Maize in Thailand
Production Systems, Constraints, and Research Priorities

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This study is part of a series of similar studies conducted in six other Asian countries: China, India, Indonesia, Nepal, Philippines, and Vietnam. The regional synthesis of these studies will provide important information to maize researchers, policymakers, and other stakeholders in the industry.

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Abstract

This is one of a series of seven in-depth country studies on maize production systems in Asia, funded by the International Maize and Wheat Improvement Center (CIMMYT) and the International Fund for Agricultural Development (IFAD). It is part of a project designed to promote sustainable intensification of maize production systems while ensuring equitable income growth and improved food security, especially for poor households that depend on maize.

Maize is one of five major crops grown in the uplands of Thailand, along with rice, cassava, sugar cane, and rubber trees. Government-promoted crop diversification, increased population growth, improved transportation networks, international trade, expansion of upland farming areas, and increased demand for grains from the domestic livestock and poultry industry stimulated Thailand's maize production beginning in the 1980s. However, Thailand's domestic maize supply is currently not sufficient to meet the needs of its in-country demands, and small quantities have to be imported.

Rapid economic growth and accelerated urbanization are expected to create an even higher demand for maize in Thailand. This trend will lead to the intensification of current maize production systems, with more land being shifted to maize production, particularly in marginal areas. Thailand's challenge is to produce more maize for an expanding market, while preserving the natural resource base and the environment through careful agricultural planning. Effective policy design and implementation must be based on comprehensive, accurate data on the current state of maize-based farming systems.

This study characterized the social and biophysical maize production environment of Thailand; examined its response to increasing maize demand; determined constraints to future productivity growth; indicated the potential environmental consequences, and examined the options available for promoting sustainable growth in maize production.

1. Introduction

1.1 Background

Maize is one of five major crops in Thailand. In addition to rice, cassava, sugarcane, and rubber, maize occupies a major portion (about 33%) of Thai upland farmlands. In 1984-85, 12.4 million *rai* (nearly 2 million ha) were planted to maize, ranking second only to rice (59 million *rai* or 9.5 million ha). In 1984, Thailand exported 3.0-3.7 million tons of maize and earned nearly 10,000 million baht (US$ 400 million), but thereafter maize area began to decline and occupied only 7.3 million *rai* (nearly 1.2 million ha) by 2002-03, with a production of around 4.5 million tons (Office of Agricultural Economics, 2003).

Maize was first planted in Thailand in 1950. At that time, it was planted in the uplands and highlands and used only for home consumption and household animal feed. When Thailand launched its first National Economic and Social Plan in 1961, maize became an export crop like rice. Government-promoted crop diversification, increased population growth, improved transportation networks, international trade, and expansion of upland farming areas made maize, cassava, and sugarcane important field crops in Thailand from the 1960s through the 1980s. Upland crop cultivation pushed into forest logging concession areas, and the increased production of maize, wet-rice, cassava, and sugarcane resulted in a concurrent decrease in forest areas. Maize farming was especially productive in these newly cleared forestlands, but the tractors used in its cultivation increased soil erosion and deforestation, which worsened throughout the 1980s, when the bulk of maize output was exported.

While Thailand was a major maize grain exporter in the 1980s, maize exports declined substantially in the 1990s as the domestic demand for grain increased along with the domestic livestock industry, which in turn processed its output into various exportable products. In recent years, Thailand's domestic maize production has not been adequate to meet domestic requirements, and small quantities of grain have been imported. Domestic maize production has also been negatively affected by variations in climatic and rainfall conditions, with occasional droughts substantially reducing maize output. Moreover, competing crops, such as sugarcane, cassava, and sunflower, sometimes replace maize when maize grain prices are low. All of these factors over the last two decades have resulted in a stagnating or decreasing trend in maize production in Thailand.

Nevertheless, maize remains a crop that is well adapted to the biophysical conditions of rural Thailand. In 2000, 1.35 million ha were planted to maize, and of all upland farm households about 37% (740,000) cultivated maize. At present, Northern Thailand is the largest maize-producing region, accounting for about 49% of the national acreage, followed by the Northeast Region with 26%. The Central Region accounts for 24% of the total maize area, leaving a tiny fraction to some of the southern provinces (Office of Agricultural Economics, 2002).

These different maize production areas apply varying management practices that in turn result in varying maize production conditions and results. Efforts to improve maize productivity and resultant farmer welfare in marginal and poverty areas of rural Thailand must begin with a study of the potential, constraints, needs, and decision-making patterns of farmer groups across the maize-producing regions of Thailand.

1.2 Objectives

This study was conducted to:

1. Observe the maize production environment, patterns, and farm-level practices in major maize farming regions of Thailand;

2. Ascertain how biophysical and socioeconomic conditions influence maize production, and thus farmer income, in upland and poverty areas; and

3. Establish the production potential, constraints, needs, and alternatives facing maize farmers in both major and marginal maize-growing areas.

1.3 Methodology

This study was conducted using techniques of rapid rural appraisal (RRA) and participatory rural appraisal (PRA) to investigate farm-level biophysical and socioeconomic conditions and farmer maize production practices. Group discussions were conducted with key informants and village leaders. Focused questionnaires were also employed to obtain more detail on individual farmer production practices, production costs, income, estimated profit, as well as on their experiences and constraints with regards to maize production. Data were analyzed using both descriptive and statistical methods.

Primary data collection was conducted in two phases. In Phase I, an RRA was conducted in 1999-2000, during which the farm-level data collected were those of 1998 and 1999 production years. Phase I RRA covered 8 provinces, 13 districts, and 24 *tambon* (sub-districts) in North, Northeast, and Central Thailand, currently the most important maize areas of the country. At each site, a group interview of at least four or five farmers was conducted, and another 8 to 15 farmers were individually interviewed using focused questionnaires. Group interviews covered village-level information on biophysical and socioeconomic conditions, trends in maize production, maize-based cropping systems, maize varieties used, pest and disease problems, credit and market sources, and other data. These interviews were supplemented with secondary information from the District Agricultural Extension Office for the sub-districts concerned. Individual farmer interviews collected specific information on production data, costs, prices, yields, input uses, and cropping practices. Eighty-five farmers across seventeen sites were interviewed in groups using participatory rural appraisal methods (PRA), and 218 more farmers from 21 sites were interviewed using focused questionnaires during the same period (Table 1). Figure 1 shows the study sites in 1999-2000.

Table 1. Phase I study sites and number of farmers interviewed, Thailand, 1999-2000.

Region / Province	District	Sub-district	Number of respondents: Informal group interviews	Number of respondents: Focused surveys	Production year
Central Plains					
1. Lop Buri	Chai Badan	Chai Badan (C1)	6	12	1998
	Pattananikom	Pattananikom (C2)	-	10	1998
		Chon Noi (C3)	2	9	1998
Lower North					
2. Nakorn Sawan	Pisari	Po Prasart (LN1)	4	7	1998
		Wang Koi (LN2)	1	7	1998
	Tak Fa	Kao Chai Tong (LN3)	4	8	1998
		Suk Sumrarn (LN4)	4	8	1998
3. Phetchabun	Nong Pai	Nong Pai (LN5)	1	8	1998
		Bua Wattana (LN6)	-	10	1998
	Chon Dan	Chon Dan (LN7)	-	8	1998
		Ta Kam (LN8)	4	8	1998
4. Kamphangphet	Muang	Na Po Kam (LN9)	6	-	1999
		Nong Pling (LN10)	5	-	1999
5. Phichit	Sam Ngam	Nong Sano (LN11)	12	-	1999
Upper North					
6. Chiang Rai	Teung	Wieng (UN1)	6	15	1999
		Ngaw (UN2)	6	16	1999
Lower Northeast					
7. Nakorn Ratchaseema	Pak Chong	Pak Chong (LNE1)	1	9	1998
		Nong Sarai (LNE2)	4	8	1998
	Dan Khun Tod	Huay Bong (LNE3)	-	5	1998
		Ta Kien (LNE4)	-	8	1998
Upper Northeast					
8. Loei	Muang	Nam Suay (UNE1)	-	15	1999
		Na Din Dum (UNE2)	-	20	1999
	Dan Sai	Dan Sai (UNE3)	6	12	1999
		Kok Ngam (UNE4)	6	15	1999
Total	**13**	**24**	**85**	**218**	**-**

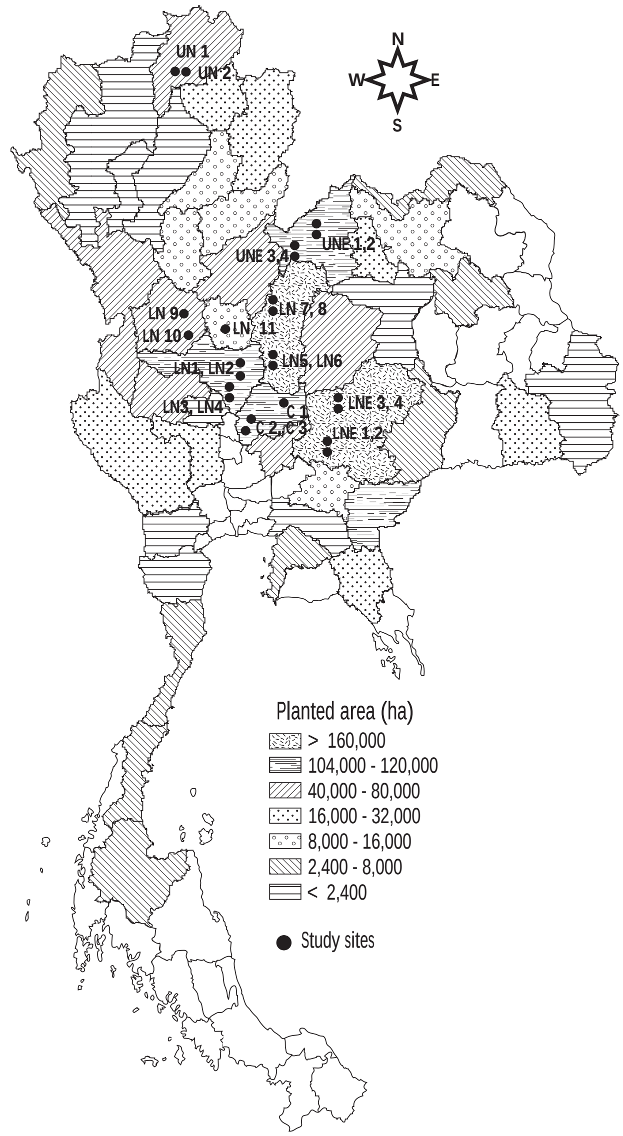

Figure 1. Phase I study sites, Thailand, 1999-2000.

In Phase II, RRA/PRA surveys were conducted in 2000 and 2001 to examine farm-level practices in major maize-producing areas in Thailand. In this phase, the study selected and expanded upon some issues for discussion, concentrated on poor farmers who farm marginal maize production areas, and placed greater emphasis on farmer group participation during data collection. Also, the focused surveys were conducted only in new sites where few prior studies had been done. The combined RRA/PRA methods allowed looking at maize farming and poor farmers' livelihoods holistically, which added strength to the study. The combined RRA/PRA methods in this phase involved secondary data collection and analysis, transect mapping, gender analysis, and individual and group interviews. Whenever possible, farmers were grouped according to wealth and gender, and interviewed separately.

Phase II added eight new sites to those surveyed during Phase I. In all sites other than Chiang Mai (where most maize output is used for household livestock), all Phase II survey sites produced maize commercially and sold the outputs to commercial feed mills serving the livestock industry. In line with the study's focus on poverty, special care was taken to select study areas where farmers are especially poor and living in marginal lands. Table 2 and Figure 2 present the sites surveyed and respondents interviewed in 2000 and 2001.

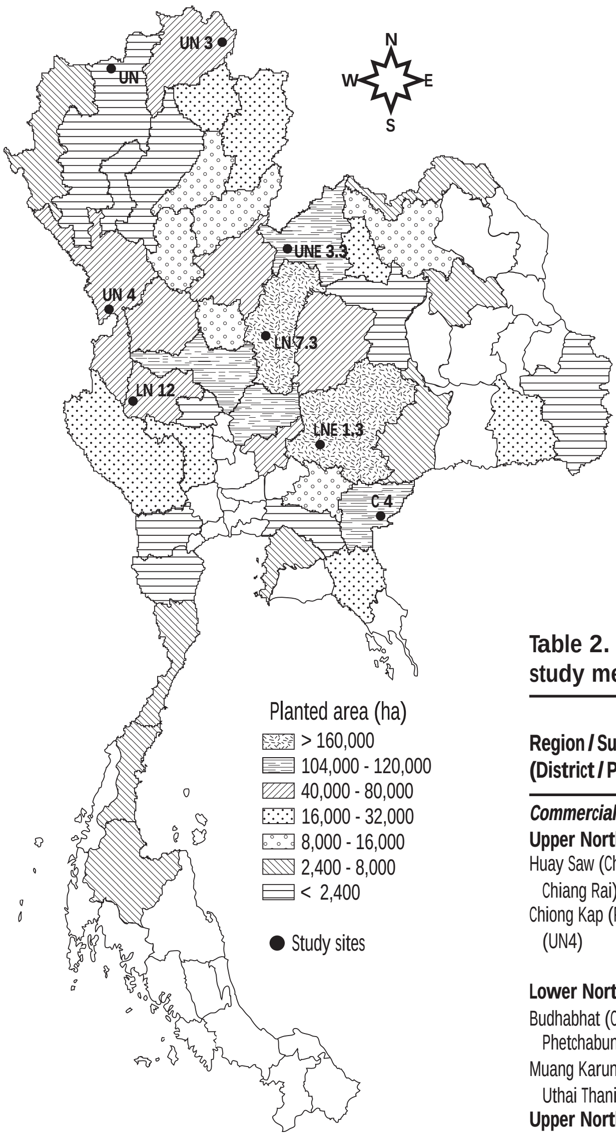

Figure 2. Phase II study sites, Thailand, 2000-2001.

Table 2. Phase II study sites and number of respondents interviewed, by study method, Thailand, 2000.

Region / Sub-district (District / Province)	Number of farmer-respondents		
	RRA	**PRA group interview**	**Focused survey**
Commercial maize production areas			
Upper North			
Huay Saw (Chiang Khong, Chiang Rai) (UN3)	Sub-district extension officer and 4 farmer leaders	2 groups of 22 farmers: 10 men and 12 women	3
Chiong Kap (Pop Pra, Tak) (UN4)	A farm leader and 3 farmers	3 groups of 26 farmers: 10 mixed gender group, 8 men, 8 women	18
Lower North			
Budhabhat (Chon Dan, Phetchabun) (LN7.3)	Sub-district extension officer and farmer leaders	4 groups of 50 farmers: 14 men, 14 women, 13 poor, 9 rich	3
Muang Karung (Ban Rai, Uthai Thani) (LN12)	A farmer leader and 3 farmers	3 groups of 25 farmers: 11 mixed gender, 6 men, 9 women	25
Upper Northeast			
Wang Yao (Dan Sai, Loei) (UNE3.3)	Sub-district extension officer and 5 farmer leaders	3 groups of 25 farmers: 9 men, 10 women, 6 poor	6
Lower Northeast			
Wang Kra Ta (Pak Chong, Nakorn Ratchaseema) (LNE1.3)	Sub-district extension officer and farmer leaders	2 groups of 23 farmers: 10 men, 13 women	—-
Central Plains			
Thai Udom (Klong Had, Sra Kaew) (C4)	Three farmer-leaders	3 groups of 24 farmers: 8 mixed gender, 7 men, 9 women	17
Semi-commercial maize production areas			
Upper North			
Muang Na (Chiang Dao, Chiang Mai) (UN5)	Farm leaders and 8 farmers	1 group of 13 male and female farmers	2
Total		**21 groups of 208 farmers**	**74**

2. Description of Maize Agro-ecologies

2.1 General Topography

Topographically, Thailand is naturally divided into four regions: North, Central Plain or Chao Phraya River Basin, Northeast or the Khorat Plateau, and South or Southern Isthmus.

The North is a mountainous region characterized by natural forests, ridges, and deep, narrow, alluvial valleys. Steep river valleys and upland areas that border the Central Plain incise these high mountains, which extend along the Burmese border down through the Malay Peninsula. A series of rivers, including the Ping, Wang, Yom, and Nan, unite in the lowlands to form the Chao Phraya watershed. Traditionally, these natural features have made possible several different types of agriculture, including wet-rice farming in the valleys and shifting cultivation in the uplands. In this region, winter temperatures are cool enough to allow the cultivation of temperate fruits such as apples, strawberries, and peaches.

The Northern region comprises three physiographic zones (Topark-Ngarm and Gutteridge, 1986): (1) the lowlands, which make up 15% of the area, and are relatively flat with fertile alluvial basins that produce paddy rice; (2) the uplands, which make up 45% of the area in undulating to hilly terrain to 500 meters above sea level (masl), and are principally planted to upland rice, maize, grain legumes and other field crops; and (3) the highlands, which make up 40% of the area with an altitude range of 500-2,500 masl, comprised of rugged, steep-sided mountains, which are dissected by high valleys and planted to upland rice, maize, and hidden cultivated areas of opium (Topark-Ngarm and Gutteridge, 1986). In this region, rainfall varies from 900 to 2000 mm, and temperatures vary from 29°C/13°F in January to 36°C/21°F in April. Temperatures decrease approximately 0.5°C per 100 m altitude, and frosts occur in sheltered highland locations. The Northern region produces the most maize in Thailand, with the majority of maize coming from the lowlands and uplands, with scattered plots in the highlands.

Central Thailand, a lush, fertile valley, is the richest and most extensive rice producing area in the country and has often been called the "Rice Bowl of Asia." The Central Plains is a lowland area dominated by cultivated paddy fields and drained by the Chao Phraya and its tributaries, the country's principal river system, which feeds into the delta at the head of the Gulf of Bangkok. The Chao Phraya system drains about one-third of the nation's territory. Here, the rather flat, unchanging landscape facilitates inland water and road transport.

