own seed processing, storage and packing facilities and also collaborates with other government agencies for some farm mechanization and post-harvest processing requirements.

Work on hybrid maize in Vietnam began in 1961 when Vietnamese scientists collaborated with Romanian experts on hybrid maize breeding and production trials. Several hybrids and inbred lines from Hungary’s Martonvasar Institute were introduced in Vietnam in 1971-73 but did not test successfully, primarily because of the great difference in the growing conditions between Vietnam and Europe (Uy 1998).

In 1973, NMRI (then known as the Song Boi Maize Research Center) initiated Vietnam’s Maize Breeding Program by collecting local germplasm and importing tropical materials from countries with similar agro-ecological conditions. More than 150 local populations and thousands of lines, populations and varieties developed by CIMMYT and breeding programs in countries such as Russia and China have been evaluated for use in the

Breeding Program (Uy 1998). Up to 1990, the Program emphasized research on developing improved OPVs with high yield, good grain quality, tolerance to adverse environmental conditions (such as drought, saline or acid soil), and resistance or tolerance to major pests and diseases (such as powdery mildew, leaf blight, *Rhizoctonia*, stalk rot and stem borer). In 1990, in response to a government initiative promoting hybrid maize adoption, the Maize Breeding Program shifted its emphasis to developing hybrid maize varieties suitable for Vietnamese production environments.

The counterpart of NMRI for maize breeding research in southern Vietnam is the IAS. Using inbred lines acquired from CIMMYT, IAS initiated hybrid maize research in 1992 and began testing single-cross hybrids in 1994. While it currently works only with single-cross maize hybrids, IAS also intends to develop double-cross and three-way-cross hybrids in the future.

In Hanoi, the National Seed Company No. 1 (NSC No. 1) produces and trades crop seed and planting materials and maintains the government’s security stock seed. It produces and supplies about 5,000 t of seed of hybrid maize, hybrid rice, beans and other vegetables from its ten seed production farms and stations. About 500 ha of land on four farms and stations are devoted to producing hybrid maize seed. The NSC No. 1 also participates actively in improving Vietnam’s seed production and technology and in creating high-quality products to meet demand.

In Ho Chi Minh City, the Southern Seed Company (SSC, sometimes referred to as National Seed Company No. 2) evaluates introduced and locally bred crop varieties prior to local adoption and investigates improvements in seed technology. The SSC produces OPV and hybrid seed of rice, maize, legumes and vegetables, usually under contract with local and foreign seed companies, for sale in the domestic and overseas markets. It has seven subsidiary provincial farms whose seed production area totals about 500 ha, apart from the area

contracted with farmer groups or cooperatives. In 1998, SSC produced and distributed about 1,300 t of hybrid maize seed. Apart from crop seed, SSC also manufactures and supplies grain processing equipment and machinery.

ROLE OF THE PRIVATE SECTOR

About half a dozen national and multinational seed companies sell hybrid maize seed in Vietnam. The major ones are Bioseed Genetics International (Vietnam), CP Seeds (allied with DeKalb), and Cargill Vietnam (soon to begin operating under the Monsanto name). Minor companies include Pioneer and Uniseeds. A local private seed company, Luong Nong Company, has recently entered the market. Of these companies, only Bioseed Genetics Vietnam has a breeding and seed production program in Vietnam. As noted, the other companies import their own seed from Thailand or the Philippines or contract with public agencies or farmer groups to produce seed locally. For example, NSC No. 1 and SSC produce hybrid maize seed on a contract basis for Pacific Seeds Ltd. (a subsidiary of ITC-Zeneca). Under the terms of the contract, Pacific Seeds sells parent seed to the government companies and receives royalties on commercial sales. These arrangements are expected to result in developments in hybrid maize research in the mother companies, benefiting the maize seed industry in Vietnam.

PUBLIC AND PRIVATE SECTOR RESEARCH INVESTMENTS

Advancements in Vietnam's maize industry can be attributed to the combined public and private sector resources devoted to maize breeding and production research. All the seed companies that

participated in the survey have maize breeding programs, agronomy research programs, or both. The public sector employs 91.5 maize researchers (in full-time equivalents), whereas the private sector employs 64 (Table 8). Sixty percent of the public sector and 17% of the private sector maize researchers are engaged in either breeding or crop management research. Thus, there were about 133 public sector scientists per million hectares of land planted to maize, or 56 public sector scientists per million tons of maize produced. These numbers represent an increase over 1990, when the public sector had 60 full-time maize researchers or about 118 researchers per million hectares of maize area (CIMMYT 1992). In 1990, the private sector was not yet active in maize research; now it has 93 scientists per million hectares of maize area and 39 scientists per million tons of maize production. The difference between sectors can be explained by the wider research network of the public sector compared to the new and smaller (single) breeding program in the private sector.

