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Maize in China

Production Systems, Constraints, and Research Priorities

Erika C.H. Meng
Ruifa Hu
Xiaohua Shi
Shihuang Zhang

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Erika C.H. Meng[1]

Ruifa Hu[2]

Xiaohua Shi[3]

Shihuang Zhang[4]

[1] Economist, International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico.

[2] Professor, Center for Chinese Agricultural Policy (CCAP), Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.

[3] Lecturer, Department of Agriculture, Henan Institute of Science and Technology, Xinxiang, Henan, China.

[4] Director and Professor, Maize Research Center, Institute of Crop Sciences, Chinese Academy of Agricultural Sciences (CAAS), Beijing, China.

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Abstract: This report was undertaken as part of a seven-country project to promote the sustainable intensification of maize production systems in upland environments in Asia. Maize is cultivated throughout China and plays a key role in farm households through its contribution to food, feed, and income. As one of the primary sources of feed in China, it has played an important role in the rapid development of poultry and livestock industries. Maize production environments are characterized in the report using findings from primary farm and village level data collected across China's maize belt. An assessment of technological constraints and needs of farm households is presented in the report, as well as the results of a maize research priority-setting workshop, where farm and village level information and experience were utilized to focus on the role of research and technology development in improving maize productivity. The identification of constraints to maize production highlighted differences in the surveyed regions, but also revealed many common problems encountered by maize farmers. Drought was targeted as a key constraint, along with others such as poor on-farm crop management, lack of technology and information dissemination, and poor seed quality. Participating farmers and scientists discussed a range of possible solutions to eliminate or minimize the effect of the constraints. Some of the constraints can largely be addressed through technological solutions, although the mere availability or development of technological solutions does not guarantee either their accessibility to farmers or their on-farm use. A challenging and unique mix of government intervention and liberalization of agricultural and market policies continue to influence maize production in China. Addressing the complex set of identified priority constraints to future maize production will necessarily involve a combination of science and policies to tackle the broader issues of markets, infrastructure, and farmer capacity.

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1. Introduction

1.1. Project and Report Objectives

Research reported in this document was undertaken as part of a broader, seven-country, three-year project funded by the International Fund for Agricultural Development (IFAD) to promote the sustainable intensification of maize production systems in upland environments in Asia. With projections of increasing demand for maize across Asia, the need to place these demand projections in the context of domestic and regional supply possibilities and constraints also took on increasing relevance. Of particular interest were implications for the role of research and technology development in improving maize productivity, including an assessment of technological constraints and needs of poor farm households.

Specifically, project objectives included:

- Collection of detailed farm-level information on maize production systems by agroecological region;
- Identification of maize production constraints, and maize production and consumption trends in these regions;
- Prioritization of production constraints; and
- Recommendations for research and development and policy actions to promote sustainable maize production.

This report focuses specifically on the research findings from primary farm-level data collected across a range of maize production environments in China, as well as the results of a maize research priority-setting workshop in China. In the remainder of this chapter, we present the methodology used for farm-level data collection and then summarize briefly national production and consumption trends in the Chinese maize economy. Chapter 2 characterizes maize production environments in China based on survey data and addresses a range of biophysical, socioeconomic, infrastructural, and institutional issues. Chapter 3 provides detailed information on maize cropping patterns, management practices, technology use, and production and utilization trends. Farm-level constraints to maize production are described in Chapter 4, while the methodology and results of the national priority-setting workshop are presented in Chapter 5. We discuss priority recommendations and policy considerations in Chapter 6.

1.2. Methodology for Farm-Level Data Collection

Although the emphasis of the broader, seven-country project was primarily on tropical upland maize production environments, such a focus in China would have limited the analysis to a relatively small percentage of maize area in southwestern China. While maize production and utilization as food, feed, and income source are indeed important to farmer livelihoods in this region, the limited focus would have precluded the discussion of maize research priorities on a national level. To better represent the overall range of maize production in the country and to expand the characterization of maize in China to include major maize production systems, the China team decided to broaden its survey efforts across both subtropical and temperate maize production environments. By doing so, we also recognized that interactions among maize, poverty, and technology are not necessarily limited to upland, tropical production environments in southwestern China.

Chinese maize production areas can be classified into six agroecological regions: Northeast, North, Yellow-Huai River Valley, Northwest, Southwest, and South. Surveys were carried out in all major maize production environments throughout China's maize belt, excluding South China, due to the relative lack of importance of maize in its production systems. Data collection was undertaken in two stages. The objective of the first stage was to characterize the variation in maize production and utilization across the five agroecological regions. Rapid Rural Appraisal (RRA) surveys were utilized to facilitate the collection of information on a range of village-level characteristics and farmer crop production and utilization practices, with special emphasis on maize.

Survey sites were selected using a three-stage, stratified sampling method. In the first stage, provinces were chosen in each agroecological region, taking into consideration such criteria as area, production, and yield of maize; share of maize in cultivated area; existing maize cropping systems; share of irrigated land; per capita income, and share of rural population. The initial selection of provinces reflected the project's focus on upland (defined for the purposes of the project as being primarily rainfed) maize production and included the provinces of Shanxi, Shaanxi, Sichuan, and Guangxi to represent the North, Northwest, and Southwest, respectively. However, the extremely important maize production areas of the Northeast and Yellow-Huai River Valley regions, represented by Jilin and Shandong provinces, respectively, were subsequently added to better represent the overall range of maize production in the country and to allow country-level priority setting.

In the second stage, two counties with contrasting characteristics in terms of infrastructure availability and level of development, as well as market opportunities, were then selected from each province. In the third stage, two surveyed villages were selected in each county, also based on contrasting infrastructural availability and development, and market opportunities.

For the RRA, approximately ten farmers were chosen from each sample village to participate in farmer group discussions. Group members were selected with the objective of reflecting as much of the existing variation in the village as possible. A list of households in the village was obtained with the assistance of the village head or village secretary; through these key informants, households were ordered from "better off" to "worse off." Using this ordered list, households were randomly selected to ensure the participation of a range of households across the wealth spectrum in the village. Participation of both males and females (although never from the same household) in the group was also ensured.

Local biophysical conditions, production and consumption trends, socioeconomic conditions in the village, farmer organizations, market conditions and prices, and cropping activities were addressed in discussions with each farmer group. In the first round of surveys, the sample consisted of a total of 50 villages from 25 counties in six provinces across the five maize production environments in China. The study team also conducted surveys at the village level with village leaders and at the county level with key county informants.

The second phase of data collection was designed to focus in more detail on the variation within a given survey location. For this purpose, a subset of 17 villages from the first round of surveys was selected. Using Participatory Rural Appraisal (PRA) methodology, interaction with four groups of farmers took place simultaneously in each village. Again, households were chosen based on wealth rankings in each sample village. Two groups of approximately ten men and ten women each were chosen at random from households in the village perceived as being better off (no household was represented in both groups), and two groups of approximately ten men and ten women each were chosen at random from households in the village perceived as being worse off. Each of the four groups evaluated crop production and related activities and discussed the physical, biological, and institutional constraints relevant to their region and production system.

1.3. Background

1.3.1. Maize production

The oldest written record of maize in China appears in *Dian Nan Ben Cao* by Lan Mao in approximately 1492 (Liang and Johnnessen 1987). The original usage of maize was as traditional Chinese medicine. The earliest written record (from 1560) of maize as a food crop mentions that maize was a popular cereal crop cultivated in conjunction with rice, wheat, and millet in Pinliang Fu, Gansu Province, in northwestern China. Records also indicate that maize was used as a tribute to the emperor (Liang and Johnnessen 1987). Other historical accounts describe the cultivation of maize in the hilly areas of Fujian Province on China's southeastern coast in the 16th century (Huang and Rozelle 2006).

By the early 20th century, maize had become one of China's major crops (Tong 2000). The maize area expanded to 10 million ha, approximately 12% of total cultivated area, between 1900 and 1930. The area sown to maize continued to increase rapidly during subsequent periods; in 22 provinces (not including northeastern China and Inner Mongolia) it increased by 20% between the periods 1937-1945 and 1946-1949 (Jiang 1947). Next to rice, wheat, and millet, maize was the fourth most cultivated cereal crop in China in 1949, when the People's Republic of China was established. By 1951, maize had exceeded millet in terms of sown area, and maize took its place as the third most cultivated cereal crop in China. Maize area continued to increase substantially during the 1950s, as yields increased. In recent years, however, trends in maize area and production have exhibited higher levels of variability. Figure 1.1 shows the trend over time in sown area and production for maize, rice, and wheat through 2003.

Relative to other cereal crops in China, the area sown to maize increased from 10% of the total area sown to cereals in 1952 to more than 27% in 2000 and 24% in 2003. Maize production increased from almost 17% of total cereal production in 1970 to almost 27% in 2003. Maize experienced the largest increase of all cereal crops in terms of production and sown area during much of the 1980s and 1990s.

Maize supply and demand in China also play an influential role in the world maize economy. China is the second largest maize producer (after the United States) in terms of both area and production. Its share of production in the world maize economy increased from 12.4% in 1970 to 17.9% in 2000 and more than 18% by 2003 (Table 1.1). Table 1.2 provides five-year averages for maize area, yield, and production between 1981 and 2003. Growth rates of production, sown area, and yield for maize and other cereals in China for selected periods between 1970 and 2003 are shown in Table 1.3.

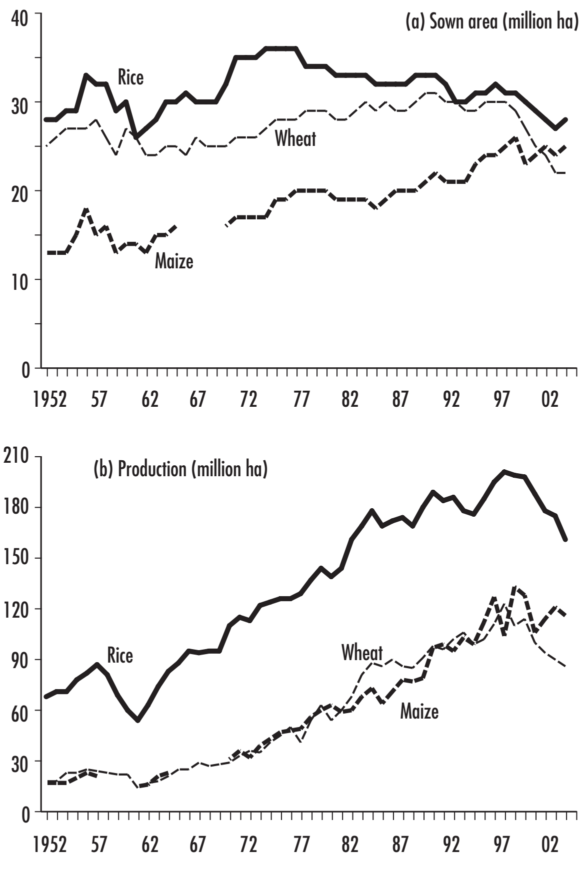

Figure 1.1. Sown area and production of maize, wheat, and rice in China, 1949-2003.
Source: NSB, 1980-2003.

Table 1.4 compares average yield and growth rate of maize in China with those in other major maize-producing countries from 1970 to 2004. The overall growth rate for maize yields in China was approximately 2.7%, slightly lower than those of Brazil and Argentina.

Table 1.1. China's maize economy, 1970-2003.

	1970	1980	1990	2000	2003
Maize in China's cereal economy					
Area share (%)	17.2	21.0	23.0	27.0	24.0
Production share (%)	16.9	20.7	24.9	26.2	26.9
China's maize in world maize economy					
Area share (%)	14.0	16.2	16.4	16.6	17.1
Production share (%)	12.4	15.8	20.1	17.9	18.2
China's wheat in world wheat economy					
Area share (%)	12.2	12.3	13.3	12.5	10.5
Production share (%)	9.4	12.5	16.6	17.0	15.5

Source: Huang and Rozelle 2006; calculated by authors using NSB Statistical Yearbook of China and FAOSTAT.

Table 1.2. Cereal and maize area, yield, and production in China, 1981-2003.

	Units	1981-85	1986-90	1991-95	1996-00	2001-03
Cereal						
Area	million ha	96	95	93	94	84
Yield	tons/ha	2.97	3.35	3.78	4.13	4.09
Production	MMT	284	316	352	388	344
Maize						
Area	million ha	18.6	20.2	21.4	24.5	24.3
Yield	tons/ha	3.5	4.01	4.74	4.89	4.81
Production	MMT	65	80.8	101.6	120	117.1

Source: NSB, Statistical Yearbook of China, various issues.

Table 1.3. Growth rates of production, sown area, and yields for maize and other cereal crops in China, 1970-2003.

	Pre-reform	Reform period			
Commodity	1970-78	1978-84	1984-90	1990-98	1998-03
Production	2.8	4.7	1.5	1.9	-3.8
Sown area	0.0	-1.1	0.2	-0.1	-3.3
Yield	2.8	5.8	1.3	2.1	-0.5
Rice					
Production	2.5	4.5	1.1	1.0	-4.2
Sown area	0.7	-0.6	0.1	-0.6	-3.3
Yield	1.8	5.1	1.0	1.6	-1.0
Wheat					
Production	7.0	8.3	1.4	2.2	-5.4
Sown area	1.7	0.0	0.5	-0.5	-6.0
Yield	5.2	8.3	0.9	2.8	0.6
Maize					
Production	7.4	3.7	4.1	4.1	-2.2
Sown area	3.1	-1.6	2.7	2.3	-1.0
Yield	4.2	5.4	1.4	1.7	-1.3

Notes: Growth rates are computed using regression method.
Source: Huang and Rozelle 2006.

The increase in the production of maize and other cereal crops in China during the last several decades has been recognized as one of the most remarkable success stories in science and technology and agricultural policy reform (Huang and Rozelle 2006; Lin 1992). Increases in production have been attributed to several factors. Development of technology, including hybrid technology; increased water availability through government-funded infrastructural projects; and the supply and use of inorganic fertilizer and other farm chemicals are important factors contributing to maize production growth (Huang et al. 1996). Institutional changes such as the household responsibility system, particularly in the early reform period (Lin 1992), have also been identified as crucial stimulus of production incentives (Huang and Rozelle 2006).

However, given the currently high levels of input use, as well as increasing water shortages and competition from industrial and commercial cash crops, technology development is expected to play the primary role in future productivity gains (Pingali et al. 1997; Huang et al. 2002). Neither increases in area nor yield from further investment in water control are expected. Furthermore, the impacts of institutional change in many cases occur over a finite period of time, and evidence shows that they have been largely exhausted in China (Huang and Rozelle 1996).

1.3.2. Maize consumption

In northern China and the poorer mountainous regions, utilization of maize prior to 1949 was primarily for farmers'own household food use, in the form of porridge or steamed bread. Maize consumption patterns remained largely stable in much of China from 1950 to 1980. However, meat demand – and the corresponding demand for maize as feed– began to increase following the reforms of the early 1980s. Figure 1.2 shows the changes in maize utilization in China from 1981 to 2000. The consumption of maize as food has decreased sharply, while utilization of maize as feed has risen rapidly.

Per capita consumption of maize as food dropped from an average of 21.2 kg in 1981-85 to 9.3 kg in 1996-2000. Per capita consumption in urban areas is significantly lower than in rural areas (Huang and Rozelle 2006). Table 1.5 shows the rapid changes in per capita consumption of maize over selected time periods between 1981 and 2000.

Huang and Rozelle (2006) also note that trends in urbanization and migration are expected to contribute further to decreasing per capita consumption of maize as food. The ratio of urban population to total population increased from 19% in 1980 to 36% in 2000 (Huang and Rozelle 2006). Urbanization, population growth, and rising per capita incomes are the same factors that have contributed to the increased importance of maize as a feed crop. Most of the increase in maize production over the last 20 years has been utilized as feed (Huang and Rozelle 2006), and a continuing increase in the demand for feed maize in Asia (and China, in particular) is expected. Whether or not this demand can be met domestically will depend on the ability to address the needs of maize farmers in the country through technology development, dissemination, and appropriate policies.

Table 1.4. Average yield and growth rates for maize in selected countries, 1970-2005.

	Average yield (MT/ha)							Growth rate (%)
Country	1970-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2003	2004-2005	1970-2005
Argentina	2.67	2.80	2.85	2.95	2.99	3.06	3.17	3.00
Brazil	1.47	1.50	1.54	1.57	1.61	1.65	1.65	2.80
China	2.49	2.57	2.67	2.83	2.98	3.08	3.19	2.70
India	1.08	1.07	1.09	1.12	1.16	1.18	1.19	2.20
Indonesia	1.18	1.23	1.28	1.35	1.40	1.46	1.53	3.50
Mexico	1.34	1.40	1.45	1.49	1.56	1.63	1.67	2.50
Nigeria	1.05	1.11	1.15	1.18	1.23	1.25	1.25	0.50
Romania	2.88	2.94	3.05	3.09	3.15	3.27	3.36	0.30
South Africa	1.87	2.05	2.05	1.96	1.95	1.92	1.91	1.50
USA	5.62	5.83	5.97	5.88	5.97	6.24	6.43	1.60

Source: FAOSTAT 2006.

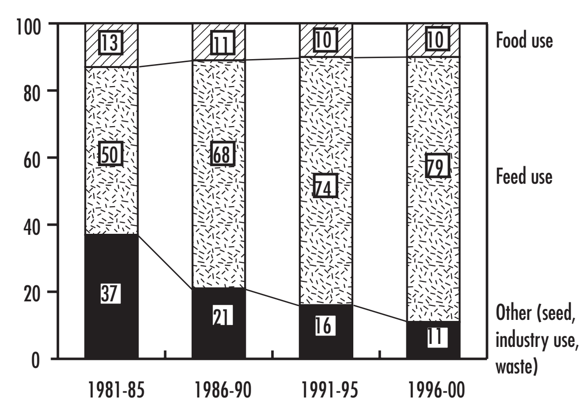

Figure 1.2. Maize consumption patterns in China, 1981-2000.

Source: Huang and Rozelle 2006.

Table 1.5. Per capita maize consumption in China, 1981-2000.

	Units	1981-85	1986-90	1991-95	1996-00
Per cap food	kg/person	21.19	14.12	12.13	9.28
Urban	kg/person	3.24	2.73	2.92	2.72
Rural	kg/person	26.20	17.99	15.66	12.11

Source: Huang and Rozelle 2006.

2. Characterization of Maize Agroecological Environments in China

2.1. Overview of Maize Agroecological Environments in China

Maize is cultivated in every province in China, but the wide range of climatic and geographical variation in the country, in addition to other factors affecting production and consumption patterns, result in significant differences in maize cropping patterns and practices.

The principal maize production areas in China are situated in a belt of very diverse environments traversing China from northeast to southwest. Figures 2.1 and 2.2, respectively, show the distribution of average maize sown area and production for 1998-2000; the pattern of the Chinese maize belt is clearly evident.

Production environments can be broadly classified into six agroecological regions: Northeast China, North China, Yellow-Huai River Valley, Northwest China, Southwest China, and South China (Figure 2.3). Together, the three agroecological regions of Northeast China, North China, and the Yellow-Huai River Valley account for approximately 70% of China's maize area and close to 75% of total maize production.[1]

The provinces and prefectures included in each agroecological region are summarized in Table 2.1. Five of the six agroecological regions (South China is excluded) are addressed in this report and include the 14 most important maize-producing provinces in China: Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Shanxi, Shandong, Henan, Shanxi, Shaanxi, Sichuan, Guizhou, Yunnan, and Guangxi.

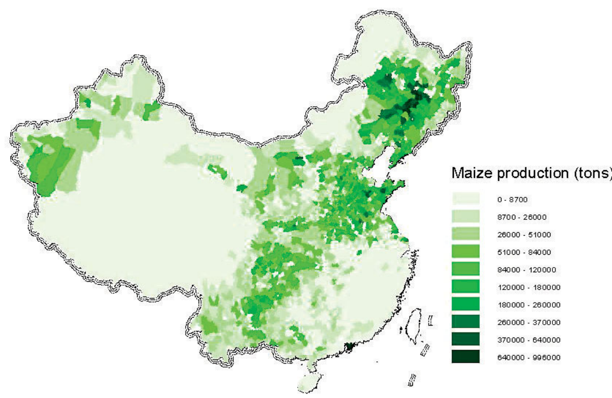

Figure 2.2. Average maize production in China by county, 1998-2000.

[1] The maize-producing region known as the North China Plain spans an area from the North China region to the Yellow-Huai River Valley, which includes the provinces of Shanxi, Hebei, Beijing, Tianjin, and Inner Mongolia.

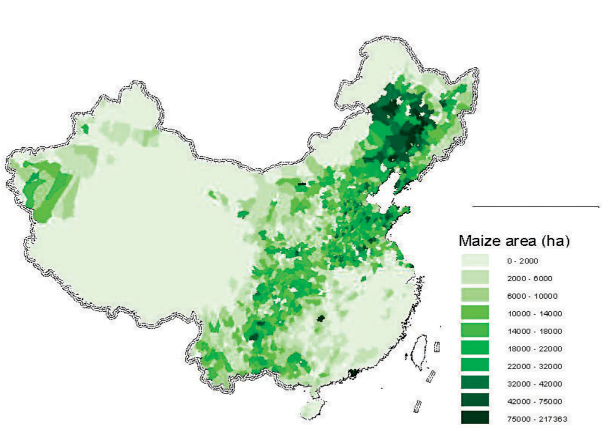

Figure 2.1. Average maize sown area in China by county, 1998-2000.

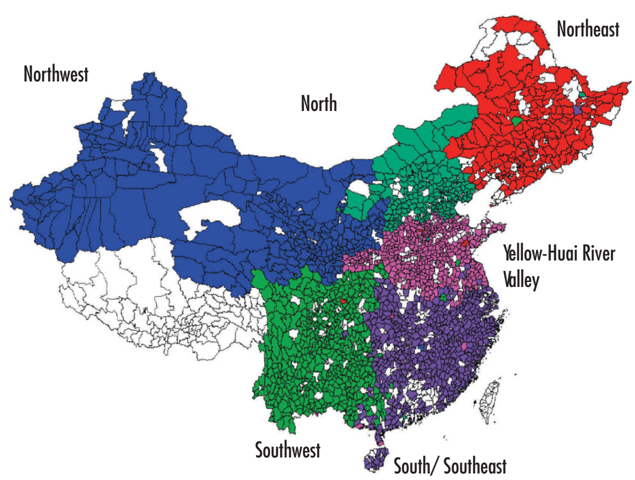

Figure 2.3. Maize agroecological regions in China.

As a result of the interaction between production and consumption factors and biophysical conditions, maize systems vary greatly within the five agroecological regions. Irrigation is an important factor. Although most of the rice (95%) and wheat (65%) areas are irrigated, the irrigated maize area is estimated at only 45% of the total maize sown area (Huang and Rozelle 2006).

Descriptive statistics on rural population, total arable land, total crop sown area, and maize sown area for the five agroecological regions are summarized in Table 2.2. The share of maize in the total crop sown area is considerably higher in the Northeast than in other regions, but maize nevertheless plays a significant role in the other regions. The fact that the crop sown area is greater than the total arable area in certain regions reflects the cultivation of more than one crop per year. The increase in the Multiple Cropping Index (MCI) from north to south reflects the gradual change in cropping systems from one crop per year, to three crops in two years, to two crops per year, and, finally, to three crops per year. An average of more than two crops per year is common in the Southwest region, while cold temperatures and short growing seasons in the Northeast region restrict farmers to one crop a year. The MCI is calculated as the ratio of the crop sown area to arable area; the crop sown area is counted twice if two crops are cultivated on the same land in one year. The average MCI for all of China during the period 1978-2000 was 1.45.

Maize production data for each agroecological region and the share of maize production systems found in each region are presented in Table 2.3. The largest maize sown areas and highest maize production levels are in the Northeast and Yellow-Huai River Valley regions. In both regions average yields are over 5 tons per hectare. Spring maize in the Northeast region is almost completely rainfed; however, due to generally good soil fertility, good growing conditions, and input use, the Northeast region is one of China's highest yielding maize-producing regions. Irrigated summer maize predominates in the Yellow-Huai River Valley and is cultivated in the plains; summer maize is also cultivated, but under rainfed conditions. Spring maize in Northwest China is likewise cultivated under both rainfed and irrigated conditions in the spring. Irrigated spring maize areas of Northwest China have the combined advantages of suitable temperatures, a longer cropping season than for summer maize, and more reliable irrigation systems. With an average of

Table 2.1. Maize agroecological regions in China.