The Northeast Region, with its poor soils, is not favored agriculturally. The region consists mainly of the arid Khorat Plateau and is characterized by a rolling surface and undulating hills, with sparse grasses covering much of the land. Harsh climatic conditions—short monsoon seasons and long dry seasons—often result in this region being subjected to heavy floods and droughts. Mountains ring the plateau on the west and the south, and the Mekong delineates much of the eastern rim. The Northeast Region is a slightly elevated plateau of 17 million ha at 100-300 masl. Rainfall varies from 900 to 2000 mm, with an average of 1250 mm per annum; 85% of this rain falls from mid-April to mid-October. Average monthly temperatures range from 30°C/17°F in December to 36°C/24°F in April. Principal land use in the region is rainfed paddy rice, upland field crops, forestlands, and grazing lands. A typical Northeast household cultivates 1-4 ha of upland crops (cassava, sugar cane, maize, horticultural crops) and raises one to three head of buffalo for use as draft animals. Many households also own a few head of cattle for draft and/or commercial sale.

The Southern Region is a hilly-to-mountainous narrow peninsula, with dramatically shaped mountains, thick virgin forests, and rich deposits of minerals and ores. Its economy is based on rice cultivation for subsistence and rubber production for industry. Other sources of income include tourism (particularly lucrative on Phuket Island), coconut plantations, and tin mining. Rolling and mountainous terrain and the absence of large rivers are conspicuous features of the South. North-south mountain barriers and impenetrable tropical forest caused the early isolation and separate political development of this region.

Together, the Chao Phraya and Mekong systems sustain Thailand's agricultural economy by supporting wet-rice cultivation and providing waterways for the transport of goods and people. In contrast, the distinguishing natural features of peninsular Thailand are long coastlines, offshore islands, and diminishing mangrove swamps.

The elevations of the North, Northeast, and Central Regions are presented in Figure 3. Maize in Thailand covers flat plains, uplands, and highlands (both with and without slopes), most of which are rainfed. In this study, two survey sites (Tueng District, Chiang Rai in the Upper North Region and Phichit in the Lower North Region) grow maize in the dry season after paddy rice. In Chiang Rai, farmers pump water from nearby streams and reservoirs to irrigate their maize crop. In Phichit, farmers invest in individual water wells, which were at one time subsidized by the government.

The Phase II study sites (Table 2) are more marginal production environments, yet they remain diverse in topography and soil conditions. These areas are either hilly sloping land (e.g., Dan Sai, Loei), narrow flat strips mostly adjacent to some hills (e.g., Chon Dan, Phetchabun), or highland plateaus (e.g., Chiang Dao, Chiang Mai). Some survey sites run along rivers but these are rather small tracts of land in the villages.

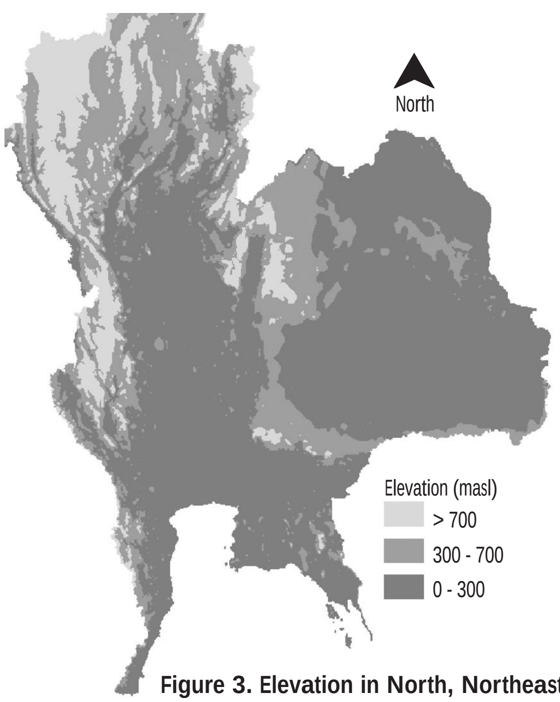

Figure 3. Elevation in North, Northeast, and Central Thailand.

2.2 Agro-ecology-Specific Maize Production Systems

The major maize production areas of Thailand can be grouped into two broad agro-ecozones: the rainfed uplands and the rice-based irrigated agro-ecozones. Upland agriculture makes up around 17% of the total agricultural production in Thailand. In the North, Northeast, and parts of the Central Plains, maize is grown in the uplands, lower mountain slopes, foothills, and highlands with altitudes greater than 500 masl. Maize does not like too much water, and the high rainfall in the South makes it unsuitable for maize production.

2.2.1 Rainfed uplands

Rainfall distribution is the major factor in rainfed upland agro-ecological zones. The rainy season in Thailand usually begins in May and lasts until the end of September. Maize is normally grown as the main first crop in every region at the beginning of the rainy season and is harvested after 100-120 days. The second crops are shorter-period crops that vary across locations even within the same region. In bimodal rainfall pattern areas, maize is planted in early April and harvested in July/August, followed by another crop of maize in a maize-maize cropping pattern. Other second crops grown are mung bean, groundnut, sorghum, red pea, and soybean.

Lopburi, Nakorn Sawan, Phetchabun, Nakorn Ratchaseema, and parts of Chiang Rai grow first-season maize from April to June, which are periods of early rain. Eighty-seven percent of maize in Thailand is produced in the first season, while 10% is produced as a second-season crop in the late rains of July and August, in Loei and other parts of Nakorn Ratchaseema and Chiang Rai.

2.2.2 Rice-based irrigated agro-ecozones

In these agro-ecozones, maize is planted in paddy fields in December or January after harvesting rice, making dry season irrigation necessary. Currently, only 3% of Thailand's total maize production comes from these areas, but the trend has been increasing in recent years. This practice was observed in the villages surveyed in Teung, Chiang Rai, and Sam Ngam, Phichit.

Some maize farmers have encroached on strictly reserved forest areas in Tak, Loei, and Chiang Mai. In these areas, farmers have neither secure land tenure nor guaranteed land entitlement. In Chiang Rai and Nakorn Ratchaseema, the government has awarded some maize farmers land reform certificates that guarantee them land use rights in land reform areas.

Historically, farmers have extensively used forestlands and forest areas for maize production. In the past 20 years, population growth, coupled with agricultural commercialization, has forced poor farmers to further exploit these frontier lands, and little forestland is left today, although some areas remain as forestlands legally. Given past patterns of land use, maize farmers often find themselves cultivating sloping land, which is vulnerable to erosion. Due to topographic and physical conditions of the lands, maize is still the only viable crop for farmers living in these areas. Alternative crops are either more risky or physically or socioeconomically unsuitable to these marginal farmers.

2.3 Biophysical Environment

2.3.1 Climate

Most survey sites averaged 400 masl in altitude, but the marginal production areas surveyed in Phase II were at 100-780 masl. Air temperatures averaged 25-27°C, with March-April as the hottest months and December-January as the coolest months (Table 3). In the last three to five years, rainfall averaged 1,100-1,500 mm/year. Rains start in April/May and peak in August/September. Recent years have seen occasional and periodic dry spells but no severe drought in the study sites. There are supplementary water sources such as wells, natural streams, reservoirs, and deep wells. Supplementary water is not, however, used for irrigating field crops but only for limited vegetable production and household use. In more favorable production areas, farmers have access to deep wells, allowing them to sometimes grow maize in the dry season. Dry season maize often gives good yield and fetches higher prices, a luxury farmers in marginal areas do not usually have.

2.3.2 Soil types

Table 4 shows the various soil types that support maize production in the Phase I and Phase II study sites, with farmer-reported advantages and disadvantages for maize cultivation.

Heavy-textured soil, such as clay and clay loam, was the most common soil type found across the surveyed maize production areas. Forty-three percent of the farmer-respondents in Phase I reported having heavy-textured soil such as clay and clay loam in their fields, 27% reported their soil as being fine-textured with mixed gravels, and 20% had medium-to-coarse textured soil. Only 10% of the farmer-respondents reported having fine-textured soil, which is most suitable to maize production. More than 30% of farmer-respondents reported having fine-textured soil in their land in areas such as Kao Chai Tong and Suk Sumrarn sub-districts, in Nakorn Sawan province and Ta Kam sub-district, Phetchabun province and Ta Kien sub-district, Nakorn Ratchaseema. Kamphaeng Phet, meanwhile, had low fertility fine-textured sandy loam soil, which has poor water-retention capacity and dries quickly after rains. In Phichit, where farmers grew dry season irrigated maize, the soil was sandy loam with good drainage.

Table 3. Terrain, altitude, rainfall, and temperature in Phase I and II study sites, Thailand, 2000.

	Terrain (estimated % of the region)					
Region / Province	Rainfed + irrigated	Rainfed lowland / upland	Rainfed highland / sloping	Average altitude (masl)	Rainfall (mm / year)	Average temperature (°C)
Commercial maize production areas						
Central Plains						
Lop Buri	0-10	77-85	5-23	60-100	1,200	28.4
Sra Kaew				120-150	1,473	26.9
Upper North						
Chiang Rai	5-65	35-95	—-	416	1,790	24.4
Tak				116	1,289	27.7
Upper Northeast						
Loei	0-20	30-65	25-50	400	1,289	26.0
Lower North						
Nakorn Sawan	10-20	60-90	10-30	35	1,110	28.4
Phetchabun	0-15	60-90	10-35	114	1,422	27.2
Kamphangphet	0-60	40-100	—-	43-107	1,287	27.6
Pichit	65	35	—-		1,198	27.0
Uthai Thani				120-150	1,474	26.5
Lower Northeast						
Nakorn Ratchaseema	0-15	65-90	10-35	150-300	1,069	27.8
Semi-commercial maize production areas						
Upper North						
Chiang Mai				310	1,140	25.6

Source: Estimates of terrain distribution from village-level secondary information and farmer interviews; rainfall from the Meteorological Department, Ministry of Communication. Rainfall was averaged for two years (1999-2000), three years (1997-1999), or 10 years, depending on data availability.

Table 4. Types of soil and their farmer-reported advantages and disadvantages, across surveyed villages, by region, Thailand, 2000.

Soil type	Selected local names	Advantages	Disadvantages
Central Plains			
Clay	*Chaibadan, Bureeram, Lopburi* (Lop Buri)	Good water-holding capacity	Difficult to plow; poor water drainage; prone to soil erosion
Dark clay	*Pakchong, Hangchat, Kaoyai, Chiangkong* (Sra Kaew-90%);	Suitable for growing maize, jackfruit, mango, longan with good yield; less chemical fertilizer application	Unsuitable for growing oranges–sour taste and poor yield
Clay loam	*Muang Kom* (Lop Buri)	Suitable for growing maize	Poor water drainage
Clay + lateritic soil	*Chiangkhan, Phusana, Kabinburi, Surin, Baitong* (Sra Kaew-10%)	Good yield if there is no drought; can grow cassava with big roots and good weight; easy harvesting	Poor water-holding capacity; requires too much fertilizer; drought-prone; low percentage of starch in cassava yield; difficult to plow
Lower North			
Clay	*Paktoa, Paisalee, Muangsri, Pakchong* (Nakorn Sawan); *Chaibadan*, *Lopburi, Wang Chompoo, Loei, Banmee, Smorthod, Lamnarai, Nakorn Pathom, Lomsak, Muaklek, Takli, Bungchanung* (Phetchabun); *Loei, Waghai* (Uthai Thani)	Good water-holding capacity; good soil fertility; less fertilizer requirement; high water-holding capacity	Difficult to plow; poor water drainage; wet/muddy in the rainy season causing poor yield
Clay loam	*Lamnara, Takli, Pakchong, Tabtong, Lopburi* (Nakorn Sawan); *Pichit, Koke Samrong, Chai Badan, Loie* (Phetchabun)	Good water-holding capacity; fair soil fertility	Poor water drainage; low soil fertility; difficult to plow; wet/muddy in the rainy season
Sandy loam	*Nakhonpathom, Pakkad, Dermbang, Tatum, Phichit* (Kamphangphet); *Kamphaengsan, Kamphaengpet, Tapanhan, Lamsonthi* (Pichit); *Sanpatong, Kaoplong, Hupkrapong, Yangtalad, Chumphang* (Uthai Thani)	Easy to plow; good soil if there is enough rain; seeds can germinate fast	Poor water-holding capacity; poor soil fertility; poor crop yield; requires too much fertilizer; poor water drainage
Upper North			
Sandy loam	Mae-Ing soil series (Chiang Rai)	Easy to plow; seeds germinate quickly	Poor water-holding capacity; poor water drainage
Sand	*Namphong, Chantuek* (Chiang Rai)	No hard-pan; easy to plow; minimal soil clodding	Poor water-holding capacity; not suitable for maize; risk of infertile soil
Sandy clay	*Pakchong, Hangchat, Chiangkong* (Chiang Rai)	Suitable for growing maize; low soil erosion	Holds too much water during rainy season, making maize prone to stem rot
Brown loam	(Tak)	Easy plowing; suitable for growing maize, mung bean, and groundnut; allows easy harvesting of groundnut	Weevils; poor groundnut yield (poor weight)
Brown clay loam	*Banchong, Chiang Khong, Mae Taeng, Pak Chong* (Chiang Mai-80%)	Suitable for growing any crop	Provides less yield than black clay loam soil
Black clay loam	*Hang Dong, Pan, Lae Ngoo, Ta Toom, Sukhothai, Phichit, Nakhonpathom* (Chiang Mai-20%)	More suitable for planting maize than reddish loam soil; absorbs more water than reddish loam soil; can be used for planting rice	Difficult to plow; not suitable for groundnut
Lower Northeast			
Clay loam	*Tali, Sobprab, Pisali* (Nakorn Ratchaseema)	Good water-holding capacity	Some laterite in soil
Black loan	*Tacli, Buengchanung* (Nakorn Ratchaseema)	Suitable for maize	Poor water-holding capacity in the dry season
Sandy loam	*Petchaboon, Pranburi, Sriracha, Korat, Satuk, Varin, Yasotorn, Dan Sai, Mabbon* (Nakorn Ratchaseema);	Good drainage	Poor water-holding capacity in the dry season; requires organic fertilizers
Clay (including red and brown clay)	*Ban Chong, Chiang Khong, Mae Taeng, Pak Chong, Sung Nern, Pakchong, Hangchat, Kaoyai, Chokchai, Sungnern, Banchong, Chiangkong, Nongmod, Maetaeng* (Nakorn Ratchaseema-70%)	Good water-holding capacity; more soil nutrients; good maize yield	Less porous soil; difficult to plow and lumpy in the rainy season; tends to lose moisture rapidly when there is no rain
Sandy clay	(Nakorn Ratchaseema-10%)	Good maize yield; easy for seed planting; fast seed germination	Tends to waterlog when raining; prone to drought
Sand	*Kumbong* (Nakorn Ratchaseema)	Good drainage	Poor soil fertility
Upper Northeast			
Sandy loam	*Hang Dong, Pan, Ratchaburi, Mae Lai* (Loei)	Easy to plow; good drainage; suitable for paddy rice	Poor soil fertility
Brown clay loam	*Lei, Wang Hai, Thatpanom, Dan Sai* (Loei)	Good water-holding capacity	Difficult to plow
Clay	*Tamuang, Mae sai, Hang dong, Chiang Rai, Loei, Chieng karn, Wang sapung* (Loei)	Good water-holding capacity	Poor soil; poor water drainage; difficult to plow
Clay loam	*Lei, Wang Hai, Thatpanom, Dan Sai, San Pa Tong, Hang Chat, Korat* (Loei)	Suitable for every crop especially maize; easy to plow	Found on sloping areas and prone to soil erosion; fair drainage

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys 1999-2000.

Many Phase II survey sites were found to have gravelly heavy-textured soils. Flat terrain near hilly lands sometimes had black or reddish fine-or fine-to-medium-textured soil. Maize also grew well in areas with sandy loam soils and good drainage. A few areas had reddish and black loam soil, which was considered good for crop production, although these areas were not widespread. Some farmers reported experiencing declining soil fertility due to erosion, and were worried about the future of maize production in these erosion-prone areas. Most farmers were interested in technologies that promote better soil conservation. Farmers reported that mechanized farming was common and worsened the soil erosion problem in sloping areas.

2.4 Institutional Environment

2.4.1 Line agency offices

The Department of Agricultural Extension (DOAE), and the Ministry of Agriculture and Agricultural Cooperatives (MOAC), with their sub-district offices, handle agricultural extension services for all crops in Thailand, including maize. The DOAE has had programs of hybrid seed and fertilizer use promotion, which initially came with government subsidies and have been credited with increased hybrid maize use in Thailand.

The Department of Agriculture (DOA), MOAC, and universities such as Kasetsart University also conduct maize agronomic and plant breeding research. Ekasingh et al. (2001a) outline the development of maize breeding research in Thailand. For farming capital, the Bank of Agriculture and Agricultural Cooperatives (BAAC) extends credit to maize farmers, who rely heavily on such financial assistance each production season.

2.4.2 Cooperatives and user groups

Some farmers organized themselves into farmer cooperatives and groups, mainly to request and obtain production credit and material inputs, especially seeds and fertilizers. Loans are paid with interest after harvesting and sale of output. These farmer cooperatives often do not deal with output marketing, which each farmer does individually through extensive networks of private merchants. Most outputs are sold to local private traders.

2.4.3 Sources of material inputs

Material farm inputs (seeds, fertilizers, and other chemical inputs) are commonly obtained through cash purchase or credit from BAAC, farmer groups, and local merchants. Farmers relied more on BAAC for seed and, to a lesser extent, fertilizers, and obtained other inputs from local merchants (Appendix, Table 1). The major reason for this practice is that farmers can purchase fertilizer and other chemical inputs from merchants on credit, but have to pay cash if obtaining them from the BAAC. Generally, no explicit interest was charged for purchasing on credit from merchants, but the price actually included implicit interests. A few farmers obtained some inputs, especially seed, from government programs located in their district, such as District Agricultural Extension Office, DOAE, or the Field Crop Research Center, DOA.

When asked about problems related to purchased inputs, most farmers said they were unhappy with the high prices of hybrid seed and fertilizers, and some questioned the quality of these inputs, especially fertilizers.