Over the last three decades, the public sector has produced 21 maize hybrids, 16 of which were developed between 1990 and 1997. Over the same period, the private (multinational) maize seed companies developed and released five new maize hybrids (Table 8). The public sector is much more efficient than the private sector, as it has more than two decades of research experience in dealing with OPVs while the private sector was allowed to enter the industry only in 1990/91. On average, the government provides the public sector around VND 1 billion per year (US\$ 74,000) to conduct maize research.² Additional funds are obtained from income-generating activities such as the sale of hybrid maize seed. Information on the level of maize research investment in the private sector is confidential.

² It should be noted that this amount is allotted to cover operating research costs only; it does not include researchers' salaries and benefits or fixed and administrative overhead costs.

Table 8. Public and private sector investments in maize research, Vietnam, 1997/98

Research indicator	Public sector	Private sector
Number of maize research programs	4	3
Number of programs with maize breeding activities	3	1
Number of maize researchers (FTEs)	91.5	64
Number of maize scientists		
Per m ha of maize area	133	93
Per m t of maize produced	56	39
Percentage of researchers engaged in maize breeding and/or crop management research	60	17
Number of cultivars developed (1966 to 1997/98)		
Improved OPVs	13	0
Hybrids	21	5
Total	34	5
Average annual research investment	VND 1 billion	a
Average annual research investment (1998 US\$)	US\$ 74,100	a

Source: CIMMYT Maize Impact Survey 1998/99.

^a Internal and confidential.

SEED PRODUCTION ARRANGEMENTS

For seed production, NMRI and IAS use several public seed companies located in the maize growing regions. The NMRI and IAS also maintain their own production farms, which are mostly used for growing parent seed as well as for producing limited quantities of commercial maize seed, in close collaboration with provincial research stations and agricultural extension offices. They also use the facilities of district seed companies for contacting farmers who might grow seed. The NMRI and IAS supply parent seed to these contract seed growers, provide technical support and implement other safeguards to ensure that the hybrid seed produced is of satisfactory quality. The NSC No.1, the SSC, and several provincial and district seed companies mainly produce seed of public hybrids.

As noted, both public and the private companies contract farmer groups or cooperatives to produce seed. Bioseed Genetics Vietnam, for example, contracts with 12-15 cooperatives around Hanoi and three to four farmer cooperatives in the south to produce their hybrid seed. Every year, NMRI

contracts about 2,000 ha of maize area with farmers to produce seed in the north. The contracting agency sets an output standard and buys back the seed produced at a premium over the current market price of maize grain. Such seed production contracts have several advantages for farmers, including regular access to technical expertise during the production period; a lower investment in maize seed production as the most expensive input, seed, is provided by the seed companies; an assured market for the produce; and a higher income.

Products of Maize Breeding Programs

As part of the CIMMYT survey on the impacts of maize research in developing countries, detailed descriptive data on cultivar characteristics were collected for all public and private materials available in the market in Vietnam. In 1990 seven maize cultivars were sold, all of them from the public sector: four improved OPVs and three conventional hybrids. Many cultivars are no longer

sold because newer materials, mostly hybrids, have been developed and released for commercialization.

GENERAL CHARACTERISTICS

From 1973 to 1997/98, 62 improved OPVs and hybrids were developed and released for commercialization in Vietnam. The public and the private sectors developed 48 and 14 materials, respectively, over this period (Annex 3). Of these, 30 of the public sector materials and 9 of the

private sector materials were released between 1990 and 1998. At the beginning of that period, public sector releases consisted mostly of improved OPVs; later, they consisted mostly of hybrids, as the government sought to increase maize production by promoting hybrids.

Currently, 44 improved OPVs and hybrids are available in Vietnam, of which 33 were developed by the public sector. These consist of 13 improved OPVs and 9 single-cross, 2 double-top-cross and 3 top-cross hybrids (Table 9).