Agroecological region	Provinces and prefectures
Northeast	Liaoning, Jinlin, Heilongjiang, Inner Mongolia (Chifeng City, Hulunbeier League, Xingan League, Tongliao City)
North China	Beijing, Tianjin, Hebei (Shijiazhuang, Tangshan, Qinhuangdao, Baoding, Zhangjiakou, Chengde, Cangzhou, Langfang), Shanxi (Taiyuan, Datong, Yangquan, Shuozhou, Yinzhou, Luliang), Inner Mongolia (Hohhot City, Baotou City, Wuhai City, Xilinguole League, Wulanchabu League, Erdos City)
Yellow-Huai River Valley	Hebei (Handan, Xingtai, Hengshui), Shanxi (Changzhi, Jincheng, Jinzhong, Linfen, Yuncheng), Shandong, Henan, Shaanxi (Xian, Baoji, Xianyang, Weinan, Yangling), Anhui (Bengbu, Huainan, Huaibei, Chuzhou, Fuyang, Bozhou, Suxian) Jiangsu (Lianyungang, Xuzhou, Yancheng, Huaiyin, Yangzhou)
Northwest	Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia (Bayannaoer League, Alashan League), Shaanxi (Tongchuan, Yanan, Yulin)
Southwest	Guangxi (Nanning, Liuzhou, Guilin, Hezhou, Baise, Hechi), Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi (Hanzhong, Ankang, Shangluo)
South China	Guangxi (Wuzhou, Beihai, Fangchenggang, Qinzhou, Guigang, Yulin), Guangdong, Hainan, Fujian, Hunan, Hubei, Zhejiang, Shanghai, Jiangxi

Sources: CAAS 1984; Liu 2002; Tong et al. 1998.

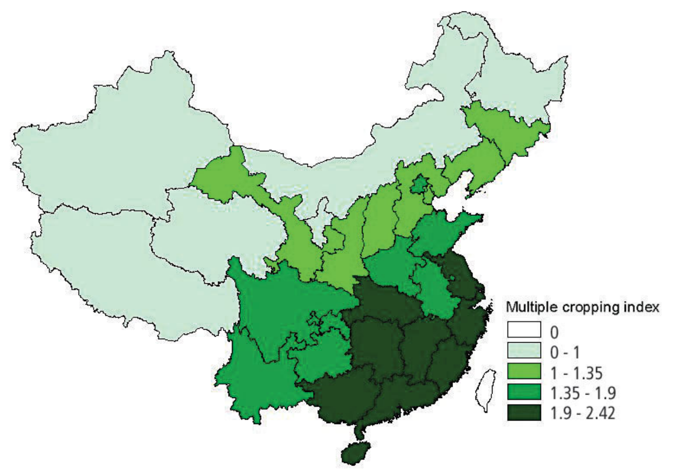

Figure 2.4. Distribution of multiple cropping index (MCI) in China.

Table 2.2. Rural population, arable land, crops and maize sown area in agroecological regions in China, 1998-2000.

	Rural population (million persons)	Arable land (million ha)	Crop sown area (million ha)	Maize sown area to crops sown area (%)	MCI (%)
Northeast	69.2	21.5	20.5	36	0.95
North	97.8	10.4	11.0	26	1.06
Yellow-Huai River Valley	241.4	24.3	39.3	19	1.62
Northwest	41.6	11.2	14.9	9	1.33
Southwest	203.9	13.0	29.4	14	2.26

Source: Authors' calculation from CCAP database based on Table 2.1.

less than 4 tons per hectare, maize yields in the Southwest region are the lowest among the five agroecological regions.

More detailed characterizations of each of the five maize agroecological regions are summarized below.

2.1.1. Northeast region

This agroecological region includes the three provinces of Heilongjiang, Jilin, and Liaoning, as well as the prefectures of northeastern Inner Mongolia (Table 2.1). Agriculture and forestry are key industries in the region, and agricultural production is the major income source for the rural population. Maize is the most important crop in terms of area and production. Other major crops include soybean, spring wheat, and rice. Although a small percentage of the maize area is irrigated, the crop is cultivated almost completely under rainfed conditions in the spring. The major maize production area in this region is located in the Songliao plain. Black loamy and brown loamy soils predominate in this region.

The climate in this region is classified as frigid humid/ semi-humid temperate, and characterized by warm, wet summers and long, very cold winters. Sixty percent of its annual precipitation of 500 to 800 mm falls between July and September. The maize cropping cycle in this region decreases as the number of frost-free days decreases. Because early frost usually appears in September and early October, fast maturing maize varieties are needed. The average maize cycle is 130 days in Heilongjiang province and 150 days in Liaoning, Jilin, and Inner Mongolia.

2.1.2. North region

This agroecological region includes the city-administered areas of Beijing and Tianjin, northern Hebei and Shanxi provinces, and central Inner Mongolia (Table 2.1). The region can be subdivided into two parts: the north plateau and hill subregion, comprising central Inner Mongolia and northern Shanxi and Hebei, and the north plain subregion consisting of the cities of Beijing and Tianjin and the northern Hebei coastal plain. The north plain subregion has favorable production conditions; most of the maize area is irrigated, and average yields are among the highest in China. The north plateau and hill subregion is predominantly rainfed and characterized by long day-length and a large daytime/nighttime temperature gap, which results in generally good maize growing conditions. An important crop in this subregion, maize is used for both food and feed, although minor grain crops, such as millet, also play an important role in food security. The growth cycle of maize varieties to the north of Shanxi and Shaanxi provinces is the longest in China, sometimes as long as 190 days. Most of the region has semiarid climatic conditions. Brown loamy and silt loamy soils predominate in this region.

2.1.3. Northwest region

This region comprises the two autonomous regions of Xinjiang and Ningxia; Qinghai and Gansu provinces; northern Shaanxi province; and western Inner Mongolia. There are two maize production systems: rainfed spring maize cultivated in hilly locations and irrigated spring maize cultivated on plateaus and terraced land. The rainfed maize system in the eastern part of the region comprises 40% of the total maize area. Here, annual precipitation is higher than in irrigated areas, and abundant sunshine and favorable temperatures are conducive to maize production. Maize in both systems is grown as the single crop in the annual growing season. Other major crops in the region include winter and spring wheat, millet, broomcorn millet, oats, buckwheat, and potato. In general, all crops are fast maturing. The use of fallow during the rainy season to build up soil moisture is common practice.

Table 2.3 Maize production in five agroecological regions, 1998-2000

	Maize production [a]			Share of maize by production system (%) [b]					
	Area (million ha)	Production (million tons)	Yield (ton/ha)	Rainfed			Irrigated		
				Spring maize	Summer maize	Fall maize	Winter maize	Spring maize	Summer maize
Northeast	7.36	39.0	5.3	99	-	-	-	1	-
North	2.90	13.9	4.8	80	-	-	-	20	-
Yellow-Huai River Valley	7.44	38.0	5.1	1	19	-	-	-	80
Northwest	1.28	7.4	5.8	40	-	-	-	60	-
Southwest	3.99	15.9	4.0	44.5	2	3.5	minimal	9	41

[a] Authors calculation from CCAP database based on Table 2.1

[b] Estimated by participants in Maize Prioritization Workshop, Beijing 2002.

2.1.4. Yellow-Huai River Valley

This region includes southern Hebei and Shanxi provinces, central Shaanxi province, Henan and Shandong provinces, and northern Anhui and Jiangsu provinces. The region is characterized by warm temperate and semi-humid monsoon climate.

There are three maize systems in the region: rainfed spring maize, rainfed summer maize, and irrigated summer maize. Rainfed spring maize is primarily cultivated in the hilly and mountainous areas in the western part of the region, including western Henan province, eastern Shaanxi province, and southern Shanxi province. Either three crops are harvested in two years or one crop is harvested per year. Other major crops include winter wheat, soybean, beans, sweet potato, potato, apple, and other fruit crops. Although spring maize was historically second in importance to winter wheat, its area has decreased as fruit crops have become more profitable. Rainfed summer maize is primarily cultivated in the hilly areas in the northern part of Anhui province, where winter wheat and summer maize are rotated every two years.

The predominant maize system in the Yellow-Huai River Valley is irrigated summer maize either rotated or relay-cropped with winter wheat in the plain areas. Other major crops in this system include cotton, peanuts, and vegetables. The summer maize cycle averages 110-115 days in the Yellow-Huai River Valley.

2.1.5. Southwest region

This region includes the provinces of Sichuan, Chongqing, Guangxi, Guizhou, and Yunnan as well as southern Shaanxi province. The region can be divided into two major maize systems, rainfed summer maize cultivated in the north of Sichuan, Chongqing, and Shaanxi, and rainfed spring maize cultivated in the south of Sichuan, Guangxi, Guizhou, and Yunnan. Furthermore, a much smaller irrigated spring maize system can be found in Sichuan province. Three cropping seasons per year are common in this region.

A cropping system common in the north is winter wheat–summer maize–fall vegetable. The summer maize cycle is similar to that of mid-season rice, approximately 110 days.

The topography of the rainfed spring maize system in the south ranges from flat to hilly to mountainous, and much of the maize in mountainous areas is cultivated in the karst geological environment typical of parts of southwestern China. The rainfed spring maize system supports additional fall or winter crops following spring maize harvest. The winter maize crop is largely green maize, cultivated and consumed more as a vegetable than as a grain crop. The cycle of spring and fall maize is approximately 100 days. However, cultivation of both fall and winter maize following spring maize has been decreasing due to competition from other crops and to changes in consumer preferences, from maize to rice.

2.2. Cropping Calendar

The duration of frost-free periods increases from 100 days in northeastern China to 360 in southwestern China. Average annual precipitation is 200-1600 mm. About two thirds of maize in China is grown under temperate conditions, with the other third divided between subtropical and tropical conditions (Liu 2002; CAAS 1984; Tong et al. 1998).

Table 2.4 summarizes biophysical data for the five maize agroecological regions. Accumulated temperatures above 10 ºC, average temperatures, and frost-free periods all increase from northeast to southwest. However, precipitation and hours of sunshine do not exhibit the same pattern with the decreasing latitude across the country.

Figure 2.5 presents a general cropping calendar for the five maize agroecological regions relevant to this study. The three agroecological regions in the north (Northeast, North, and Northwest) typically cultivate one crop per year, although three crops in two years is

Table 2.4. Biophysical environments in five major maize agroecological regions, China.

	>10º C accumulated temperature (ºC)	Average temperature (ºC)	Sunshine (hours)	Frost-free period (days)	Rainfall (mm/year)	Altitude (m)
Northeast	1300-3700	-14	2300-3000	100-200	500-800	50-100
North	2000-3600	-12	2500-3200	120-200	200-600	50-100
Yellow-Huai River Valley	3400-4700	10-14	2200-2800	170-220	500-1100	50-100
Northwest	2000-4500	0-12	2600-3400	140-170	10-250	300-3000
Southwest	3500-6500	15-18	1200-2600	240-360	800-1600	200-3000

Sources: CAAS 1984.

also possible in the southern part of the North and Northwest maize agroecological regions. The Yellow-Huai River Valley region is generally characterized by two crops per year, while three crops a year is common in the Southwest maize region.

Crop alternatives are more limited in non-irrigated areas, and maize has traditionally held a comparative advantage over other crops, for example, in the Northeast rainfed spring region. In other agroecological regions of China, maize is most commonly grown as a second crop in annual rotations. In parts of North China, particularly on the North China plain, farmers cultivate maize after harvesting winter wheat. In areas of the Yellow-Huai River Valley, wheat crops are planted with enough space between rows to allow sowing maize prior to the wheat harvest (relay cropping). In the Southwest region, which includes both subtropical and tropical maize areas, climatic conditions allow more flexible rotations, and maize can be incorporated into rotations with a wide range of crops, including potato, rape, vegetables, and melons.

2.3. Maize Production and Poverty

Per capita income in counties with a maize area of more than 4,000 hectares was an average 1,981 yuan in 2000 (Table 2.5). This figure is lower than both the 2,313 yuan average in counties with less than 4,000 hectares of maize and the national average of 2,135 yuan.

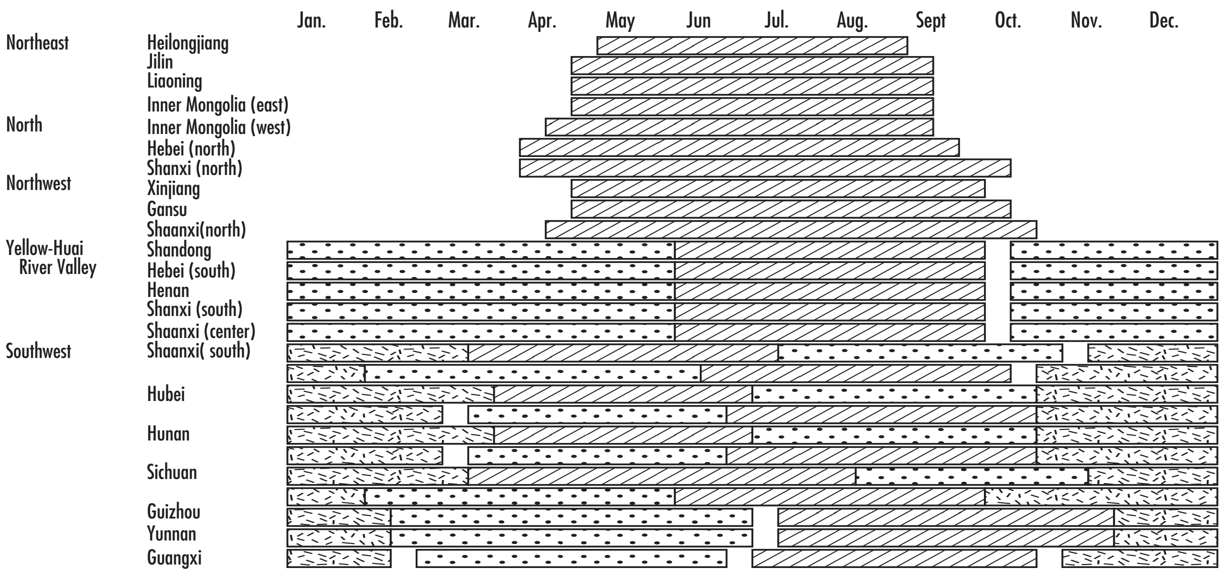

Figure 2.5. General cropping calendar for selected maize agroecological regions in China.
Note: Each block represents one maize cycle.

Table 2.5. Comparison of per capita farmer's net income (PCFI) between major and non-major maize production counties[a], 2000.

	Number of poverty counties			
	PCFI= <666 yuan	PCFI= <1000 yuan	PCFI= <1500 yuan	PCFI (yuan)
Major maize production counties	28	126	391	1981
Non-major maize production counties	17	100	285	2313
All China	45	226	676	2135

[a] A major maize county is defined as one with maize sown area greater than 4000 hectares.
Source: Authors' calculation from CCAP database.

In 2002, of a total of 45 officially designated national poverty counties with average per capita incomes of less than 625 yuan, 28 cultivated maize on more than 4000 hectares. A similar relationship between a large maize area and low income levels can also be observed at per capita income increments of 1,000 yuan and 1500 yuan. Figure 2.6 overlays counties with average annual per capita income of less than 1,000 yuan and 1,000 to 1,500 yuan over counties with a maize area greater than 4,000 hectares. A relationship clearly exists between maize production and rural poverty; however, these data do not provide further details regarding the causal nature of this relationship.

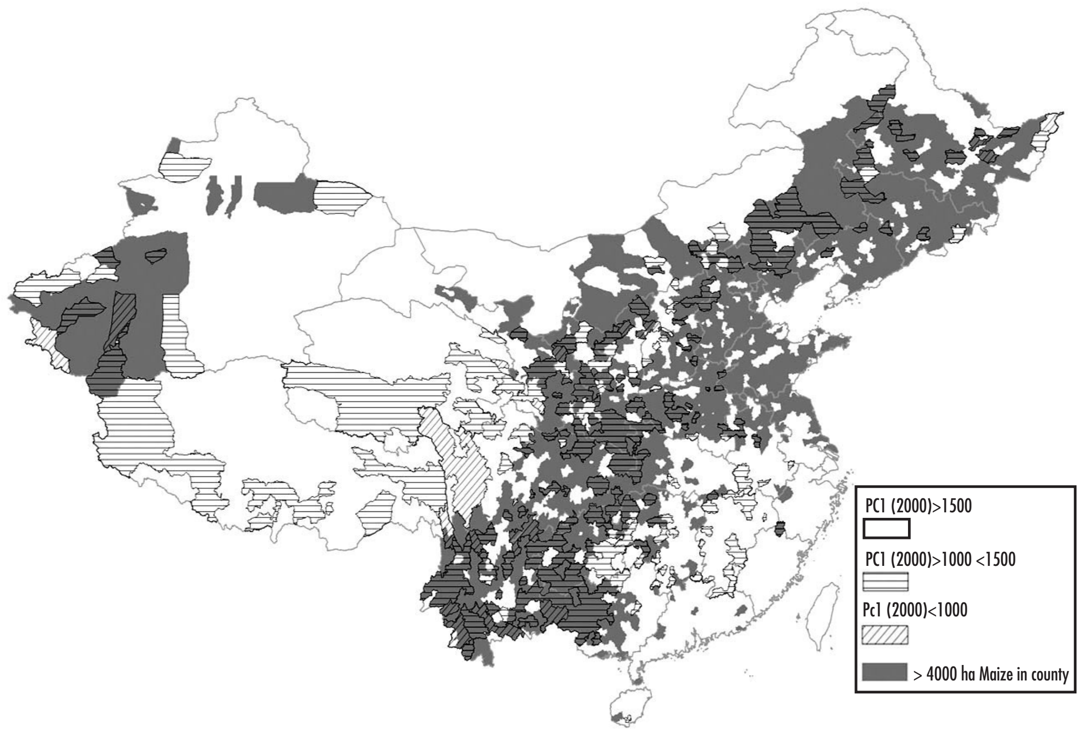

Figure 2.6. Maize production and per capita income.

2.4. Survey Sites

Table 2.6 lists the 50 survey sites in China along with the corresponding maize agroecological regions and production systems.

Figure 2.7 places the surveyed villages in the context of average county-level maize production in China in the period 1998-2001. All sites are situated within China's maize belt. In Figure 2.8, the surveyed villages are illustrated in the context of three categories of county average per capita income.

2.5. Climatic Conditions

Annual precipitation across the five agroecological regions ranged from 375 mm in the irrigated spring maize systems of the Northwest to over 1500 mm in villages cultivating both spring and winter season maize in the Southwest. Average precipitation and precipitation ranges at planting, flowering, and harvesting for the maize systems are presented in Table 2.7.

Average annual temperatures, as well as averages and ranges across the maize season, are presented in Table 2.8. The wide range of climatic conditions across maize producing environments in China is evident, with a minimum annual average temperature of 5.8^{o}C observed in survey sites in the Northeast region and of 28^{o}C in areas cultivating both rainfed spring and fall maize in the Southwest.

Table 2.6. Agroecological classification of 50 surveyed villages.

Maize growing region	Primary maize production system	Secondary maize production system	Province	County	Township	Village
Northeast	Rainfed spring		Jilin	Changling	Dong Liu Hao	Jin Shui
Northeast	Rainfed spring		Jilin	Changling	Dong Liu Hao	Ma Lian
Northeast	Rainfed spring		Jilin	Gongzhuling	Chao Yang Po	Li Jia Dian
Northeast	Rainfed spring		Jilin	Gongzhuling	Chao Yang Po	Liao He
North	Irrigated spring	Rainfed spring	Shanxi	Lishi	Xingyi	Yancun
North	Irrigated spring		Shanxi	Qingxu	Wucun	Kongcun
North	Irrigated spring		Shanxi	Qingxu	Xigu	Xiluopo
North	Rainfed spring		Shanxi	Lingshi	Mahe	Yangjiayuan
North	Rainfed spring		Shanxi	Lingshi	Mahe	Zhangsong
North	Rainfed spring		Shanxi	Lishi	Xinyi	Xinyi
North	Rainfed spring		Shanxi	Shouyang	Pingshu	Gucheng
North	Rainfed spring		Shanxi	Shouyang	Pingshu	Taian
Northwest	Irrigated spring		Shaanxi	Shenmu	Dabaodang	Bulawan
Northwest	Irrigated spring		Shaanxi	Shenmu	Dabaodang	Yongfeng
Northwest	Rainfed spring		Shaanxi	Luochan	Jiuxian	Leijiawan
Northwest	Rainfed spring		Shaanxi	Luochan	Jiuxian	Jinjiayuan
Northwest	Rainfed spring		Shaanxi	Yanan	Nanniwan	Gaofangcun
Northwest	Rainfed spring		Shaanxi	Yanan	Nanniwan	Santaizhuang
Yellow-Huai River Valley	Irrigated summer	Irrigated spring	Shandong	Jiaxiang	Ma Ji	Xia Hua Lin
Yellow-Huai River Valley	Irrigated summer		Shandong	Jiaxiang	Huang Gai	Zhang Gai
Yellow-Huai River Valley	Irrigated summer		Shandong	Ningjing	Cai Hu Dian	Dong Dian Liu
Yellow-Huai River Valley	Irrigated summer	Irrigated spring	Shandong	Ningjing	Zhang Da Zhuang	Wang Zhuang
Yellow-Huai River Valley	Irrigated summer		Shandong	Zhucheng	Lu Biao	Da Cun
Yellow-Huai River Valley	Irrigated summer		Shandong	Zhucheng	Zhi Gou	Wang Cun
Yellow-Huai River Valley	Rainfed summer	Rainfed spring	Shanxi	Hongtong	Kongyu	Yutou
Yellow-Huai River Valley	Rainfed spring	Rainfed summer	Shanxi	Hongtong	Kongyu	Shangan
Southwest	Rainfed summer	Rainfed spring	Shaanxi	Ankanghanbing	Jiangbei	Shuangquan
Southwest	Rainfed summer	Rainfed spring	Shaanxi	Ankanghanbing	Yinghu	Yuxing
Southwest	Irrigated spring		Sichuan	Bazhong	Mingyang	Gaodianzi
Southwest	Irrigated spring		Sichuan	Shehong	Taihe	Tangjiajin
Southwest	Irrigated spring	Rainfed summer	Sichuan	Shehong	Chenggu	Xiongjiaci
Southwest	Rainfed spring	Rainfed winter	Guangxi	Debao	Zourong	Baming
Southwest	Rainfed spring	Rainfed fall, rainfed winter	Guangxi	Debao	Maai	Longhua
Southwest	Rainfed spring	Rainfed winter	Guangxi	Duan	Daxing	Jiudun
Southwest	Rainfed spring	Rainfed winter	Guangxi	Duan	Baoan	Pingwang
Southwest	Rainfed spring	Rainfed winter	Guangxi	Longan	Doujie	Ouli
Southwest	Rainfed spring	Rainfed fall	Guangxi	Longan	Qiaojian	Yanluo
Southwest	Rainfed spring		Guangxi	Tiane	Bala	Bala
Southwest	Rainfed spring		Guangxi	Tiane	luipai	Yubang
Southwest	Rainfed spring	Rainfed fall	Guangxi	Wuming	Ningwu	Liangxin
Southwest	Rainfed spring	Rainfed fall	Guangxi	Wuming	Yuqian	Peilian
Southwest	Rainfed spring	Rainfed summer	Shaanxi	Ziyang	Donghe	Majiazhuang
Southwest	Rainfed spring		Shaanxi	Ziyang	Chengguan	Nanmucun
Southwest	Rainfed spring	Irrigated spring	Sichuan	Bazhong	Guangyinjin	Ercun
Southwest	Rainfed spring	Irrigated spring	Sichuan	Guangan	Pengjia	Baiyang
Southwest	Rainfed spring		Sichuan	Guangan	Guangmen	Huiwencun
Southwest	Rainfed spring		Sichuan	Lezhi	Laodong	Wulichong
Southwest	Rainfed spring	Rainfed fall	Sichuan	Lezhi	Dongshan	Yixuecun
Southwest	Rainfed spring		Sichuan	Xuanhan	Liuchi	Liangfeng
Southwest	Rainfed spring		Sichuan	Xuanhan	Liuchi	Liuping

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

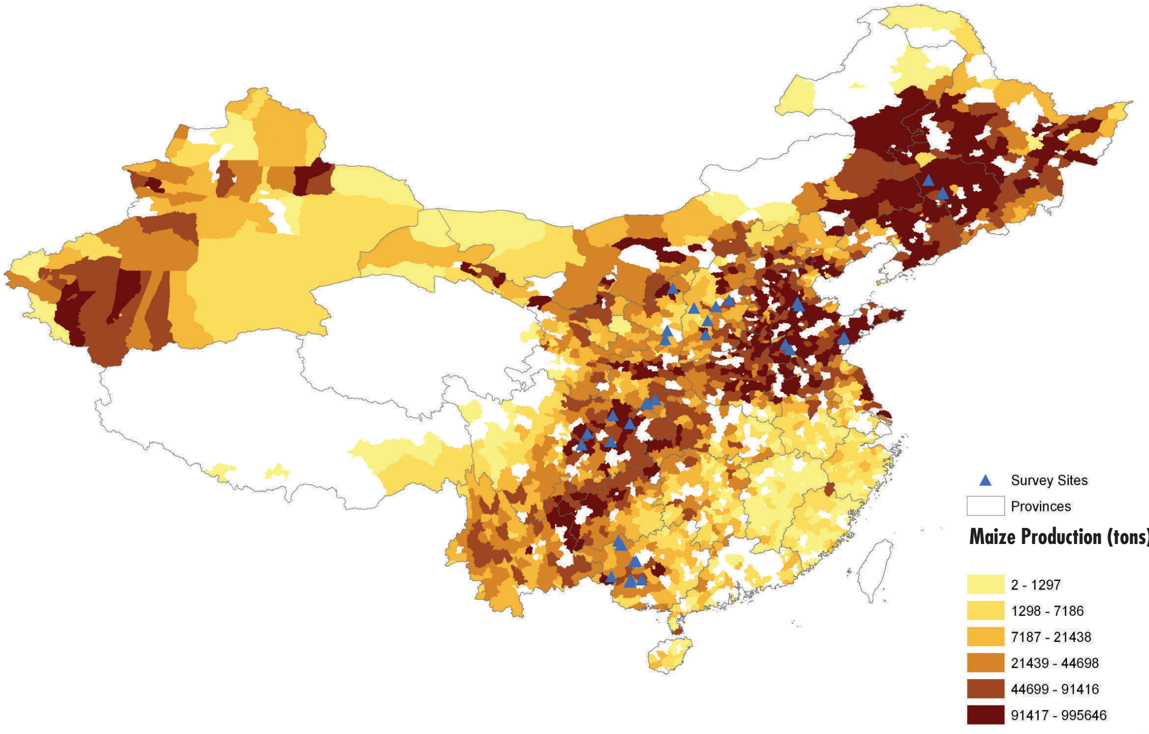

Figure 2.7. Survey sites and maize production, 1998-2001.