2.4.4 Credit institutions

In general, maize farmers in Thailand depend heavily on borrowed capital. Only 13% of the farmer-respondents in this study used their own capital in crop production. About 35% of farmers borrowed farm capital from either BAAC or local merchants, while another 51% used a combination of their own and borrowed capital. As such, an overwhelming majority (87%) of farmer-respondents depended somehow on borrowed farm capital (Appendix, Table 2a). Of the total amount borrowed, at least 70% was obtained from BAAC and 20-70% was obtained from local merchants. Maize farmers in Tak and Chiang Mai (Upper North) also borrowed farming capital from their village funds (Appendix, Table 2b).

When farmers borrowed from local merchants, some had to pay 3-5% interest a month on top of the higher price of required inputs they bought through credit. In contrast, the loan interest rate from BAAC, agricultural cooperatives, or farmer groups was only 9-12% per year.

2.4.5 Prices of farm inputs and outputs

Table 5 summarizes the range of input and output prices reported from the survey areas. After extensive programs of hybrid seed promotion, most farmers in Thailand are now growing hybrid maize. In 1998-99, hybrid maize seed prices were high at 80-90 baht/kg (US$ 2.00-2.25/kg), compared to 15 baht /kg (US$ 0.38/kg) for seed of open pollinated varieties (OPV). Taking an average output price of 3.50 baht/kg (US$ 0.09/kg) in 1999, the grain-to-seed price ratio for maize in Thailand was as high as 1:26. However, farmers quickly learn that using improved maize seed does not cost more, it pays more. In Thailand, an increase of only 0.4 t/ha yield (at 4 baht/kg, or US$ 0.10/kg) will pay for the cost of single-cross hybrid seed to sow 1 ha (at 80 baht/kg or US$ 2.00/kg and a seed rate of 18 kg/ha), provided all other input costs remain the same (Ekasingh et al., 2001b).

Fertilizer prices were around 350-400 baht per 50-kg bag. The most common fertilizers used in maize production were urea (46-0-0), Triple 15 (15-15-15), and 16-20-0, which cost 310.75, 414.43 and 399.30 baht per 50-kg bag, respectively. The price of the same formula fertilizer can be quite different depending on the brand.

Table 5. Average prices of maize seed, urea, and agricultural labor, Phase I study sites, Thailand, 2000.

Study site	No. of farmers inter-viewed	Average maize seed price (baht/kg)	Average urea price (baht/kg)	Wage rate (baht/person-day)
Central Plains–Lopburi				
Chai Badan, Chai Badan	12	85.2	6.36	120
Pattananikom, Pattananikom	10	75.0	6.23	120
Chon Noi, Pattananikom	9	71.3	7.13	120
Lower North				
Nakorn Sawan				
Po Prasart, Pisari	7	84.6	6.03	100
Wang Koi, Pisari	7	83.3	5.67	100
Kao Chai Tong, Tak Fa	8	78.6	6.55	100
Suk Sumrarn, Tak Fa	8	79.4	6.51	120
Phetchabun				
Nong Pai, Nong Pai	8	80.7	6.00	120
Bua Wattana, Nong Pai	10	88.9	6.86	120
Chon Dan, Chon Dan	8	75.1	5.98	100
Ta Kam, Chon Dan	8	83.7	5.88	100
Upper North–Chiang Rai				
Wieng, Teung	15	78.6	8.79	100
Ngaw, Teung	16	72.2	5.47	100
Lower Northeast–Nakorn Ratchaseema				
Pak Chong, Pak Chong	9	75.8	7.00	100
Nong Sarai, Pak Chong	8	79.1	6.24	100
Huay Bong, Dan Khun Tod	5	85.0	7.60	100
Ta Kien, Dan Khun Tod	8	84.3	7.20	100
Upper Northeast–Loei				
Nam Suay, Muang	15	84.4	5.79	100
Na Din Dum, Muang	20	85.8	6.03	100
Dan Sai, Dan Sai	12	85.8	6.50	100
Kok Ngam, Dan Sai	15	85.0	5.40	70
Total/average all sites	**218**	**81.5**	**6.21**	**104**

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey 1999-2000.

Agricultural wages were around 120 baht/person-day (US$ 3.00/person-day), depending on location and off-farm opportunities. In some areas wage rate variation depended on gender, i.e., male laborers received 100-120 baht, while female laborers received 80-100 baht per day.

The price of maize grain in Thailand depends on its moisture content, which can vary depending on season, month, and harvesting method. In 1999, the average farm gate price for maize was 3.64 baht/kg (US$ 0.09/kg, the lowest being 2.98 baht/kg (US$ 0.08/kg) in September and the highest 4.58 baht/kg (US$ 0.12/kg) in May/June. In 2000, the farm gate price of maize ranged from as low as 2.20 baht/kg (US$ 0.06/kg) in a remote Upper North site in August to as high as 4.60 baht/kg (US$ 0.12/kg) in a Lower North site in December/January, when maize is dried in the fields before harvesting. Grain output prices also depended on grain quality and on how far a given site was from Bangkok. Maize from the Upper North usually fetched a lower price compared to that from the Lower North and the Lower Northeast.

Farmers observed that input prices have increased in recent years, while output prices have remained more or less at the same level or even declined. Ekasingh et al. (2001b) reported that profit from maize farming has been minimal. The highest profit from maize farming in the study area was 5,110.90 baht/ha (US$ 127.80/ha) and the lowest profit was 762.80 baht/ha (US$ 19.10/ha).

2.5 Infrastructure

2.5.1 Accessibility and irrigation facilities

Maize farmers have good access to product markets because transportation infrastructure and systems are good in Thailand. In remote maize production areas, difficult road situations have forced farmers to harvest and sell their maize in the dry season, even if the output is ready for harvest in the rainy season. This is a rare situation, and occurs primarily because farmers cannot sell their rainy season grains for a good price after harvest. Most farmers have access to reasonable roads, and merchant services are readily available.

Most maize in Thailand is cultivated in the uplands, making the need for irrigation minimal. Only baby corn and sweet corn are normally planted in irrigated fields after the main season wet-rice cultivation, and only selected maize-producing areas in Phichit and Chiang Rai have access to irrigation facilities.

2.5.2 Post-harvest facilities

Maize farmers in Thailand store their output in sacks inside storage barns. Storage facilities are often quite basic, usually composed of farm sheds. Most farmers sell their output after milling in their fields, for which they contract a milling machine from merchants. The machine is brought to the village, and milling is normally done on wet grains right after harvesting.

2.5.3 Markets and marketing practices

The 1999 RRA survey found that about 55% of maize farmers sold their output immediately after harvest. About 25% kept the output for a month or two before selling, 15% kept it for two to three months, and about 5% kept it for more than three months. The longest time farmers stored the output while waiting for better market prices was five months.

In all sites except Sra Kaew (Central Plains) and Nakorn Ratchaseema (Lower Northeast), small merchants would come into the villages and offer to buy farmers' maize production. If the farmers provided threshing labor, the small merchants would thresh the grain at no extra cost.

Most merchants who came to the villages had lent farmers some capital for household or farm production use; the farmers were therefore obliged to sell their output to the merchant-financiers. In a few cases, farmers themselves performed the merchants' task of assembling the outputs for delivery. In some cases, merchants from other districts would come and trade in the villages. Small pick-ups or large trucks transported the maize grain after assembly. In Sra Kaew and Nakorn Ratchaseema, the normal practice was for farmers to use carts fixed to small tractors to transport their maize grain to the merchants. Some maize farmers in Uthai Thani (Lower North) sold their output to BAAC, and those in Nakorn Ratchaseema (Lower Northeast) sold their grain to cooperatives.

2.6 Socioeconomic Characteristics

2.6.1 Households and ethnicity

Most maize farmers in Thailand are ethnically Thai, and only a minority belongs to hill tribes. The hill tribes grow yellow and white dent and semi-dent maize in the highlands for food and home-based animal feed. The Thai maize farmers grow yellow flint and semi-flint maize for the commercial animal feed market. A minority of the Thai group grows white dent maize and sweet corn for sale and home use.

2.6.2 Literacy and level of education

Most family members have either primary (4-6 years of schooling) or secondary education. Only about 1% of them have tertiary education. On average across Thailand, Thai people attended school for 7.2 years, and 38.9% in the 6-24 year age range is illiterate (National Statistics Office, 2000).

2.6.3 Landholdings and tenure systems

In 1999, the average size of maize farms across all surveyed areas was 7.3 ha. About 33% of the farmer-respondents had a small farm (average: 2 ha). Almost 36% of farmers had a medium-size farm (5 ha), and 31% had large farms (average: about 16 ha) (Appendix, Table 3). Only Pattananikom district, in Lopburi province, and Pak Chong district, in Nakorn Ratchaseema province, had farmers with large farms of more than 16 ha. The largest farm size found was 80 ha, in tambon Pak Chong, Nakorn Ratchaseema province. Maize farmers in the Central Plains, Lower North, and Lower Northeast farmed larger plots than those in the Upper North. Maize farm areas in Pattananikom district, Lopburi, Pisari district, and Nakorn Sawan and Pak Chong district, Nakorn Ratchaseema, averaged 20.8 ha, 12.3 ha, and 26.1 ha, respectively. In contrast, maize farmers in Wieng and Ngaw sub-districts in Chiang Rai province (Upper North) only had 2.2-3.4 ha on average. The large farmers in these areas had 6 ha.

In the uplands and highlands, most farmers do not have land certificates, and land can be used only once a year. In the plains, most farmers have their own land and land certificates. They use land one to three times a year, while farmers who have neither land nor land certificates will rent land from others for growing crops.

In1998-1999, 145 (67%) of the 218 maize farmers interviewed owned their farmland, 49 (22.5%) were part owners, and 23 (10.6%) were tenants (see Appendix, Table 3, for details). Large farmers have a higher proportion of rented land than smaller farmers. For example, maize farmers in Pak Chong sub-district, Nakorn Ratchaseema and Pattananikom in Lopburi who have more than 16 ha rented over 60% of their farmland for maize cultivation. In terms of area involved, farmers in Lopburi and Pak Chong, Nakorn Ratchaseema, had more rented area under maize than their own land.

2.6.4 Utilization of maize

Maize in Thailand is predominantly used for animal feed, with 80-100% production being sold to commercial poultry and livestock feed mills. It is a highly commercial crop, handled by an extensive network of merchants. Maize sold as animal feed is mainly used domestically, and only a small fraction is exported.

Meanwhile, about 5-20% of all maize grown in Thailand is consumed as food, either as white corn or sweet corn. Among the survey areas, traditional maize consumers were reported in Pop Pra district, Tak province and Chiang Dao district, Chiang Mai province (Upper North), and in Pak Chong district, Nakorn Ratchaseema province (Lower Northeast).

2.6.5 Types of farmers

One exercise conducted in this study was the classification of maize farmers within the community by income group, for which farmer-respondents were asked to provide descriptions and general characteristics. Farmers in the survey sites were classified into three income groups—poor, medium, and rich farmers—and each group was characterized in terms of farm size, income source, household size, and number of owned livestock, among other parameters identified by the farmer-respondents themselves.

Poor farmers were characterized as those having farms not exceeding 10 *rai* (1.6 ha). Medium farmers have about 20-50 *rai* (3.2-8 ha), while well-to-do farmers can have 50, 100, or more *rai* (8-16 ha). The majority (69.3%) of farmers were either medium or poor, and only a few (30.7%) were well-to-do. Ownership of land (especially paddy land) and other assets such as tractors, vehicles, and income are among factors differentiating farmer groups (Figures 4 and 5).

Farmers' incomes tended to vary according to location. Maize farmers in the flat terrain of the Central Plains, Lower North, and Lower Northeast of Thailand have relatively larger average farm sizes at 77.4, 40.8, and 74.5 *rai* (12.4, 6.5, and 11.9 ha), respectively, and their income is higher than that of farmers in the Upper North and Upper Northeast. Poorer farm households earned an average 30,000 baht (US$ 750) per household per year. Medium farm households earned an average of 50,000-80,000 baht (US$ 1250-2,000) per household per year, and well-to-do farmers averaged more than 100,000 baht (US$ 2500) per household per year. The main source of income of well-to-do farmers was maize production, but poorer households depended mostly on salaried employment for their livelihoods. Well-to-do farmers, on the other hand, obtain a larger proportion of their income from non-farm occupations. Table 6 summarizes the characteristics of the maize farmers in the marginal uplands of Thailand by wealth status.

2.6.6 Poverty and level of income

The profitability of maize production in Thailand was calculated based on primary yield and input/output price data collected during individual farmer interviews in 1999. At that time, farmers could obtain a profit of 1,230-4,087 baht/ha from maize cultivation. Table 7 shows that maize production in the late rainy season, the dry season, and on smaller farms gave higher profits than during the early rainy season or on medium and large farms.

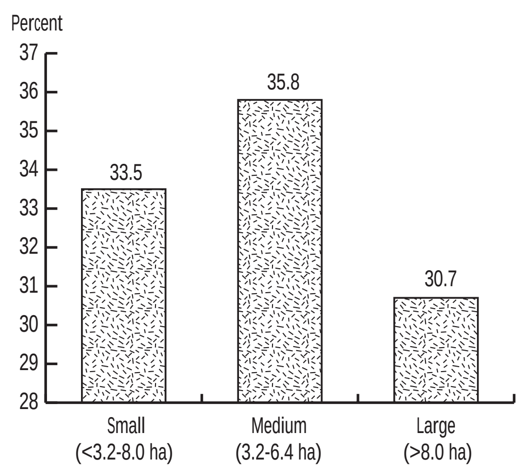

Figure 4. Farmers in the study area, as classified by farm size, Thailand, 1998-1999.

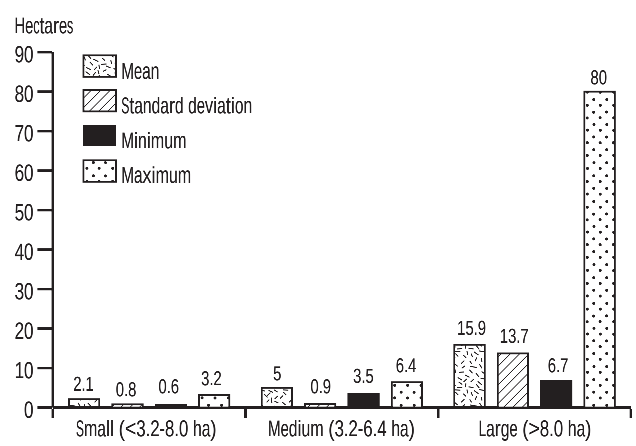

Figure 5. Mean, standard deviation, minimum, and maximum maize cultivation area, classified by farm size, Thailand, 1998-1999.

In terms of total household income, however, large farms earned higher profits than medium and small farms did. Large farms enjoyed a return on cash costs of around 52,000 baht per household, while medium farms averaged 25,000 baht/household and small farms averaged 12,500 baht per household. The income of a Northern Thai farmer averaged around 81,191 baht per household, while the income of Central Plains and Northeast farmers averaged around 80,161 and 79,101 baht per household, respectively, in 1999.

Analyses at the sub-district level showed that in 1998-99 many maize production sites in Thailand experienced low grain yields and high production costs, such that farmers earned very little profit, or even incurred losses, from maize cultivation (Table 8). Some of these areas were Dan Sai and Kok Ngam sub-districts, Loei province (Upper Northeast), Pattananikom and Chai Badan sub-districts, Lopburi province (Central Plains) and Bua Wattana and Chon Dan sub-districts, Phetchabun province (Lower North).

Nevertheless, maize remains the main source of income in the study sites, contributing an average of 70% of total household income across the 24 sub-districts surveyed. The remaining 30% is accounted for by production of other crops, livestock, and off-farm employment (Appendix, Table 4). Maize production in Huay Bong sub-district, Nakorn Ratchaseema province (Lower Northeast), contributed the smallest proportion (35.7%) of total household income, while in Dan Sai sub-district, Loei province (Upper Northeast) it contributed the most (94.7%) to household income.

Farmer-respondents reported that maize was easy to grow and had low production risks compared to other crops. Maize was drought tolerant, had no insect or disease problems, and allowed double cropping. Maize was also the best crop for the rainfed uplands with good rainfall. BAAC would lend money to maize

Table 7. Measures of maize production profitability, Thailand, 1998-1999.

	Average profit (baht/ha)	Return on cash costs (baht/ha)	Return on cash costs (baht/household)
Crop season			
Early rainy	1,494	4,663	35,066
Late rainy	4,087	6,681	56,655
Dry	3,544	9,731	21,797
Average farm size			
Small (<3.2 ha)	2,181	6,019	12,520
Medium (3.2-6.4 ha)	2,000	5,094	25,266
Large (>6.4 ha)	1,232	3,269	51,781

Source: IFAD-CIMMYT RRA/PRA Surveys, Thailand, 1998-99.

Table 6. Farmer classification and characteristics by wealth group, Phase II study sites, Thailand, 2000.