Table 9. Characteristics of maize cultivars released, by sector, Vietnam, 1966 to 1997/98

Characteristic	Public sector (cultivars released in 1966-1997/98)	Private sector (cultivars sold in 1997/98)
Total number of cultivars released	48	14
Number of maize cultivars remaining on the market	33	11
Improved OPVs	13	0
Hybrids		
Single cross	9	7
Double cross	0	1
Double top-cross	2	1
Three-way cross	0	2
Top-cross	5	0
Ecological adaptation		
Lowland tropical	48	14
Grain color		
White	3	0
Yellow	29	14
Grain texture		
Flint	2	3
Semi-flint	23	7
Dent	4	0
Semi-dent	8	3
Days to maturity		
Extra-early (<100 days)	3	1
Early (100-110 days)	11	9
Intermediate (110-120 days)	11	2
Late (120-135 days)	7	0
Extra-late (>135 days)	0	0
Number of releases by period		
1970-79	3	0
1980-89	14	5
1990-99	30	9

Source: CIMMYT Maize Impact Survey 1998/99.

The first OPV developed by NMRI, HS36, was released in 1973. It is no longer available in the market, and was never considered a commercial success. The most commercially successful public hybrid so far has been NMRI's LVN10, for which an estimated 1,800 t of seed was sold in 1997. LVN10 is popular with Vietnamese farmers because its field performance and yield potential are comparable to those of the more expensive private sector hybrids. This public-sector hybrid is sold at attractive prices ranging from VND 14,000 to VND16,000/kg (US\$ 1.04 to US\$ 1.19/kg). The most recently released public-sector hybrid is MX1, the first hybrid developed by SSC. MX1, whose seed costs VND 18,000/kg (US\$ 1.33/kg), is a single-cross hybrid, has a potential yield of 7-8 t/ha (similar to that of LVN10) and matures 7-10 days faster than LVN10.

The 11 hybrids marketed by the private sector consist of 7 single-cross, 1 double-cross, 1 double-top-cross and 2 three-way-cross hybrids (Table 9). Five of these cultivars were developed in Vietnam and the rest were imported, mostly from the various company headquarters in Thailand. The first private sector hybrid, CP-DK888, released in 1991, is popular with farmers because of its high yield and strong tolerance to a wide range of production stresses. Priced at VND 38,500/kg (US\$ 3.08/kg), CP-DK888 faces strong competition from the less expensive but equally good LVN10.

All maize cultivars marketed in Vietnam are adapted to the lowland tropical production environments. Most are yellow, semi-flint and of early to intermediate maturity (100-120 days to harvest), fitting the requirements of the livestock and poultry industries. The public sector also provides very early and late maturing hybrids for the central highlands and mountainous regions.

USE OF CIMMYT GERmplasm

From 1973 to 1990, NMRI released 17 improved OPVs with an average grain yield potential of 3-6 t/ha. Some of these cultivars were developed using

CIMMYT germplasm, including Populations 17, 18, 26, 28, 31, 36, 49, 63, Tuxpeño, Suwan-1 and Suwan-2 (Uy 1998). From 1990 to 1999, NMRI released 24 hybrids using materials maintained in its own maize gene pool. Early, intermediate, and late-maturing hybrids with yield potentials of 4-6, 5-6 and 5-7 t/ha, respectively, were first released in 1991-93. More conventional hybrids (mostly single crosses and double crosses) have been released since then.

Three private-sector hybrids available in Vietnam contain CIMMYT's Population 28 in their pedigrees. Twenty-five of the 48 public-sector OPVs and hybrids were developed using some CIMMYT germplasm (Pools 17 and 18, Experimental Varieties 54 and 524 and Populations 21, 26, 28, 31, 36, 49 and 63).

Private- and public-sector breeding programs use CIMMYT maize germplasm in different ways. From the limited information on pedigrees gathered during the survey, it appears that the public sector mostly uses CIMMYT populations, pools or experimental varieties as basic germplasm for their breeding and direct varietal releases. The private sector meanwhile acquires breeding lines (inbred lines or hybrids as parents and new genetic stocks) from CIMMYT for their pedigree or germplasm improvement program. Both sets of materials are subjected to substantial improvement prior to incorporation into the maize research and breeding programs.

Many of the survey respondents stated that the CIMMYT materials were not "specific enough" to be used directly in breeding programs. Some respondents noted that it is inefficient for commercial breeders to improve the CIMMYT materials themselves. CIMMYT maize breeders responded to this by stating that CIMMYT's mandate is to develop germplasm suitable for a larger number of agro-ecological zones and environmental conditions. Turning this germplasm into more location- or environment-specific cultivars should be the responsibility of national agencies involved in maize breeding research and development.

Seed Marketing and Distribution

As noted, sales of hybrid maize seed in Vietnam have grown rapidly since the early 1990s, when the first commercial hybrids appeared in the market. The total market for hybrid seed is currently estimated at around 5,000 t, of which approximately half is produced by public companies and half is produced (or imported) by private companies. In addition, a number of small provincial seed companies produce and sell seed of non-conventional hybrids and improved OPVs. The commercial maize seed market in Vietnam is estimated to have grown from about 25 t in 1992 to 5,350 t in 1997 (Table 10), decreasing to about 3,400 t in 1998 because unpredictable weather and after-

effects of the Asian crisis provided disincentives for maize production.