Figure 2.8. Survey sites and average per capita income, 2000.

Table 2.7. Precipitation (mm) in surveyed maize production sites in China.

Agroecological region	Maize system	Annual average	Spring planting Avg	Spring planting Min-max range	Spring flowering Avg	Spring flowering Min-max range	Spring harvesting Avg	Spring harvesting Min-max range	Summer planting Avg	Summer planting Min-max range	Summer flowering Avg	Summer flowering Min-max range	Summer harvesting Avg	Summer harvesting Min-max range
Northeast	Rainfed spring	453.8	64.1	na	121.0	na	216.4	na	-	-	-	-	-	-
North	Irrigated spring	462.0	na	na	na	na	na	na	-	-	-	-	-	-
	Rainfed spring	500.0	23.7	0-30	81.0	7-160	207.9	7-300	-	-	-	-	-	-
Northwest	Irrigated spring	375.0	19.0	10.3--26.4	77.1	36.1--118.1	93.6	59--128.2	-	-	-	-	-	-
	Rainfed spring	551.9	28.4	6.4-75	137.0	6.4-308.3	187.3	39.6-378.9	-	-	-	-	-	-
Yellow-Huai River Valley	Irrigated summer	473.7	na	na	na	na	na	na	123.0	na	143.3	na	152.4	na
	Rainfed spring/summer	na	7.9	1.2--14.3	120.8	65.4--151.7	154.7	123.1--186.2	10.8	4.7--20.4	141.3	72.6--159.6	184.5	140.3--201.7
Southwest	Rainfed summer	799.3	48.8	4.6--34.4	251.7	73.1-89.9	247.8	115.8-132.0	88.7	70.8--120	320.6	129--216	198.2	146--232
	Irrigated spring	920.9	42.0	20-105	242.3	144.4--261.7	303.5	140.9--390	28.3	0--96.4	509.8	278.9--526.5	227.6	29-349.8
	Rainfed spring (all sites)	1282.4	77.1	5-310	438.2	42.1--1118.2	271.3	30-401.8	373.1	0-1200	563.8	7.9--1300	149.4	5.7--308.5
	Rainfed spring (one season)	1219.0	85.4	3.7-120	498.0	85.4-1118.2	292.3	85.8-401.8	262.7	109-886	412.2	145-718.7	218.6	96.6-308.5
	Rainfed spring/fall	1300.0	60.0	5—100	400.0	200—650	263.0	100-300	512.0	500-1000	513.0	500-110	52.0	10—100
	Rainfed spring/fall/winter	1527.3	77.7	58.8—96.8	218.0	179.6—263.8	298.1	119.8—352.9	387.9	152.8—559.8	649.0	7.9-721.1	70.9	5.7—159.9

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.8. Temperature (°C) in surveyed maize production sites in China.

Agroecological region	Maize system	Annual average	Spring planting Avg	Spring planting Min-max range (°C)	Spring flowering Avg	Spring flowering Min-max range	Spring harvesting Avg	Spring harvesting Min-max range	Summer planting Avg	Summer planting Min-max range	Summer flowering Avg	Summer flowering Min-max range	Summer harvesting Avg	Summer harvesting Min-max range
Northeast	Rainfed spring	5.8	na	na	18.7	na	22.5	na	-	-	-	-	-	-
North	Irrigated spring	9.6—10.2	14.5	5.2—19	24.0	18.9—29.6	11.0	5.2—17.8	-	-	-	-	-	-
	Rainfed spring	9.0	12.8	8-14.2	21.4	16.7-32	15.0	3-25.7	20.0	15—25	26.0	20—32	13.0	3—20
Northwest	Irrigated spring	8.9	9.0	1.3—9	22.0	15—28	7.7	12—22	-	-	-	-	-	-
	Rainfed spring	13.4	13.9	8.1—16.4	25.6	19.4—28.3	24.2	20.2—25.8	13.2	19.6—28.4	26.9	23.6—29.7	23.0	16.4—22.7
Yellow-Huai River Valley	Irrigated summer	na	13.9	8.1—16.3	25.6	19.4—28.2	24.2	20.2—25.7	24.1	19.6—28.3	27.6	23.6—29.7	20.2	16.4—22.7
	Rainfed spring/summer	9.3	7.6	1.7-16	21.7	15.5-26.7	11.8	7.3-16.5	-	-	-	-	-	-
Southwest	Rainfed summer	15.7	16.2	na	26.0	na	28.4	na	26.4	na	28.2	na	22.2	na
	Irrigated spring	17.3	8.4	4.3—12.7	24.3	21.7—28.5	28.7	26.5—36.4	21.5	19.1—24.2	27.2	23.9—30.7	20.8	13.3—23.3
	Rainfed spring (all sites)	18.1	12.7	-1.4—37.4	23.9	8.9—38.3	24.3	13.3-42	24.3	7.9-35.8	24.7	13.4-39.2	19.6	12-39.1
	Rainfed spring (one season)	22.1	7.9-35.8	26.70	13.4-39.2	20.43	14.1-39.1	na	-	-	-	-	-	-
	Rainfed spring/fall	25.0	13.0	8—28	24.0	15—34	25.0	18—38	30.0	25—37	20.0	15—32	15.0	12—28
	Rainfed spring/winter	20.8	13.3	5.2—20.3	23.1	14.4—27.7	24.5	19.5—28.8	25.7	21.7—33	23.0	14.7—31.8	20.1	13.9—28.2

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

2.6. Infrastructure

2.6.1. Roads and transportation

Infrastructural development has been a major priority for government investment, especially roads and national highways. Over the last two decades, China's road network doubled to more than 1.4 million kilometers and, in 2000, it accounted for 76% of national freight movement. Although the increase in the share of freight traveling over roads has come at the expense of railroads and inland waterways, these traditional modes of transportation continue to be significant. However, similar to the road network, their quality and coverage are not uniform within the country (Huang and Rozelle 2006).

Infrastructure at the village level is similarly variable in quality and coverage. Internal road infrastructure in our surveyed villages ranged from generally good quality roads with good accessibility, particularly in the Yellow-Huai River Valley region, to very difficult access from one part of the village to another in several villages of the Southwest rainfed spring and summer maize areas. Travel by motorcycle provided the fastest means of access under these conditions, but walking was stated as the most commonly used means of transportation. All surveyed villages had electricity, with the exception of one village in the Southwest rainfed spring maize region.

Village access to the main road was between 0 and 8 km and averaged 1.5 km. Distances to the primary market varied considerably more, ranging from 0 to 30 km with an average of 5.8 km.

2.6.2. Markets

The primary sales outlets for maize were government grain bureaus, private traders, and local markets. Sales to other farmers in the farmer's own village and neighboring villages took place depending on the specific region and maize production system. The possibility of selling maize to local feed factories was also mentioned in surveyed villages in the Northeast and Yellow-Huai River Valley, although it did not appear to be a common option. Policies on grain procurement by the government have alternated between implementation and liberalization many times over the last several decades, and the grain quota for farmers has also fluctuated significantly as a consequence (Huang and Rozelle 2006). In 2000, the government began to eliminate grain procurement quotas, first in regions with a grain deficit and, subsequently, in regions showing a surplus. However, implementation appears to have been somewhat uneven at the local level.

Implementation of a 1998 central government policy prohibiting traders and private companies from purchasing grain from farmers and limiting their activities to wholesale and retail markets was also uneven across surveyed villages. Farmers in one surveyed village in the rainfed spring maize system, for example, disagreed about whether or not traders were allowed to come to the village. Farmers in other villages noted that traders had only recently begun to come. In other villages, traders were still not an available option for maize sales.

Sales to government grain depots accounted for a significant share of maize sales, particularly in the Northeast. This dominance is likely a function of the strong association of the Northeast with national maize

Table 2.9. Infrastructural availability and conditions in surveyed villages.

Agroecological region	Maize system	Total road infrastructure in village (km)	% passable to traffic	% affected by rain	Distance to nearest roadhead (km)	Distance to primary market (km)
Northeast	Rainfed spring	18.8	24.0	88.0	0.8	3.1
North	Irrigated spring	2.5	88.9	44.4	0.9	6.0
	Rainfed spring	5.2	100.0	76.9	2.0	10.8
Northwest	Irrigated spring	13.8	9.1	90.9	2.1	3.3
	Rainfed spring	2.9	25.8	81.7	2.4	4.5
Yellow-Huai River Valley	Irrigated summer	13.7	58.5	62.2	2.0	4.3
	Rainfed spring/summer	3.8	53.3	80.0	0.4	3.5
Southwest	Rainfed summer	17.0	26.5	100.0	3.0	7.5
	Irrigated spring	5.3	43.5	84.4	0.0	2.3
	Rainfed spring (all sites)	14.3	95.5	77.5	1.4	6.6
	Rainfed spring (one season)	28.2	67.4	76.3	0.9	5.9
	Rainfed spring/fall	29.8	72.7	79.7	1.2	6.0
	Rainfed spring/winter	10.3	87.8	97.6	2.5	9.0

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

production and a long-standing tradition of government procurement in this region. Since government purchases in the Northeast only take place during harvest, at other times of the year maize was sold to other outlets, primarily private traders. Sales to government grain bureaus were also significant in areas of the Southwest where the government price was slightly higher than the price offered by private traders. Private traders nevertheless played a considerable role and offered the option of exchanging maize for rice and flour.

Many farmers in the North region preferred not to sell to government depots due to what they perceived to be overly strict standards for grain moisture content and cleanliness. The quality requirements of private traders, on the other hand, were much lower, and the price acceptable. Exchanging maize with private traders for other goods such as flour, rice, and fruit was very common in the Northwest region, but much less significant in the Northwest and part of the Southwest.

The volume of maize purchases seemed to be relatively low, and the maize purchases that took place were primarily from other farmers in the village, although local markets were sometimes used. Maize purchases were observed mostly in the Southwest. Farmers in one village in the Southwest rainfed spring area commented that poor households purchased maize for food, while rich households purchased it for feed.

2.6.3. Irrigation infrastructure

In most of the Northeast, North, Northeast, and Southwest regions, the predominant maize crop is spring maize under rainfed conditions. A small number of sites in each of those regions, particularly the Northwest and Southwest, cultivate irrigated spring maize. Village-managed tubewells and reservoirs were the primary source of irrigation water in surveyed villages in Northwest China, while large irrigation schemes were present in Sichuan province (Southwest region). Irrigation water for spring maize in North China was primarily supplied through surface infrastructure managed at the village level.

Sources of irrigation water for summer maize in the Yellow-Huai River Valley survey sites were predominantly village- and household-managed tubewells. In some villages, additional irrigation water was available from surface infrastructure and from village-managed reservoirs. All other summer maize areas cultivated the crop under rainfed conditions.

The fact that maize is cultivated under rainfed conditions, however, does not necessarily imply that there are no irrigation options. In the predominantly rainfed spring maize sites in the Southwest region, villages reported an average of 35% irrigated paddy land out of total arable area, with only one village reporting no paddy land. In the irrigated spring maize areas of the Southwest region (Sichuan province), the share of paddy land rose as high as 50% of arable land. Several villages in the Southwest (Guangxi province) also reported the use of concrete tanks built to collect rainwater. These water collection tanks were managed either at the village or individual household level. Investment was estimated at approximately 4,000 yuan (approximately US$ 480) in the surveyed village in Guangxi province where the largest number of water collection tanks was observed. Surveyed villages in the Northeast region also reported being able to irrigate from 10% to 58% of their total arable land using household-managed tubewells.

Table 2.10. Maize marketing: share of maize sales to different outlets.

Agroecological region	Maize system	Government agencies[a]	Private traders (including barter)	Public markets	Other farmers (own and neighboring villages)
Northeast	Rainfed spring	67.5	24.0	0.0	8.5
North	Irrigated spring	25.0	55.0	3.3	16.7
	Rainfed spring	2.2	75.8	0.0	22.0
Northwest	Irrigated spring	0.0[a]	18.0	4.5	77.5
	Rainfed spring	6.5	61.0	12.5	20.0
Yellow-Huai River Valley	Irrigated summer	24.0	25.0	30.7	20.7
	Rainfed spring/summer	0.0	52.5	0.0	47.5
Southwest	Rainfed summer	0.0	85.0	0.0	15.0
	Irrigated spring	5.0	0.0	80.0	15.0
	Rainfed spring (all sites)	15.7	42.3	19.4	23.3
	Rainfed spring (one season)	10.4	38.5	29.0	22.1
	Rainfed spring/fall	27.5	57.6	5.6	9.3
	Rainfed spring/winter	13.7	32.9	13.8	39.6

[a] No government-purchased maize reported by farmers in surveyed villages during 2001.
Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

2.7. Institutional Environment

2.7.1. Sources of inputs

Prior to the decree and implementation of the Seed Law in 2000, agricultural research and plant breeding in China was almost completely publicly managed. Public seed companies were the only organizations allowed to multiply and sell cereal seed, while breeding was restricted to research institutes in the national agricultural research system. The seed industry consisted of public county seed companies whose responsibility it was to conduct regional yield trials and screen adapted varieties, multiply and sell seed, and carry out extension activities. Non-public seed companies and organizations were excluded from marketing seed of any major crop, including maize, cotton, and oilseed crops; local seed markets were monopolized by county seed companies.

The most significant change brought about by the new seed law was the elimination of the market monopoly by seed companies in the public seed system. The new seed law permits all public companies, research institutes, private companies, and individuals that are certified by the provincial agricultural administration to multiply and market seed. Although a large number of national seed companies have failed since the new seed law, surviving companies are producing and marketing seed of conventional crops, including hybrid seed. Some have also begun their own breeding programs. Currently, the seed industry consists of a public and private mixture of small, local seed companies with highly variable products and services. Approximately 50 established companies develop, produce, and sell hybrid seed wholesale, while thousands of small, local seed retailers sell seed to farmers.

The distribution and sales of inputs such as fertilizer were controlled by the government until the commercialization of the fertilizer industry began, in the late 1980s. Fertilizer became available on the market at both subsidized (with quota) prices (determined by the amount of grain sold to government procurement agencies) and liberalized (non-quota) prices. The commercial fertilizer trade grew quickly with the entry of many private companies and traders (Huang and Rozelle 2006).

Table 2.12 summarizes the main sources of inputs utilized by farmers in the surveyed villages. At the time of our survey, it was difficult to assess the impact of the Seed Law. Seed of local varieties was largely saved from the previous harvest or exchanged/borrowed from other farmers. Seed of open-pollinated varieties (OPVs) was also saved or exchanged by farmers, but included seed purchased from other farmers. For example, farmers in Wu Ming county of the Southwest rainfed spring and fall maize regions saved seed of local and open-pollinated varieties or exchanged seed with relatives, neighbors, and farmers in neighboring villages. These sources were convenient, and farmers expressed confidence in the quality and purity of the seed obtained. In several surveyed villages, no other seed sources were available. However, farmers in other villages commented that seed of local varieties and OPVs was available in local markets but was of dubious quality.

Sources of hybrid seed included government extension stations at the township level, seed companies, private traders, village committees, and local seed producing households. The primary reason for not using a particular source was concern over seed quality. Not being able to purchase seeds on credit was also cited as a constraining factor.

Various organizations, including input companies and agricultural extension stations at the village, township, and county level, sold fertilizers to farmers in the surveyed villages. Private traders were also cited as frequent sources of fertilizer. Sources of pesticides were similar to sources supplying fertilizer.

2.7.2. Farmer associations

None of the surveyed villages in the North China irrigated or rainfed spring maize regions, Northwest irrigated or rainfed spring maize regions, Southwest rainfed summer maize region, or Yellow-Huai River Valley rainfed summer maize region reported the presence of farmer associations related to agricultural activities. Only one village in the irrigated summer maize Yellow-Huai River Valley described farmer associations for vegetable production, including coordinated seed purchase and bean curd processing. A farmer association for the coordinated purchase of onion seed was also reported in the Northeast rainfed spring maize region. Farmer associations were more numerous in the surveyed villages of the Southwest rainfed spring maize region. Several associations facilitated the management of water storage tanks and irrigation for rice production. Farmer associations for the transplant of rice seedlings and the coordinated sale of products such as fruit, ginger, and fish were also described. However, no associations related to maize production or sale were reported.

2.7.3. Credit institutions

Access to formal rural credit has not improved for farmers, and previous research has found evidence that local credit cooperatives have stopped lending to farmers (Huang and Rozelle 2006). Loans are available for agricultural production purposes, such as livestock production and fertilizer purchases, but they have decreased over time in favor of small business development and house construction (Huang and Rozelle 2006).

Table 2.11. Main input sources.

Agroecological region	Maize system	Local seed	OPV seed	Hybrid seed	Fertilizer	Pesticide	Herbicide
Northeast	Rainfed spring	-	-	Seed company, private trader, public agriculture technology extension station	Township level cooperative, government agricultural input company, private traders	Township level cooperative, government agricultural input company, private trader	Township level cooperative, government agricultural input company, private trader
North	Irrigated spring	-	-	Seed company	Township level cooperative, private traders	Township level cooperative, private trader	Township level cooperative, private trader
	Rainfed spring	Saved seed	-	Seed company	Township level cooperative, private traders, government agricultural input company	Private trader, seed station	Private trader, seed station
Northwest	Irrigated spring	-	-	Seed company, village committee	Private traders	Agricultural technology company (township or county level), private trader	Agricultural technology company (township or county level), private trader
	Rainfed spring	Saved seed	-	Seed company, private trader, seed company	Private traders, government agricultural input company in county town	Private trader, county town, own village, seed company	Private trader, county town, village, seed company
Yellow-Huai River Valley	Irrigated summer	Saved seed	-	public agriculture technology extension station, seed company	Township level cooperative, private traders, government agricultural input company	Township level cooperative, public agriculture technology extension station, private trader, government agricultural input company, plant protection station	Township level cooperative, public public agriculture technology extension station, private trader, government agricultural input company, plant protection station
	Rainfed spring summer	-	-	Seed company	Private traders	Private trader	Private trader
Southwest	Rainfed summer	-	-	Seed company, county seed company center in harvest season	Township level cooperative, own village	Township level cooperative, own village	Township level cooperative,village
	Irrigated spring	Saved seed	Saved seed	Seed company	Township level cooperative, public agriculture technology extension station, government agricultural input company, county town	public agriculture technology extension station, government agricultural input company, township	public agriculture technology extension station, government agricultural input company, township
	Rainfed spring (all sites)	Saved seed, exchange	Saved seed, exchange, purchase, borrowed from other farmers	public agriculture technology extension station, seed company, seed production area, self saved, township level cooperative	Township level cooperative, public agriculture technology extension station, private traders, government agricultural input company	Township level cooperative, public agriculture technology extension station, agricultural technology company (township or county level), private trader, county town	Township level cooperative, public agriculture technology extension station, agricultural technology company (township or county level), private trader, county town
	Rainfed spring (one season)	Saved seed	Saved seed, exchange, purchase, borrowed from other farmers	public agriculture technology extension station, seed company, township level cooperative, township seed company	Township level cooperative, public agriculture technology extension station, private traders	Township level cooperative, public agriculture technology extension station, agricultural technology company (township or county level), private trader	Township level cooperative, public agriculture technology extension station, agricultural technology company (township or county level), private trader
	Rainfed spring/fall	Saved seed, exchange	Saved seed, exchange, purchase	public agriculture technology extension station, seed company	Township level cooperative, public agriculture technology extension station, private traders	Township level cooperative, public agriculture technology extension station, private trader	Township level cooperative, public agriculture technology extension station, private trader
	Rainfed spring/ winter	Saved seed, exchange	Saved seed, exchange, purchase	public agriculture technology extension station, seed company, seed production area, self saved	Township level cooperative, public agriculture technology extension station, private traders, government agricultural input company	Township level cooperative, agricultural technology company (township or county level), county town	Township level cooperative, agricultural technology company (township or county level), county town

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Specific sources of credit used varied both across different agroecological regions and also by maize system within an agroecological region. The specific purpose of the loan and the amount of money borrowed played a large role in determining the credit source. Relatives and friends were the most frequent source of credit when it came to small or short-term loans, such as those required for purchasing crop inputs. This source was preferred due to convenience and because no interest or collateral were demanded; farmers usually turned to other options only when this source was not available or when the amount of money needed was too large.

One similarity across the surveyed villages was the infrequent use of government banks as a credit source. Obtaining bank credit was difficult primarily because of the collateral required and the complexity of the loan process; thus a large number of interviewed farmers did not view banks as a realistic credit option. The use of rural credit cooperatives was more widespread, as the loan process was felt by most to be simpler relative to that of banks. However, farmers still had concerns regarding collateral and high interest rates. Several villages reported that certain households had had limited access in the past to credit programs supported by the World Bank and other international organizations. These programs usually provided small, short-duration loans. Private moneylenders were particularly prevalent in some villages in the Northwest rainfed spring, Yellow-Huai River irrigated summer, and Southwest rainfed spring regions, but villagers usually only turned to this source of credit in an emergency or when no other credit sources were available.

2.7.4. Output and input prices

Table 2.13 presents average maize prices received prior to and immediately after harvest for hybrid, local, and open-pollinated varieties at the primary maize outlets. Although the development and integration of maize markets were impacted by a complex combination of government policy interventions, infrastructure bottlenecks, and transaction costs, many other factors, including the increased number of participants and volume of trade, also contributed to continuing advances in market integration (Park et al. 2002). Both regional price variation and annual variation have decreased in recent years as market integration continues to take place (Huang and Rozelle 2006).

Prices of the most commonly used maize inputs are provided in Table 2.14. The fertilizer industry has experienced waves of government decentralization and regained control over the past three decades, but the most recent market liberalization, in the late 1990s, resulted in declining prices. In our sample, the average price of urea ranged from 1.46 yuan/kg in the rainfed spring maize areas of the Southwest to 1.56 yuan/kg in the Yellow-Huai River Valley.

The deregulation of seed prices, which previously were established by government price bureaus, began during the late 1990s and continued until seed prices were completely liberalized. Upward trends in both seed prices and seed-to-grain price ratios were observed through the mid 1990s (Huang and Rozelle 2006). The regional variation observed at that time continues to appear across our surveyed sites. Although representations of the regions are not exactly comparable between our sample and earlier samples, compared with estimates from 1996, ratios in the Northeast have

Table 2.12. Main credit sources in surveyed villages.

		Government banks	Rural credit cooperatives	Private money lenders	Relatives/ friends	Other sources
Northeast	Rainfed Spring	0	6	70	14	10
North	Spring irrigated	0	6	1	93	0
	Rainfed spring	0	24	1	75	0
Yellow-Huai River Valley	Irrigated summer	1	24	38	23	14
	Rainfed summer	0	0	10	90	0
Northwest	Irrigated spring	0	20	0	80	0
	Rainfed spring	5	35	0	55	5
Southwest	Irrigated spring	0	70	0	30	0
	Rainfed spring (all)	4	35	12	44	5
	Rainfed spring (one season)	1	29	21	43	6
	Rainfed spring/fall; spring/ winter; spring/fall/winter	7	44	0	46	3

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

decreased substantially, while those in the Yellow-Huai River Valley region have increased slightly (Table 2.15). Prices of competing and complementary crops from survey sites are shown in Table 2.16.