	Farmer group by wealth status		
Survey site	**Poor**	**Medium**	**Rich**
Chiang Khong district, Chiang Rai (Upper North)	Farm size: < 1.6 ha(upland + paddy fields) Income: 15,000 baht/household/year	Farm size: 1.6-4.8 ha(upland + paddy fields) Income: 30,000-40,000 baht/household/year	Farm size: 4.8-11.2 ha (paddy fields 3.2-9.6 ha and upland 2.4 ha) Income: 70,000-80,000 baht/household/year
Pop Pra district, Tak (Upper North)	Farm size: < 3.2 ha Low income	Farm size: 3.2-6.4 ha No capital, or low, inadequate capital Not enough land; some need to rent more land	Farm size: > 8 ha
Chon Dan district, Phetchabun (Lower North)	Farm size: < 1.6 ha	Farm size: 3.2 - 8 ha	Farm size: > 8 ha
Ban Rai district, Uthai Thani (Lower North)	Farm size: < 1.6 ha	Farm size: 3.2-4.8 ha	Farm size: >16 ha; own tractors
Dan Sai district, Loei (Upper Northeast)	Farm size: < 3.2 ha Capital: < 10,000 baht	Farm size: 4.8-8 ha Capital: 30,000-50,000 baht	Farm size: 8-16 ha Capital: >50,000 baht
Pak Chong district, Nakorn Ratchaseema (Lower Northeast)	Farm size: 1.6-3.2 ha	Farm size: 3.2-8 ha	Farm size: > 8 ha
Klong Had district, Sra Kaew (Central Plains)	Farm size: < 1.6 ha Income: high percent from wages	Farm size: 3.2-6.4 ha Income: 70% from crops; 30% from wages	Farm size: > 8 ha Income: 80% from crops, 20% from wages
Chiang Dao district, Chiang Mai (Upper North)	Farm size: 0.8 ha Income: <10,000baht/year	Farm size: 1.6-3.2 ha Income: 15,000-20,000 baht/year	Farm size: > 4.0 ha Income: 20,000-30,000 baht/year

Source: IFAD-CIMMYT PRA Surveys, Thailand, 2000.

farmers more easily, and good markets were available for the output. When output prices were high, all maize farmers enjoyed good income. For the past 10 years, however, the price of maize grain has been stagnant, while production costs have been increasing. For example, in Chiang Khong sub-district, Chiang Rai province, droughts or extended dry spells and maize grain price pegged at 2.50 baht/kg for the last 10 years have caused farmers to switch from maize cultivation to planting fruit trees. Farmers thus reported that while they favor growing maize, they might decide to quit planting the crop if better alternatives present themselves.

Table 8. Yield, grain price, and production costs by sub-district, Thailand.

Study site	Yield (t/ha)	Grain price (baht/kg)	Production costs (baht/kg)	Net profit (baht/ha)
Central Plains-*Lopburi*				
Chai Badan, Chai Badan	3.37	3.26	3.27	842.4
Pattananikom, Pattananikom	2.95	3.12	3.53	-354.4
Chon Noi, Pattananikom	4.44	3.41	2.68	3,240.3
Lower North				
Nakorn Sawan				
Po Prasart, Pisari	4.34	3.36	2.60	3,296.0
Wang Koi, Pisari	3.60	3.57	3.51	2,017.4
Kao Chai Tong, Tak Fa	3.90	3.46	2.60	3,359.4
Suk Sumrarn, Tak Fa	4.60	3.41	2.30	5,110.9
Phetchabun				
Nong Pai, Nong Pai	3.75	2.99	2.75	1,274.6
Bua Wattana, Nong Pai	3.61	3.31	3.55	469.8
Chon Dan, Chon Dan	3.83	2.98	3.91	957.8
Ta Kam, Chon Dan	3.79	3.54	2.62	3,486.3
Upper North-*Chiang Rai*				
Wieng, Teung	4.20	3.34	3.12	1,008.9
Ngaw, Teung	5.10	3.47	2.46	3,582.0
Lower Northeast-*Nakorn Ratchaseema*				
Pak Chong, Pak Chong	4.46	3.72	2.62	4,910.8
Nong Sarai, Pak Chong	3.54	3.62	3.42	707.6
Huay Bong, Dan Khun Tod	3.27	3.74	3.61	424.6
Ta Kien, Dan Khun Tod	3.14	4.07	3.60	1,478.1
Upper Northeast-*Loei*				
Nam Suay, Muang	3.18	4.03	3.25	2,480.9
Na Din Dum, Muang	3.84	4.07	3.13	3,614.9
Dan Sai, Dan Sai	2.18	4.24	5.10	762.8
Kok Ngam, Dan Sai	2.06	4.58	4.00	1,193.4

Source: IFAD-CIMMYT RRA/PRA Surveys, Thailand, 1998-99.

3. Maize Production Trends and Systems

3.1 Maize Production Trends

During the production year 1997/98, Thailand produced 3.83 million tons of maize from 1.4 million ha (Office of Agricultural Economics, 1999). Using geographic information system tools to study land suitability for maize at the district and provincial levels, a study found that some 14.6 million ha (28.6%) of all areas in Thailand was suitable for growing maize (Office of Agricultural Economics, 2000). Maize is currently planted in 1.3-1.4 million ha, yet the 2000 study found that 4.4 million ha were suitable for growing the crop. This indicates that Thailand has the land potential to expand its maize area by another three million ha, although the potential success of growing maize on this land will, of course, depend on both biophysical and socioeconomic conditions.

Maize area in Thailand declined from about 1.8 million ha in 1990 to stabilize at around 1.2 million ha today. Low maize grain prices and high production costs are the major reasons for the decline. Some areas in Chiang Rai (Upper North) now plant only one maize crop a year, when before they grew two. In Nakorn Ratchaseema (Lower Northeast), Phetchabun (Lower North), and Loei (Upper Northeast), some maize areas are now planted to fruit trees. In Sra Kaew province (Central Plains), some maize farmers have switched to sugarcane and cassava (Appendix, Table 5). In Tak (Upper North) farmers continue to grow maize, but only because there are no good crop substitutes. In Chiang Dao district, Chiang Mai, maize area slightly increased in the last couple of years with the adoption of hybrid maize. Chiang Dao farmers, however, have small farms planted to a variety of crops; hence, the increase in maize area was not substantial. In general, farmers' decisions to continue maize cultivation depend heavily on favorable maize grain prices compared to those of competing crops. As of 2001, the maize area in Thailand was stable at around 7 million *rai* (1.2 million ha) (Figure 6).

Several studies have looked at maize production and its general constraints. Saran and Sanit (1997) found that the majority (63.7%) of maize farmers in Pak Chong district, Nakorn Ratchaseema (Lower Northeast), tended to maintain the same farm size over time due to land and labor constraints, while 19% tended to reduce theirs due to high production costs. A range of factors was found to constrain increased maize production, including drought or extended dry spells, soil degradation, high input (fertilizers, maize seed), low grain prices, and unfair treatment from grain merchants (Saran and Sanit, 1997; Tipatorn et al., 1994; Mullika and Bumpen, 1997).

3.2 Maize Production Systems

3.2.1 Major farm enterprises

Thai farmers usually plant maize as their major farm enterprise. In addition, most maize is grown in the uplands, where there is limited opportunity to pursue any other enterprise. Some minor or secondary crops can be grown either before or after maize, but they would provide an even lower income than maize. Other sources, including wage employment, contribute about 30% of maize farmers' incomes.

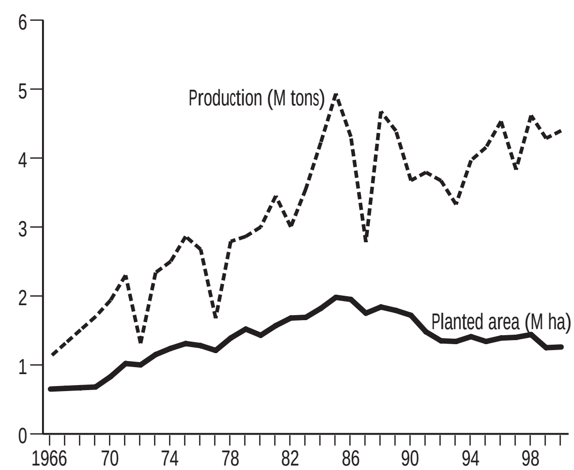

Figure 6. Maize area and production, Thailand, 1966-2000.

3.2.2 Crops and cropping patterns

Most maize areas surveyed in this study had two cropping seasons, but only six (out of 31) sub-districts planted maize in both seasons. In most of the Lower Northeast, Upper Northeast, and some parts of the Lower North, farmers planted only one crop of maize per year during the early rainy season from April to June (Table 9). In Ngaw sub-district, Chiang Rai, dry season maize was planted after wet season paddy rice. In Loei province (Upper Northeast), farmers planted only one crop of maize in the rainy season, but some would plant it between rows of fruit trees. Some farmers also integrated maize into young banana plantations, or rotated it with cassava. In Kamphangphet (Lower North), farmers planted the first maize crop in the early rainy season, followed by second and third maize crops when there was sufficient water. In Uthai Thani (Lower North) and a few other areas, maize is grown in the late rainy season (Figure 7).

After maize, Central Plains and Lower North farmers commonly plant sunflower, sorghum, or mung bean, and Upper North farmers grow groundnut, black bean, or garlic. In Phichit (Lower North), farmers grow dry season irrigated maize after their wet season paddy rice, a practice that is being promoted by the District Agricultural Office. Other crops grown after maize include soybean, chili, cotton, cassava, Job's tears, and rice-beans.

In Chiang Mai (Upper North), farmers plant both maize and groundnut in the early and late rainy seasons. Maize is less risky than groundnut but is grown primarily to feed backyard animals because its market price is often low and unprofitable. Groundnut, meanwhile, tends to have more variable yields but better prices.

To fully exploit field moisture and shorten growth periods, farmers sometimes plant the new crop while maize is still standing in the fields. This was observed especially in late season rice, beans, cotton, and mung bean.

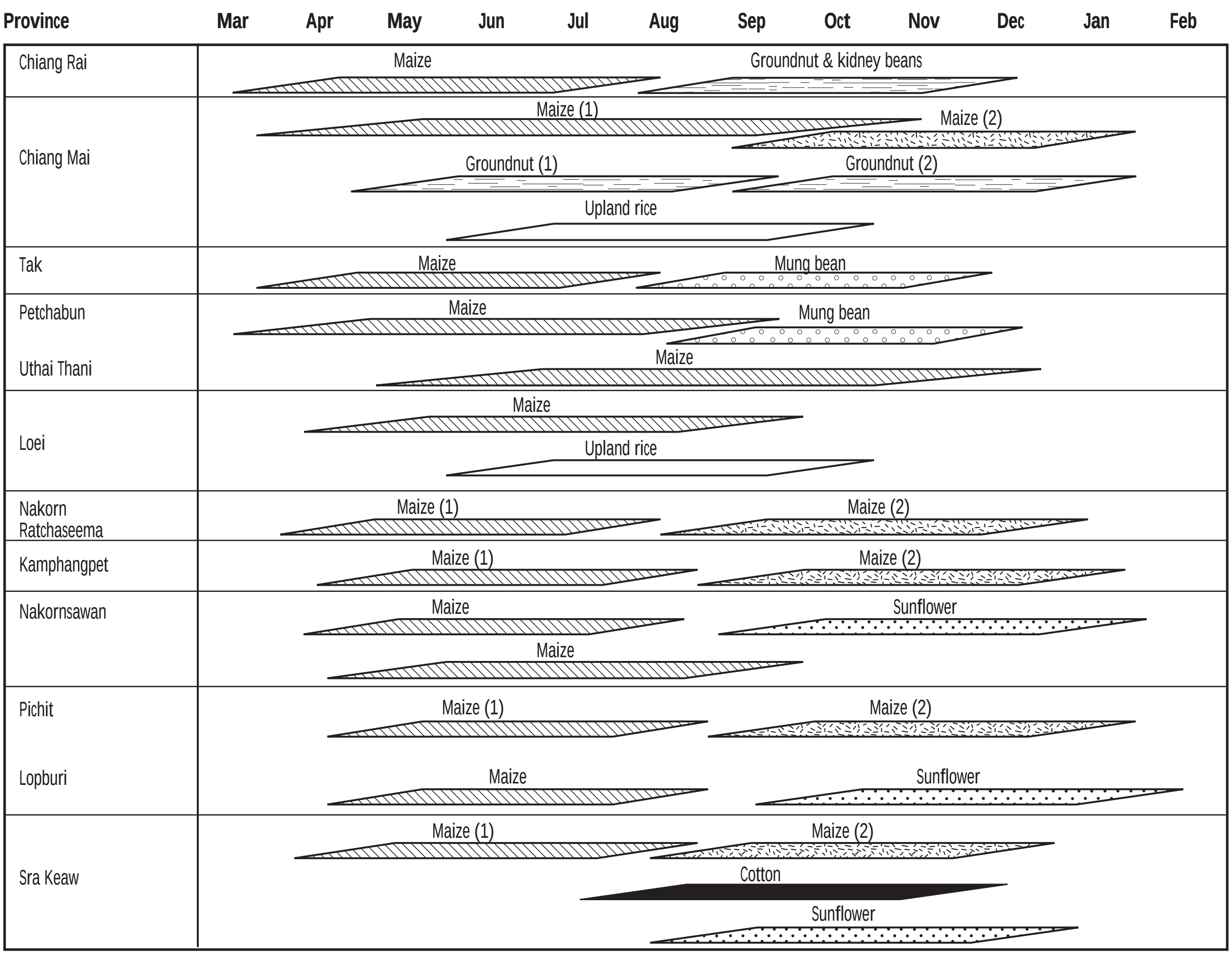

Figure 7. Maize-based cropping systems in Phase I and Phase II study sites, Thailand.

Table 9. Maize-based cropping patterns in selected regions, Thailand.

Location	Major cropping pattern	Minor cropping pattern
Central Plains		
Lop Buri		
Chai Badan, Chai Badan	Maize–sunflower	Maize–sorghum
Pattananikom, Pattananikom	Maize–sunflower	Maize
Chon Noi, Pattananikom	Maize–sunflower	Maize–sorghum
Sra Kaew		
Thai Udom, Klong Had	Maize–maize; maize–cotton; maize–sunflower	Maize–soybean; maize–mung bean
Lower North		
Nakorn Sawan		
Po Prasart, Pisari	Maize–sunflower	Maize–chili
Wang Koi, Pisari	Maize–sorghum	Maize
Kao Chai Tong, Tak Fa	Maize	Maize–sunflower
Suk Sumrarn, Tak Fa	Maize	Maize–sunflower
Phetchabun		
Nong Pai, Nong Pai	Maize–mung bean	—-
Bua Wattana, Nong Pai	Maize–mung bean	Maize
Chon Dan, Chon Dan	Maize–mung bean	Maize
Ta Kam, Chon Dan	Maize	—-
Budhabhat, Chon Dan	Maize	Maize–mung bean; maize–black bean
Kamphangphet		
Na Po Kam, Muang	Maize–maize, banana	Maize–maize–maize
Nong Pling	Maize, cassava	Mung bean
Pichit		
Nong Sano, Sam Ngam	Maize–maize Paddy rice–maize	Maize–maize–maize
Uthai Thani		
Muang Karung, Ban Rai	Maize	Maize, paddy rice (in lowlands); maize, fruit trees
Upper North		
Chiang Rai		
Wieng, Teung	Maize–maize	Maize
Ngaw, Teung	Paddy rice–maize	Maize
Huay Saw, Chiang Khong	Maize Maize and fruit trees	Maize–groundnut; maize–black bean; maize–maize
Tak		
Chong Kap, Pop Pra	Maize–mung bean	Maize; maize–garlic; maize/ groundnut intercropped
Chiang Mai		
Muang Na, Chiang Dao	Maize, upland rice, groundnut, vegetables in the early rainy season Groundnut, maize, vegetables in the late rainy season	
Lower Northeast		
Nakorn Ratchaseema		
Pak Chong, Pak Chong	Maize	Maize–maize
Nong Sarai, Pak Chong	Maize–maize	Maize
Wang Kra Ta, Pak Chong	Maize–maize	Mung bean–maize; maize and fruit trees
Huay Bong, Dan KhunTod	Maize	Maize–cassava
Ta Kien, Dan Khun Tod	Maize	—-
Upper Northeast		
Loei		
Nam Suay, Muang	Maize	Maize <-> fruit orchards
Na Din Dum, Muang	Maize	Maize <-> fruit orchards
Dan Sai, Dan Sai	Maize	Maize–mung bean
Kok Ngam, Dan Sai	Maize	Maize–groundnut
Wang Yao, Dan Sai	Maize, upland rice	Maize–rice–beans; maize–rice–beans; upland rice–rice–beans; maize–Job's tears

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys 1998-99 and 2000.

Fruit trees were the primary competing crops of maize, especially in highland areas such as Chiang Rai and Tak (Upper North), Loei (Upper Northeast), and Phetchabun (Lower North), where maize yields and grain prices were quite low. Fruit trees grown include lychee, longan, tamarind, and mango. While government extension officials promoted these fruit trees, only a few farmers actually adopted them because of capital and irrigation constraints. Farmers who grew fruit trees struggled with lack of irrigation water and consequent poor yield levels.

Growing fruit trees in the rainfed uplands is recognized as an ecologically sound practice, but there are still practical problems such as the identification of suitable species and varieties, and there is also concern that fruit tree based land use systems can be jeopardized if not carefully planned with sufficient technical support. To date, fruit trees are not yet widely adopted in the rainfed uplands of Thailand, and farmers were found to have limited options to switch from maize to other crops.

In the Central Plains and Lower North lowland areas (e.g., Sra Kaew and Uthai Thani provinces), sugarcane and cassava were the crops competing with maize. Physically, farmers could switch to the two competing crops. Sugarcane requires a large area, high capital, and good market outlets, which were often controlled by a sugarcane mill. Cassava requires less capital than sugarcane, but has a low output price, similar to that of maize. Consequently, lowland farmers still preferred to plant maize because it is easy to grow, has a short growing cycle, and the grain can be stored for higher prices. Both sugarcane and cassava need to be sold right after harvest.

3.2.3 Maize cropping calendar

In Thailand, the first crop of maize is usually grown in May. Land preparation and sowing begins in April/May after the first rain, and harvesting is done beginning in August and through September. The second maize crop starts in September and ends by December. The rainy season starts in April and lasts until October, after which there is very little rain. The second season of maize gets only a few weeks of rain, and crop production is often subject to high risk of drought. Farmers harvest their product dry in the fields in either December or January.

The third maize season, from January to April, is only possible in paddy fields with irrigation. Since only a limited area can be planted with third season maize, the small output often fetches a relatively high price.

3.2.4 Maize varieties grown and farmer preferences

In 1999/2000, only 4 of the 218 farmer-respondents (barely 2%) across 24 sites in 8 provinces were still growing OPV maize. These four respondents reported having temporarily switched from hybrids to OPV maize due to lack of farming capital to purchase (single-cross) hybrid seed, which is four to six times more expensive than OPV seed (Table 10). CPDK 888 was the most popular single-cross hybrid variety, followed by C919 and C717 from Cargill group. CPDK 888 is better harvested when dry in the field, while both C919 and C717 mature early and give good fresh grain weight. A few farmers planted Novartis and Pioneer hybrids.