Local branches of the Department of Agricultural Extension in the provinces and districts are responsible for promoting new maize cultivars, particularly hybrids, together with the recommended technology package. The extension services disseminate this information through radio and television programs as well as demonstration trials in farmers' fields. The public agencies market maize seed through the government marketing and distribution networks in each province or district. The central government transfers funds for maize seed acquisition to the public seed companies, who buy the seed either from public or private sources. The

Table 10. Description of the national maize seed market, Vietnam, 1997/98

Market indicator	Public sector	Private sector
Number of maize cultivars currently available in the market	34	8
Average seed price paid by farmers (US\$/kg)		
Improved OPVs	0.22	na
Hybrids		
Single cross	1.15	2.59
Double cross, three-way cross	1.07	1.59
Average seed-to-grain price ratios		
Improved OPVs	na	na
Hybrids		
Single cross	19.81	7.75
Double cross, three-way cross	10.24	7.25
Estimated total market share (%)	51.1	48.9
Estimated hybrid market share (%)	47.2	52.8
Total sales of commercial maize seed (t)	2,821	2,704
Composition of maize seed sales (t)		
Improved OPVs	420	0
Hybrids	2,421	2,704
Commercial maize seed sales (t)		
1990	na	0
1991	na	0
1992	na	25
1993	na	225
1994	na	550
1995	na	690
1996	na	1,150
1997	2,700	2,650
1998	1,300	2,138

Source: CIMMYT Maize Impact Survey 1998/99.

Note: na=not available.

public seed companies then coordinate with district seed companies and district agricultural extension offices to distribute the seed to maize farmers, usually on credit. Farmers pay for the seed after harvest or as soon as they have the money. It is estimated that about 80% of the seed requirement is met through this state-managed distribution system and that about 15% of seed is exchanged among farmers (Mai Thi Sam 1997).

The private seed companies distribute their products through their own sales networks located in the provinces. The seed is sold primarily to private wholesalers or retailers, although some is sold to local government agencies. The seed distribution network may differ greatly between the northern and southern regions. The SSC, believed to be the largest hybrid maize seed supplier in the country, distributes 80% of its seed through private dealers in the south and mostly through district government agencies in the north. The district government agencies are usually responsible for implementing the central government's subsidized maize seed distribution program, which is aimed at promoting the use of hybrid maize and other new production technologies. Sales to local distributors usually involve a part-cash, part-credit payment agreement.

SEED PRICES AND MARKET SHARES

Table 10 shows the difference between the price of maize seed from the public and private sectors. Seed of public-sector, single-cross hybrids costs an average of VND 15,500/kg (US\$ 1.15/kg) and is about 56% cheaper than single crosses from the private sector, which have an average price of VND 35,000/kg (US\$ 2.80/kg). Double-cross and three-way-cross hybrids are similarly priced within each sector, but the price varies between the two sectors. Double- and three-way-crosses from the public sector are cheaper by about 34%, with an average retail price of VND 14,500/kg (US\$ 1.07/kg); those

from the private sector cost around VND 21,500/kg (US\$ 1.72/kg). The price differences are more obvious in terms of seed-to-grain price ratios. While the cost of hybrid seed from the private sector is 10-20 times higher than the maize grain price, that of public hybrids is 7 times the grain price.

Attractive prices and a well-established sales network have helped the public agencies secure about 51% of the total improved OPV and hybrid maize seed market. The market leader is NMRI, with 26% of the market, followed closely by Bioseed Genetics Vietnam and CP Seeds. These three companies control almost 70% of the commercial maize seed market in Vietnam. On average, the public and private sectors provide about 3,000 and 2,500 t, respectively, of maize seed annually.

The private sector controls almost 53% of the hybrid maize seed market, as against 47% by the public agencies. In the future, the extent of public- and private-sector activity in Vietnam's maize seed industry will depend on the sustainability and profitability of the market, given the overall policy environment provided by the government.