2.8. Socioeconomic Characteristics

2.8.1. Households

Villages in the Southwest rainfed spring maize region reported that a significant share of their village population worked off farm for some part of the year, usually in cities within the province, although migration to other provinces also took place. Off-farm employment was also significant in surveyed villages of the Yellow-Huai River Valley but much less common for farmers in surveyed villages of the Northeast rainfed spring wheat region.

Farm size varies significantly by agroecological region. Our survey sample mirrors national and regional averages, with larger farm sizes in the Northeast region and much smaller ones in the Southwest region. Average farm sizes ranged from 2.61 mu (0.2 ha) in the Southwest irrigated spring maize area to a high of over 17 mu (1.1 ha) in the Northeast. Per capital arable land ranged from 0.9 mu (0.06 ha) in the Southwest, to 4.3 mu (0.3 ha) in the Northwest rainfed spring maize system.

2.8.2. Ethnicity

Most of the population in the surveyed villages in the Northeast, North, Northwest, and Yellow-Huai River Valley were Han Chinese. Very small populations (< 1%) of ethnic Manchus and Mongols were reported in the Northeast region, and of Tu Jia ethnic groups in the North rainfed spring maize system. Minority groups (including the Zhuang, Yao, and Hui) were much more prevalent in the Southwest rainfed spring/fall/winter maize systems. The largest group, the Zhuang, were the majority ethnic group in some of these villages.

2.8.3. Education

Levels of education attained varied considerably across the surveyed areas in the five maize agroecological regions. Detailed information is presented in Table 2.18. The largest share of the population in most villages completed middle school.

2.8.4. Land tenure

Under the household responsibility system (HRS) reform that began in 1979, collective land was allocated to individual households based on household size or a combination of household size and labor. Since private ownership of agricultural land does not officially exist in China, this so-called responsibility land remains collectively owned and subject to periodic reallocation by village leaders. Farmers are supposed to have complete use and income rights to the land during the contract period. The Rural Land Contract Law of 2002 was implemented to improve short- and long-term agricultural productivity by further expanding and ensuring the rights of contract holders.

Most agricultural land in the surveyed villages falls under the category of responsibility land. Villages can also maintain an area of unallocated “contract land,” which is rented to households on a short-term basis. The prevalence of contract land varies considerably from village to village, since land reforms in China have been implemented locally. Several of the surveyed villages, particularly in the Southwest and Yellow-Huai River Valley regions, manage most or all of their agricultural land as contract land. While the purchase and sale of agricultural land are also not officially permitted, agricultural land may be rented, or subcontracted, from households that are not cultivating the land. In all the surveyed villages, the amount of agricultural land in this category was small to non-existent. Finally, small amounts of land are sometimes allocated for household plots largely used to cultivate vegetables for household consumption, a practice reported by most surveyed villages in the North and Southwest regions, but uncommon in surveyed villages in other regions.

2.8.5. Maize utilization

Maize utilization differed widely across the various agroecological regions. Although the use of maize for food has been decreasing across China, all surveyed villages, with the exception of a few in the North and Northwest regions, reported that the share of maize consumed as food ranged from less than 1% in the Yellow-Huai River Valley to as high as 50-60% in the Southwest rainfed spring/fall and spring/winter maize regions. Maize in these regions was still consumed daily as the main staple food (in the form of porridge), although a growing trend towards replacing maize with rice was observed. Household utilization of maize was particularly high in all Southwest maize systems, where the share of total production consumed was often greater than 80%, with, in most cases, a substantial share allocated for feed. Feed use was particularly significant in the Southwest irrigated and rainfed spring maize systems, the North rainfed spring maize system, and the Northwest irrigated spring maize system. The proportion of maize sold was largest in the Northeast spring maize region and the Yellow-Huai River Valley irrigated summer maize system.

Table 2.13. Average maize prices by sales outlet and season.

Agro-ecological region	Maize system	Current prices (yuan/kg)																	
		Hybrid						Local						OPV					
		Farm gate		Nearest market		Government		Farm gate		Nearest market		Government		Farm gate		Nearest market		Government	
		after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting	after harvest	before planting
Northeast	Rainfed spring	0.86	0.92	0.86	0.95	0.84	-	-	-	-	-	-	-	-	-	-	-	-	-
North	Irrigated spring	0.84	0.90	0.91	0.96	0.97	-	-	-	-	-	-	-	-	-	-	-	-	-
	Rainfed spring	na	na	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Northwest	Irrigated spring	-	-	-	-	0.90	1.10	0.62	-	-	-	-	-	-	-	-	-	-	-
	Rainfed spring	0.85	1.16	0.96	1.20	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow/Huai River Valley	Irrigated summer	0.78	1.10	0.81	0.82	0.74	-	-	-	-	-	-	-	-	-	-	-	-	-
	Rainfed spring/summer	0.89	1.15	0.92	0.93	0.85	-	-	-	-	-	-	-	-	-	-	-	-	-
Southwest	Rainfed summer	0.74	1.00	0.75	0.90	0.83	-	0.75	1.10	0.75	1.15	0.80	-	-	-	0.90	1.10	0.90	-
	Irrigated spring	-	-	0.88	1.10	-	-	-	-	0.80	1.13	0.93	-	-	-	0.80	1.15	0.86	-
	Rainfed spring (all sites)	0.79	0.94	0.82	1.12	0.85	0.87	-	-	0.90	1.10	-	-	-	-	-	-	-	-
	Rainfed spring (one season)	0.83	1.16	0.86	1.11	0.85	0.88	-	-	0.80	1.10	0.86	-	-	-	0.80	1.10	0.86	-
	Rainfed spring/fall	0.78	0.88	0.79	0.94	0.87	0.89	-	-	0.80	1.20	1.00	-	-	-	0.80	1.20	-	-
	Rainfed spring/winter	0.72	0.74	0.74	0.83	0.84	0.80	-	-	0.99	1.36	1.14	-	-	-	0.99	1.36	-	-

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.14. Average prices of maize production inputs in surveyed villages.

Agroecological region	Maize system	Most common chemical fertilizers used (Current prices yuan/kg)									
		Urea	NPK compound	Ammonium bicarbonate	Ammonium nitrate	Ammonium metaphosphate	Super-phosphate	Phosphate nitrate	Potassium chloride	Zinc fertilizer	Manure (yuan/m³)
Northeast	Rainfed spring	1.55	1.20	-	1.00	2.45	-	-	2.02	-	-
North	Irrigated spring	1.50	-	0.43	1.23	2.20	0.45	1.20	-	-	-
	Rainfed spring	1.41	1.13	0.41	1.28	-	0.44	1.24	-	-	-
Northwest	Irrigated spring	1.40	1.50	0.42	-	-	-	-	-	-	70.00
	Rainfed spring	1.40	1.25	0.40	-	2.36	0.44	-	-	-	-
Yellow/Huai River Valley	Irrigated summer	1.56	1.20	0.49	-	2.46	0.47	-	-	4.70	-
	Rainfed spring/summer	1.40	1.00	0.42	1.40	-	0.45	1.00	-	-	-
Southwest	Rainfed summer	1.50	1.62	0.51	-	2.10	-	-	-	-	-
	Irrigated spring	1.53	1.42	0.40	-	-	0.36	-	-	1.60	-
	Rainfed spring (all sites)	1.46	1.05	0.51	-	-	0.43	-	1.58	1.83	-
	Rainfed spring (one season)	1.46	1.03	0.52	-	-	0.43	-	2.00	1.83	-
	Rainfed spring/fall	1.47	1.25	0.49	-	-	0.39	-	1.43	-	-
	Rainfed spring/winter	1.47	0.90	0.50	-	-	0.49	-	1.49	-	-

Source: IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.14. Cont'd...

		Maize seed (yuan/kg)			Labor wage rate (yuan/per person/day)						Power rental(yuan/mu)						Transportation costs for fertilizer (yuan/50 kg)		Transportation costs for maize (yuan/50 kg)	
					Male			Female			Only cattle		Cattle with driver		Tractor with driver					
Agroecological region	Maize system	Local variety	OPV	Hybrid	Busy season	Slack season	Local off-farm work	Busy season	Slack season	Local off-farm work	Spring	Summer	Spring	Summer	Spring	Summer	Primary market	Secondary market	Primary market	Secondary market
Northeast	Rainfed spring	-	-	5.80	20.00	19.17	19.38	15.00	10.00	14.33	-	-	-	-	-	-	0.38	0.83	na	0.34
North	Irrigated spring	-	-	6.60	20.00	na	20.83	15.00	na	12.50	-	-	15.00	14.33	10.00	12.33	na	na	na	na
	Rainfed spring	0.80	-	4.86	18.75	15.50	19.60	8.00	6.00	9.33	-	-	21.50	20.25	20.00	18.60	0.63	1.17	na	na
Northwest	Irrigated spring	-	-	5.50	24.50	17.50	25.00	12.50	11.25	13.75	-	-	20.00	-	-	25.00	-	-	0.01	na
	Rainfed spring	-	-	5.26	27.00	19.33	19.00	17.50	13.50	14.33	17.50	17.50	30.00	30.00	15.00	20.00	0.50	-	0.50	na
Yellow/Huai River Valley	Irrigated summer	1.20	-	5.04	24.42	22.92	21.67	17.40	16.00	19.33	20.00	20.00	40.00	32.50	13.19	-	0.83	0.50	1.25	2.17
	Rainfed spring/summer	-	-	4.26	na	na	21.67	na	na	10.00	-	-	40.00	40.00	30.00	30.00	na	na	na	na
Southwest	Rainfed summer	-	-	6.94	25.00	na	20.00	na	12.50	13.50	-	-	-	30.00	-	22.50	na	na	na	na
	Irrigated spring	-	-	7.76	30.00	24.50	18.33	28.00	22.67	15.67	-	-	-	50.00	-	38.25	0.83	0.75	0.75	0.75
	Rainfed spring (all sites)	0.62	1.65	7.72	20.88	19.37	17.76	19.81	16.00	16.69	15.00	23.33	32.00	33.75	22.00	28.75	1.21	1.55	1.22	1.50
	Rainfed spring (one season)	-	2.00	7.04	22.67	19.81	19.17	22.11	16.29	16.78	15.00	23.33	32.00	38.50	22.00	31.33	1.56	1.25	1.51	1.00
	Rainfed spring/fall	1.10	0.96	7.60	18.75	17.33	14.00	15.67	14.00	14.75	-	-	-	41.75	-	31.25	0.73	1.00	0.88	1.00
	Rainfed spring/winter	0.90	-	9.36	15.33	18.33	17.50	14.33	17.33	17.30	-	-	-	26.67			1.00	2.00	1.00	2.00

Source: IFAD-CIMMYT-CCAP RRA/PRA sur veys, 2001-2002.

Table 2.15. Average seed-to-grain price ratios.

Agroecological region	Maize system	Hybrid maize to farmgate price	Hybrid maize to nearest market price	Hybrid maize to grain price, 1985 (Huang et al. 1999)	Hybrid maize to grain price, 1990 (Huang et al. 1999)	Hybrid maize to grain price, 1995 (Huang et al. 1999)
Northeast	Rainfed spring	6.74	6.74	1.68	3.58	5.96
North	Irrigated spring	7.86	7.25	-	-	-
	Rainfed spring	-	-	-	-	-
Northwest	Irrigated spring	-	-	-	-	-
	Rainfed spring	6.17	5.48	-	-	-
Yellow-Huai River Valley	Irrigated summer	6.22	6.46	1.43	5.39	4.79
	Rainfed spring/summer	4.63	4.81	-	-	-
Southwest	Rainfed summer	9.38	9.25	-	-	-
	Irrigated spring	-	8.82	-	-	-
	Rainfed spring (all sites)	9.72	9.46	1.37	3.16	4.59
	Rainfed spring (one season)	8.52	8.16	-	-	-
	Rainfed spring/fall	9.74	9.68	-	-	-
	Rainfed spring/winter	13.00	12.72	-	-	-

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002; Huang et al. 1999.

Table 2.16. Price (yuan/kg) of competing and complementary crops and products.

Agroecological region	Maize system	Wheat	Soybean	Potato	Broomcorn millet	Millet	Green bean	Tobacco	Sesame	Peanut	Sweet potato	Cotton	Apple	Rice	Banana	Cassava	Sugarcane
Northeast	Rainfed spring	-	1.70	0.60	-	-	-	-	-	-	-	-	-	-	-	-	-
North	Irrigated spring	1.00	-	0.60	0.82	-	-	-	-	-	-	-	-	-	-	-	-
	Rainfed spring	1.02	2.00	0.60	0.80	1.70	3.00	-	-	-	-	-	-	-	-	-	-
Northwest	Irrigated spring	1.20	2.40	0.48	-	1.00	-	-	-	-	-	-	-	-	-	-	-
	Rainfed spring	1.06	1.70	0.48	1.08	1.38	-	-	-	-	-	-	1.34	-	-	-	-
Yellow-Huai River Valley	Irrigated summer	-	1.84	-	-	-	-	-	-	1.84	0.58	14.00	-	-	-	-	-
	Rainfed spring/summer	0.95	1.91	-	1.00	-	2.80	3.60	4.20	1.40	-	10.00	5.00	-	-	-	-
Southwest	Rainfed summer	1.20	1.86	0.64	1.40	-	2.70	-	4.40		-	-	-	1.00	2.00	0.26	0.38
	Irrigated spring	1.06	2.30	-	-	-	-	-	-	1.55	0.20	10.00	-	1.00	-	-	na
	Rainfed spring (all sites)	1.06	2.18	0.50	1.20	-	2.60	-	4.40	2.20	0.36	14.00	-	0.86	1.56	-	na
	Rainfed spring (one season)	-	1.80	-	-	-	-	-	-	2.20	0.50	14.00	-	0.80	1.36	0.16	0.22
	Rainfed spring/fall	1.20	2.40	0.50	1.20	-	2.60	-	4.40	2.20	0.43	14.00	-	0.83	1.86	0.16	0.22

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.17. Demographic and socioeconomic characteristics of surveyed villages.

Agroecological region	Maize system	Population			Labor force			Total # of households	% Female-headed households	Average household size	Average farm size (mu)	Total village arable area (mu)	Per capita arable land (mu)	Agricultural tax (yuan/mu)
		Total	% Male	% Female	Total	% Male	% Female							
Northeast	Rainfed spring	1781.3	50.8	49.2	897.5	57.0	43.0	114	19.8	4.0	17.33	1749.4	1.5	12.3
North	Irrigated spring	1574.7	48.6	49.3	720.0	55.1	44.9	424	16.5	3.7	6.71	1875.0	2.8	13.1
	Rainfed spring	1135.2	52.1	47.2	462.8	58.7	41.3	310	32.5	3.8	9.47	2971.9	2.4	10.7
Northwest	Irrigated spring	557.0	50.9	49.1	326.5	53.6	46.4	167	36.0	3.3	7.23	3169.6	2.7	4.5
	Rainfed spring	381.5	53.1	51.5	149.0	52.7	47.5	88	28.8	4.4	10.00	7546.3	4.3	6.9
Yellow-Huai River Valley	Irrigated summer	1513.8	50.7	49.3	823.8	52.9	47.1	379	25.0	4.0	4.36	1200.0	2.1	15.8
	Rainfed spring/summer	830.0	57.2	42.8	600.0	55.0	45.0	191	25.8	4.1	11.30	903.3	2.3	16.8
Southwest	Rainfed summer	1162.5	49.7	50.3	552.5	52.6	47.4	284	22.5	4.2	4.07	1155.0	1.0	21.5
	Irrigated spring	1599.3	56.6	52.1	928.7	50.4	49.6	442	24.6	3.6	2.61	1166.0	0.7	29.1
	Rainfed spring (all sites)	2427.0	51.4	48.6	1260.2	53.7	46.3	519	22.4	4.5	4.14	2055.6	0.9	8.8
	Rainfed spring (one season)	1542.0	52.4	47.6	708.1	54.1	45.8	466	25.5	3.7	3.65	1586.4	na	25.9
	Rainfed spring/fall	2826.0	52.4	47.6	1668.3	57.1	42.9	671	22.5	4.2	7.82	5426.0	1.8	20.9
	Rainfed spring/winter	2427.0	51.4	48.6	1260.2	53.7	46.3	519	22.4	4.5	4.14	2055.6	0.9	8.8

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.18. Education status.

		Average						Range					
		Proportion of population by educational attainment (%)						Proportion of population by educational attainment (%)					
Agroecological region	Maize system	Illiterate	Below elementary school level	Elementary school level	Milddle school level	High school level	Higher than high school level[a]	Illiterate	Below elementary school level	Elementary school level	Milddle school level	High school level	Higher than high school level[a]
Northeast	Rainfed spring	0.0	3.5	20.0	55.0	21.3	0.5	0	0-10	10-30	50-60	7-30	0-3
North	Irrigated spring	3.0	2.2	19.2	61.7	13.7	0.3	1-5	0.5-5	10-28	60-65	9-22	0-1
	Rainfed spring	6.0	11.2	38.6	36.0	8.1	0.1	2-10	1-20	25-50	26-50	4-13	0-0.5
Northwest	Irrigated spring	3.0	1.5	6.5	75.5	11.5	2.0	2-4	1-2	3-10	70-81	3-20	2
	Rainfed spring	5.3	14.3	28.3	38.8	16.0	0.0	0-20	2-30	10-38	20-50	9-20	0
Yellow-Huai River Valley	Irrigated summer	14.3	13.0	23.7	35.7	13.2	0.6	5-40	1-25	5-40	10-82	5-20	0-3
	Rainfed spring/summer	12.5	17.5	25.0	32.5	12.5	0.1	10-15	15-20	20-30	30-35	5-20	0-0.1
Southwest	Rainfed summer	11.0	9.0	20.0	47.5	12.5	0.0	2-20	8-10	10-30	35-60	5-20	0
	Irrigated spring	0.3	3.7	39.0	45.0	11.7	0.3	0-1	0-10	8-60	20-80	10-15	0-1
	Rainfed spring (all sites)	4.5	20.3	37.5	26.9	10.6	0.3	0-15	0-40	10-70	9-46	2-30	0-1.2
	Rainfed spring (one season)	4.3	17.5	41.0	28.5	8.3	0.4	0-15	0-33	8-70	14-80	3-15	0-1
	Rainfed spring/fall	4.0	27.2	29.4	26.8	12.7	0.0	0-10	15-40	10-50	9-40	2-30	0
	Rainfed spring/winter	3.0	13.0	34.0	34.8	15.0	0.2	0-5	0-23	20-50	25-44	10-20	0-1.2

[a] Includes technical schools (2-3 years) and universities (4 years).

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.19. Land tenure.

Agroecological region	Maize system	Average Land tenure system (%): Household plot	Respon-sibility land	Subcontract land	Contract land	Other	Range Land tenure system (%): Household plot	Respon-sibility land	Subcontract land	Contract land	Other
Northeast	Rainfed spring	0.0	94.0	10.0	6.0	0.0	0	90-100	10	2-10	0
North	Irrigated spring	5.7	76.3	2.7	17.3	0.7	0-10	50-95	0-8	5-40	0-2
	Rainfed spring	3.1	87.6	0.6	9.3	0.0	0-13	53-100	0-3	0-46	0
Northwest	Irrigated spring	0.0	100.0	0.0	0.0	0.0	0	100	0	0	0
	Rainfed spring	0.0	73.4	1.9	26.8	0.0	0	27-100	0-3	0-70.2	0
Yellow-Huai River Valley	Irrigated summer	1.0	59.1	6.7	39.1	1.7	0-5	0-100	0-20	0-100	0-5
	Rainfed spring/summer	0.2	90.0	0.0	10.0	0.0	0-1	90-100	0	10	0
Southwest	Rainfed summer	9.5	65.5	8.0	25.0	0.0	7-12	27-88	0-16	0-50	0
	Irrigated spring	5.5	94.5	0.0	0.0	0.0	0-10	0	0	90-100	0
	Rainfed spring (all sites)	5.7	76.5	0.0	18.6	0.0	2-21	0-98	0-2.6	0-100	0-3
	Rainfed spring (one season)	7.6	64.6	2.5	27.9	0.6	2-21	0-96	0-2.6	0-93	0-3
	Rainfed spring/fall	6.7	85.3	0.0	8.3	0.0	5-10	80-95	0	0-100	0
	Rainfed spring/winter	5.7	76.5	0.0	18.6	0.0	3-10	6-97	0	0-93	0

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.20. Maize utilization.

Agroecological region	Maize system	Used in household as food (%)	Used in household as feed (%)	Sold or bartered (%)	Kept as seeds (%)	Waste/ spoilage (%)	Carr y-over stock (%)	Average duration of storage (days)
Northeast	Rainfed spring	6.5	13.8	76.0	0.0	3.8	0.0	90
North	Irrigated spring	2.7	35.3	55.0	0.0	3.7	3.3	180
	Rainfed spring	1.8	22.2	69.0	0.0	4.8	2.2	172
Northwest	Irrigated spring	0.5	72.5	23.5	0.0	2.5	0.5	na
	Rainfed spring	2.3	26.3	65.8	0.0	3.5	1.8	143
Yellow-Huai River Valley	Irrigated summer	3.1	19.9	72.8	0.0	3.0	1.1	183
	Rainfed spring/summer	3.0	57.5	34.0	1.0	1.0	3.5	210
Southwest	Rainfed summer	17.5	35.0	30.0	0.0	5.0	12.5	60
	Irrigated spring	5.7	90.0	3.7	0.0	0.6	0.7	120
	Rainfed spring (all sites)	15.9	63.7	12.6	1.8	2.6	3.4	162
	Rainfed spring (one season)	6.0	71.3	14.2	0.9	3.0	4.9	158
	Rainfed spring/fall	22.0	62.0	12.5	0.0	0.8	2.8	180
	Rainfed spring/winter	31.0	50.0	9.6	5.2	3.2	1.0	150

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 2.21. Characterization of farmer variation across agroecological regions.

	N	Age	Education (years)	Farm size (mu)	Maize area (mu)	# of maize varieties	# pigs	# poultry	Non ag employment (%)	TV ownership (%): Color	B/W	None
All farmers	681	44.8	5.3	8.8	5.3	1.5	2.6	32.1	30	36	52	14
All "better off"	348	44.6	5.6	9.9	5.8	1.6	3.4	51.6	30	45	49	8
All "worse off"	333	45	5.1	7.7	4.7	1.5	2	8	29	26	55	20
Northeast	86	40.1	7.1	17.8	14.7	2	3.4	13.4	17	39	53	2
North	67	50.6	5.2	15.9	11.2	2.9	0.3	7.3	21	39	58	3
Yellow-Huai River Valley	213	45.8	4.7	4.4	2.8	1.3	4.7	168.4	41	52	44	7
Northwest	73	41.8	3.3	18.2	4.5	1.2	1.3	7.1	53	45	45	14
Southwest	239	44.8	6.2	4.8	2.7	1.4	2.5	12.3	26	15	57	28

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

2.8.6. Characterization of variation in participating farmers

Although interaction with farmers took place in group settings, brief interviews were carried out with each participating farmer in order to better characterize the variation of farmers in our sample and to be able to place participating farmers within a broader context. The survey was not designed to achieve, in our farmer sample, statistical representation of all households in their respective regions. Instead, the characteristics summarized in Table 2.22 reflect the range of variation in household and farmer characteristics across maize agroecological regions. While most farmers participating in group discussions (with the exception of farmers in the Northwest) cultivated between one and three varieties, the maximum number of maize varieties cultivated by a single household reached seven in the North region and five in all other regions.

2.8.7. Local perceptions of poverty and wealth

Definitions of poverty and wealth can vary substantially across regions. Thus farmer groups were asked to discuss local perceptions of poverty and wealth within the context of their own villages. During these discussions, each group characterized households considered to be relatively better off and those considered to be relatively more disadvantaged in the village. Table 2.22 presents a summary of farm household characteristics by agroecological region and maize system. Not surprisingly given existing government policies, farmers in surveyed villages across the agroecological regions agreed, in most cases, that factors such as household and farm size were not useful distinguishing factors. However, many farmers felt that differences in age and education levels of heads of households were a distinguishing factor. The source of household income was a significant factor across all regions. Wealthier households appeared to depend less on agriculture, particularly maize farming, as a source of income.

Table 2.22. Local perceptions of poverty and wealth in 50 surveyed villages.