Across all survey sites, maize farmers, even those who only grow the crop for household animal feed, preferred hybrid seed from private companies. They specifically preferred maize varieties with high yield potential and good grain weight (Table 11). Cropping patterns determine the characteristics of the maize varieties that farmers will plant. If farmers grow late rainy season maize followed by early rainy season maize, for the first season they prefer early maturing varieties that will give good fresh grain weight. If farmers will not be planting any crop following maize, they choose a variety with good dry grain weight.

In many sites, maize farmers also try to grow new hybrids as recommended by seed company salesmen and BAAC officials. Farmers stop using the new hybrids when the crop fails. New hybrids that performed satisfactorily were used repeatedly, sometimes for up to 10 years, until farmers found new or better ones. For instance, CPDK 888 has been in the market for more than 10 years, and farmers reported that its seed quality is seen to be declining. Farmers felt that the seed quality of such expensive varieties ought to be maintained through time. In some instances, farmers stated a preference for hybrids that were released earlier and have since become unavailable on the market.

In general, maize farmers prefer to buy and plant reasonably priced seed that produce early maturing, high yielding hybrids with large ears and good grain color. More specifically, farmers like their maize plants to yield two or three big pods with large grains and small well-filled ears. Other farmer-identified characteristics desired in a maize plant included high germination rate, good plant height, drought tolerance, insect and disease resistance/tolerance, resistance to lodging, and ease of harvesting (Table 12; see also Benjavan, 1996, and Tippatorn, 1994). Farmers also look for good fresh weight in early maturing varieties, and good dry weight for the late maturing ones. Some farmers also reported planting government subsidized hybrids, while still others chose hybrids with cheaper seed to lower their maize production costs.

Table 11. Maize varieties commonly planted by farmers and reasons for their adoption, Thailand, 2000.

Commonly grown maize varieties	Reasons farmers chose a variety
C333	Promoted by government extension officials (no longer planted)(Muang Karung, Ban Rai district, Uthai Thani)
C717	Good grain yield and color; cheap seed; small ears; easy to harvest
C727	Suitable for the soil (Central Plains)
C919	Good/high yields and fresh grain weight; good grain color; early maturing; easy to harvest; small ears
C949	High yield; good grain color; small ears; easy to harvest
CPDK 888	Good/high yield; suitable for the soil (Upper North, Lower North); healthy plants; drought tolerant; good dry grain weight; can be harvested dry; produces two ears per plant; no lodging
CPDK 989	High yield/good weight; drought tolerant; no lodging; suitable for the soil (Lower North, Central Plains)
CPDK 999	High yield; suitable for the soil (Upper North)
Pioneer 3012	Promoted by government extension officials (Thai Udom, Klong Had district, Sra Kaew)
White glutinous maize	Used for home consumption

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys, 2000.

Table 10. Hybrid and open pollinated varieties (OPVs) used by maize farmers and their seed prices in Phase I study sites, Thailand, 1998-99.

	Farmer-respondents		Maize seed price (baht/kg)			
Maize seed type	Number	% of total	Minimum	Maximum	Mean	Standard deviation
Single-cross hybrids	**265**	**97.8**				
CPDK888	141	52.0	50	100	82.5	8.54
Cargill 717	14	5.2	67	80	73.7	5.07
Cargill 919	51	18.8	45	110	83.4	11.29
Pioneer	22	8.1	49	98	81.1	15.05
Pacific	7	2.5	28	72	43.3	24.44
Novartis	30[1]	11.1	49	90	74.6	14.07
OPV maize	**6**	**2.2**	**15**	**15**	**15.0**	**—-**

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys 1999-2000.

[1] 22 farmers in *tambon* Ngaw (Upper North) planted these in the dry season.

Note: Percentages shown in this table are not a result of a random representation of all maize farmers in Thailand and should be used with care.

Table 12. Characteristics of maize varieties most desired by farmers, Thailand, 2000.

Farmer-identified maize characteristics	Farmer-respondents Number	%
Lower seed prices	133	61.0
High yield	38	17.4
Drought tolerance	23	10.6
Good quality	18	8.3
Insect pest resistance	17	7.8
High germination rate	15	6.9
Early maturity	8	3.7
Seeds can be kept for another season	4	1.8
Other (good shape, size, color, easy to harvest)	15	6.9

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 2000.

3.2.5 Land preparation and crop management practices

Table 13 summarizes the farm operations and practices found in the eight sub-districts surveyed during the Phase II study. For some areas surveyed, land preparation consisted of land clearing, burning crop residues, and tillage by tractors. Land clearing and burning of crop residues were often done in February-March, and tillage was mostly done in April, just before sowing. All survey sites used large tractors for land preparation–tilling the soil twice in the plains and once on sloping lands. Soil tillage was done less frequently in sloping areas because it exposes the land to soil erosion and is more costly. In the uplands of Uthai Thani (Lower North), farmers had small farms, which they tilled twice, first with large tractors and then with their own small tractors.

In Phase I, 15 of the 24 survey areas were using mechanical seeders to plant maize, especially on large farms in the Lower North, Lower Northeast, and Central Plains Regions. These seeders are of many types: some allow combined seeding and fertilizer application, some are attached to a two-wheel tractor, and still others can be attached to large four-wheel tractors. In Ta Kam sub-district in Chon Dan, Phetchabun (Lower North) a mechanical seeder attached to a two-wheel tractor was used, while in smaller farms of eight sub-districts in the Upper North, Upper Northeast, and Lower North Regions, maize was planted using manual labor (Table 13).

Planting is done from mid-April to early May for the early rainy season, and in July for the late rainy season. In Chiang Rai and Chiang Mai (Upper North) and in

Table 13. Operations and practices used in maize production, Thailand, 2000.

	Huay Saw, Chiang Rai	Chong Kap, Tak	Budhabhat, Phetchabun	Muang Karung, Uthai Thani	Wang Yao, Loei	Wang Kra Ta, N. Ratchaseema	Thai Udom, Sra Kaew	Muang Na, Chiang Mai
Land preparation								
Land clearance	Slash & burn of crop residues	Plow crop residues under	Plow crop residues under	Slash & burn of crop residues	Slash & burn of crop residues	Plow crop residues under	Burn residues	Slash & burn of crop residues
Tillage operations (No.)	1-2	1	2	3-4	1	2	2	1
Planting method								
Manual	√	√	—	—	√	—	—	√
Seeder with tractor	—	√	√	√	—	√	√	—
Seed rate (kg/ha)	15.6-21.9	15.6-18.9	18.9-23.0	18.9-21.9	17.5-21.9	15.6-20.0	15.6-20.6	18.8-21.9
Plant spacing (cm)	na[a]	30 x 80	25 x 75	20 x 70	75 x 75	na	na	25 x 80
Weeding								
Weeder with small tractor	√	—	—	√	—	—	—	—
Pre-emergence	—	√	√	√	√	√	√	√
Post-emergence	√	√	√	√	√	√	√	√
Fertilizer use								
No. of times applied	1	1	2	2	1	2	2	1
Timing of fertilizer application	During sowing	20-30 days after sowing	1st during sowing or ~20 days after; 2nd 45-60 days after sowing	1st during sowing or ~20 days after; 2nd 45-60 days after sowing	During sowing or ~20 days after	1st during sowing; 2nd 45-60 days after sowing	1st during sowing; 2nd 45-60 days after sowing	1st 45-60 days after sowing
Fertilizer type	46-0-0	16-20-0 46-0-0	15-15-15 16-20-0 46-0-0	15-15-15	16-20-20	16-20-0 46-0-0	46-0-0 15-15-15	46-0-0
Rate of fertilizer use (kg/ha)	150	220	250-375	250-375	125-150	300-375	250-375	100-300
Harvest method	Manual	Manual	Manual	Manual	Manual	Manual	Manual	Manual
Exchange labor	√				√			√
Hired labor		√	√	√		√	√	

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 2000.

[a] na = not available.

Loei (Upper Northeast), where maize areas are somewhat sloping and farms are small, maize was still planted manually with exchange farm labor. In other sites, planting was done using a planter fixed to a small tractor.

Farmers planted their maize at distances of either 25-30 x 75-80 cm or 75-80 x 75-80 cm, using around 19-22 kg/ha of seed, with 2-3 seeds/hill. Seed rate tended to be greater when maize was planted manually than when a mechanical seeder (normal seed rate: 2 seeds/hill) was used. Some farmers replanted spaces where seeds did not germinate and thinned to allow at least one to two plants per hill one month after sowing in case of drought.

In Chiang Rai (Upper North), Kamphaengphet and Phichit (Lower North), farmers had access to irrigation water pumped from rivers, reservoirs, or deep wells. They would irrigate three to four times per season, i.e., once before sowing and at 20, 50, and 70 days after sowing. Farmers reported having better yields yet higher fuel costs with irrigation. In total, the average net profit of rainy season maize production (2,187.50 baht/ha) was lower than that during the dry season (3,556 baht/ha).

Weed control was reportedly more important than insect and disease control in maize cultivation in Thailand. Farmers would spray pre-emergence herbicide after planting and do mechanical weeding when the maize plants were about 30-40 days old. Mechanical weeding was sometimes done simultaneously with the second round of fertilizer application. Post-emergence herbicide was also used when weeds were occasionally abundant.

Across Thailand, mechanization of farm operations is becoming a necessity for maize farmers, especially for land preparation, sowing, fertilizer application, and weeding. Small trucks are also used for transporting farm inputs and output. Mechanized land preparation, however, leads to soil erosion on sloping land, and maize cultivation in such areas may not be sustainable in the long term. Farmers recognize this production constraint but report that they unfortunately have very few means to combat it.

3.2.6 Labor use

In order of magnitude, harvesting, weeding, manual sowing/planting, and fertilizer application required the most labor in maize production. Larger farms usually use family and hired labor, while smaller farms, such as those in Chiang Rai and Chiang Mai (Upper North) and Loei (Upper Northeast), used only family and exchange labor. Hired labor in general was paid 80-120 baht/person-day; labor for herbicide application was paid at 80-100 baht/*rai*, while that for harvesting was paid 20-25 baht/sack of maize ears harvested.

In all sites, men and women farmers helped each other in maize production. The men prepared the land and carried/transported farm inputs and outputs. They also drove small tractors during crop establishment (planting), while the women planted the seed and applied fertilizers. In some sites, women farmers would do more manual planting, weeding, and harvesting than the men. But the men would help the women carry and handle the sacks of maize grain.

3.2.7 Material input use

Thai farmers planted maize using an average seeding rate of 16.9 kg/ha (Table 14). About 52.3% of the farmer-respondents seeded maize at 12.5-18.8 kg/ha, and about 25% of maize farmers, mostly from Phetchabun and Nakorn Ratchaseema, seeded at a rate higher than 18.8 kg/ha to protect against low seed germination.

The most popular fertilizers used in maize production were ammonium phosphate (16-20-0), urea (46-0-0), and complete fertilizer (15-15-15). More than 65% of farmer-respondents used either ammonium phosphate or urea, and 30% of them used complete fertilizer. Farmers applied fertilizers either once or twice in maize production. For a one-time application, fertilizers were applied at 20 days after sowing, but most farmers applied fertilizers twice. The first fertilizer application was done simultaneously with sowing, using a mechanical seeder. The second application was done either at flowering or 45-60 days after sowing. Fertilizers were placed next to the maize plants without soil cover. In Uthai Thani (Lower North), two-wheel tractors were used to cover the fertilizers with soil. Where maize is sown manually, farmers applied fertilizers either at planting or 20 days after sowing.

Farmers fertilized their maize at a range of 100-375 kg/ha with an average of 215 kg/ha. Of the farmer-respondents, 40% fertilized at 125-250 kg/ha, and 26% at 250-375 kg/ha. Farmers in Loei province fertilized at the lowest rate (125-187.5 kg/ha), while those in Nakorn Ratchaseema applied the highest (300-375 kg/ha). On average, the recommended fertilizer application rate was 187.5-312.5 kg/ha. On average, Thai maize farmers applied 57.8 kg/ha of nitrogen, 25.6 kg/ha of phosphorus, and 5.4 kg/ha of potassium (Table 14).

Richer maize farmers in traditional maize growing areas such as Phetchabun and Uthai Thani (Lower North) and Nakorn Ratchaseema (Lower Northeast) applied a higher rate of fertilizer than the other farmers did. All farmer-respondents claimed that higher maize yield would not be possible without chemical fertilizers, but concurrently recognized the decline of soil fertility with continuous maize cropping.

3.2.8 Harvest and post-harvest practices

In all surveyed villages, maize harvesting was done manually using family, exchange, and hired labor. Harvesting teams were contracted from outside the villages, sometimes coming from as far as other provinces or regions. Many Northeasterners made their living harvesting maize, making 20-25 baht/sack of maize ears. When the maize ears were too hard to separate from the plant, laborers asked for higher wages, causing farmers to avoid such maize hybrids. Farmer-respondents reported that the labor costs for harvesting was a substantial economic factor in maize production. In Teung sub-district, Chiang Rai, and Dan Sai sub-district, Loei, farm sizes were small, and exchange labor was used to harvest maize, thereby reducing cash costs.

Table 14. Seed and fertilizer use in farmers' maize fields, Thailand, 1998-1999.

Survey site	Seed rate (kg/ha)	Total fertilizer rate (kg/ha)	Equivalent nutrients (kg/ha) N	P	K
Central Plains–*Lopburi*					
Chai Badan, Chai Badan	14.8	175.0	38.1	23.8	11.3
Pattananikom, Pattananikom	14.9	201.3	47.5	27.2	9.8
Chon Noi, Pattananikom	16.8	210.6	71.3	12.8	9.4
Lower North					
Nakorn Sawan					
Po Prasart, Pisari	16.8	316.9	91.9	34.9	2.0
Wang Koi, Pisari	17.7	296.9	85.6	34.0	—
Kao Chai Tong, Tak Fa	17.1	240.0	59.4	32.5	5.0
Suk Sumrarn, Tak Fa	15.1	263.8	70.6	32.4	2.9
Phetchabun					
Nong Pai, Nong Pai	18.2	179.4	54.4	18.1	1.9
Bua Wattana, Nong Pai	19.8	320.6	108.8	26.3	—
Chon Dan, Chon Dan	19.5	301.9	85.6	35.9	—
Ta Kam, Chon Dan	21.0	168.8	35.6	28.1	—
Upper North–*Chiang Rai*					
Wieng, Teung	19.4	168.8	55.6	14.3	0.8
Ngaw, Teung	14.7	288.8	92.5	26.6	2.2
Lower Northeast–*Nakorn Ratchaseema*					
Pak Chong, Pak Chong	20.0	339.4	101.9	36.4	2.6
Nong Sarai, Pak Chong	18.2	181.3	61.3	34.9	2.0
Huay Bong, Dan Khun Tod	20.0	188.1	31.3	22.5	19.6
Ta Kien, Dan Khun Tod	15.3	225.6	44.4	36.9	5.5
Upper Northeast–*Loei*					
Nam Suay, Muang	17.3	176.3	49.4	20.6	15.0
Na Din Dum, Muang	19.1	189.4	35.0	28.8	15.0
Dan Sai, Dan Sai	11.2	106.3	20.0	17.0	7.0
Kok Ngam, Dan Sai	13.6	152.5	24.4	23.6	7.9
All sites	16.9	215.0	57.8	25.6	5.4

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 1999-2000.

Maize was harvested in one of two ways, depending on whether another maize crop would follow or not. Farmers who grew a second maize crop harvested the first in July right after maturity, when the fresh grains still had 20-30% moisture content ("wet"). Maize harvested this way had to be sold immediately even at low prices because fungi attacks the fresh grain when stored. Farmers reported that maize weight would be very much reduced if stored, such that the higher prices obtained at a later date might not cover the loss of income due to the lower grain weight. Farmers also felt that storage requires additional grain handling and management.

Meanwhile, farmers who grew only one maize crop left the plants to dry in the field until harvest in September, October, or even November. Maize grains were then harvested "dry" (15-20% moisture content). Some farmers sold the grain immediately after harvest, and others kept the grain in storage barns while waiting for better prices. Most farmers had their own storage barns.

Most maize farmers did not keep their output and instead immediately sold it, especially grain harvested in the rainy season. This practice allowed farmers to avoid the post-harvest aflatoxin problem. The grain, however, had high moisture content and was often sold at low farm gate prices. A few farmers kept their "wet" grain in sacks in storage sheds, but aflatoxin often set in. Most farmers sold their grain to merchants after milling with a machine that was also contracted from merchants. The mill is hauled to the village, where milling is done immediately after harvest. The merchants dried and stored the milled grain in their silos. Large feed mill companies to whom merchants sold the grain also stored it in their facilities. As most maize is now consumed domestically, people no longer consider aflatoxin a major problem.

3.2.9 Yields and reasons for the yield gap

In 1999, the national average maize yield in Thailand was 2.74 t/ha, with early and late rainy season average yields of 2.72 t/ha and 2.88 t/ha, respectively (Office of Agricultural Economics, 1999). This national average yield was considered quite low, considering that 87% of farmers use private sector hybrid seed (mostly single-cross). In 2000, the national average maize yield increased to 3.49 t/ha (Office of Agricultural Economics, 2000), although actual yield levels varied by production area (Table 15).

In this study, maize yields across all surveyed sites averaged about 3.66 t/ha, with about 87 maize farmers (40%) producing 3.13–4.69 t/ha, and 34 (15%) harvesting 4.69-6.25 t/ha. Eleven (5%) of the farmer-respondents obtained at least 6.25 t/ha, but 21 (10%) obtained an unusually low yield of less than 1.88 t/ha. Another 65 (30%) of the farmer-respondents obtained a relatively low yield of 1.88-3.13 t/ha. A comparison across seasons shows that the average dry season maize (irrigated) yield was the highest, at 4.97 t/ha (Appendix, Table 6a), while the average early rainy season maize yield was 3.52 t/ha, and the late rainy season average was 3.75 t/ha (Appendix, Table 6b).