Key Issues

IMPROVING MAIZE PRODUCTIVITY

Vietnam has recorded impressive gains in its maize economy since the 1970s, particularly with regard to maize hybrid technology. These gains were achieved primarily because of the government's vigorous effort to promote hybrids through sustained investment in hybrid maize research, subsidies for seed production and distribution, improvements in agricultural production and marketing infrastructure, and aggressive extension campaigns that educated farmers about the advantages of adopting hybrids. At present, the government provides public research institutions and farmers a production subsidy of about VND 8-10 million (US\$ 590-740) per ton of hybrid maize grain produced, in

addition to a subsidy of VND 2,000-5,000 (US\$ 0.15-0.37) per kilogram of seed to farmers, especially to encourage production in marginal environments. The subsidy provides farmers producing hybrid seed with financial support to cover the cost of parent stock, material inputs such as fertilizers and pesticides and irrigation fees. With such financial and technical assistance from the government, both small- and large-scale farmers have adopted hybrid maize production.

According to Bui Thi Dan *et al.* (1998), maize production in Vietnam can be further promoted in several ways. Maize cultivation can be concentrated in more favorable areas where there is good irrigation and drainage (especially for the winter maize crop), and more maize seed, especially hybrid seed, can be produced at a lower cost in the provinces. Farmers can be further encouraged (through extension and other means) to adopt new production techniques, including hybrid maize, and to use better practices to minimize post-harvest losses. In addition, various maize and maize-based consumer products can be developed and promoted.

INTELLECTUAL PROPERTY RIGHTS

Despite the impressive gains achieved in the use of hybrid maize, the maize seed industry in Vietnam may be entering a difficult period. As in any other developing country in Asia, the lack of effective plant variety protection laws makes it difficult for private companies to safeguard their materials. While the private sector has established a strong presence in Vietnam with the introduction of many excellent hybrids, the lack of an effective intellectual property law discourages many private companies from introducing their very best products. Several leading multinational seed companies that are active elsewhere in the region have decided not to enter the Vietnam maize seed market until the intellectual property rights issue is resolved.

EQUITY IN THE SEED INDUSTRY

Current government policies also raise questions about fairness. There is a perception among private companies that they have to compete with government agencies that not only receive subsidies but also benefit from favorable regulatory treatment. It is expected that the government will soon require commercial maize seed importers to establish their own seed research and production facilities in Vietnam. They will be given two or three years to establish local production facilities, during which time they will be allowed to import a limited amount of maize seed for sale in the domestic market. Private companies may not want to establish local breeding and production facilities because it will be difficult to secure parent lines and production costs will be higher in this low-volume seed market. In view of this situation, private companies operating in Vietnam are reassessing their long-term priorities and overall marketing strategies.

What lessons can be learned from Vietnam's maize seed industry? The Vietnamese experience is interesting because the national maize program has released, produced and sold commercial hybrids in direct competition with the private sector. In the short run, this competition has benefited maize farmers as seed of superior hybrids has become widely available, often at extremely low prices. Over the longer term, however, private companies may not be willing or able to continue to compete against a public sector that benefits from government support in the form of financial subsidies and favorable regulatory treatment. If the private companies scale back their activities because it is simply too difficult to do business in Vietnam, the maize seed industry will revert to being a government monopoly. In that case, the range of technology available to farmers may become severely restricted.

REFERENCES

- Bui Thi Dan, Pham Van Trong and Thu Nguyen Van. 1998. Post-harvest practices, marketing, utilization of maize in Vietnam. In D.P. Baldos (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, Nakhon Ratchasima, Thailand.
- CIMMYT. 1992. *1991/92 World Maize Facts and Trends: Maize Research Investment and Impacts in Developing Countries*. Mexico, D.F.
- Department of Agricultural and Forestry Extension. 1999. Ministry of Agriculture and Rural Development (MARD), Hanoi, Vietnam.
- Do Hai Dien, 1997. Seed production and processing of maize in Vietnam and Nam Dinh Province. In D.P. Baldos (ed.) *Seed Production of Maize in Asia and Researches in Crop Management*, Report of the 3rd Regional Training Course on Maize Agronomy and Production. Asian Maize Training Center, Suwan Farm, Pak Chong, Nakhon Ratchasima, Thailand.
- FAOSTAT. 1999. FAO Statistical Database, Production Domain, accessed March and April 1999. FAO, Rome.
- GSO (General Statistical Office). 1996; 1997. *Vietnam Statistical Yearbook*, Statistical Publishing Office, Hanoi, Vietnam.
- Ha, Dang Thanh. 1993. *Economic inefficiency of corn farmers in the province of Dong Nai, Vietnam*. Unpublished M.Sc. thesis, College of Economics and Management, University of the Philippines Los Baños, College, Laguna, Philippines.
- Mai Thi Sam, 1997. Maize seed marketing and distribution in Vietnam: the case of Thanh Hoa province. In D.P. Baldos (ed.) *Seed Production of Maize in Asia and Researches in Crop Management*, Report of the 3rd Regional Training Course on Maize Agronomy and Production. Asian Maize Training Center, Suwan Farm, Pak Chong, Nakhon Ratchasima, Thailand.
- NMRI (National Maize Research Institute) 1998. *National Maize Research Institute* (brochure), Ha Tay, Vietnam.
- Statistical Publishing Office. 1995. *Agricultural, Forestry and Fishery Statistics 1985-95*. Hanoi, Vietnam.
- Uy, Tran Hong, 1998. The situation of maize research and development of Vietnam in recent years. Paper presented at the Third Tropical Asian Maize Network (TAMNET) Meeting, Hanoi, Vietnam, 27-29 October.