Agroecological region	Maize system	Disadvantaged households	Well-off households	Comments
Northeast	Rainfed spring	Older household head, large majority of household income from maize; up to 3 pigs; 0-2 head of cattle; little to no off farm income	Younger household head, farm income from cash crops, such as watermelon; 2-30 pigs; 2-5 head of cattle; substantial off farm income	Few differences in household size and education across household types
North	Irrigated spring	Lower education level of house hold head; older household head (over 50); 50% or more of income from maize	Higher education levels of household head; younger household head (30-40); clever household head; less than 30% of income from maize; substantial off farm income; more crops	No difference in household size
	Rainfed spring	Larger household size (5-6); less educated household head; 40-50% of income from maize; little to no off farm income; 0-1 pigs	Smaller household size (3-4); more educated household head; less than 20% of income from maize; off farm income; 1-5 pigs	No difference in age or household size; no difference in crops cultivated; no difference in cattle (1 head)
Northwest	Irrigated spring	Larger household size (5-6); less educated household head; older household head (over 50); 30-40% of income from maize; more off farm employment	Smaller household size (3-4); more educated household head; younger household head (30-40); 10-30% of income from maize; little off farm employment	No difference in farm size or crops cultivated; no difference in cattle owned
	Rainfed spring	Less educated; household head over 50; few fruit trees or animals; some maize income but most from other agricultural crops	More educated; household head between 30-40; less income from maize than poor household; more cash crops such as apple trees and tobacco	Few differences in household size; no difference in farm size; off farm income both under 30%, few differences in animal ownership
Yellow-Huai River Valley	Irrigated summer	May be older but usually no difference; 40-60% of income from maize; less than 20% off farm income; more pigs and chickens; may need to purchase maize	May be younger but usually no difference; less than 20% of income from maize; 65% or more off farm income; few to no pigs or chickens	No difference in household size or education; no difference in farm size or crops cultivated

Table 2.22. Cont'd...

Agroecological region	Maize system	Disadvantaged households	Well-off households	Comments
	Rainfed summer/ spring	Majority of income from agriculture; no off farm income	Small share of income from agriculture; large share of off farm income	No difference in household size or education; no difference in farm size or crops cultivated; no difference in share of income from maize; both raise few animals
Southwest	Spring irrigated	Less educated household head; 20-30% of household income from maize and 30-60% from agriculture	Better educated household head; less than 10% of household income from maize and less than 25% from agriculture; plant more rice than poor; majority of income from off farm employment	Little difference in household size; no difference in farm size (all small); no difference in pigs (1-2)
	Rainfed summer	Household head less educated; over 50 years old; 15-18% of income from maize; approx. 50% of income from agriculture; 1 pig; more chickens raised (20)	Household head better educated; less than 40 years old; 3-10% of income from maize; less than 30% of income from agriculture; more than 50% of income from off farm income; 2-6 pigs; fewer chickens raised (10)	No difference in household size or farm size; no difference in crops cultivated
	Spring rainfed	Less educated household head; older household head; smaller farm size; income from maize ranges from 10-100%; off farm income usually under 30%; usually more chickens	More educated household head; middle aged or young household head; larger farm size; income from maize ranges from 1-27%; off farm income over 70%; usually fewer chickens	All households raised pigs but no pattern discernable; little difference in cattle ownership although some poor households owned none

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

3. Maize Production Systems and Trends in China

3.1. Maize Cropping Calendar

A calendar of maize cropping seasons across the five agroecological regions is presented in Figure 3.1, while a more detailed scheme of maize management practices in selected sites of our survey sample is presented in Figure 3.2. Planting of rainfed spring maize in the North and Northwest China regions begins in the first half of April, and harvesting is done from September through October. Maize in the Northeast spring rainfed region is generally planted in the latter half of April and harvested in the first half of October. Irrigated summer maize in the Yellow-Huai River Valley is planted from mid-May to early June and harvested from late September to early October.

Planting of rainfed spring maize in the Southwest begins as early as mid-February and continues through mid-March, with harvest taking place from mid-June to early July. Irrigated spring maize, however, is sown in the second half of March and usually harvested in mid-August. Where maize is not sown directly but, instead, transplanted into the field, seedling generation begins in early March and transplanting takes place from late March to early April. Summer maize in the Southwest is planted in mid-May and harvested at the end of August or early September.

Villages that plant a fall maize crop do their sowing almost immediately after harvesting the spring maize crop in the latter half of July. Fall maize is harvested in the first half of November. Often planted on rice paddies as a third crop between two rice crops, winter maize is generally planted in early December and harvested in the first half of April.

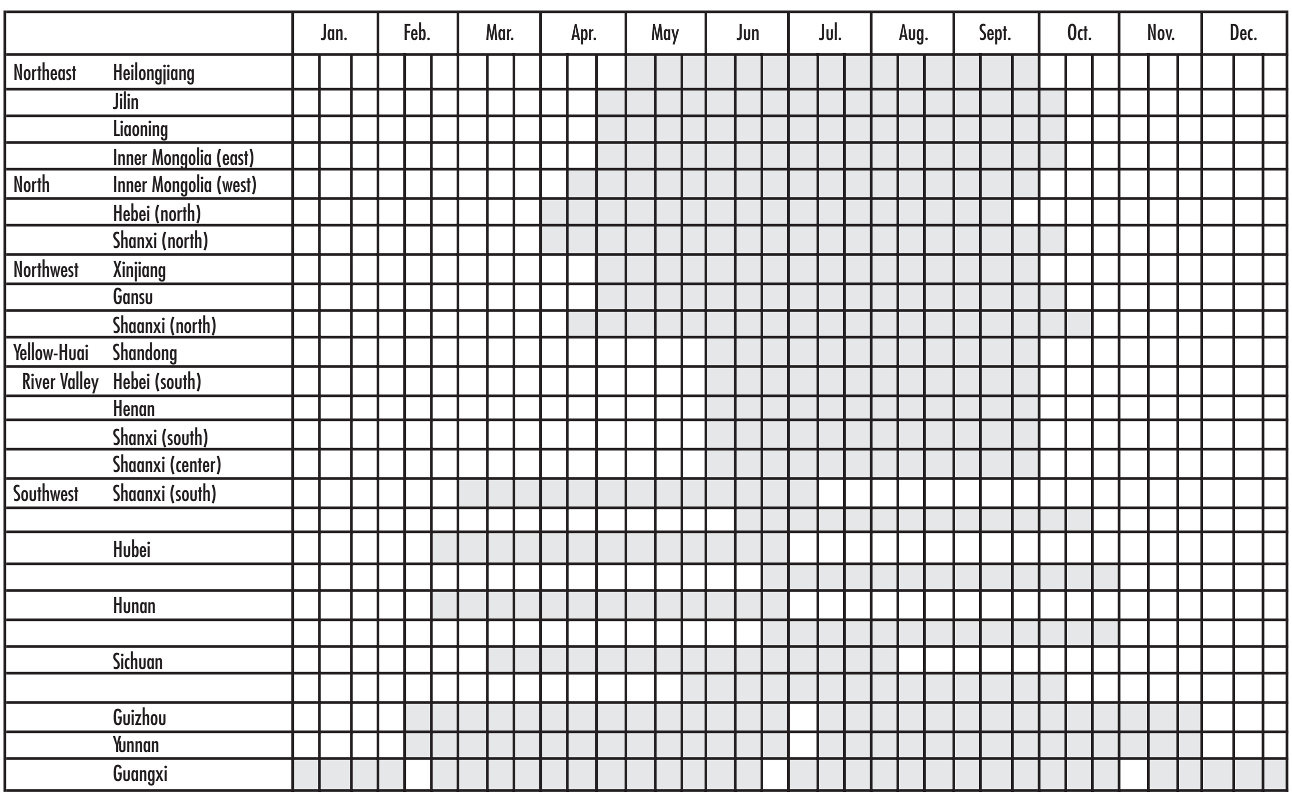

Figure 3.1. Maize cropping seasons in five agroecological regions.

Agro-ecological region	Maize production system	County	Village			Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sept.			Oct.			Nov.			Dec.	
Northeast	Rainfed spring	Gongzhuling	Liaohecun											L	PS	P/F		T	W		W	F										H/D	L/F1							
Northeast	Rainfed spring	Gongzhuling	Lijiadian												P	F		T				W	W/F	W/PS			PS					H	L/F1			D				D
Northeast	Rainfed spring	Changling	Maliancun									PS/F1				P		W		PS		F/Z										H	L/F1						D	
Northeast	Rainfed spring	Changling	Dajinshuicun											L		P/F			T/PS	W		F/I/W/PS										H	L/F1						D	
North	Rainfed spring	Shouyang	Guchengcun										L	F1/P					W	T		W		PS									H/D/L/F1							
North	Rainfed spring	Shouyang	Taiancun										L	F1/P/C						T/W			W										H/D/L/F1							
North	Irrigated spring	Qingxu	Kongcun							I		F/L		F1/P		T/W/I			I	F/W		I			I/W								H/D/L/F1							
North	Irrigated spring	Qingxu	Xiluobai							I		F/L		F1/P/C		T/W/I			I	F/W			I			I/W							H/D/L/F1							
Northwest	Irrigated spring	Shenmu	Yongfeng							I	L				L/F1/P		T/W/I				I/F/W			I/Z/W				I				H			D	I				
Northwest	Irrigated spring	Shenmu	Pulawan							I	L				L/F1/P		T/W/I			I/F				I/W/F/Z				I				H			D	I				
Northwest	Rainfed spring	Yanan	Gaofangcun							D				L/F1/P				T/W/PS			F/W			F/W									H							
Northwest	Rainfed spring	Yanan	Santaizhuang												L/F1/P		T/W			F				W/F/Z									H		D					
Yellow-Huai	Irrigated summer	Zhucheng	Dacun																	F1/P	F/PS/W		I/T		PS/F	PS					H		D			D				
Yellow-Huai	Irrigated spring	Zhucheng	Wangcun	Wheat/vegetable/maize (maize sown after vegetable harvest)									L		P	F		T			F						H													
Yellow-Huai	Irrigated summer	Zhucheng	Wangcun	Wheat/garlic/maize (maize sown after garlic harvest)													F1	P	W	T	F	W							H					D						
Yellow-Huai	Irrigated summer	Jiaxiang	Zhangtan	Wheat-maize (maize sown after wheat harvest)																P/I	PS		T	I	F/PS	I	PS				H					D	D			
Yellow-Huai	Irrigated summer	Jiaxiang	Xiahualin	Wheat/maize (maize sown before wheat harvest)															P/A/I		T/PS	PS		PS/F	PS						H			D						
Yellow-Huai	Irrigated summer	Jiaxiang	Xiahualin	Wheat/garlic/maize (maize sown after garlic harvest)														P/A/I	T/PS		PS				PS/F	PS			H					D						
Yellow-Huai	Irrigated summer	Ningjing	Dongdianliu	Wheat-maize															P/A/I	PS/T			I/PS	W/F		PS/I				H		D								
Yellow-Huai	Irrigated summer	Ningjing	Wangzhuang	Wheat/maize (maize sown before wheat harvest)													L/I	P	PS	PS/W/T				F/I	PS/I					H	D								D	
Southwest	Rainfed spring	Lezhi	Wulichong	Transplant						L		SD			P/F1/PS				F/W			(F)/PS				H/D														
Southwest	Rainfed spring	Lezhi	Wulichong							L			P/F1/PS		F/T			F/W				PS				H/D														
Southwest	Rainfed spring	Lezhi	Yixuecun	Transplant						L		SD			P/F			F			W/PS/F					H/D														
Southwest	Rainfed spring	Lezhi	Yixuecun										L/F1/P				F/T		W		PS/F					H/D														
Southwest	Rainfed spring/fall	Debao	Bamingcun			L				F1/P					F/W/T			PS					H/D		L/F1/P		F				PS/W				H/D					
Southwest	Rainfed spring/fall	Debao	Longhua			L				L	P				F/W/T			PS					H/D		L/F1/P			F/T		PS	W				H/D					
Southwest	Rainfed spring/fall	Wuming	Liangxin				L		F1/P			F/T						W/PS			H/D			L		F1/P		W/T				PS				H/D				
Southwest	Rainfed winter	Wuming	Liangxin				T/W	F			PS			H/D																								L/P		
Southwest	Rainfed spring/fall	Wuming	Peilian				L		F1/P			F/W/T			F/PS						H/D		L/P				F/W/T			F				H/D						

L = till (land preparation); T = transplant/thin seedlings; C = plastic cover; PS = pesticide application; I = irrigation; P = plant / transplant; F = fertilizer application; F1 = base fertilizer application (manure); H = harvest; D = shelling; SD = plant seedlings for transplant; W = weed; Z=intertill; A = weeding with machine

Figure 3.2. Maize crop management calendar for surveyed villages.

Information on the duration of the maize cycle from surveyed villages is summarized in Table 3.1. The maize cycle increases from a minimum of around 90 days in the rainfed spring maize systems in the Southwest region to a maximum of 180 days in the rainfed spring maize systems in the North and Northwest regions, although the average cycle in those regions ranged from 140-150 days. The cycle of maize varieties planted in surveyed villages of the Northeast region was 150-170 days.

Table 3.1. Maize cycle in surveyed villages.

Agroecological region	Maize system	Duration of cycle (days)
Northeast	Rainfed spring	150-170
North	Irrigated spring	150
	Rainfed spring	Up to 180
Northwest	Irrigated spring	150
	Rainfed spring	Up to 180
Yellow-Huai River Valley	Irrigated summer	120-140
	Rainfed summer	100-150
Southwest	Rainfed summer	90-100
	Irrigated spring	140-150
	Rainfed spring	120-150
	Rainfed fall	105-120

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

The cropping cycle of local varieties, compared to that of hybrids, appeared to vary by maize production system. Local varieties in the Northwest were noted for their short cycle, while farmers in the Southwest often described local varieties as having long cycles. The exceptions were the short-cycle glutinous (waxy) varieties. Open-pollinated varieties, still cultivated in the Southwest, were also noted for their long cycle.

3.2. Maize Cropping Patterns

Table 3.2 shows the staple crops and other major crops cultivated in surveyed villages in the five maize agroecological regions. The diversity of crop alternatives available to farmers decreases sharply from the Southwest region, where the widest range of crops was reported by farmer groups, to the Northeast region, which had the fewest options. However, even though, taken together, there were more crop alternatives in the Southwest region, in any given village and often even in a given township, a much smaller number of crops was in fact cultivated. In that sense, the actual alternatives for farmers were much more limited.

Table 3.2. Major crops in surveyed villages by maize agroecological region.

Agroecological region	Maize production system	Staple crops	Other crops
Northeast	Spring rainfed	maize, soybean, rice	broomcorn millet, millet, vegetable, sorghum, red bean, melons, potato, sunflower, peanut
North	Spring rainfed	maize, wheat, potato	soybean, millet, sunflower, oats, sorghum, sweet potato, buckwheat
	Spring irrigated	maize, wheat, potato	soybean, millet, sunflower, wheat, sorghum, watermelon
Yellow-Huai River Valley	Spring rainfed	wheat, maize, cotton	soybean, sweet potato, green bean, sesame, watermelon, beans, peanut, garlic
	Summer irrigated	wheat, maize, cotton	soybean, sweet potato, green bean, watermelon, peanut, sorghum, green Chinese onion, capsicum, onion, field and garden vegetable, tobacco, garlic
	Summer rainfed	wheat, maize, cotton	soybean, sweet potato, millet, green bean, watermelon, sesame, sorghum, cotton, potato, field vegetable
Northwest	Spring rainfed	maize, wheat, potato	tobacco, rape, millet, common fennel, wheat, broomcorn millet
	Spring irrigated	maize, broomcorn millet, potato	millet, soybean, wheat
Southwest	Spring irrigated	rice, maize	sugarcane, rape, peanut, capsicum, soybean, sweet potato, chestnut, mulberry, potato, tea, sesame, green-bean, beans
	Summer rainfed	maize, wheat	rape, sugarcane, peanut, capsicum, soybean, sweet potato, chestnut, mulberry, potato, tea, sesame, green-bean, beans
	Spring rainfed (one season)	maize, rice	soybean, vegetable, watermelon, potato, rice, peanut, sweet-potato, cotton, cassava, capsicum, bamboo, chestnut, mulberry, tea, green-bean, wheat, peas, beans, dryland lotus, rape
	Spring / fall / winter rainfed	maize, rice	soybean, peanut, capsicum, sweet potato, pumpkin, black bean, bamboo, rice, potato, dryland lotus, rape

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Maize cropping patterns in surveyed villages are listed in Table 3.3. Maize is included in a significant part of local cropping patterns in all the survey sites, but as with crop diversification, alternative cropping patterns with and without maize varied considerably across maize systems. The range of options in the Northeast is much more limited than in regions where the climate allows more cropping flexibility, and irrigation is more common.

Table 3.3. Major cropping patterns in surveyed villages by maize agroecological region.

Agroecological region	Maize production system	Major maize cropping patterns	Other cropping patterns
Northeast	Rainfed spring maize	maize; maize/soybean	soybean, potato, spring wheat, broomcorn millet
North	Irrigated spring maize	maize-wheat; maize	soybean, rice, potato, spring wheat, broomcorn millet
	Rainfed spring maize	maize; maize-wheat; maize-wheat-soybean, maize/soybean, maize/potato,	wheat, wheat-millet, wheat-sorghum, wheat/ broomcorn millet, wheat-sunflower, potato, oats
Northwest	Irrigated spring maize	maize, maize/potato	wheat, millet, soybean, broomcorn millet, potato
	Rainfed spring maize	maize, maize-wheat	wheat, wheat/buckwheat, wheat/broomcorn millet, sweet potato-wheat, tobacco/wheat, tobacco, potato, sorghum, soybean, broomcorn millet, beans, rape, rice
Yellow-Huai River Valley	Rainfed spring maize	maize, wheat/maize	cotton, wheat/cotton, wheat-soybean (millet, sesame, green bean, broomcorn millet, peanut, sweet-potato, field vegetables), vegetables, fruits
	Irrigated summer maize	wheat-maize, wheat/maize, maize/soybean-wheat, wheat/garlic-maize	wheat/cotton, cotton, wheat/garlic, fruits, vegetables
	Rainfed summer maize	wheat-maize, wheat/garlic/maize (or maize/soybean)	wheat/cotton, wheat/garlic/cotton(watermelon), wheat-soybean, wheat-millet, wheat-sesame, wheat-green bean
Southwest	Rainfed summer maize	maize/beans(sorghum)-wheat, maize-maize, maize/potato/wheat(sweet potato), wheat-maize, wheat-maize/soybean(green bean), maize/beans- wheat, maize-soybean (vegetable, rice) , maize/ wheat, wheat-maize/sesame, wheat/vegetable- sweet potato/maize/soybean, maize/sorghum-wheat, maize-maize/sweet potato, maize/ potato –wheat	rice/wheat, rice/rape, potato/maize, wheat-sorghum, rice-rice, lotus, rape-rice, rice-wheat
	Rainfed spring maize (one season)	maize-soybean/cassava, maize-soybean, maize/beans-wheat, maize/cassava-soybean, maize-sweet potato-soybean, maize-soybean (cotton, peanut), maize/ pumpkin(ramie, sweet potato), maize/soybean -sunflower (soybean), wheat-maize/soybean, wheat-maize/sesame-maize/potato, potato/ vegetable-maize/sweet potato, maize/sweet potato-wheat/vegetable, wheat/vegetable- sweet potato/maize/ soybean-maize/cassava, maize-maize/ sweet potato, maize-rice-sweet potato, maize/vegetable-sweet potato, rice/ wheat, wheat-maize, wheat-maize/green bean, rape/maize, wheat/vegetable-maize/ vegetable	wheat-sorghum, wheat-sweet potato, wheat-rice, wheat-green bean, wheat-peanut, rape-cotton, sugarcane, rice-rice, rice-sweet potato, rice-potato, rice-vegetable, rice/fish, lotus, rape-rice, rice-vegetable-wheat, barley-rice, rice/fish
	Rainfed spring/fall maize (two seasons)	maize-soybean(vegetable, cotton, peanut), maize-maize, maize/beans(sorghum)-wheat, maize/sweet potato-soybean, maize-rice-sweet potato, maize/cassava-soybean, maize-sweet potato-rape/vegetable, maize- soybean/ cassava, maize-sweet potato-soybean, maize/ pumpkin (ramie, sweet potato), maize-maize/ sweet potato, wheat-maize, maize-rice	wheat-sorghum, rice-rice, rape-rice-rice, buckwheat-rice, sugarcane
	Rainfed spring/fall/winter maize (three seasons)	maize-sugarcane-maize, maize-vegetable-maize, maize-sugarcane,	vegetables, fallow

Note: "-" indicates crop rotation and "/" indicates intercropping.
Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

3.2.1. Potential substitute crops for maize

Information on crop alternatives to maize and the factors farmers consider when choosing a crop provides a better understanding of the local role of maize and its importance relative to other crops and activities. It can also give some indication of local farmers' interest in continuing to cultivate maize in the future. Farmers in the PRA discussion groups were asked which crops were potential substitutes for maize, and of those substitutes, which they would be most likely to cultivate should they decrease the maize area (Table 3.4). Interestingly, farmers in some villages initially had difficulty responding because the hypothetical situation of not growing maize was hard to imagine. This was particularly the case with some farmers in the Southwest rainfed spring region, albeit for very different underlying reasons. The need for maize as feed for animals raised in the household was the overriding reason for farmers in villages that cultivated rainfed spring maize, particularly in Sichuan province. For households in Guangxi province that continued to consume maize as a staple food, not to cultivate the staple crop was an option that would not normally be considered.

In villages characterized by mountainous terrain, very little or no irrigated paddy land, and a higher share of poor soils, maize is the highest yielding staple food crop. Unless income is available from the sale of agricultural products or from off-farm employment, the purchase of other staple foods, such as rice, is not an option for many households. However, in other villages in the Southwest where rice was cultivated and had largely taken the place of maize as the staple food, other options such as sugarcane were available. Marketing factors, including prices and sales opportunities, became the overriding basis for cropping decisions. While farmers in the Northeast rainfed spring maize region came up with alternatives that included soybean, potato, and watermelon, there was also concern, for reasons of income risk, that maize could not be completely replaced by other crops.

Overall, the most important considerations for choosing a viable alternative crop to maize, other than suitability for the growing season and cropping conditions, were related to the income earning potential of the crop, e.g., price and ease of marketing, plus the amount of time and labor needed to grow it. Soybean was particularly singled out across all regions as requiring less labor than maize. Common fennel in the Northwest rainfed spring region, sunflower in the North rainfed spring region, and sugarcane in the Southwest rainfed spring/fall/winter region[2] were also recognized for their labor saving attributes. Farmers in the North rainfed spring region and the Northwest rainfed spring region were more likely than those in other regions, with the exception of certain villages in the Southwest rainfed spring/fall/winter maize system, to consider the crop's potential for direct household consumption when deciding among competing crops.

3.2.2. Tradeoffs between maize and other crops

Discussions also took place regarding farmers' perceptions of the advantages and disadvantages of maize and other crops cultivated in their villages (Table 3.5). The importance of maize as a source of income is evident across all production systems. The fact that farmers clearly identified it as a source of food and feed for animals raised in the household reinforced its importance in direct and indirect food security.

[2] Rainfed spring/fall/winter includes spring (one season) maize; spring and fall, and spring and winter (two seasons) maize systems; and spring, fall, and winter (three seasons) maize systems in the Southwest region.

Table 3.4. Preferred substitute crops for maize in surveyed villages.

Agroecological region	Maize production system	Spring maize	Summer maize	Fall maize	Winter maize (sweet corn)
Northeast	Rainfed spring	soybean, potato, melons	Na	Na	Na
North	Rainfed spring	millet, broomcorn millet, soybean, sorghum, potato, sunflower, red bean	Na	Na	Na
Northwest	Rainfed spring	soybean, potato, common fennel, tobacco	Na	Na	Na
Yellow-Huai River Valley	Irrigated summer	cotton, peanuts, sweet potato, fruit	cotton, soybean, hot pepper, millet	Na	Na
Southwest	Rainfed spring	cot pepper, soybean, ginger, cotton, peanut, sweet potato, winter melon, sugar cane, cassava, banana		soybean, vegetables, black bean, sweet potato	vegetables

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Table 3.5. Perceived advantages and disadvantages of maize by farmer group.