In terms of fresh yield (>30% moisture content), farmers in the study sites obtained 800-900 kg/*rai* (5.0-5.6 t/ha), except in Huay Saw sub-district, Chiang Khong, Chiang Rai (Upper North), where fresh yields were only 500-600 kg/*rai* (3.1-3.7 t/ha). Farmers in Huay Saw sub-district apply fertilizer only once and only one kind of fertilizer over the years. Maize growing areas that have grown maize repeatedly for some 20 years show soil fertility problems (Table 16).

When farmers harvested their maize dry, yields were lower, about 400-800 kg/*rai* (2.5-5.0 t/ha). In Wang Yao sub-district, Loei (Upper Northeast) and Muang Na sub-district, Chiang Mai (Upper North), for example, yields were rather low at 400-500 or 500-600 kg/*rai* (2.5-3.75 t/ha), for reasons similar to those in Chiang Rai (mentioned above). Farmers applied fertilizers only once, used the same kind repeatedly, and used a low fertilizer rate of application. In Wang Yao, farmers had termite and rat problems while drying maize in the field and during storage in the barns.

In contrast, farmers in Muang Karung sub-district, Uthai Thani (Lower North) and Wang Kra Ta sub-district, Nakorn Ratchaseema (Lower Northeast), applied fertilizers twice and used more than one kind of fertilizer. Farmers in Chiong Kap sub-district, Tak (Upper North), applied fertilizer only once but used a high rate and more than one kind of fertilizer together.

In seven out of eight study sites in Phase II, farmers sold all their maize to merchants and did not keep any for home use or for seed. In Muang Karung sub-district, Uthai Thani, some farmers collected fallen (leftover) maize grain in the fields for chicken feed. In Chiong Kap sub-district, Tak and Wang Kra Ta sub-district, Nakorn Ratchaseema, a few farmers kept some low-quality maize grain for pig feed. Farmers said that hybrid maize gave them higher yields, and the high output allowed them to keep some grain as animal feed after they sold the majority. In Chiang Dao district, Chiang Mai, hill farmers normally plant yellow maize for animal feed, leaving the remaining output for sale. In the last three years, however, hill farmers switched to hybrid maize and enjoyed higher yields, so they changed their cropping patterns. Early rainy season maize was planted for the market, and only a small proportion of seed was kept for planting in the late rainy season or the following year. In the late rainy season, when only 30% of the land was planted to maize, harvested grain was used for animal feed.

Table 15. Average hybrid maize yield levels in different locations, Thailand.

Location	Production period	Hybrid maize yield (t/ha)	Reference
Upper North Region	1994	4.30	Tipatorn et al., 1994
Nakorn Sawan (Lower North)	1994	3.67	Benjavan, 1996
Phetchabun, Chiang Rai and Chaiyaphum (paddy areas)	1996/97	4.06-5.31	Mallika and Bumpen, 1997
Pak Chong, Nakorn Ratchaseema (Lower Northeast)	1997	2.96 (early rainy) 2.91 (late rainy)	Saran and Sanit, 1997
Pak Chong, Nakorn Ratchaseema (Lower Northeast)	2000	4.08 (early rainy) 4.19 (late rainy)	Saran and Sanit, 2001
Mae Chaem District, Chiang Mai (Upper North)	2000	5.60	Surasak, 2000

Table 16. Maize yield and disposal, Thailand, 2000.

Region/Sub-district (District/Province)	Maize yield (t/ha)			Use (%)	
	Minimum	Maximum	Average	Sale	Home use
Commercial maize production areas					
Upper North					
Huay Saw (Chiang Khong, Chiang Rai)	1.56	7.50	3.1-3.75[a]	100	-
Chiong Kap (Pop Pra, Tak)	1.69	6.90	4.90	95	5
Lower North					
Budhabhat (Chon Dan, Phetchabun)	4.37	8.75	5.0-5.60 [a/]	100	-
Muang Karung (Ban Rai, Uthai Thani)	0.88	6.66	4.37	100	-
Upper Northeast					
Wang Yao (Dan Sai, Loei)	1.25	4.88	2.5-3.10	100	-
Lower Northeast					
Wang Kra Ta (Pak Chong, Nakorn Ratchaseema)	3.10	7.50	5.00	95	5
Central Plains					
Thai Udom (Klong Had, Sra Kaew)	3.10	9.37	5.62 [a/]	100	-
Semi-commercial maize production areas					
Upper North					
Muang Na (Chiang Dao, Chiang Mai)[b]	1.25	5.62	3.1-3.75	80	20

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 2000.

[a] Fresh grain price at 30-40% moisture content. The rest was dry grain price.

[b] In Muang Na sub-district, Chiang Mai, early rainy season grain was sold, and late rainy season grain was used for animal feed.

4. Constraints to Increasing Maize Production Growth

4.1 Biotic and Abiotic Constraints

Farmer-respondents in the Phase I study reported drought and dry spells as the most important problem during the 1998-99 production year. Drought was especially damaging to maize plants when occurring after planting or during flowering. In other years, there was too much rain, and this variability in climatic conditions adversely affected maize yields. Other maize production constraints reported included insect and pest problems. Farmer-respondents also complained about low yields and high seed costs (Table 17).

In Chiang Mai, Surasak (2000) found that agricultural extension, farmer education and skill enhancement, expansion of credit, and good supervision of such credit (in addition to farm size and climatic conditions) contributed to better efficiency in maize production. Better and faster transfer of general and market information was another important factor in the promotion of efficient maize farming, underscoring the necessity for improving farm infrastructure and management.

Table 17. Reported biotic and abiotic constraints to maize cultivation, Phase I, Thailand, 1998-1999.

Maize production constraint	No. of farmers reporting	Percent of all surveyed farmers
Drought/dry spells	136	62.4
Insects and pests	63	28.9
Diseases	55	25.2
Low output prices	49	22.5
High seed prices	46	21.1
Too much rain in certain periods	31	14.2
Low soil fertility	27	12.4
High fertilizer costs	21	9.6
Labor scarcity in some periods	20	9.2
Rats	17	7.8
Other	22	10.1

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 1999-2000.

4.1.1 Major maize pests and diseases

Major diseases and pests identified by farmers included downy mildew, rust, rats, and stem borers, although maize is more tolerant to diseases than other upland crops. About 28.9% of farmer-respondents reported insect and pest problems in their maize crop, and 25.2% of them reported disease problems (Table 17).

4.1.2 Soil fertility and crop management

Although most farmers use single-cross hybrids, maize yields are still low because of poor soil fertility. Some farmers cannot apply appropriate fertilizer levels because of limited farming capital, again causing low maize yields. Labor scarcity also causes problems of inadequate crop care. It is interesting to note, however, that farmers refuse to use low cost hybrid or OPV seed, even when they cannot use enough fertilizer to realize the potential of their preferred hybrid maize. Regardless of whether their refusal is due to ignorance or simple preference, it does lead to high maize production costs.

Soil erosion and soil infertility are the main problems in highland areas and sloping land, making it important to introduce soil technologies such as land conservation, crop rotation, and soil improvement methods such as incorporation of green manure crops, to farmers in these areas.

In these marginal areas, it is also important to improve yield and reduce production costs to increase farm profits. Some farmer practices can be improved to help reduce maize production costs. For example, planting methods can be adjusted to economize on seed use. Minimum tillage should also be developed as a conservation farming practice to enhance soil fertility and stabilize maize production systems.

4.2 Institutional Constraints

4.2.1 Information constraints

Agricultural extension/information dissemination services in the Thai Government system require improvements in quality and extent, especially to reach marginal and remote areas. It is important to provide farmers in these areas with information on the government's annual alternative or assistance programs such as the Good Seeds Program and Price Support Program. The availability of services and information from BAAC is very different for better-off and marginal farmers, and poor infrastructure facilities aggravate the difference in access to information. BAAC staff work in close-to-town areas more than in remote and less accessible areas; thus farmers in close-to-town areas have more access to services and information.

4.2.2 Labor and material inputs supply constraints

Farmers lamented that prices of maize production inputs (seed, fertilizer, tractor hire, harvest labor) have been increasing through the years, while output prices have either remained the same or decreased, resulting in lower farm profits, especially for farmers in remote areas. Because of distance from markets, these farmers pay more for their inputs and receive less for their product. Poor and marginal, they are the first to quit maize cultivation when profits diminish or disappear. Of all inputs, harvest labor is the top expenditure, followed by fertilizers, tractor hire, and seed.

4.2.3 Credit sources and constraints

Almost all farmer-respondents in Phases I and II depended on short-term loans for maize production, because their own capital was usually not sufficient for their farm production and home consumption needs. Planting, fertilizer application, and harvesting are the production stages when farmers need the most capital. The two most important sources of farm credit were the Bank of Agriculture and Agricultural Cooperatives (BAAC) and the merchants (usually seed and agricultural input suppliers). BAAC provided low-interest, short-term 30,000 *baht* production loans, which farmers often found inadequate. Farmers also reported that BAAC services were not as good or convenient as those provided by merchants. In 2001, the Thai government initiated a BAAC program of a three-year debt moratorium, but its benefits to maize farmers are yet to be seen.

Farmers supplemented inadequate BAAC credit with loans from merchants who charge higher interest rates. Merchants extended two types of credit: cash credit and in-kind farm input credit. Maize farmers commonly took the in-kind farm input credit, even though inputs were often more expensive than those bought on the market. In this case, farmers are obliged to sell their output to merchants (who also provide threshing facilities) and repay all loans immediately after maize harvest. Normally, net settlements are made at the time of threshing and output sale. A high interest rate of 5% per month was charged for cash loans and if loans were paid late. Poor farmers, however, could not borrow from merchants due to their lack of credit worthiness. Local merchants established close relationships with farmers by providing all kinds of assistance related to family welfare. High-interest loans from merchants, however, further reduced maize farmers' small profits.

When maize grain prices are low, farmers often find themselves debt-ridden and short of cash. They usually "solve" this problem by getting credit from one source to repay another, a practice that in the long term seriously erodes agricultural production capital. For instance, loans from BAAC were priority loans, and farmers would often borrow from merchants to repay these loans and maintain their credit worthiness. Fresh loans could be obtained from BAAC within a few days. Farmers would use the new BAAC loan to repay merchants even before maize was planted. Thus capital is not really used for farm production or investment, but only to repay old debts.

In one study site in Putthabat sub-district, Phetchabun province, farmers formed groups and borrowed among themselves to repay BAAC. Once a farmer's loan was repaid, he or she could borrow from BAAC again. The money was then lent to another farmer to repay a BAAC loan, so a new loan could be obtained. This cycle continued until all members in the group could repay and re-borrow from BAAC.

4.3 Other Constraints

Maize farmers reported facing input/output transportation problems. During the rainy season, feeder roads are inaccessible by trucks, making it difficult for farmers to sell their output. In some sites, labor and agricultural machinery were also reported to be scarce. If land preparation is not done in time, planting is delayed and this can adversely affect maize yields.

Thai maize farmers commonly reported low output prices as an important constraint to maize production. This led to maize farmers receiving low returns for their labor and capital, and sometimes experiencing losses.

Special attention is given to maize production in the highlands, uplands, and remote areas where farmers suffer many disadvantages. The land in such areas is prone to low soil fertility and high soil erosion. Due to transportation problems, input prices are higher and output prices are lower. Farmers in these remote areas receive less extension service and information from government and BAAC officials. They also do not have many options in choosing other crops, as other crops also have disadvantages. Profit from maize cultivation is meager, and many farmers have quit maize farming and switched to non-farm employment. Some farmers migrate to towns before and after maize cultivation or even during slack labor periods while maize is grown. Lowland farmers and those living near market centers or the so-called "corn belt," such as those in Nakorn Ratchaseema in the Northeast, Lopburi and Saraburi in the Central Plains Region, and Nakorn Sawan in the Lower North, enjoy good levels of profit from maize farming.

This study found that maize farmers in Thailand were responsive to modern technology, such as seed, mechanization, and chemical input use. Most farmers planted single-cross hybrid maize seed even if it was more expensive than OPVs. They also mechanized land preparation and planting, used adequate fertilizers, and readily applied herbicides for weed control. The profitability of maize production has, however, not been generally impressive. More dependence on purchased inputs, higher production costs, low or stagnant output prices, and high capital requirements all tax the livelihood of maize farmers. Because many farmers found no better alternative to maize, they reported having no choice but to grow maize, although some wanted to stop growing it in the long run.

Nevertheless, this study found that maize is quite profitable when grown in the dry season, under irrigation, and when maize prices are high. Phichit (Lower North) and Chiang Rai (Upper North) farmers who grew dry season maize were quite happy with maize cultivation. In contrast, farmers who grew maize under rainfed conditions needed to modify their cropping practices to either improve yields or reduce production costs. Currently, extension services to disseminate good maize practices are still lacking. Farmers are not yet comfortable with soil conservation or soil improvement methods. Farmer knowledge of how to better manage production inputs and the environment leaves much to be desired, and this ignorance contributes to poor farm profits and low national average maize yield. Research programs, extension services, and policies in support of maize cultivation therefore need to be designed and implemented with care.

In general, Thai farmers' maize production potential is greatest when there is good soil, adequate rainfall, more than one crop per year, larger farm sizes, more capital, adequate equipment and machinery, and proximity to feed mills. Under those conditions, medium and relatively richer farmers, but not poor farmers, survive well with maize cultivation. Poor farmers still plant maize because competing crops do not offer better alternatives. If maize production conditions remain the same in Thailand, maize cultivation will certainly decrease in marginal areas despite the country's need for greater maize supply in the future.

This study found that many maize farmers would prefer to grow fruit trees such as tamarind, mango, lychee, and longan, which have the potential to generate more income. Some farmers have actually transformed a small area of their farms into fruit tree orchards. Many production constraints, however, also confront fruit tree production. These include capital, land suitability for fruit tree farming, availability of irrigation, and ready output market. Fruit trees also take longer to yield output and income, yet farmers need regular income annually. Some farmers would like to grow other crops such as sugarcane or cassava, but sugarcane production requires more capital, and some soils are not suitable for cassava. Maize farmers were often not knowledgeable about yields or market prices of other field crops they could grow. Therefore, maize—generally easy to grow, insect and drought-tolerant, and non-labor-intensive—is still *the* crop for many farmers, particularly poor farmers, in the study sites.

To summarize, maize will continue to be an important crop both in favorable and marginal areas of Thailand. Maize has many advantages over competing crops and substantial potential impacts on farmer welfare. In reality, however, socioeconomic and biophysical factors can influence the type and extent of welfare derived from maize production. These factors, in turn, can be influenced through appropriate policies and research, which will be critical to the future of maize producers and of the maize industry in Thailand.

5. Setting an Agenda for Maize Research and Development in Thailand

5.1 Methodology for Identifying Priority Constraints

Given the many constraints reported in each agro-ecozone, one must find a way to combine and compare constraints across agro-ecozones to obtain some idea of a prioritized agenda for maize research and development in Thailand. This study used the methodology developed at CIMMYT (see Pingali and Pandey, 2001, for details) to help prioritize productivity constraints across maize systems in tropical ecologies and geographic regions. Three criteria are used for prioritizing public research: efficiency, the extent of poverty, and the extent of marginality in the production agro-environment. An efficiency index estimates the returns a given research investment would yield, i.e., the biggest bang for the research buck. It approximates how the alleviation of constraints by either research or extension-cum-research would most likely contribute to total production gains. A poverty index modifies the efficiency index to give some weight to poor farmers and their food security situation. With a higher proportion of poor people, the poverty index associated with the constraint is higher. Constraint ranking based on the poverty index should be closely looked at when poverty alleviation is a major concern for researchers and policymakers. The subsistence farming index similarly modifies the efficiency index by targeting public investments toward more subsistence oriented agricultural areas, the presumption being that more commercially oriented areas are, or will be, served by the private sector. The combined index is the weighted average of the three indices, in which weights of 0.5, 0.3, and 0.2 were given to efficiency, poverty, and subsistence farming, respectively.

Since most of Thailand's maize production systems are commercially oriented, research prioritization for maize will only apply the efficiency and poverty indices (Table 18). The efficiency index remains defined as above. The poverty index is constructed by applying incidence of poverty, which in turn is defined as the proportion of poor people to total rural population in a particular ecological region. This study used the Thailand Development and Research Institute 2000 data on the proportion of poor people in each district. These proportions were then aggregated to the agro-ecological zone level. Twelve agro-ecological zones for maize production in Thailand were identified by this study (Appendix, Table 7).

To conduct the initial maize research and development prioritization exercise, a workshop was organized on 2-3 August 2001 in Chiang Mai University for 26 maize technology experts from the public and private sectors in Thailand. Two social scientists from CIMMYT also attended. The workshop applied all three indices in the prioritization exercise. A follow-up workshop was conducted on 13-14 February 2003 to discuss the results and actions taken from the 2001 workshop. Thirty-two public and private sector experts, many of whom attended the 2001 workshop, attended the 2003 workshop. Research priorities identified by the study were confirmed and refined at this workshop, which used only the efficiency and poverty indices. The 2003 workshop participants expressed satisfaction with the results and the follow-up of the 2001 workshop. Some agencies reported having acted on the maize research priorities identified in the 2001 workshop, and committed to using the refined results from the 2003 workshop.

Table 18. Method used for prioritizing maize productivity constraints in Thailand.

Efficiency index	Poverty index	Combined index[a]
Is a product of: • Importance of constraint • Yield gain associated with constraint alleviation • Total production by maize ecology and region • Probability of success in finding a solution to the constraint	Is a product of: • Efficiency index and incidence of poverty in a particular ecology and geographic region (poverty incidence is defined as an average percentage of poor people in the respective region in 2000)	Is the sum of: 0.7 * efficiency index and 0.3 * poverty index

[a] Weights can be revised.