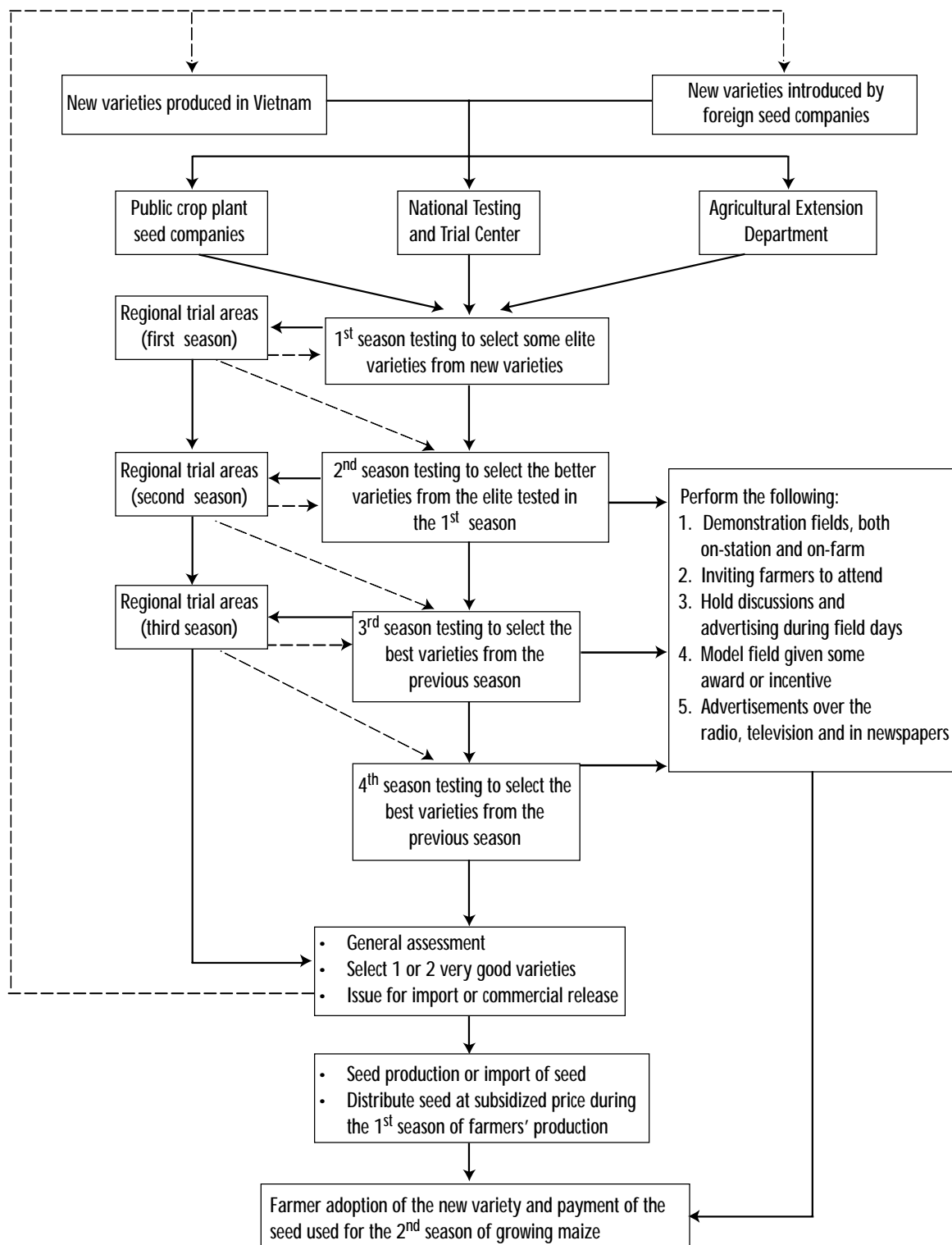
Annex 1

CLASSIFICATION OF SELECTED PROVINCES INTO MAIZE PRODUCTION ZONES/SYSTEMS, VIETNAM

Subsistence systems		Commercial systems			
Mountainous region	Central coast	Highlands and midlands	Red River Delta	Southeastern region	Mekong River Delta
Ha Giang	Ha Tinh	Son La	Ha Noi	HCM City	Long An
Tuyen Quang	Quang Binh	Hoa Binh	Hai Phong	Binh Phuoc	Dong Thap
Cao Bang	Quang Tri	Phu Tho	Ha Tay	Binh Duong	An Giang
Lang Son	Thua Thien	Vinh Phu	Hai Duong	Tay Ninh	Tien Giang
Lai Chau	Qnam Dnang	Bac Giang	Hung Yen	Dong Nai	Ben Tre
Lao Cai	Quang Ngai	Bac Ninh	Thai Binh	Baria Vtau	Vinh Long
Yen Bai	Binh Dinh	Gia Lai	Ha Nam		Tra Vinh
Thai Nguyen	Phu Yen	Kon Tum	Nam Dinh		Can Tho
Bac Can	Khanh Hoa	Dac Lac	Ninh Binh		Soc Trang
Quang Ninh	Ninh Thuan	Lam Dong	Thanh Hoa		Kien Giang
	Binh Thuan		Nghe An		Minh Hai

Annex 2

SCHEME OF TESTING AND RECOMMENDATION OF NEW VARIETIES IN VIETNAM



Source: Do Hai Dien (1997).