Agroecological region	Maize production system	Rich male		Rich female		Poor male		Poor female	
		Advantages	**Disadvantages**	**Advantages**	**Disadvantages**	**Advantages**	**Disadvantages**	**Advantages**	**Disadvantages**
Northeast	Rainfed spring	Source of income	Low yield	Source of income	Low yield	Labor saving	Low profitability	Good yield	Low profitability
		Used as feed	Unstable and low price	Used as feed	Unstable price	Government purchase price	Affected by drought	Easy to sell	Affected by drought
		Can be intercropped	Affected by drought	Stalks burned as fuel	Affected by drought	Easy to sell	Unstable price	Source of income	
		Labor saving		Good for non-level land		Home consumption		Home consumption	
		Easy to market		Easy to market		Used as feed		Used as feed	
				Labor saving		Stalks burned as fuel		Easy to manage	
						Easy to manage			
North	Rainfed spring	High yield	Difficult to store in summer	Guarantee of food	Affected by drought	Grain and stalks used as feed	Susceptible to disease	Safe crop	Unstable price
		Stable yield	Difficult to sell	Not affected by hail	Not good to eat	Safe crop		High yield	
		Drought tolerant		High yield	High labor requirements	Easier to sell than other crops		Stable yield	
		Not affected by hail		Source of income				Can be sold at decent prices	
		Good source of income						Used as feed	
		Easy to grow and manage in field							
		Flexibility in harvest time							
Northwest	Rainfed spring	Used for feed	Low price	Stable yield	Low price	Safe crop	Low price	Used as feed	Low yields Low price
		Can be exchanged for rice and wheat flour		Used for feed		Used as feed		Home consumption	High fertilizer requirements
				Sold for income		Source of income		Can be exchanged for rice and flour	
				Can be exchanged for rice and wheat flour		Can be exchanged for other goods		Labor saving	
				Good marketability					
Yellow-Huai River Valley	Irrigated summer	Source of income	Low profit	Source of income	Low price	Used as feed	Low price	Source of income	Low price
		Used as feed	Unstable yield	Used as feed	Requires pesticides –susceptible to insects and diseases	Good to eat (maize porridge and steamed buns)	Low profit	Easy to manage	Requires pesticides – susceptible to insects and diseases
		Home consumption (maize porridge and steamed buns)	Disease and pest susceptibility	Home consumption (maize porridge and steamed buns)	Fake seeds	Labor saving		Good marketability	Fake seeds
		Good marketability		Good marketability		Better yield than soybean		Good for cropping with wheat	
		More labor saving than cotton, garlic, pepper		Food guarantee					
		Residues used for fuel		Good for cropping with wheat					
		Easy to irrigate		Better yield than soybean					
Southwest	Rainfed spring (one season)	Used as feed	Not drought tolerant	Good yields	Not drought tolerant	Used for feed	Affected by drought and water logging	Used for feed	Susceptible to disease and insects
		Source of income		Used for feed	Susceptible to disease and insects	Source of income	Lodging	Source of income	
				Source of income		Home consumption	Susceptible to disease and insects	Home consumption	
				Home consumption					
	Rainfed spring/fall	Home consumption	Susceptible to disease and insects	Home consumption	Low yields	Home consumption	Low yield	Home consumption	Low yields in drought
		Used as feed		Used as feed	Lodging problems	Used as feed	Susceptible to disease and insects	Used as feed	Susceptible to disease and insects
		Surplus can be sold		Source of income	Susceptible to disease and insects	Source of income		Source of income	Not drought tolerant
		Stalks burned as fuel		Stalks burned as fuel	Affected by water logging	Used for government grain quota		Can sell maize stalks	Affected by water logging
		Labor saving relative to rice							
	Rainfed spring/winter	Staple food	Not as tasty as rice	Staple food	Lower price than rice	Staple food	None	Staple food	Low price
		Grain and stalks used as feed		Used for feed		Used for feed		Grain and stalks used as feed	Affected by wind
		Stalks burned as fuel		Source of income					

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

3.3. Land Preparation and Crop Management Practices

3.3.1 Land preparation and sowing

A range of land preparation practices is utilized across the agroecological regions, although considerable differences were observed between areas with single-season cropping patterns and those with multiple-season cropping patterns. In areas of the Northeast, North, and Northwest regions characterized by single-season cropping, land preparation takes place over a period of several months. Traditionally, after the fall harvest, fields are deep-tilled to remove stubble from the preceding crop and prepare for spring production. If irrigation water is available, it is applied at this time; regardless of irrigation, manure may be applied.

According to participants in the group discussions, the major benefits of this winter till is that it allows collecting fall and winter precipitation, preserving the resulting moisture deep in the soil, and eradicating soil pests. Winter plowed land also captures the early spring sunshine more effectively, which raises soil temperature and improves seed germination. Farmers also recognized that winter tillage has a disadvantage: it induces soil erosion when strong winter winds blow over areas with little snow cover. The land is tilled a second time immediately prior to maize planting and often harrowed as well. Most farmers who use this practice also apply chemical fertilizer during planting.

Although most survey participants in these northern regions continued to practice fall tilling, the practice has decreased because of the increasing number of farmers with off-farm employment during the agricultural off-season and the opportunity costs associated with returning home or staying home to plow. Moreover, the practice of manure application, which takes place at the same time as fall tilling, has also begun to decline in some areas due to time and labor requirements (this activity is usually carried out by young men), and to decreasing household supplies of manure. A single spring tilling and chemical fertilizer application prior to planting is becoming more common for their lower labor and machinery costs.

Some farmers in the North and Northwest regions also carry out an additional tilling at the seedling stage of the spring maize crop. This consists of piling soil up on the upper roots of the plant to prevent lodging, increase soil moisture retention, and control weeds. This practice is repeated once or twice before tasseling.

In the majority of villages in the Northeast, most surveyed farmers reported using machines for land preparation, fertilizer application, and planting, although some continue to use draft animals for tilling. Most villages in the North irrigated and rainfed spring regions also use machines for land preparation, although draft animals continue to be used, particularly in rainfed areas. If using draft animals for fall tilling, farmers generally wait until spring tilling to apply fertilizer because they believe that soil is not tilled deeply enough by animal traction. Manpower is also used in particularly small plots. Machines are common in Northwest irrigated and rainfed spring maize areas; however, manpower and animal traction are used just as much as mechanization in rainfed areas, particularly to remove crop stubble. Sowing was most frequently done by human labor in both the North and Northwest.

Farmers in the North rainfed spring and Northwest irrigated spring maize frequently utilized plastic covering (mulching) for maize cultivation. Plastic is laid on the land following tilling and either land leveling or furrowing. The plastic can be spread either before or after maize planting with the use of animals or by hand. In all surveyed villages, sowing is done largely by hand. Farmers credit the use of plastic mulch with raising soil temperatures, reducing weeds, and preserving soil moisture. The technology's advantages are particularly evident in North China, where the frost-free period is short. However, due to higher input costs and labor requirements, the degree to which plastic mulch is used for maize production varies across households.

In survey sites in the Yellow-Huai River Valley, farmers plant maize directly after the wheat harvest with no tillage. Wheat is harvested by combine, and maize is seeded manually or with a seeding machine into the wheat residues. For maize intercropped with vegetables (a frequently observed cropping system, particularly maize and garlic), two practices were observed. In the first, farmers leave a wide space for summer crops when planting garlic, wheat, or other winter crops. For example, farmers leave 40-60 cm for maize between 4 to 6 wheat rows, approximately 20 cm apart. In the spring, maize is sown into the space 30 to 45 days before the winter crop is harvested. Manure or inorganic fertilizer is applied prior to maize planting.

The longer maize cycle made possible by planting before harvesting the winter crop has a positive effect on yields, but was believed by some farmers to reduce winter crop yields due to the reduced area planted. In the second practice, maize is usually sown 10-15 days before harvesting the winter crop (wheat and garlic, among others), but without the use of wider row spacing, to minimize the negative effects on winter crop yields. Maize yields are usually lower than with the first practice because a later sowing date limits the height of maize at the time of wheat harvest. Machinery is also used for land preparation in the Yellow-Huai River Valley, but sowing practices include the use of manual labor as well as of machines and animals to pull seeders.

Wheat-maize intercropping practices (especially wide spacing) are also used in irrigated spring maize in the Southwest. The use of transplanted seedlings, common in irrigated spring maize, was also found in rainfed spring maize areas. The practice gives farmers more time for land preparation or allows more time for the preceding crop to grow. In Sichuan province, farmers raise maize seedlings and transplant them to the wheat field right after the wheat harvest. The disadvantage of the practice lies in the higher labor costs required to produce and transplant the seedlings.

Farmers in other maize systems in the Southwest, including rainfed summer maize and rainfed spring/fall/winter maize, carry out land preparation and planting activities using mainly animal traction and manual labor. Many farmers raise cattle and other livestock specifically for cropping activities and for producing organic fertilizer. Farmers noted that animal traction was often the only method suitable for tilling the small and/or mountainous plots typical of much of Guangxi province.

3.3.2. Crop management practices

Fewer differences were observed across maize systems in the five regions with respect to the application of chemical fertilizers. In addition to the base fertilizer applied at planting by all farmers, most farmers also apply a topdressing (usually nitrogen) at least once (and sometimes twice). If fertilizer is applied only once, application takes place at the booting stage (ear development). The second application, if it occurs, is at the elongation stage. Farmers opted for one application to reduce chemical costs and labor use, and to shorten the interval between base fertilizer application and fertilization at elongation.

Because land is not tilled for summer maize in the Yellow-Huai River Valley, farmers apply base fertilizer on the preceding crop before intercropping the maize or after roguing (thinning of seedlings). In some areas, fertilizer is applied after elongation instead of at the seedling stage.

Across regions, weeding is done depending on necessity. However, in most cases, weeding is done together with roguing, fertilizer application, and pest control. Farmers in the Northeast, North, and Northwest regions generally weeded twice; a single weeding was more likely in the Yellow-Huai River Valley and the Southwest. Farm animals and manual labor were most commonly used for weeding in the Northeast, North, and Northwest regions. The advantage of using animals was primarily speed and labor savings; the disadvantage was that the animals could damage the seedlings. Weed control in the Yellow-Huai River Valley irrigated summer maize system and the Southwest irrigated spring maize system is carried out both with herbicides and by hand. Weeding in the remaining maize systems is primarily carried out by hand. The use of pesticides was mentioned only in the Yellow-Huai River Valley irrigated summer maize region, where they are applied by male labor. All other pest control is carried out by hand. Finally, with a few exceptions where machines are used, all maize is harvested manually.

Table 3.6 summarizes information on land preparation and crop management practices farmers use on maize in survey sites from the various maize agroecological regions.

3.4. Soil Management Practices

Farmers were asked to describe any management practices they applied to reduce or prevent soil erosion and improve soil fertility. Farmers participating in our discussion groups in the Northeast rainfed spring region and the Yellow-Huai River Valley irrigated summer maize region did not implement any practices targeted at erosion. Those in the Yellow-Huai River Valley rainfed summer region and the North irrigated and rainfed spring regions described a practice that involved raking and compressing soil to conserve moisture and control erosion. Farmers in the North region highlighted that fall/winter deep tilling helps moisture from rain and snow penetrate the soil. Some farmers in the Northwest mentioned digging ditches and building ridges to retain soil and level sloping lands, but many others did not apply management practices targeted at preventing soil erosion. Farmers across the Southwest maize systems used a variety of methods, including digging ditches and building soil ridges and walls. Covering the soil with plastic sheeting is also believed to prevent erosion. Many farmers in the North, Northeast, Northwest, and Southwest regions had participated in government programs that promoted planting trees and grass to minimize soil erosion.

Participants in the Northeast felt that soil fertility in their maize fields was generally good. Thus they did not carry out activities specifically to improve fertility levels, with the exception of deep tilling, which they believed improves soil fertility by loosening the soil and increasing ground temperature. Both green manure crops and the application of soybean and cotton seed cakes have been utilized in the region in the past, but the use of arable land for green manure crops and the cost of the soybean and cotton cakes posed strong disincentives for their use. In all regions, manure application was singled out as a key means of improving soil fertility; it also results in easier weeding, less compact soil, more soil moisture retention, and higher soil temperatures. The perceived disadvantages of manure application included high labor requirements and increased weeds.

Table 3.6. Maize crop management by production system.

Agroecological region	Maize system	Fall till/Winter fertilization	Spring till/Base fertilization	Sowing	Transplant seedlings yes or no	Use of plastic mulch yes or no	Intertill / Weeding /Top fertilization # of times or no	Pesticide application	Irrigation	Harvest
Northeast	Rainfed spring	Land deep tilled using mechanized equipment after har vesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage (usually with mechanized equipment) followed by harrowing before sowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. All farmers fertilize before sowing.	Tractor-pulled seeders or use of work animals with human labor after 1-2 times spring tilling.	no	no	Most farmers intertill 1-2 times during maize growth season, using machinery or animals the first time and hand tools the second time. Usually intertilling takes place with top fertilizing 40 days after sowing.	no	no	By hand
North	Rainfed spring	Land deep tilled using mechanized equipment after har vesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage with mechanized equipment or animals followed by harrowing before sowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. All farmers fertilize before sowing.	Tractor-pulled seeders or use of work animals with human human labor after 1-2 times spring tilling.	no	Yes, by some farmers at sowing. After germination, holes in the plastic are made by hand to allow seedlings to grow.	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	Little to no irrigation available.	By hand
North	Irrigated spring	Land deep tilled using mechanized equipment after har vesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage (usually with mechanized equipment) followed by harrowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. Irrigation and fertilization before sowing.	Tractor-pulled seeders or use of work animals with human human labor after 1-2 times spring tilling.	no	yes, but not common	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	yes, from irrigation canals	By hand
Northwest	Rainfed spring	Land deep tilled using mechanized equipment after har vesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage with mechanized equipment or animals followed by harrowing before sowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. All farmers fertilize before sowing.	Most farmers use animals with human labor to sow; a minority use tractor pulled seeders. Very few farmers transplant seedlings.	yes but not common	Yes, by some farmers at sowing. After germination, holes in the plastic are made by hand to allow seedlings to grow.	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	very few counties have irrigation water (usually from Yellow River).	By hand
Northwest	Irrigated spring	Land deep tilled using mechanized equipment after har vesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage (usually with mechanized equipment) followed by harrowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. Irrigation and fertilization before sowing. Most farmers do not till	Most farmers use tractor pulled seeders. Others use animals with human labor to sow after 1-2 times spring tilling.	no	yes, but not common	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	yes, from irrigation canals	By hand
Yellow/Huai River Valley	Summer irrigated	Most farmers do not till before sowing maize.	Most farmers do not till before sowing maize.	Maize usually sown by hand before wheat is har vested. If intercropping wheat with garlic or vegetables, tillage is often carried out by hand or by animal after garlic or vegetables are har vested but while wheat is still in the field. If wheat is cultivated alone, maize is sown about 10 days before wheat is har vested.	no	no	After the maize reaches 3 leaf stage, deep intertilling using hands tools to integrate residue into soil and fertilization. Irrigation before intertilling or after wheat harvest.	twice to control maize borer	Most farmers Irrigate maize as needed	Most by hand

Table 3.6. Cont'd..

Agroecological region	Maize system	Fall till/Winter fertilization	Spring till/Base fertilization	Sowing	Transplant seedlings yes or no	Use of plastic mulch yes or no	Intertill / Weeding /Top fertilization # of times or no	Pesticide application	Irrigation	Harvest
Yellow/Huai River Valley	Rainfed spring	Land deep tilled using mechanized equipment after harvesting fall crops and before the land freezes. No harrowing after fall tillage.	Spring tillage (usually with mechanized equipment but also with animals) followed by harrowing. Approximately half of farmers till twice in spring with sowing taking place at second tillage. All farmers fertilize before sowing.	Most farmers use tractor pulled seeders. Others use animals with human labor to sow after 1-2 times spring tilling.	no	no	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	no	By hand
Yellow/Huai River Valley	Rainfed summer	no	no	Tillage, sowing, and fertilizer application after wheat harvest predominates. Sowing before wheat harvest also takes place.	no	no	Most farmers intertill 1-2 times during maize growth season using animals the first time and hand tools the second time.	no	Very few farmers	By hand
Southwest	Irrigated spring	no	no	Wheat-maize intercropping predominates. Space for maize is reserved when planting wheat. Maize sown by hand in the spring and usually has reached elongation stage at wheat harvest.	no	no	Most farmers intertill 1-2 times using hand tools.	no	no	By hand
Southwest	Rainfed summer	no	no	Land is tilled, maize is sown, and fertilizer applied after wheat harvest.	no	no	Most farmers intertill 1-2 times using hand tools.	no	no	By hand
Southwest	Rainfed spring (one season maize)	no	Tillage 1-2 times (one time most common) before sowing in Guangxi, where the agro-system is maize-other crops, and maize is not intercroped. No spring tillage in Sichuan and other regions,where maize is relay or intercropped with other crops.	In Guangxi, farmers sow when land is tilled (first or second time). Planting is with animals or by hand. In Sichuan and other regions, wheat-maize intercropping is the most common agrosystem model. Farmers leave space for maize when sowing wheat. Maize is sown by hand in the spring. Maize is at elongation stage at wheat harvest.	no	no	Most farmers intertill 1-2 times using hand tools.	no	no	By hand
Southwest	Rainfed spring / Fall / Winter (two season maize)	no	Tillage 1-2 times (one time most common) before sowing.	Most using hand tools (using hoe).	no	no	Most farmers intertill 1-2 times using hand tools.	no	no	By hand

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

All farmers in the North, Northwest, Yellow-Huai River Valley, and Southwest regions mentioned a government program aimed at "returning residues to the fields" as a means of improving soil fertility. Difficulties encountered by farmers, particularly in the North and Northwest, included the additional cost of purchasing or leasing machines to chop the residues and the fact that they use the residues as animal feed. Arid climates within these two regions were believed to impede the breakdown of residues, which negatively affected seedling emergence.

3.5. Maize Varieties

3.5.1. Farmers' preferred traits

Farmers ranked the characteristics they considered to be most important in a maize variety. Table 3.7 compiles the top three characteristics ranked by each group according to the maize production system. High yield was the highest ranked characteristic in almost every farmer group across all agroecological regions. Drought tolerance, lodging resistance, and disease and pest resistance also consistently ranked high among the groups. Farmers in the Northeast and Yellow-Huai River Valley regions were particularly concerned with good germination. Characteristics related to the cropping system, including suitability for intercropping, were also raised in the Yellow-Huai River Valley and Southwest regions. Stalks that broke down easily after harvest was also a trait valued by farmers in the Yellow-Huai River Valley.

Characteristics such as color were not frequently mentioned, but did appear in the rankings of farmer groups in the Southwest, Northwest, and Northeast regions. A reddish-yellow (orange) color was preferred by groups of poor farmers, both men and women, in the Northeast and Northwest regions. However, a pure yellow color was preferred in maize for consumption and sale in the rainfed spring and fall systems of the Southwest. Some farmers in the North rainfed spring region also considered maize of this color easier to sell.

Table 3.7. Most important maize characteristics by farmer group.

Agroecological region	Maize production system	Rich male	Rich female	Poor male	Poor female
Northeast	Rainfed spring	High yield	High yield	High yield	High yield
		Drought tolerant	Drought tolerant	Good germination	Drought tolerant
		Insect resistant	Insect resistant	Drought tolerant	Short duration
		Pure seed	Good germination	Resistant to lodging	Full kernels
		Good germination			
North	Rainfed spring	High yield	High yield	Drought tolerant	High yield
		Disease resistant	Short duration	High yield	Fully developed cob
		Resistant to lodging	Disease resistant	Short duration	Disease resistant
			Resistant to lodging	Disease resistant	Good germinatio
Northwest	Rainfed spring	High yield	High yield	High yielding	High yield
		Drought tolerant	Reddish-yellow color	Drought tolerant	Drought tolerant
		Resistant to lodging	Drought tolerant	Resistant to disease	Short duration
			Short duration	Short duration	
				Resistant to lodging	
Yellow-Huai River Valley	Irrigated summer	High yield	High yield	High yield	High yield
		Good germination	Resistant to lodging	Disease resistant	Disease and insect resistant
		Stable yield	Disease and insect resistant	Big cob size	Resistant to lodging
		Short duration	Big kernel size	Good germination	Big cob size
Southwest	Rainfed spring (one season)	High yield	High yield	High yield	High yield
		Disease resistant	Disease resistant	Good for intercropping (leaves should not block sun)	Disease resistant
		Good for intercropping	Short stature	Thin cob	Drought tolerant
	Rainfed spring/fall	High yield	High yield	High yield	High yield
		Drought tolerant	Good price	Drought tolerant	Resistant to lodging
		Not affected by waterlogging	Disease resistant	Disease tolerant	Resistant to disease and insects
		Resistant to disease and insects	Big kernels	Resistant to lodging	Short duration
	Rainfed spring/winter	High yield	High yield	High yield	High yield
		Drought tolerant	Resistant to lodging	Disease resistant	Stable yield
		Resistant to lodging	Drought tolerant	Resistant to lodging	Big cob size
		Stable yield	Seed can be saved	Good germination	Seed can be saved

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Characteristics that appeared more frequently in the rankings included big ears and full kernels, although this trait is related to production concerns. Only groups in the Southwest and Northwest considered taste to be of importance in selecting a maize variety. Farmers in the Southwest rainfed spring/winter region also looked for varieties that were suitable for hilly or mountainous terrain and had good storage qualities.

3.5.2. Cultivated varieties

With very few exceptions, the varieties cultivated across all maize agroecological regions in China are hybrids. According to surveyed farmers in the Northeast, Yellow-Huai River Valley, and the Southwest irrigated spring maize region, no OPVs or local varieties were cultivated in these systems. A few local varieties are still sown in small areas in the irrigated spring and rainfed spring maize systems of the North and Northwest agroecological regions. These include glutinous (waxy) varieties that were praised for their consumption qualities. Other traits attributed by farmers to the local varieties found in those systems include a short cycle and low yields. Because of their short cycle, these varieties are used to fill unexpected gaps in maize plots caused by germination problems in seed from other varieties.

Both OPVs and local varieties, including glutinous (waxy) varieties, continue to be cultivated in areas of the Southwest rainfed spring, fall, and winter maize systems. Hybrid varieties covered the largest share of the spring maize area, but local varieties and, particularly, OPVs occupied a much larger portion of the fall maize area than hybrids. Compared with 1996 estimates, the share of local varieties appears to have decreased slightly, while that of hybrid varieties has increased (Song, 1998). Local varieties and OPVs are considered to be better adapted to the climate and soil conditions in mountainous terrain. Specifically, farmers considered the reduced amount of sunlight and shallow soils to be limiting factors for the performance of commercial hybrid varieties. Percent area planted to different maize types across maize production systems is provided in Table 3.8.

Farmer perceptions of OPVs and local varieties differed across survey sites in the Southwest. The fact that farmers could save seed of OPVs and local varieties for planting next cycle was frequently cited as an important advantage. However, local varieties and OPVs are no longer cultivated in several villages due to low yields and insect and disease problems. In sites where local varieties are still sown, their low yields were acknowledged as disadvantages, but their consumption qualities were also highlighted. Glutinous maize (waxy) varieties were particularly singled out for consumption quality and for preparing specific foods, but these varieties did not seem to be considered the main staple crop in the same way as other maize varieties are. They are often planted in small mountain plots only after the primary maize crop has been planted.

In villages where OPVs are no longer cultivated, the main reasons given for their replacement included their long cycle, physical properties (e.g., tall stature and big leaves that require greater plant spacing), low yields, and high grain moisture content at harvest. Opinions of their consumption qualities varied considerably. In villages where cultivation continues, farmers seemed generally pleased with the big kernel and ear size, and consumption qualities. Because of their drought tolerance, hybrid varieties are preferred for fall planting by many farmers in the Southwest rainfed spring/fall maize system, where drought is a major production constraint.

Table 3.9 compiles the varieties named during the survey, farmers' main reasons for sowing them, and sources of information about the variety.

Table 3.8. Share (%) of maize type by maize system.

		Variety type in Spring maize area			Variety type in summer maize area			Variety type in autumn maize area			Variety type in winter maize area		
Agroecological region	Maize system	local variety	OPV	hybrids	local variety	OPV	hybrids	local variety	OPV	hybrids	local variety	OPV	hybrids
Northeast	Rainfed spring	0.00	0.00	100.00	-	-	-	-	-	-	-	-	-
North	Irrigated spring	0.33	0.00	99.67	-	-	-	-	-	-	-	-	-
	Rainfed spring	0.14	0.00	99.86	-	-	-	-	-	-	-	-	-
Northwest	Irrigated spring	0.50	0.00	99.50	0.00	0.00	100.00	-	-	-	-	-	-
	Rainfed spring	0.25	0.00	99.75	0.75	0.00	99.25	-	-	-	-	-	-
Yellow-Huai	Irrigated summer	0.00	0.00	100.00	0.00	0.00	100.00	-	-	-	-	-	-
River Valley	Rainfed spring/summer	0.50	0.00	99.50	0.00	0.00	100.00	-	-	-	-	-	-
Southwest	Rainfed spring/summer	15.0	0.0	85.0	15.80	0.00	84.30	-	-	-	-	-	-
	Irrigated spring	0.00	0.00	100.00	-	-	-	-	-	-	-	-	-
	Rainfed spring (all sites)	13.32	10.42	76.26	-	-	-	23.00	19.50	57.50	1.7	26.7	71.7
	Rainfed spring (one season)	5.0	2.8	92.2	-	-	-	-	-	-	-	-	-
	Rainfed spring/fall	26.0	17.0	57.0	-	-	-	32.0	23.0	45.0	-	-	-
	Rainfed spring/winter	6.0	29.3	64.7	-	-	-	3.3	26.7	70.0	1.7	26.7	71.67

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 3.9. Cultivated varieties by agroecological region, reasons for cultivation, and source of information.