5.2 Priority Constraints Identified in this Study

Table 19 shows the priority maize production constraints identified during the August 2001 workshop. Drought was reported as a priority constraint in many agro-ecozones except in the Upper North. Soil infertility was reported as a priority problem in marginal upland and highland environments. Rust, ear rot, stem borers, stalk rot, insect damage to seedlings, and downy mildew were reportedly prevalent in most environments. Poor seed quality was a commonly named constraint despite the availability of commercial brand hybrid seed. Noticeably, many important maize production constraints were related to poor agronomic practices (e.g., inappropriate fertilizer selection and application, inappropriate land preparation, and poor water management), which can be alleviated through better extension services.

Table 19. Priority constraints determined during the August 2001 workshop.

	Irrigated environment	Rainfed upland favorable environment	Rainfed upland marginal environment	Highland environment
Upper North	1. Incorrect land preparation 2. Inappropriate water management 3. Low seed quality 4. Seedlings damaged by insects 5. Stems eaten by rats 6. Post harvest fungi (aflatoxin) 7. Lodging (strong wind) 8. Thrips	1. Lodging 2. Stem rot 3. Rust 4. Drought 5. Downy mildew 6. Waterlogging 7. Low seed quality 8. Soil infertility 9. Termites, ants	1. Soil infertility 2. Inappropriate land preparation 3. Drought 4. Low seed quality 5. Ear rot 6. Downy mildew	
Lower North		1. Drought 2. Flooding in some areas 3. Degradation of soil fertility 4. Rust 5. Stem borers	1. Drought 2. Soil infertility 3. Rust	1. Leaching 2. Inappropriate land preparation 3. Drought 4. Rust
Upper Northeast		1. Downy mildew 2. Drought 3. Low seed quality 4. Rust 5. Stem borer 6. Fungi (aflatoxin) 7. Too much rain		1. Soil infertility 2. Ear rot 3. Low seed quality 4. Drought 5. Downy mildew 6. Rats 7. Beetles
Lower Northeast		1. Drought 2. Rust 3. Inappropriate land preparation 4. Unsuitable fertilizer application 5. Lack of land conservation and rehabilitation 6. Unsuitable seed use 7. Too dense plant intervals 8. Aflatoxin	1. Drought 2. Lack of land conservation and rehabilitation 3. Unsuitable fertilizer application 4. Inappropriate land preparation 5. Inappropriate maize variety choice	
Central Plains		1. Unsuitable fertilizer application 2. Leaf blight, sheath blight 3. Stalk rot 4. Inappropriate variety choice 5. Inappropriate land preparation 6. Aflatoxin 7. Too dense plant intervals 8. Flooding 9. Ear rot	1. Drought 2. Soil degradation 3. Unsuitable fertilizer application 4. Inappropriate land preparation 5. Too dense plant intervals 6. Inappropriate variety choice 7. Seedlings damaged by insects 8. Aflatoxin 9. Waterlogging	

5.2.1 Priority constraints comparing each region and agro-ecological zone

Table 20 shows the top 30 priority constraints by region and agro-ecological zone. While the ranking of constraints differed when the efficiency index was applied and the poverty index was used, the list (set) of priority constraints was very similar, and ranking differed only slightly. Favorable upland areas in the Upper and Lower North Regions and marginal upland areas in the Lower Northeast and Central Plains received higher priority when poverty criteria were incorporated. Diseases (rust, banded leaf/sheath blight, stalk rot) and problems related to agronomic practices dominated the list.

Using the combined index, constraints in the Lower North such as rust, corn borer, soil infertility, drought, and waterlogging received high priority due to the importance of the region (Table 21). The Upper North and Central Plains Regions were ranked next, with lodging, downy mildew, stalk rot, rust, and poor seed quality prioritized for the Upper North, and soil infertility, inappropriate fertilizer use, inappropriate land preparation, and variety choice for the Central Plains. The Lower Northeast ranked fourth and the Upper Northeast ranked last in importance for priority constraints. Soil infertility, inappropriate fertilizer use, inappropriate variety choice, rust, and inappropriate land preparation were priority constraints in the Lower Northeast, while downy mildew was a priority constraint in the Upper Northeast (Table 21).

5.2.2 Priority constraints for the country

The February 2003 workshop also prioritized maize production constraints across the whole of Thailand. Here, ranking was done by problems regardless of agro-ecozones. Averages of ranking, yield gains, and probability of finding a solution were obtained for all agro-ecozones for each problem. Only the efficiency index was calculated for each problem. Results show that rust is the top maize production constraint in Thailand, followed by soil infertility and drought. Table 21 shows the overall priority constraints for Thailand using an adaptation of this method. These priorities will be useful for agencies planning their research and extension programs, and the participants expressed their satisfaction with this method.

5.3 Recommendations for Future Action

The experts' opinions in the workshop were extended to creating recommendations for responding to particular maize production problems/constraints (Table 22). Most policy and technology options outlined to address the priority constraints had a high probability of success. Technology options to address the problems of rust, downy mildew, and corn borers, for example, had a 75-95% probability of success. These ranged from conventional breeding, chemical control, and management practices to genetic engineering. Resistant varieties were perceived as being more successful if developed by genetic engineering rather than conventional breeding. Most private sector workshop participants were very optimistic of genetic engineering methods. Public sector participants were more cautious of such technology options. Policy and administrative changes were suggested to solve seed quality problems.

The most difficult constraints to solve appeared to be those related to drought and, to a lesser extent, to excess rain. While planting dates and practices can be adjusted by farmers, the probability of success in addressing drought and flooding was deemed by workshop participants to be very low.

Table 20. Priority constraints to maize production in Thailand, 2003.

Region and agro-ecological zone[a]	Production constraint	Priority ranking by index: Efficiency index	Priority ranking by index: Poverty index
LN-FU	Rust	1	1
LN-FU	Soil infertility	2	2
LN-FU	Drought	3	3
UN-FU	Lodging	4	4
UN-FU	Banded leaf/sheath blight	8	5
LN-FU	Waterlogging	5	6
C-FU	Inappropriate fertilizer use	6	7
UN-FU	Rust	10	8
C-MU	Soil infertility	7	9
C-MU	Inappropriate fertilizer use	9	10
C-FU	Inappropriate variety choice	12	11
LNE-MU	Soil improvement	13	12
C-MU	Inappropriate land preparation	11	13
LNE-MU	Inappropriate fertilizer use	14	14
C-MU	Drought	15	15
LNE-FU	Rust	16	16
LNE-MU	Inappropriate land preparation	17	17
LNE-FU	Inappropriate land preparation	18	18
LNE-FU	Inappropriate fertilizer use	19	19
UNE-FU	Downy mildew	23	20
LNE-FU	Drought	20	21
C-FU	Banded leaf/sheath blight	21	22
LNE-MU	Drought	22	23
C-FU	Stalk rot	24	24
LN-H	Rust	25	25
UN-MU	Seed quality	27	26
LN-MU	Rust	26	27
UNE-FU	Seed quality	28	28
UN-MU	Drought	29	29
UNE-FU	Drought	30	30

Source: IFAD-CIMMYT-Thailand National Maize R&D Priority-Setting Workshop, February 2003.

[a] Regions: UN - Upper North; LN - Lower North; UNE - Upper Northeast; LNE - Lower Northeast; C - Central Plains. Agro-ecological zones: FU - favorable uplands; MU - marginal (unfavorable) uplands; H – highlands.

Table 21. Maize production priority constraints based on combined index, Thailand, 2003.

Priority ranking across regions and agro-ecozones[a]: Rank	Agro-ecozone	Constraint	Priority ranking by region and agro-ecozone: Agro-ecozone	Constraint	Rank
1	LN-FU	Rust	LN-FU	Rust	1
2	LN-FU	Corn borer	LN-FU	Corn borer	2
3	LN-FU	Soil infertility	LN-FU	Soil infertility	3
4	LN-FU	Drought	LN-FU	Drought	4
5	UN-FU	Lodging	LN-FU	Waterlogging	10
6	C-FU	Inappropriate fertilizer use	C-FU	Inappropriate fertilizer use	6
7	UN-FU	Downy mildew	C-MU	Soil infertility	8
8	C-MU	Soil infertility	C-MU	Inappropriate fertilizer use	11
9	UN-FU	Stalk rot	C-FU	Inappropriate variety choice	14
10	LN-FU	Waterlogging	C-MU	Inappropriate land preparation	15
11	C-MU	Inappropriate fertilizer use	C-MU	Inappropriate variety choice	18
12	UN-FU	Rust	C-MU	High plant density	19
13	LNE-MU	Soil infertility	C-MU	Drought	20
14	C-FU	Inappropriate variety choice	C-FU	Inappropriate land preparation	21
15	C-MU	Inappropriate land preparation	C-FU	High plant density	27
16	UN-FU	Seed quality	UN-FU	Lodging	5
17	LNE-MU	Inappropriate fertilizer use	UN-FU	Downy mildew	7
18	C-MU	Inappropriate variety choice	UN-FU	Stalk rot	9
19	C-MU	High plant density	UN-FU	Rust	12
20	C-MU	Drought	UN-FU	Seed quality	16
21	C-FU	Inappropriate land preparation	LNE-MU	Soil infertility	13
22	LNE-MU	Inappropriate varietal choice	LNE-MU	Inappropriate fertilizer use	17
23	LNE-FU	Rust	LNE-MU	Inappropriate variety choice	22
24	LNE-MU	Inappropriate land preparation	LNE-FU	Rust	23
25	LNE-FU	Inappropriate land preparation	LNE-MU	Inappropriate land preparation	24
26	LNE-FU	Inappropriate fertilizer use	LNE-FU	Inappropriate land preparation	25
27	C-FU	High plant density	LNE-FU	Inappropriate fertilizer use	26
28	LNE-FU	Inappropriate variety use	LNE-FU	Inappropriate variety choice	28
29	LNE-FU	Soil infertility	LNE-FU	Soil infertility	29
30	UNE-FU	Downy mildew	UNE-FU	Downy mildew	30

Source: IFAD-CIMMYT-Thailand National Maize R&D Workshop, February 2003.

[a] Regions: UN - Upper North; LN - Lower North; UNE - Upper Northeast; LNE - Lower Northeast; C - Central Plains. Agro-ecological zones: FU - favorable uplands; MU - marginal (unfavorable) uplands; H – highlands.

5.4 Conclusions

The two priority setting workshops provided a venue for dialogue and discussions among maize experts in Thailand and were viewed as a success by all participants. The priority setting exercise was assisted by the RRA and PRA studies because farmers' opinions and field-level data were provided to the experts during the workshop. The exercises helped public and private sector researchers see the whole picture of research needs and prioritization across all maize production agro-ecological zones in Thailand. Each expert was able to carry some of the recommendations suggested by the workgroup back to their home offices.

Table 22. Policy and technology options to address maize production constraints, probability of success, and potential partners, Thailand.

Problem / constraint	Policy / technology options	Probability of success	Potential partners
Rust	1. Resistant variety developed by conventional breeding	95%	Department of Agriculture (DOA), Kasetsart University (KU)'s Suwan Farm, Private seed companies
	2. Change planting time	80%	KU's Suwan Farm, DOA, private seed companies
	3. Chemical control	80%	Chemical companies, DOA, Kasetsart University
	4. Molecular genetic engineering	90%	Kasetsart University, DOA, BIOTEC, private seed companies
	5. Crop rotation	75%	Kasetsart University, DOA, Department of Agricultural Extension (DOAE)
Downy mildew	1. Resistant variety developed by conventional breeding	90%	DOA, KU's Suwan Farm, private seed companies
	2. Chemical control	95%	Chemical companies
	3. Change planting time	80%	Kasetsart University, DOA, DOAE, private sector
	4. Molecular genetic engineering	90%	Kasetsart University, DOA, BIOTEC, private seed companies
	5. Crop rotation	75%	Kasetsart University, DOA, DOAE
Corn borers	1. Genetic engineering (biotechnology)	100%	BIOTEC, Kasetsart University, private seed companies
	2. Marker-assisted selection (biotechnology)	90%	Kasetsart University, DOA, private seed companies
	3. Chemical control (Furadan)	90%	Chemical company, DOA
	4. Change planting time	80%	Kasetsart University, DOA, DOAE, private sector
	5. Biological control	80%	Kasetsart University , DOA, DOAE, private sector
	6. Crop rotation	75%	Kasetsart University, DOA, DOAE
	7. Resistant variety developed by conventional breeding	50%	Kasetsart University, DOA, private seed companies
Soil fertility	- Use recommended fertilizer	80%	DOA
	- Crop rotation	80%	DOA
	- Use manure	50%	DOA
	- Soil conditioning	5%	Department of Land Development (DLD)
	- Green manure cover crop	40%	DLD
	- Conservation tillage	30%	DOA, private sector
Inappropriate land preparation	- Use of a subsoiler	20%	DOAE
	- Contour bunding	10%	DLD
	- Land leveling	30%	DOA
	- Minimum tillage	20%	DOAE
	- Appropriate use of farm equipment	80%	DOAE, DOA
	- Farmers' training	80%	DOAE, DOA
Waterlogging	- Prepare land using correct methods	60%	DOA, DOAE
	- Use drainage system	60%	DOA, DOAE
	- Use of fertilizer for recovering	30%	DOA
	- Retain appropriate maize population per area	35%	Public sector, private sector, farmer
	- Use resistant varieties developed by conventional breeding	20-70%	DOA, private sector
Inappropriate use of maize variety	1. Generate farmers' training in seed selection by: - comparing results of maize variety study for each ecozone; - selecting suitable maize varieties in each ecozone to make guidebook - demonstration plots - extend selected variety to farmers	80%	DOA, DOAE, universities, Private sector (set up central organization to operate on farm variety trial)
	2. Educate farmers to select maize variety by themselves	90%	
Poor seed quality	1. Law enforcement to prevent impurity in seed production	80%	DOA
	2. Change seed law to increase germinating percentage from 70% to 80%	80%	DOA
Inappropriate maize planting density	Develop seed information and technology practice in each ecozone and transfer to farmer by: - training and demonstration on each variety seed rate - field days - provide handbooks or recommendations with seed bag	60%	DOA, DOAE, universities Private sector
Drought	1. Adjust planting date related to rain distribution by using rainfall data in each ecozone	35%	Public sector, private sector, farmers
	2. Use appropriate maize variety fit to rain distribution	50%	Public sector, private sector, farmers
	3. Improve soil fertility and structure to hold more water	40%	Public sector, private sector, farmers

Source: IFAD-CIMMYT-Thailand National Maize R&D Workshop, February 2003.

6. References

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7. Appendix

Table 1. Important sources of farm inputs, Thailand, 1999.

Input sources	Seed		Fertilizer		Chemical inputs	
	No. of farmers	%	No. of farmers	%	No. of farmers	%
Merchants	74	33.9	105	48.2	128	76.6
Bank of Agriculture (BAAC)	78	35.8	58	26.6	13	7.8
Cooperatives	29	13.3	29	13.3	18	10.8
District Extension Office[1]	32	14.7	—-	—-	2	1.2
Farmers' group	—-	—-	22	10.1	6	3.6
Combination of sources	5	2.3	4	1.8	—-	—-
Total	**218**	**100.0**	**218**	**100.0**	**167**	**100.0**

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys 1998-1999.
[1] Served a government program that provided subsidized seed (50% subsidy).

Table 2a. Farmer use of capital in maize production, Phase I study sites, Thailand, 1998-99 (in % households).

Study sites	Used own capital	Borrowed all capital needed	Combined own and borrowed capital	Total
Central Plains				
Lop Buri				
Chai Badan, Chai Badan	8.3	33.3	58.3	100
Pattananikom, Pattananikom	30.0	20.0	50.0	100
Chon Noi, Pattananikom	11.1	33.3	55.6	100
Lower North				
Nakorn Sawan				
Po Prasart, Pisari	14.3	14.3	71.4	100
Wang Koi, Pisari	—-	28.6	71.4	100
Kao Chai Tong, Tak Fa	12.5	25.0	62.5	100
Suk Sumrarn, Tak Fa	—-	62.5	37.5	100
Phetchabun				
Nong Pai, Nong Pai	—-	62.5	37.5	100
Bua Wattana	30.0	20.0	50.0	100
Chon Dan, Chon Dan	—-	75.0	25.0	100
Ta Kam, Chon Dan	—-	37.5	62.5	100
Kamphaengphet				
Na Po Kam, Muang	n.a.[a]	n.a.	n.a.	n.a.
Pichit				
Nong Pling, Sam Ngam	n.a.	n.a.	n.a.	n.a.
Nong Sano, Sam Ngam	n.a.	n.a.	n.a.	n.a.
Upper North				
Chiang Rai				
Wieng, Teung	60.0	0.0	40.0	100
Ngaw, Teung	25.0	6.3	68.8	100
Lower Northeast				
Nakorn Ratchaseema				
Pak Chong, Pak Chong	22.2	22.2	55.6	100
Nong Sarai, Pak Chong	25.0	—-	75.0	100
Huay Bong, Dan KhunTod	—-	60.0	40.0	100
Ta Kien, Dan Khun Tod	12.5	12.5	75.0	100
Upper Northeast				
Loei				
Nam Suay, Muang	—-	73.3	26.7	100
Na Din Dum, Muang	5.0	35.0	60.0	100
Dan Sai, Dan Sai	—-	58.3	41.7	100
Kok Ngam, Dan Sai	—-	66.7	33.3	100
Average across all sites	**13.3**	**35.3**	**51.4**	**100**

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 1998-19 99.
[a] n.a. = not available.

Table 2b. Sources of capital used in maize cultivation, Phase II study sites, Thailand, 2000.