Annex 3

MAIZE CULTIVARS RELEASED IN VIETNAM, 1966-97/98

Cultivar name	Year of release	Type of material	Owner	Grain color	Grain texture	Important industrial trait	Days to maturity	Ecological niche	Contains CIMMYT materials	CIMMYT material used	Use of CIMMYT material	Commercial success?
HS36	1973	OPV	PUB	—	SD	—	—	TL	Yes	POP36	11	No
TH2A	1976	OPV	PUB	Y	SF	—	110-120	TL	No	—	—	No
TH2B	1977	OPV	PUB	Y	SF	—	110-120	TL	No	—	—	No
VM1	1980	OPV	PUB	WH	D	—	120-135	TL	Yes	POP 21, V.524	11	Yes
HLS	1985	OPV	PUB	Y	SF	—	90	TL	No	—	—	No
MSB31	1985	OPV	PUB	Y	F	—	—	TL	Yes	POP31	11	Yes
DL11	1986	OPV	PUB	Y	SF	—	—	TL	—	—	—	Yes
MSB26	1986	OPV	PUB	Y	SF	—	—	TL	Yes	POP26	11	Yes
MSB49	1986	OPV	PUB	WH	D	—	100-110	TL	Yes	POP49	12	Yes
TSB1	1986	OPV	PUB	Y	SD	—	115-130	TL	No	—	—	No
TSB2	1987	OPV	PUB	Y	SF	—	100-115	TL	No	—	—	No
G-45	1988	SC	PRIV	Y	SF	—	100-110	TL	—	—	—	Yes
G-49	1988	SC	PRIV	Y	SF	—	100-110	TL	—	—	—	Yes
HL 31	1988	OPV	PRIV	Y	—	—	—	TL	—	—	—	No
PI-3011	1988	SC	PRIV	Y	SF	—	100-110	TL	No	—	—	Yes
PI-3012	1988	SC	PRIV	Y	SF	—	100-110	TL	No	—	—	Yes
HL24	1988	OPV	PUB	Y	SF	—	—	TL	—	—	—	Yes
Pool 17B	1988	OPV	PUB	Y	—	—	—	TL	Yes	POOL17	—	—
Pool 18	1988	OPV	PUB	Y	—	—	—	TL	Yes	POOL18	—	—
Q1	1988	OPV	PUB	Y	—	—	—	TL	Yes	POP63	—	—
Q2	1988	OPV	PUB	Y	SD	—	100-115	TL	Yes	POP28	11	No
HL36	1989	OPV	PUB	Y	SD	—	90	TL	Yes	POP36	—	No
NEPTH	1989	OPV	PUB	WH	—	—	<100	TL	No	—	—	No
LD 1	1990	TC	PUB	Y	SF	—	—	TL	—	—	—	Yes
LD 2	1990	TC	PUB	Y	SF	—	—	TL	—	—	—	Yes
LD 3	1990	TC	PUB	Y	SF	—	—	TL	—	—	—	Yes
Pop 28	1990	OPV	PUB	Y	SD	—	—	TL	Yes	POP28	11	Yes
Pop 28 x TSB1	1990	OPV	PUB	Y	SD	—	—	TL	—	—	—	Yes
Pop 28 x TSB2	1990	—	PUB	Y	SF	—	—	TL	Yes	POP28, Suwan2	—	Yes
Q 63 (OPM)	1990	OPV	PUB	WH	—	OPM	—	TL	Yes	POP63	11	Yes
CP-DK888	1991	SC	PRIV	Y	SD	—	100-120	TL	No	—	—	Yes
LS3	1991	—	PUB	—	—	—	110-120	TL	Yes	POP49	11	—
LS4	1991	—	PUB	—	—	—	100-110	TL	Yes	POP28	21	—
LS5	1991	—	PUB	—	—	—	100-110	TL	—	—	—	—
LS6	1991	—	PUB	—	SD	—	110-120	TL	Yes	POP28	21	—
LS7	1991	—	PUB	—	—	—	120-135	TL	Yes	POP28	11	—
LS8	1991	—	PUB	—	SF	—	120-135	TL	—	—	—	—
LVN1	1991	SC	PUB	—	SF	—	100-110	TL	—	—	—	—