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
Northeast rainfed spring	Hybrid Dan yu 13	high yield, bigger ear, good agronomic characters (tall stature, upright leaf), drought tolerant, early maturity	seed company
	Dan yu 15	high yield, bigger ear, good agronomic characters (tall stature, upright leaf), drought tolerant, early maturity	seed company
	Dan yu 22	high yield, big kernel	seed company
	Deng Hai No. 9	high yield, planted experimentally, needed to change variety, full season maturity, strongly extended by government, insect tolerant	seed company, relatives or friends
	Deng Hai No. 1	high yield, lodging resistant, recommended by government extension agents, wide adaptability (to different environments)	agricultural technology extension station, seed company
	Hai dan 2	high yield, insect tolerant	seed company
	Hai He 3	high yield, good color, lodging resistant, good agronomic characters (tall stature, upright leaf), disease tolerant	agricultural technology extension station
	Gong Zhu No.1	high yield, needed to change variety, drought tolerant	agricultural technology extension station
	Ji dan180	early maturity, big kernel, easy to buy, high yield, stable performance, no barren kernels at the tip of ear	seed company
	Ji dan 209	early maturity, stable performance, recommended by government extension agents, high price, high yield, big kernel	agricultural research institute, provincial academy of agricultural sciences
	K508	bigger ear, big kernel	seed company
	Liao dan 24	high yield, tolerant to high density planting, lodging resistant, drought tolerant, disease resistant	seed company
	CAU 108	big kernel, big ear, high yield, stress tolerant	seed company
	CAU 180	early maturity	seed company
	CAU3138	high yield	seed company
	Shaan dan 911	bigger ear, big kernel	provincial academy of agricultural sciences
	Si dan 158	high yield, insect tolerant, make good advertisement	seed company
	Si Mi 21	high yield, plump seed, big kernel, early maturity, tolerant to high density planting, resistant to smut, good germination, local hybrid, drought tolerant	provincial academy of agricultural sciences, seed company, agricultural technology extension station
	Si Mi 25	stable performance, early maturity, new variety, good germination, tolerant to high density planting	seed company, agricultural technology extension station
	Tie dan 10	full season, high yield	seed company
	Xi dan 2	high yield, new variety	seed company
	Xin 81	high yield, lodging resistant, disease tolerant	agricultural technology extension station, provincial academy of agricultural sciences
	Xin Tie 10	high yield, drought tolerant, big ear, big kernel	agricultural technology extension station, seed company
	Ye dan 44	early maturity, high yield, stable performance, lodging resistant	agricultural research institute, agricultural technology extension station
	Ye dan 51	stable performance, early maturity	seed company
	Zheng dan 958 Huang Mo (HuangZao4xMo17)	high yield, big ear stable yield, short duration (less than 120 days and earlier than Zhong Dan 2), used to fill in spaces where seed from other varieties has not generated	seed company na

Table 3.9. Cont'd...

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
North irrigated spring			
	Hybrid		
	Jin dan 30	high yield, high protein level, easy to sell	seed company
	Jin dan 36	drought tolerant, lodging resistant, disease tolerant, no barren kernel on the tip of ear	seed company, agriculture college
	Mao yu 22	planted experimentally	seed company
	CAU 108	high yield, drought tolerant	private traders, seed company
	CAU 602	high yield, plump kernel	agriculture college
	CAU3138	high yield	seed company
	Shaan dan 911	drought tolerant, high yield	seed company
	Zhong dan No. 2	high yield	seed company
North rainfed spring			
	Hybrid		
	Zhong dan 9409	Quality protein maize, new variety	seed company
	Dan yu	early maturity, high yield, big ear	seed company, agricultural bureau
	Gao Nong 1	high yield	seed company
	Gao Nong 5	adapted to local environments	seed company
	Jin dan 30	high yield, high protein level, easy to sell	seed company
	Jin dan 34	high yield, new variety	seed company
	Jin dan 35	high yield	seed company
	Jin dan 34	high yield, plant experimentally	seed company
	Jin dan 36	wide adaptability (to different environments), high yield	seed company, provincial academy of agricultural sciences
	CAU108	adapted to local environments, high yield	agricultural technology extension station, seed company
	CAU 602	high yield, plump kernel	agriculture college
	CAU 3138	high yield, big kernel	seed company, agricultural technology extension station
	Tai dan 30	high yield	seed company
	Tang Kang 5	adapted to local environments, early maturity	seed company
	Yan dan 14	adapted to local environments	seed company
	Ye dan 13	high yield	seed company
	Ye dan 51	high yield	
	Zhang yu 1	adapted to local environments, early maturity, high yield	seed company
	Zhong dan No.2	high yield	agricultural research institute
	Zhong dan 13	planted experimentally	seed company
	Zhong yuan dan 32	high yield	seed company
	Local		
	Bai ma ya (white dent)	good consumption quality - taste	
Northwest irrigated spring			
	Hybrid		
	Dan yu 13	high yield, big ear, planted experimentally	seed company
	Shaan dan 911	high yield, tolerant to high density planting, big kernel, full season	agricultural technology extension station
	Zhong dan No.2	high yield, adapted to local environments, early maturity, disease resistant	seed company, agricultural technology extension station, collective (village/village team)

Table 3.9. Cont'd...

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
North irrigated spring			
	Han dan 931	high yield	Agricultural technology extension station
	Hu dan 4	cannot buy the desired seed	seed company
	Shaan dan 9	plump kernel, early maturity	seed company
	Shaan dan 911	big ear, high yield	seed company
	Shen dan 10	high yield, early maturity	seed company
	Zhong dan No.2	high yield	seed company, agricultural technology extension station
	Local		
	Xiao bai (early white) maize	good to eat (sweet), early maturity, thin skinned kernels	family, neighbors
Yellow-Huai River Valley irrigated summer			
	Hybrid		
	984	new variety	seed company
	Dan yu 13	early maturity, new variety	relatives and friends
	Deng Hai No.1	early maturity, high yield	seed company, relatives and friends
	Deng Hai 9	early maturity, high yield, recommended by government extension agents for high yield, drought tolerant, lodging resistant, disease tolerant	seed company, obtained from another county
	Fu hua 1	high yield	seed company
	Lu dan 14	new variety, high yield, big ear, early maturity, good color, stable performance, tolerant to high density planting	seed company, seed company township station
	Lu dan 50	high yield, disease tolerant, disease and insect tolerant, big ear, strong seedling	seed company township station, seed company
	Lu dan 109	high yield	seed company township station
	Lu dan 963	lodging resistant, big ear, new variety	agricultural technology extension station
	Lu dan 981	new variety, high yield, disease tolerant	seed company
	Lu yu 10	early maturity, tolerant to high density planting, big kernel, high yield, big ear, lodging resistant	seed company
	CAU 108	high yield, lodging resistant, new variety, drought tolerant, wind resistant, disease tolerant	seed company, seed company township station
	CAU 3138	big ear, high yield, no options for other varieties	seed company, seed company township station
	Shen dan 7	big ear, thin cob (internal), high yield	
	Shen dan 10	high yield, big ear, lodging resistant, disease and insect tolerant,	seed company, seed company township station
	Tun yu No.1	lodging resistant, early maturity, high yield	seed company
	Xi yu No.1	big ear, lodging resistant	seed company
	Yan dan 14	the only variety available in village at the time	seed company township station
	Ye dan No.2	the only variety available in village at the time	agricultural technology extension station
	Ye dan 12	stable performance, few varieties available then, high yield, stable production, disease tolerant, lodging resistant, new variety	seed company, seed company township station
	Ye dan 13	high yield, stable performance	seed company, seed company township station
	Ye dan 14	few other choices for varieties	seed company township station
	Ye dan 19	new variety	seed company township station
	Zheng dan 958	lodging resistant, high yield, thin cob (internal), big kernel	seed company township station, agricultural research institute

Table 3.9. *Cont'd...*

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
Yellow-Huai River Valley rainfed summer	**Hybrid**		
	Dan yu series	high yield, no choice for other varieties	private traders, seed company township station
	Jin dan	High yield, recommended by government extension agents	seed company township station
	CAU 3138	big ear, high yield, no options for other varieties	seed company, seed company township station
	Zhong dan No. 2	high yield	seed company township station
Southwest rainfed summer			
	Hybrid		
	Hu dan No. 4	early maturity, short stature	seed company township station
	Mao yu 22	high yield, good profit, full season, stable performance, drought tolerant	seed company township station
	Mian dan No.1	full season, stable performance, drought tolerant	seed company township station
	CAU 3138	short stature, upright leaves - good for intercropping	seed company township station
	Shaan dan 902	high yield, big kernel, good color, early maturity	seed company township station
	Shaan dan 911	high yield, introduced by neighbors, good consumption quality - taste	seed company, seed company township station
	Ye dan 13	short stature, upright leaves - good for intercropping, high yield, new variety	seed company township station
	Yun dan 1	good consumption quality – taste, full season	seed company township station
	Zheng dan 958	high yield, short stature, upright leaves - good for intercropping, good consumption quality – taste	seed company township station, seed company, agricultural technology extension station
Southwest irrigated spring			
	Hybrid		
	9313	recommended by government extension agents	agricultural bureau
	Chen dan 14	early maturity	agricultural bureau
	Chen dan 19	high yield, tolerant to high density planting, high yield, recommended by government extension agents, short stature	agricultural technology extension station, seed company, Agricultural bureau
	Chuan dan 9	high yield	agricultural technology extension station
	CAU 108	high yield, recommended by government extension agents, planted experimentally	agricultural technology extension station, seed company
	Zheng dan 958	high yield	agricultural technology extension station
Southwest rainfed spring (one season)			
	Hybrid		
	2 hao huang	big ear	seed company
	3 hao huang	big ear	seed company
	Cheng dan 18	high yield, easy to shell, big kernel, recommended by extension agents, short stature, big ear	agricultural technology extension station, seed company
	Cheng dan 931	recommended by extension agents	seed company
	Chuan dan 9	big ear, thin cob (internal)	seed company
	Chuan dan 13	high yield, recommended by extension agents	agricultural technology extension station
	Da Zai	high yield	variety from Shaanxi
	Dan yu	thin cob (internal), lodging resistant	seed company township station, seed company

Table 3.9. *Cont'd...*

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
	Gui ding 1	lodging resistant	agricultural bureau
	Guo chan 2	short stature	seed company
	Jian she 1	big ear, short stature, wind resistant	seed company
	Nan 7	lodging resistant, high yield	seed company
	CAU 108	na	na
	Ya yu 2	big ear, thin cob (internal), no options for other varieties	seed company, agricultural technology extension station
	Ye dan 13	high yield, recommended by government extension agents	agricultural technology extension station
	yu le 1	na	agricultural technology extension station
	Zheng Da 619	recommended by extension agents, adapted to local environments, planted experimentally, high yield	agricultural technology extension station, agricultural bureau
	Zhong dan No.2	recommended by extension agents, high yield	agricultural technology extension station
	OPV		
	Mo Huang (Mo17xHuangzao4)	recommended by extension agents, high yield, lodging resistant	agricultural technology extension station, agricultural bureau
	Local Bai ma ya (white dent)	good consumption quality - taste	agricultural technology extension station
Southwest rainfed spring/fall			
	Hybrid		
	Chao Tian 20	early maturity	na
	Chuan dan 13	drought tolerant, disease and insect tolerant	agricultural technology extension station
	Chuan dan 9	high yield	agricultural technology extension station
	Gui dan 5	drought tolerant, disease tolerant, big ear	agricultural technology extension station
	Gui dan 16	recommended by extension agents	provincial maize research institute
	Gui dan 22	high yield, stable performance	agricultural technology extension station
	Gui ding No.1	high yield, recommended by extension agents	agricultural technology extension station, provincial maize research institute
	Gui san 5	adapted to local environments, disease tolerant, new variety	agricultural technology extension station
	Hua dan No.1	drought tolerant	agricultural research institute
	Han dan 931	high yield, stable performance	agricultural technology extension station
	Nan ding No.1	big kernel, drought tolerant	agricultural technology extension station, agricultural research institute
	CAU 3138	high yield, planted experimentally	agricultural technology extension station
	song yan 32	high yield	agricultural research institute
	Ye dan 13	recommended by extension agents, big kernel	agricultural technology extension station
	OPV		
	Mo bai (Tuxpeno 1)	drought tolerant, insect tolerant, low nitrogen tolerant, big kernels, thin ear	provincial maize research institute
	Local		
	Glutinous maize (waxy)	good to eat, early harvest, doesn't lodge, can save seed	family, neighbors
	Bai ma ya (white dent)	can save money by saving seed, higher yielding than local yellow	family, neighbors
	Local Yellow	can save seeds, good for maize porridge, good ear development, resistant to disease, earlier maturity	family, neighbors

Table 3.9. *Cont'd...*

Maize agroecological region	Variety name	Reasons for cultivation	Source of information about variety
Southwest rainfed spring/winter			
	Hybrid		
	833	no choice for other varieties	agricultural technology extension station
	Gui dan 22	high yield, good consumption quality - taste	aeed company
	Gui dan 26	high yield	seed company
	Gui san 1	recommended by government extension agents, high yield, lodging resistant	agricultural technology extension station
	Gui san 5	recommended by extension agents	agricultural technology extension station
	Hua dan	recommended by extension agents, drought tolerant, lodging resistant, planted by neighbors, big ear, big kernel	agricultural technology extension station, relatives or friends
	Hua yu	drought tolerant, wind resistant, disease tolerant, high yield, planted by neighbors	agricultural technology extension station, seed company
	Nan ding No.1	planted experimentally, recommended by extension agents, high yields	agricultural technology extension station, agricultural research institute
	Nan Xiao	planted experimentally	agricultural technology extension station
	CAU 3138	planted experimentally	agricultural technology extension station
	Ye dan 13	Short stature, drought tolerant, tolerant to high densety	agricultural technology extension station
	Zheng Da 619	high yield, new variety, short stature, drought tolerant, lodging resistant, high yield	agricultural technology extension station, seed company
	OPV		
	Mo bai (Tuxpeno 1)	can save seeds, good to eat, long ear, big kernels, considered by farmers in some villages not to lodge and be drought tolerant (although others disagreed)	agricultural technology extension station
	Mo huang (Mo17xHuangzao4)	can save seeds, good for pig feed – sweeter taste, good to eat	agricultural technology extension station
	Local		
	Bai ma ya (white dent)	well adapted to hilly plots, drought tolerant, big ear, considered delicious by some (but not all) households, stable yield, good for feed, good root system and can use fertilizer efficiently, shorter stature compared to other variety options, can save seed	family, neighbors
	Local Yellow	good for feed, waterlogging tolerant, delicious, doesn't rot easily, resistant to small black bug, tall stature but doesn't lodge	family, neighbors
	Yellow glutinous maize (waxy)	well adapted to hilly plots, drought tolerant, good to eat, early maturity	family, neighbors
	White glutinous maize (waxy)	well adapted to hilly plots, drought tolerant, used for home consumption (particularly in specific dish "ciba"), can substitute for rice, short stature - doesn't lodge, fewer insects	family, neighbors

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

3.6. Level of Input Use

Input use across maize production systems is presented in Tables 3.10a and 3.10b. Production costs were not calculated for surveyed villages, but estimated production costs for the surveyed provinces in 1999-2001 from the National Agricultural Production Cost and Revenue Information Summary are presented in Table 3.11. The cost of materials is highest in Guangxi and Jilin provinces, although cost in Jilin decreased over the observed time period. The opportunity costs of labor are consistently higher in Sichuan province.

3.7. Sources of Technology Information

Although the extension system in China has been negatively impacted by the lack of funds, expanded agenda, and often conflicting objectives (including selling inputs to the same farmers to whom they disseminate information), government extension stations and agricultural input companies continue to be a major source of technological information for farmers in the surveyed villages. Extension stations are managed largely at the township level, although county-managed stations also exist. Government input companies are largely managed at the county level and located in the county seat. The importance of technology sources varies considerably across maize production systems. Seed companies in the Southwest region and private traders in the Northwest region play a role in disseminating information about maize production technologies, while in the Northeast farmers rely heavily on other farmers for their information.

3.8. Yields and Yield Gap

Given the differences between minimum and maximum yields observed within each village, farmers were asked to discuss the reasons for the yield gap. Except in the Yellow-Huai River Valley, difference in soil quality was the explanation provided across all agroecological regions and maize systems. However, the most prevalent reasons were related to farmers' management and their ability to purchase the optimal amount of inputs, particularly fertilizer. Table 3.14 summarizes the main reasons provided by farmers in each region to explain the existence of the yield gap among farmers in their villages.

3.9. Post-Harvest Practices

Across all agroecological regions and maize systems, harvested maize was taken to the household for air or sun drying. Storage methods ranged from the use of bags, small storehouses, and piles outside the home to storage in clay urns and on shelves in wooden cupboards. Maize is primarily shelled by machine across all regions, although shelling by hand continues to take place in North China and, particularly, in the Southwest maize systems. Except in the Southwest, where maize is generally shelled immediately after harvest in all three seasons due to weather-related reasons and insect problems, maize in all other surveyed locations is usually stored, and the timing of shelling is determined by marketing needs. In areas of the North and Northwest regions, seed of local varieties, which is saved for the next crop, is often hung outside the house. In the Southwest, again due to climatic and insect problems, seed is generally stored in closed containers kept inside the house. Farmers in one village in the Southwest rainfed spring region commented that they stored maize seed separately from maize grain (together with their money) in the safest and driest place in the house.

Farmers in all surveyed villages had access to electric mills in their villages. Some households in the irrigated summer maize systems of the Yellow-Huai River and the Southwest rainfed spring system had access to small electric home mills. Table 3.15 summarizes post harvest practices in the various agroecological regions.

3.10. Production and Utilization Trends

Farmers discussed their perceptions of trends in maize production and consumption over the past ten years. Tables 3.16 and 3.17 summarize the perceived trends and accompanying rationale.

3.10.1. Trends in production

Low yields, abiotic stresses, low prices, and marketing were prominent factors in decisions to decrease the maize area. Also important were agroecological suitability and the economic benefits of cultivating maize relative to other crops. Farmers in the Southwest rainfed spring system agreed that in the past ten years the share of maize area planted to local varieties and OPVs had decreased due to their negative traits, particularly low yields and lodging. The fall season maize area in the Southwest also decreased, due to drought and because other crops are more profitable. Since winter maize competes with many other vegetable crops, its area has also declined, largely due to competition for land.

3.10.2. Trends in utilization

Utilization trends over the last ten years described by farmer groups confirm the decline in the consumption of maize as food. The association of maize with a lower standard of living and a preference for rice and wheat as primary staple foods was evident from the explanations provided by farmers. The use of maize as feed increased among farmers across almost all surveyed villages due to increased animal production and maize availability.

Table 3.10a. Labor use in maize production (labor days/mu).

Agroecological region	Maize system	All labor			Land preparation/ Preparing plastic cover		Seedling preparation		Planting/ transplanting		Opening plastic for seedlings		Thinning		Mid season plowing		Fertilizer application		Weeding		Insect control		Irrigation		Harvesting		Shelling	
		All labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor	Male labor	Female labor
Northeast	Rainfed spring	8.0	4.0	4.1	1.0	1.0	-	-	0.4	0.5	-	-	0.4	0.4	0.1	-	-	-	0.3	0.4	0.1	0.1	0.5	0.5	0.7	0.6	0.6	0.6
North	Irrigated spring	21.3	10.8	10.5	1.2	1.3	-	-	0.6	0.6	-	-	0.9	0.9	1.0	1.0	2.0	1.7	1.5	1.5	0.9	0.9	-	-	1.3	1.3	1.4	1.4
	Rainfed spring	22.2	11.4	10.7	1.4	1.3	1.5	1.5	0.7	0.7	1.0	1.0	0.6	0.6	1.5	1.5	1.7	1.3	1.6	1.5	0.2	0.1	-	-	1.2	1.2	0.1	0.1
Northwest	Irrigated spring	32.9	16.6	16.3	3.0	2.5	-	-	1.8	1.8	1.0	1.0	0.5	0.8	1.0	1.0	2.0	2.0	2.3	2.8	0.1	0.1	3.3	2.3	1.3	1.8	0.5	0.5
	Rainfed spring	12.0	6.1	5.8	2.0	1.9	-	-	0.5	0.4	-	-	0.8	0.8	0.0	0.0	0.9	0.9	0.5	0.5	0.1	0.0	-	-	1.3	1.3	0.1	0.1
Yellow/Huai	Irrigated summer	19.6	10.0	9.7	0.7	0.5	-	-	1.0	0.7	-	-	0.6	0.5	1.6	1.6	0.4	0.4	1.4	1.4	0.7	0.8	0.8	0.8	1.7	1.7	1.2	1.2
River Valley	Rainfed spring/summer	19.4	10.6	8.9	3.5	2.0	-	-	0.5	0.5	-	-	0.5	0.5	-	-	0.5	0.5	1.8	1.8	0.3	0.1	-	-	2.5	2.5	1.0	1.0
Southwest	Rainfed summer	12.5	6.5	6.0	0.8	-	-	-	1.5	1.0	-	-	-	0.8	-	-	0.8	1.0	1.0	1.0	0.3	-	-	-	1.3	1.3	1.0	1.0
	Irrigated spring	27.6	13.8	13.8	1.5	1.5	1.5	1.5	2.3	2.3	-	-	-	-	-	-	3.3	3.3	1.3	1.3	0.4	0.4	-	-	1.7	1.7	1.8	1.8
	Rainfed spring (all sites)	31.2	15.6	15.6	2.3	1.9	1.4	1.9	1.8	1.9	-	-	0.4	0.5	1.8	1.7	1.8	1.8	1.6	1.5	0.4	0.4	-	-	1.6	1.7	2.4	2.4
	Rainfed spring (one season)	30.0	15.1	14.9	3.0	2.2	1.6	2.1	2.2	2.4	-	-	-	-	-	-	1.9	1.9	1.6	1.4	0.4	0.4	-	-	1.7	1.7	2.8	2.8
	Rainfed spring/fall	24.3	11.8	12.5	1.2	1.2	0.5	0.5	1.6	1.6	-	-	0.5	0.5	1.0	1.0	1.4	1.4	2.0	2.0	0.3	0.3	-	-	0.8	1.5	2.5	2.5
	Rainfed spring/winter	25.9	12.8	13.1	1.8	1.8	-	-	1.3	1.3	-	-	0.4	0.4	2.3	2.0	1.8	1.8	1.3	1.8	0.6	0.6	-	-	1.7	1.7	1.7	1.7

Table 3.10b. Maize input use (kg/ha).

Agroecological region	Maize system	Maize seed			Urea			Ammonium bicarbonate			Superphosphate			Ammonium metaphosphate			NPK compound			Manure (yuan/m³)		
		local	OPV	hybrid	local	OPV	hybrid	local	OPV	hybrid	local	OPV	hybrid	local	OPV	hybrid	local	OPV	hybrid	local	OPV	hybrid
Northeast	Rainfed spring	-	-	48	-	-	368	-	-	-	-	-	998	-	-	212	-	-	319	-	-	4167
North	Irrigated spring	30	-	39	225	-	300	-	375	750	-	-	750	-	-	175	-	-	263	4000	-	6000
	Rainfed spring	-	-	47	300	-	213	1500	-	1050	750	-	750	-	-	188	-	-	375	-	-	3000
Northwest	Irrigated spring	-	-	36	-	-	263	2250	-	1500	-	-	-	-	-	188	-	-	-	5000	-	7000
	Rainfed spring	-	-	43	188	-	197	-	-	750	-	-	563	-	-	225	-	-	-	-	-	2000
Yellow/Huai	Irrigated summer	-	-	49	-	-	563	-	-	844	-	-	750	-	-	175	-	-	525	-	-	3000
River Valley	Rainfed spring/summer	-	-	43	-	-	150	-	-	750	-	-	750	-	-	-	-	-	-	-	-	6000
Southwest	Rainfed summer	-	-	38	-	-	188	-	-	1350	-	-	-	-	-	-	-	-	-	-	-	3250
	Irrigated spring	-	-	26	-	-	225	-	-	1125	-	-	1500	-	-	-	-	-	675	-	-	2000
	Rainfed spring (all sites)	50	50	28	141	159	146	436	356	848	584	225	553	-	-	-	300	413	380	1655	2000	1800
	Rainfed spring (one season)	29	23	23	103	75	108	383	-	1042	644	-	567	-	-	-	150	-	383	1440	-	1775
	Rainfed spring/fall	49	41	34	225	-	178	525	-	625	-	-	625	-	-	-	375	-	563	2750	-	1500
	Rainfed spring/winter	71	58	32	188	188	188	356	356	488	225	225	225	-	-	-	413	413	425	2000	2000	2000

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.
Note: Not all chemical fertilizers are used simultaneously.

Table 3.11. Maize costs (yuan/ha) of production in surveyed provinces, 1999-2001.