Study sites	Own-to-borrowed capital ratio	Sources of capital (%)					
		BAAC	Agricultural	Village funds	Merchants	Relatives	Cooperative
Commercial maize production areas							
Upper North							
Chiang Rai							
Huay Saw, Chiang Khong	n.a[a]	100	—	—	30	10	—
Tak							
Chong Kap, Tak	30 : 70	20	—	10	70	10	—
Lower North							
Nakorn Sawan							
Po Prasart, Pisari	n.a	86	—	—	—	14	—
Wang Koi, Pisari	n.a	78	—	—	12	—	—
Kao Chai Tong, Tak Fa	n.a	10	—	—	30	40	20
Suk Sumrarn, Tak Fa	n.a	33	—	—	42	—	25
Phetchabun							
Budhabhat, Chon Dan	60 : 40	75	10	—	20	5	—
Uthai Thani							
Muang Karung, Ban Rai	20 : 80	70	10	—	60	5	—
Upper Northeast							
Loei							
Wang Yao, Dan Sai	30 : 70	90	—	—	10	—	—
Nam Suay, Muang	—	100	—	—	—	—	—
Na Din Dum, Muang	—	100	—	—	—	—	—
Dan Sai, Dan Sai	—	85	—	—	—	—	15
Kok Ngam, Dan Sai	—	13	—	—	—	—	87
Lower Northeast							
Nakorn Ratchaseema							
Pak Chong, Pak Chong	—	18	—	—	36	10	36
Nong Sarai, Pak Chong	—	20	—	—	40	—	40
Huay Bong, Dan KhunTod	—	60	—	—	—	20	20
Ta Kien, Dan Khun Tod	n.a.	n.a.	25	—	—		
Central Plains							
Sra Kaew							
Thai Udom, Klong Had	30 : 70	90	10	—	10	—	—
Lop Buri							
Chai Badan, Chai Badan	n.a.	62	—	—	30	8	—
Pattananikom, Pattananikom	n.a.	86	—	—	—	14	—
Chon Noi, Pattananikom	n.a.	100	—	—	—	—	—

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 2000.

[a] n.a. = not available.

Table 3. Landholdings and land tenure system, Phase I study sites, Thailand, 1998-99.

	Farmer landholdings (ha)			Land tenure (% land)		Land tenure (% of households)		
Study sites	**Average**	**Min**	**Max**	**Owned**	**Rented**	**Landowners**	**Part owners**	**Tenants**
Central Plains								
Lop Buri								
Chai Badan, Chai Badan	11.9	1.0	25.6	42.6	57.4	50.0	33.3	16.7
Pattananikom, Pattananikom	20.8	4.0	40.0	31.7	68.3	30.0	50.0	20.0
Chon Noi, Pattananikom	3.7	1.6	8.0	37.1	62.9	77.8	11.1	11.1
Lower North								
Nakorn Sawan								
Po Prasart, Pisari	12.3	1.6	30.4	51.5	48.5	42.9	57.1	—
Wang Koi, Pisari	5.6	1.9	8.0	65.2	34.8	85.7	14.3	—
Kao Chai Tong, Tak Fa	3.3	1.4	8.0	60.2	39.8	75.0	—	25.0
Suk Sumrarn, Tak Fa	8.2	0.6	19.2	35.7	64.3	25.0	37.5	37.5
Phetchabun								
Nong Pai, Nong Pai	4.6	1.6	8.0	48.4	51.6	62.5	25.0	12.5
Bua Wattana, Nong Pai	9.0	4.8	18.4	48.1	51.9	50.0	40.0	10.0
Chon Dan, Chon Dan	5.4	1.6	8.8	58.8	41.2	37.5	62.5	—
Ta Kam, Chon Dan	3.9	2.4	6.4	65.0	35.0	75.0	12.5	12.5
Upper North								
Chiang Rai								
Wieng, Teung	3.4	0.7	6.7	48.7	51.3	66.7	33.3	—
Ngaw, Teung	2.2	0.8	5.9	51.9	48.1	43.8	31.3	25.0
Lower Northeast								
Nakorn Ratchaseema								
Pak Chong, Pak Chong	26.1	4.5	80.0	23.9	76.1	66.7	33.3	—
Nong Sarai, Pak Chong	4.7	1.6	9.6	53.6	46.4	37.5	25.0	37.5
Huay Bong, Dan KhunTod	6.1	1.0	17.0	100.0	—	100.0	—	—
Ta Kien, Dan Khun Tod	6.8	3.2	11.2	75.9	24.1	75.0	25.0	—
Upper Northeast								
Loei								
Nam Suay, Muang	6.0	1.6	11.7	100.0	—	80.0	—	20.0
Na Din Dum, Muang	2.6	1.3	6.4	56.1	43.9	95.0	5.0	—
Dan Sai, Dan Sai	5.7	1.6	11.2	100.0	—	100.0	—	—
Kok Ngam, Dan Sai	8.7	4.3	21.8	63.0	37.0	73.3	6.7	—
All sites	**7.3**	**0.6**	**80.0**	**41.2**	**58.8**	**67.0**	**22.5**	**10.6**

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 1999-2000.

Table 4. Total and maize household income, Thailand, 1998-99.

Study sites	Total income (baht / household)	Maize income (baht / household)	Contribution of maize income to total income (%)
Central Plains			
Lop Buri			
Chai Badan, Chai Badan	165,767	115,580	69.7
Pattananikom, Pattananikom	214,044	143,784	67.2
Chon Noi, Pattananikom	131,111	50,644	38.6
Lower North			
Nakorn Sawan			
Po Prasart, Pisari	233,371	179,824	77.1
Wang Koi, Pisari	118,857	78,132	65.7
Kao Chai Tong, Tak Fa	63,937	38,960	60.9
Suk Sumrarn, Tak Fa	168,375	129,321	76.8
Phetchabun			
Nong Pai, Nong Pai	98,845	44,621	45.1
Bua Wattana, Nong Pai	206,198	148,743	72.1
Chon Dan, Chon Dan	83,363	54,950	65.9
Ta Kam, Chon Dan	70,544	51,256	72.7
Upper North			
Chiang Rai			
Wieng, Teung	50,669	34,619	68.3
Ngaw, Teung	60,629	36,945	60.9
Lower Northeast			
Nakorn Ratchaseema			
Pak Chong, Pak Chong	506,978	408,633	80.6
Nong Sarai, Pak Chong	69,150	40,676	58.8
Huay Bong, Dan KhunTod	159,000	56,750	35.7
Ta Kien, Dan Khun Tod	113,263	89,193	78.7
Upper Northeast			
Loei			
Nam Suay, Muang	85,120	72,201	84.8
Na Din Dum, Muang	52,750	32,550	61.7
Dan Sai, Dan Sai	54,246	51,363	94.7
Kok Ngam, Dan Sai	100,549	78,125	77.7
All sites	**122,313**	**86,054**	**70.4**

Source: IFAD-CIMMYT-Thailand RRA/PRA Survey, 1999-2000.

Table 5. Area planted to maize in selected provinces by region, 1990-2002 (000 ha).

	Central Plains	Lower North					Lower Northeast		Upper North			
Year	Lop Buri	Nakorn Sawan	Petcha-bun	Kamphaeng phet	Phichit	Uthai Thani	Nakorn Ratchaseema	Loei	Chiang Mai	Chiang Rai	Sra Kaew	Tak
1988	174.6	130.2	270.9	62.5	19.5	84.0	167.2	168.9	7.5	40.1		60.6
1989	155.9	116.4	247.4	67.1	19.7	90.3	166.6	172.7	2.8	39.8		60.1
1990	154.6	101.8	237.8	66.0	19.0	71.0	178.7	161.1	3.4	39.8		65.7
1991	114.8	93.7	168.3	74.3	15.7	71.0	104.1	156.7	6.4	39.4		75.9
1992	102.4	77.3	189.5	57.2	10.8	40.5	132.9	133.5	1.6	39.1		57.2
1993	101.5	84.8	174.6	57.2	13.3	40.5	149.4	105.7	2.9	48.2		59.0
1994	131.2	95.1	188.4	50.1	14.5	42.5	165.3	106.2	4.7	46.5	88.0	57.7
1995	111.7	94.0	219.0	47.9	14.2	27.2	140.0	109.1	4.7	44.0	86.8	57.7
1996	113.7	93.2	221.9	51.0	14.5	38.1	152.5	111.4	3.4	45.2	89.0	59.9
1997	109.0	98.8	194.6	38.9	14.0	47.3	171.6	114.1	2.8	47.9	102.2	58.0
1998	114.1	108.6	204.6	45.3	8.4	45.5	177.6	109.8	2.9	49.0	104.3	73.9
1999	98.0	91.0	174.0	36.5	8.6	44.2	157.0	72.7	3.1	49.9	85.8	67.9
2000	98.5	91.4	175.7	36.5	8.8	44.9	157.2	69.2	5.3	54.1	87.1	72.5
2001	96.9	89.6	169.9	37.6	8.9	46.1	157.3	70.0	6.1	53.7	83.1	71.8
2002	94.3	88.2	169.5	34.0	9.2	44.0	154.7	68.3	6.6	54.0	58.6	75.6

Source: Statistical Agricultural Economic Office, 1988-2003.

Table 6a. Maize yields (t/ha) in the late-rainy season and irrigated (dry season) areas, selected sites, Thailand, 1998-99.

Study sites	N	Mean	Standard Deviation	Minimum	Maximum
Late–rainy season					
Central Plains–*Lop Buri*					
Chai Badan, Chai Badan	1	3.13	-	3.13	3.13
Lower North					
Kao Chai Tong, Tak Fa, Nakorn Sawan	1	5.21	-	5.21	5.21
Ta Kam, Chon Dan, Phetchabun	1	5.00	-	5.00	5.00
Lower Northeast					
Nakorn Ratchaseema					
Pak Chong, Pak Chong	6	5.11	1.24	3.75	6.88
Nong Sarai, Pak Chong	2	4.45	1.17	3.62	5.27
Huay Bong, Dan Khun Tod	5	3.27	1.41	2.01	5.56
Ta Kien, Dan Khun Tod	8	3.15	1.23	1.48	4.69
Upper North					
Wieng, Teung, Chiang Rai	7	3.70	1.17	1.90	5.47
Upper Northeast–*Loei*					
Na Din Dum, Muang	9	3.32	0.86	1.71	4.38
All sites	40	3.75	1.28	1.48	6.88
Irrigation area (dry season)					
Upper North–Ngaw, Teung, Chiang Rai	14	4.97	1.21	0.28	7.00

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys, 1999-2000.

Table 6b. Maize yields (t/ha) in the early-rainy season, selected sites, Thailand, 1998-99.

Study site	N	Mean	Standard Deviation	Minimum	Maximum
Central Plains–*Lop Buri*					
Chai Badan, Chai Badan	11	3.39	1.32	1.95	6.25
Pattananikom, Pattananikom	9	2.95	1.26	1.38	5.10
Chon Noi, Pattananikom	9	4.44	1.28	2.50	6.25
Lower North					
Nakorn Sawan					
Po Prasart, Pisari	7	4.34	0.89	2.64	5.35
Wang Koi, Pisari	7	3.60	1.56	1.67	5.36
Kao Chai Tong, Tak Fa	7	3.72	1.00	2.50	5.21
Suk Sumrarn, Tak Fa	8	4.60	0.88	3.42	5.86
Phetchabun					
Nong Pai, Nong Pai	8	3.75	0.75	2.73	4.88
Bua Wattana, Nong Pai	10	3.61	1.29	2.26	7.00
Chon Dan, Chon Dan	8	3.83	1.20	1.88	5.63
Ta Kam, Chon Dan	7	3.62	1.32	2.34	6.09
Upper North-*Chiang Rai*					
Wieng, Teung	8	4.64	1.65	2.66	6.95
Ngaw, Teung	2	6.00	0.45	5.69	6.33
Lower Northeast–*Nakorn Ratchaseema*					
Pak Chong, Pak Chong	3	3.18	1.51	1.46	4.32
Nong Sarai, Pak Chong	6	3.23	1.39	1.39	4.69
Upper Northeast-*Loei*					
Nam Suay, Muang	15	3.18	0.96	1.82	4.88
Na Din Dum, Muang	11	4.28	1.83	2.80	8.75
Dan Sai, Dan Sai	12	2.18	1.02	0.94	4.02
Kok Ngam, Dan Sai	15	2.06	0.64	0.80	3.24
All sites	**163**	**3.52**	**1.41**	**0.80**	**8.75**

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys, 1999-2000.

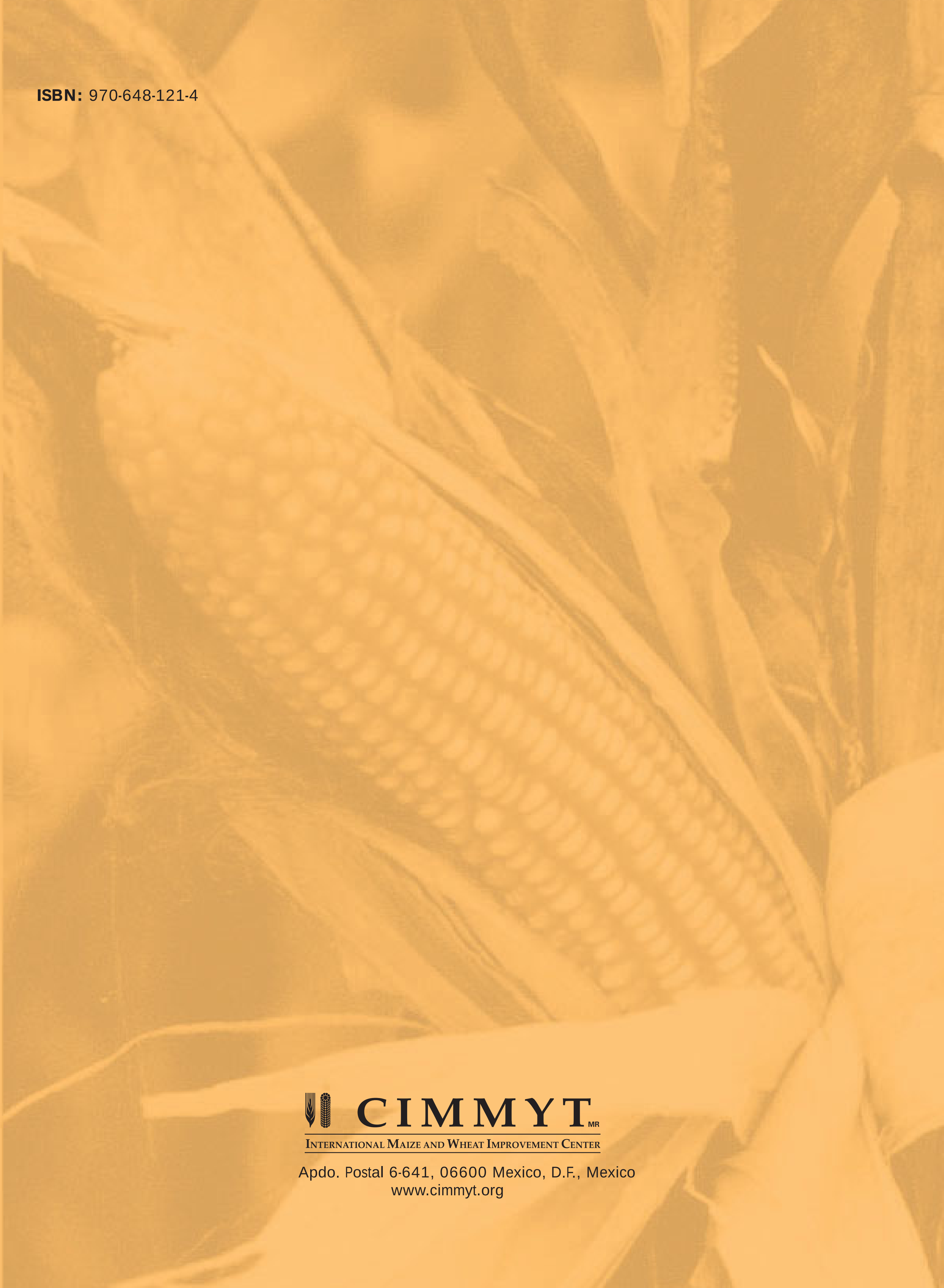
Table 7. Survey sites (listed as sub-district, district, province) classified by agro-ecological zones identified in the study, Thailand, 1998-2000.

Region	Irrigated environments	Rainfed environments		
		Uplands		Highlands
		Favorable [a]	Marginal [b]	
Upper North	*Irrigated North (NI):* Ngaw, Teung, (Chiang Rai); Sam Ngaw, Nongsano (Phichit)	*Upper North Favorable Upland (UN-FU):* Wieng, Tueng (Chiang Rai); Chong Kap, Pop Pra (Tak)	*Upper North Marginal Upland (UN-MU):* Huay Saw, Chiang Khong (Chiang Rai); Muang Na, Chiang Doa (Chiang Mai)	
Lower North		*Lower North Favorable Upland (UN-FU):* Po Prasat and Wang Koi, Paisali (Phetchabun); Koa Chai Tong and Suk Samran, Tak Fa (Nakorn Sawan); Nong Pai and Bua Wattana, Nong Pai (Phetchabun); Na Bor Kam, Muang (Kamphangphet); Muang Karung, Ban Rai (Uthai Thani)	*Lower North Marginal Upland (UN-MU):* Nong Pling, Muang (Kamphangphet)	*Lower North Highland (UN-H):* Chon Dan, Budhabhat and Ta Kham, Chon Dan (Phetchabun)
Upper Northeast		*Upper Northeast Favorable Upland (UNE-FU):* Nam Suay and Na Din Dam, Muang (Loei)		*Upper Northeast Highland(UNE-H):* Dan Sai, Wang Yao and Kok Ngam, Dan Sai (Loei)
Lower Northeast		*Lower Northeast Favorable Upland (LNE-FU):* Pak Chong and Wang Ka Ta, Pak Chong (Nakorn Ratchaseema)	*Lower Northeast Marginal Upland (LNE-MU):* Nong Sarai, Pak Chong; Huay Bong and Ta Kian, Dan Kun Toad (Nakorn Ratchaseema)	
Central Plains		*Central Plains Favorable Upland (C-FU):* Chon Noi, Pattananikom (Lop Buri); Thai Udom, Klong Had (Sra Kaew)	*Central Plain Marginal Upland (C-MU):* Chai Badan, Chai Badan and Pattananikom, Pattananikom (Lop Buri)	

Source: IFAD-CIMMYT-Thailand RRA/PRA Surveys, 1998-99 and 2000.

[a] Favorable uplands: agro-ecological zones (districts) with high average maize yields.

[b] Marginal uplands: agro-ecological zones (districts) with lower average maize yield.



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