LVN11	1991	TC	PUB	—	SF	—	110-120	TL	—	—	—	—
LVN16	1991	SC	PUB	—	—	—	120-135	TL	—	—	—	—
LVN19	1991	SC	PUB	—	—	—	120-135	TL	—	—	—	—
LVN32	1991	TC	PUB	—	—	—	100-110	TL	—	—	—	—
9670	1992	DC	PRIV	Y	SD	—	100-110	TL	No	—	—	—
CP-DK999	1992	SC	PRIV	Y	F	—	100-110	TL	No	—	—	No
LVN6	1993	SC	PUB	Y	SD	HS	110-120	TL	Yes	POP31	21	No
CV1	1994	OPV	PUB	—	SF	—	—	TL	Yes	POP28	11	—
LVN10	1994	SC	PUB	Y	SF	HS	120-135	TL	No	—	—	Yes
LVN12	1994	DTC	PUB	Y	SF	—	110-120	TL	Yes	POP28	21	Yes
VN1	1994	OPV	PUB	Y	SF	HS	110-120	TL	Yes	POP21, V.54	11	No
9681	1996	DTC	PRIV	Y	SF	—	100-105	TL	No	—	—	—
9696	1996	TWC	PRIV	Y	F	—	110-115	TL	Yes	POP28	21	New
919V	1996	mod SC	PRIV	Y	SF	—	105-110	TL	No	—	—	—
LVN20	1996	SC	PUB	Y	D	HS	100-110	TL	Yes	POP49,26	11	Yes
LVN5	1996	DTC	PUB	Y	SF	HS	100-110	TL	Yes	POP28	21	Yes
MSB2649 (VIAMIT)	1996	OPV	PUB	Y	D	HS	100-110	TL	Yes	POP49	11	No
VN2 (waxy)	1996	OPV	PUB	WH	GLUT	—	<100	TL	No	—	—	Yes
9698	1997	SC	PRIV	Y	F	—	90-93	TL	Yes	POP28	21	New
9636	1998	TWC	PRIV	Y	SF	—	100-105	TL	Yes	POP28	21	New
LVN17	1998	SC	PUB	Y	SF	HS	110-120	TL	No	—	—	Yes
LVN18	1998	DTC	PUB	—	SD	—	110-120	TL	—	—	—	—
LVN26	1998	SC	PUB	—	SF	—	100-110	TL	Yes	POP26	21	—
LVN4	1998	SC	PUB	Y	SF	HS	110-120	TL	No	—	—	Yes
MX1	1999	SC	PUB	Y	F	—	90	TL	No	—	—	—
TSB3 (sweet corn)	—	OPV	PUB	—	—	—	—	TL	—	—	—	—

Note: Type of material: OPV = open-pollinated variety; CH = conventional hybrid; SC = single-cross hybrid; mod SC = modified single-cross hybrid; DC = double-cross hybrid; TWC = three-way-cross hybrid; DTC = double-top-cross hybrid; TC = top-cross hybrid. Owner: PRIV = private material; PUB = public material. Grain color: Y = yellow; WH = white. Grain texture: F = flint; SF = semi-flint; D = dent; SD = semi-dent; GLUT = glutinous. Ecological niche: TL = tropical lowland. Use of CIMMYT material: 11 = population, pool or experimental variety used as basic germplasm (substantial improvement done after receipt from CIMMYT); 21 = inbred line or hybrid used in pedigree program (substantial improvement done after receipt from CIMMYT). Important industrial trait: OPM = quality protein maize; HS = high starch.