	1999				2000				2001				Average			
	Materials cost	Labor cost	Labor days	Total cost	Materials cost	Labor cost	Labor days	Total cost	Materials cost	Labor cost	Labor days	Total cost	Materials cost	Labor cost	Labor days	Total cost
China	2171	1886	193	4056	2072	1860	186	3932	2054	1916	186	3970	2099	1887	188	3986
Guangxi	2296	2000	192	4296	2322	2048	195	4370	2308	2048	195	4356	2309	2032	194	4340
Sichuan	1796	3524	344	5320	1580	3387	317	4967	1516	3532	327	5048	1631	3481	329	5112
Shaanxi	1623	1506	198	3129	1441	1890	225	3331	1532	1874	213	3406	1532	1757	212	3289
Shanxi	2107	1368	195	3476	1986	1342	189	3328	1919	1406	188	3326	2004	1372	191	3376
Jilin	2467	1563	142	4030	2387	1419	129	3806	2162	1148	131	3310	2339	1377	134	3715
Shandong	1862	1615	174	3478	1782	1544	158	3326	1765	1545	152	3310	1803	1568	161	3371

Real prices (base year = 2000).

Source: National Agricultural Production Cost and Revenue Information Summary (Quanguo Nongchanpin Chengben Shouyi Ziliao Huibian). The Development and Reform Committee, China. 1999-2001.

Table 3.12. Main sources of technology information in surveyed villages.

		Government extension and agricultural input companies	Seed company	Agricultural universities	Private traders	Neighbors/ Other farmers	TV/ Radio	Other
Northeast	Spring rainfed	20	0	0	0	65	15	0
North	Spring irrigated	30	0	0	0	50	10	10
	Spring rainfed	48	0	0	4	16	32	0
Yellow-Huai	Summer irrigated	58	2	2	1	27	11	0
River Valley	Summer rainfed	35	0	0	0	48	18	0
Northwest	Spring irrigated	30	0	0	10	10	50	0
	Spring rainfed	50	3	0	8	10	27	2
Southwest	Spring irrigated	87	3	0	0	3	2	5
	Spring rainfed (all)	63	9	1	2	10	9	6
	Spring rainfed only	76	1	1	3	11	7	3
	Spring/ fall; Spring/ winter; spring/ fall/winter rainfed	49	19	1	2	8	11	10

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Table 3.13. Maize yields by agroecological region and maize type.

		Average of maize yield levels (tons/ha)									Range of maize yield (tons/ha)								
		Local variety			OPV variety			Hybrid variety			Local variety			OPV variety			Hybrid variety		
Agroecological region	Maize system	Most common	Minimum	Maximum	Most common	Minimum	Maximum	Most common	Minimum	Maximum	Most common	Minimum	Maximum	Most common	Minimum	Maximum	Most common	Minimum	Maximum
Northeast	Rainfed spring	-	-	-	-	-	-	6.6	4.1	8.7	-	-	-	-	-	-	0.7-1.1	5.0-7.5	7.5-10.0
North	Irrigated spring	-	-	-	-	-	-	5.5	2.9	7.5	-	-	-	-	-	-	0.4-1.0	0.4-4.5	3.6-11.3
	Rainfed spring	1.2	0.8	1.6	-	-	-	6.8	3.9	9.6	0.9-1.5	0.8	1.1-2.3	-	-	-	0.4-1.4	1.5-6.0	3.8-15.0
Northwest	Irrigated spring	3.0	2.3	3.8	-	-	-	7.9	4.5	11.3	3.0	2.3	3.8	-	-	-	1.0-1.1	3.6-5.3	10.5-12.0
	Rainfed spring	1.5	0.8	2.3	-	-	-	5.2	2.6	7.3	1.5	0.8	2.3	-	-	-	0.5-0.8	2.3-3.8	6.8-7.5
Yellow-Huai River Valley	Irrigated summer	-	-	-	-	-	-	6.1	4.1	7.8	-	-	-	-	-	-	0.7-1.0	3.8-5.3	7.5-9.0
	Rainfed spring/summer	-	-	-	-	-	-	4.1	3.0	6.4	-	-	-	-	-	-	0.4-0.7	2.3-3.8	5.3-7.5
Southwest	Rainfed summer	1.8	0.8	2.4	-	-	-	3.8	2.6	4.9	1.8	0.8	2.4	-	-	-	0.4-0.7	1.5-3.8	3.8-6.0
	Irrigated spring	1.5	0.8	2.3	-	3.0	3.8	5.1	4.0	6.5	1.5	0-1.5	2.3	-	3.0	3.8	0.6-0.8	3.0-5.3	6.0-7.5
	Rainfed spring (all sites)	2.2	1.3	2.7	2.4	1.7	3.1	4.6	3.3	6.1	0.8-3.8	0-2.9	1.1-4.5	1.9-3.0	1.1-2.6	2.3-4.1	0.3-1.0	0.8-5.3	2.3-9.0
	Rainfed spring (one season)	2.1	1.3	2.7	1.9	1.5	2.3	4.6	3.0	5.9	0.9-3.7	0.8-1.9	1.1-4.5	1.9	1.5	2.3	0.4-1.0	0.8-6.0	3.0-8.3
	Rainfed spring/fall	2.2	1.1	2.6	3.0	1.5	3.8	5.3	4.0	7.5	0.8-3.0	0.4-2.3	1.1-4.5	3.0	1.5	3.8	0.6-0.8	3.0-5.3	7.5
	Rainfed spring/winter	2.3	1.5	2.9	2.4	1.8	3.1	4.3	3.5	5.8	1.8-3.4	0.8-2.9	2.3-4.1	1.9-3.0	1.1-2.6	2.3-4.1	0.3-0.9	0.2-5.3	2.3-9.0

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Table 3.14. Main reasons for yield gap in surveyed villages.

Agroecological region	Maize system	Reasons for yield gap
Northeast	Rainfed spring	Difference in soil fertility Different maize variety Low fertilizer investment
North	Irrigated spring	Difference in soil fertility Low chemical and organic fertilizer investment Inability to weed on time
	Rainfed spring	Difference in soil fertility Low fertilizer investment Inability to weed on time Fertilizer not applied on time
Northwest	Irrigated spring	Low fertilizer investment Inability to irrigate on time Difference in soil fertility
	Rainfed spring	Low fertilizer investment Difference in soil fertility Inability to weed on time Inability to thin seedlings on time
Yellow-Huai River Valley	Irrigated summer	Low fertilizer investment Low pesticide investment Inability to irrigate on time Inability to weed on time Labor shortage
	Rainfed summer	Low fertilizer investment Inability to weed on time Low seed quality Fertilizer not applied on time Low pesticide investment
Southwest	Rainfed summer	Difference in soil fertility Low fertilizer investment Fertilizer not applied on time Inability to weed on time Inability to thin seedlings on time
	Irrigated spring	Low fertilizer investment Different maize variety Fertilizer not applied on time Inability to weed on time
	Rainfed spring (one season maize)	Difference in soil fertility Low fertilizer investment Fertilizer not applied on time Inability to weed on time
	Rainfed spring/fall	Maize disease and insects Fertilizer not applied on time Inability to weed on time Inability to thin seedlings on time Difference in soil fertility
	Rainfed spring/winter	Low fertilizer investment No use of plastic Fertilizer not applied on time Inability to weed on time Inability to thin seedlings on time Difference in soil fertility

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Table 3.15. Post harvest practices in surveyed villages.

Agroecological region	Maize production system	Drying	Shelling	Grain storage method	Seed storage method	Milling method	Milling location
Northeast	Rainfed spring	Air dried in piles in household	Machine	Bags, storehouse, piles outside home	Na	Electric mill	Own village
North	Irrigated spring	Sun dried in household, dried on wooden shelves	Hand powered machine, by hand with stick	Bags, urn, piles outside home	Na	Electric mill	Own village
	Rainfed spring	Sun dried in household, dried on wooden shelves	Mostly machine, by hand	Bags, wooden box, hanging outside house	Hung in household	Electric mill	Own village
Northwest	Irrigated spring	Sun dried in household, dried on wooden shelves	Machine	Bags	Hung in household	Electric mill	Own village
	Rainfed spring	Sun dried in household, dried on wooden shelves	Machine	Bags, wooden box/cupboard	Hung in household	Electric mill	Own village, neighboring village
Yellow-Huai River Valley	Irrigated summer	Sun dried on rooftop or on ground in household	Machine	Bags, urn	Na	Electric mill	Household, own village, neighboring village
	Rainfed summer	Sun dried on rooftop or on ground in household	Machine, by hand	Bags, water urn, in piles on cement floor	Na	Electric mill	Own village, neighboring village
Southwest	Rainfed summer	Sun and air dried	By hand	Bags, water urn, wooden box/cupboard	Hung in household	Electric mill	Own village
	Irrigated spring	Sun dried	By hand	Water urn	Dried, shelled, and stored in closed container	Electric mill	Household, own village
	Rainfed spring (one season)	Sun dried in household, dried on wooden shelves	Mainly by hand, some machine	Water urn, wooden box/ cupboard, metal box, scattered in piles	Hung in household; dried, shelled and stored in closed container	Electric mills of varying sizes	Household, own village

Source: IFAD-CIMMYT-CCAP RRA/PRA Surveys, 2001-2002.

Table 3.16. Trends in maize area and yields in the last ten years.

Agroecological region	Maize system	Surveyed villages (No.)	Maize area	Rationale	Surveyed villages (No.)	Maize yields	Rationale
Northeast	Rainfed spring	1	increasing	good yields, available market	3	increasing	good varieties, improved management
		2	decreasing	low maize prices, drought			
		1	unchanged	good yields	1	unchanged	drought
North	Irrigated spring	3	decreasing	drought, low yields, low price, difficult to sell, increased sorghum area	1	increasing	
					2	decreasing	drought
	Rainfed spring	5	increasing	good yields, good profit, available market	4	increasing	good varieties, more fertilizer use, use of plastic, irrigation
Northwest	Irrigated spring	2	increasing	good yield, available market, suitable crop for agroclimate	2	increasing	good varieties, more fertilizer use, use of treated seed
	Rainfed spring				3	increasing	good varieties, more fertilizer use
		4	decreasing	low price, increased cash crops area (apple and tobacco)	1	decreasing	drought
Yellow-Huai River Valley	Irrigated summer	2	increasing	stable production, low labor requirements, decreased tobacco area	5	increasing	good varieties, more fertilizer and pesticide use, irrigation, fertilizer and irrigation applied on time
		3	decreasing	low price, increased cash crops area (cotton), high input costs			
		1	unchanged	traditional area	1	unchanged	yield limit reached
	Rainfed spring /summer	1	decreasing	drought, low price	2	increasing	good varieties, more fertilizer and pesticide used, high investment in inputs
Southwest	Rainfed summer	1	increasing	decreased rice area due to water shortage	1	increasing	good varieties, good technology
		1	decreasing	drought	1	decreasing	pest problems
	Irrigated spring	1	increasing	good yield, increase in pigs, better crop in drought and flood	2	increasing	good varieties, more fertilizer use, use of plastic and transplanted seedlings
		1	decreasing	improvements in land (leveling) make rice cultivation possible	1	unchanged	-
		1	unchanged	maize suitable for agroclimate			
	Rainfed spring (all sites)	2	increasing	good yields, increase in pigs, decrease in cotton area, unstable hot pepper price	11	increasing	-
		7	decreasing	reforestation program, increase in cash crop area (sugarcane and mulberry trees), water now available for rice paddy	1	unchanged	-
		1	unchanged	maize suitable for agroclimate, cannot plant other crops in land			
	Rainfed spring (one season)	2	increasing	good yield, increase in pigs, decreased cotton area	7	increasing	increased fertilizer use, use of plastic, improved management, better varieties
		7	decreasing	reforestation program, increase in cash crop area (sugarcane and mulberry trees), water now available for rice paddy			
		1	unchanged	suitable for agroclimate	1	unchanged	-
	Rainfed spring/fall	4	decreasing	increased sugarcane area	2	increasing	increased fertilizer use, increased seeding rate, better varieties
	Rainfed spring/winter	1	decreasing		2	increasing	increased fertilizer use
		3	unchanged	can't plant other crops			

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Table 3.17. Trends in utilization of maize in the last ten years.

Agroecological region	Maize system	Surveyed villages (No.)	Maize as food	Rationale	Surveyed villages (No.)	Maize as feed	Rationale
Northeast	Rainfed spring	3	decreasing	improved living standards, increased demand for rice and wheat, not good to eat	4	increasing	increased pig and livestock production
North	Irrigated spring	3	decreasing	improved living standards, increased demand for rice and wheat	2	increasing	increased animal production
					1	decreasing	
	Rainfed spring	4	decreasing	improved living standards, increased demand for rice and wheat, not good to eat	4	increasing	increased livetock production
Northwest	Irrigated spring	2	decreasing	improved living standards, increased demand for rice and wheat	2	increasing	increased livestock, maize difficult to sell
	Rainfed spring	4	decreasing	improved living standards, increased demand for rice and wheat	3	increasing	increased livestock, maize difficult to sell
					1	decreasing	
Yellow-Huai River Valley	Irrigated summer	1	increasing	increased maize area, children like to eat	6	increasing	increased livestock, more maize produced
		4	decreasing	improved living standards, increased demand for rice and wheat			
	Rainfed spring /summer	2	decreasing	increased demand for wheat, not good to eat	2	increasing	increased livestock production
Southwest	Rainfed summer	2	decreasing	improved living standards, increased demand for rice and wheat	2	increasing	good yields
	Irrigated spring	3	decreasing	improved living standards, increased demand for rice and wheat	3	increasing	increased pig production
	Rainfed spring (all sites)	18	decreasing		13	increasing	
		1	unchanged		2	decreasing	
			Increase first, then decrease		1	increase first, then decrease	
	Rainfed spring (one season)	9	decreasing	improved living standards, increased demand for rice, not good to eat, fed to pigs	6	increasing	increased pig and livestock production
		1	unchanged		1	decreasing	use less maize in feed mix
					1	increase first, then decrease	pig prices up then down
	Rainfed spring/fall	5	decreasing	increased demand for rice, maize used for livestock	3	increasing	increased pig and livestock production, good maize yields
					1	decreasing	use purchased feed
					1	increase first, then decrease	
	Rainfed spring/winter	4	decreasing	improved living standards, increased demand for rice, not good to eat, fed to pigs	4	increasing	increased pig production
					1	unchanged	

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

4. Maize Production Constraints

An important part of the interaction with farmer groups was discussing the constraints they experienced in all aspects of maize production. Farmers were asked to list the constraints and estimate yield losses from each constraint as well as the percentage of maize area in the village that was affected. Farmer-elicited constraints for maize production are summarized in Table 4.1.

4.1. Abiotic Constraints

Farmers consistently singled out drought as the key abiotic constraint to maize production in all regions and maize systems with the exception of the Yellow-Huai River Valley irrigated summer maize system, Northwest irrigated spring maize system, and Southwest irrigated spring maize system. Drought was nevertheless a concern even in primarily irrigated systems due to periodic uncertainty regarding water availability and timing of availability. Farmers in most groups perceived a worsening trend in drought and its impacts on maize yields. The worsening trend for early frost is also a concern in the Northeast, as well as the North and Northwest rainfed spring maize systems, because it affects the timing of planting. Surface waterlogging that often had negative effects on yields was reported in the Yellow-Huai River Valley irrigated summer maize system. Farmers in the Southwest region identified floods, soil erosion, and soil infertility as having considerable negative impacts on maize productivity.

4.2. Biotic Constraints

4.2.1. Major field diseases and insects

Farmers identified a wide range of field insect pests, including corn borer, cutworm, and corn leaf aphid, which were common across all the maize agroecological regions. Problems with other insects such as mole cricket, wireworm, armyworm, and red spiders varied across maize systems. Caterpillars, grasshoppers, and weevils were particularly damaging in the Southwest region.

Diseases identified by farmers included head smut – particularly in the North, Northwest, and Northeast– and *Turcicum* leaf blight, banded leaf and sheath blight, and *Maydis* leaf blight in the Southwest. Sugarcane mosaic virus and maize rough dwarf virus were the diseases of greatest concern to farmers in the Yellow-Huai River Valley.

4.2.2. Major storage insects and problems

Grain weevils and rodents were the primary cause of post harvest storage losses across all maize agroecological regions. Farmers in the Southwest rainfed spring/fall/winter maize systems also described storage problems caused by moths, although there was no mention of moth larvae. Problems with stored maize grain and maize seed in the Southwest region were worse than in other regions due to climatic conditions, and estimated post harvest losses there were considerably higher than in any other surveyed region.

4.3. Institutional and Economic Constraints

4.3.1. Inputs

Serious concern due to the quality of inputs was raised by farmers in all maize regions. Low-quality seed and questionable purity of purchased seed were the most frequently cited problems. Also common across regions were the sale of fake fertilizer and pesticides, as well as the inability of farmers to detect them. Farmers in the Southwest rainfed spring/fall/winter maize systems and the Northeast rainfed spring region also had trouble finding seed of desired varieties. In the Southwest, these difficulties were compounded in some areas by the existence of few outlets for seed purchase and the limited period of time seed was available. In the Northeast, the supply of seed of certain varieties was insufficient to meet the demand.

Table 4.1. Farmer-elicited maize production constraints.

Maize agroecological region	Abiotic constraints	Biotic constraints	Technology	Markets and infrastructure
Northeast				
Rainfed spring	• drought • soil erosion • dry and hot wind • hail • sandstorm • frost	• dead smut • corn borer • cutworm • sugarcane mosaic virus • maize rough dwarf virus • common smut • white grubs • *Turcicum* leaf blight • stalk rot • *Fusarium moniliforme* • rodents • grain weevils	• poor knowledge of cultivation techniques and crop management • lack of technology dissemination system • poor grain qualityo • lodging • poor quality of seed (e.g., low germination)	• low maize price • maize marketing difficulties – few sales outlets • high fertilizer price • fake fertilizer • seed of some varieties in short supply • unstable seed price
North				
Rainfed spring	• drought • low soil fertility • soil erosion • dry and hot wind • frost	• head smut • corn borer • red spider mite • common smut • aphid • sugarcane mosaic virus • maize rough dwarf virus • stalk rot • ear roto • *Turcicum* leaf blight • cutworm • wireworm • rodents • grain weevils • mole cricket	• poor quality of seed • poor knowledge of cultivation • techniques and crop management • lodging	• fake pesticide, seed, and fertilizer • lack of market information (e.g., maize prices) • unstable maize price • limited marketing opportunities
Irrigated spring	• drought • low soil fertility • hail • high wind • frost • flood	• head smut • red spider mit • stalk rot • common smut • corn borer • sugarcane mosaic virus • *Turcicum* leaf blight • maize rough dwarf virus • ear rot • cutworm • mole cricket • wireworm • grain weevils • rodents	• Poor knowledge of cultivation • techniques and crop management • poor quality of seed • lodging	• fake pesticide, seed, and fertilizer • lack of market information • unstable maize price
Yellow-Huai River Valley				
Rainfed spring	• low soil fertility • drought • hail • strong wind	• corn borer • cutworm	• poor knowledge of cultivation • techniques and crop managementom • poor quality of seed • low farm mechanization	• lack of technology dissemination system • unstable maize price • high production costs • unstable seed price • fake fertilizer and pesticide • unstable fertilizer price
Rainfed summer	• low soil fertility • drought • strong wind • hail • high temperature	• *Turcicum* leaf blight • corn borer • stalk rot • sugarcane mosaic virus • bollworm • aphid • red spider mite • army worm • maize rough dwarf virus • cutworm • southern rust	• poor knowledge of cultivation techniques and crop management • poor quality of seed • low mechanization level • lack of knowledge about pesticide	• lack of technology dissemination system • unstable maize price • high production costs • fake fertilizer and pesticide • unstable fertilizer price

Table 4.1. Cont'd...

Maize agroecological region	Abiotic constraints	Biotic constraints	Technology	Markets and infrastructure
North				
		• smut, grain weevils • mole cricket • rodents • wheel rot		• machinery shortages in busy season • high cost of machinery rental • unstable seed price
Irrigated summer	• drought • low soil fertility • strong wind • water logging • hail • high temperature at flowering • rapidly decreasing water table	• *Turcicum* leaf blight • corn borer • stalk rot • maize rough dwarf virus • sugarcane mosaic virus • bollworm • army worm • common smut • cutworms • aphid • mole cricket • red spider • southern rust • grain weevils • powdery mildew • rodents	• poor knowledge of cultivation techniques and crop management • poor quality of seed • inadequate information on pesticide usage • outdated machinery	• lack of technology dissemination system • unstable maize price • high production costs • insufficient electricity supply • unstable fertilizer price • unstable seed price • fake fertilizer • machinery shortages in busy season
Northwest				
Rainfed spring	• drought • low soil fertility • soil erosion • frost • hail	• head smut • red spider • common smut • cutworm • sugarcane mosaic virus • aphid • maize rough dwarf virus • grain weevils • rodents	• poor knowledge of cultivation techniques and crop management • lack of suitable new varieties • poor quality of seed (e.g., insect infestations in purchased seed) • lodging • current varieties not suitable for silage	• high fertilizer and pesticide price • fake fertilizer, seed, and pesticide • low maize price • low purchasing power fo purchased good • shortage of animals during busy season
Irrigated spring	• high wind • low soil fertility • frost • hail	• head smut • red spider • sugarcane mosaic virus • smut • aphid • cutworm • maize rough dwarf virus • ear rot • *Turcicum* and *maydis* leaf blight • rodents • grain weevils	• lack of technology for economical/efficient water use • lodging	• fake fertilizer, pesticide, and seed
Southwest				
Irrigated spring	• high wind • soil erosion	• corn borer • corn leaf aphid • cutworm • *Turcicum* leaf blight • rodents • grain weevils	• lack of desirable varieties	• difficulties selling maize • low quality fertilizer • fake fertilizer and pesticides • high cost for shelling machine • high maize production costs
Rainfed spring	• drought • low soil fertility • strong wind • soil erosion • flood • lack of microelements in • soil (such as Cu, Zn) • hail	• banded leaf and sheath blight • corn borer • *Turcicum* and Maydis leaf blight • ear rot • cutworn • southern rust • army worm	• cultivated varieties susceptible to insects and diseases • poor grain quality • low seed germination rate • poor fertilizer quality • lack of suitable production technology • OPV degradation	• low level of investment in inputs • low purchasing power for purchased goods • problems with maize marketing • lack of well functioning dissemination system • low maize price • high seed cost

Table 4.1. Cont'd...

Maize agroecological region	Abiotic constraints	Biotic constraints	Technology	Markets and infrastructure
Southwest				
		• stalk rot • aphid • head smut • corn silkworm • locust • weevils • rodents • storage moths	• lack of machinery suitable for hillside plots • lack of knowledge to distinguish the quality of fertilizer and pesticides • lodging • lack of desirable varieties	• low per capita land – scale of production too small • poor road network • labor shortages • fake seed and pesticide • high cost for shelling machine • few outlets to purchase seed • limited time period to purchase seed • high deposit required for seed purchase
Rainfed summer	• drought • low soil fertility • soil erosion • strong wind • flood • hail	• corn borer • banded leaf and sheath blight • *Maydis* leaf disease • ear rot • army worm • stalk rot • *Turcicum* leaf blight • southern rust • corn silkworm • cutworm • locust • grain weevils • rodents • storage moths	• cultivated varieties susceptible to insects and diseasesos • lack of suitable production technology • poor grain qualitY • varieties are sensitive to high temperature • lack of early varieties • lack of suitable new varieties • poor seed quality • varieties not suitable to high density planting • lack of suitable machinery for hillside plots • lack of knowledge to distinguish the quality of fertilizer and pesticides	• problems with maize marketing –few sales outlets • low level of investment in inputs • lack of well functioning dissemination system • poor transportation infrastructure • poor seed purity • small production scale (low per capita land) • high fertilizer price relative to maize price • high seed price • labor shortage during busy seasons • fake pesticide and seed • shortage of animal traction due to lack of grass
Rainfed fall	• drought • low soil fertility • soil erosion • low temperatures • flood	• *Maydis* leaf blight • corn borer • banded leaf and sheath blight • southern rust • grain weevils • army worm • corn silkworm • caterpilloar	• poor grain quality of • lack of suitable production technology • OPV degradation • lack of early varieties • varieties not suitable to high density planting • low germination rate of seed	• low level of investment in inputs • problems with maize marketing- few sales outlets • difficulties in purchasing hybrid seed • few outlets for seed purchase • difficulties in purchasing fertilizer and pesticide • lack of well functioning dissemination system • poor seed purity • poor transportation infrastructure • low maize price • small production scale (low per capita land) • poor quality of fertilizer available • labor shortage during busy seasons • high cost for shelling machine

Source:IFAD-CIMMYT-CCAP RRA/PRA surveys, 2001-2002.

Labor shortages during busy seasons posed constraints in the Southwest, while machinery bottlenecks contributed to delays in cropping activities in the Yellow-Huai River Valley irrigated summer maize system. The shortage of draft animals had the same effect in the Northwest and Southwest spring rainfed maize systems. Farmers in the Yellow-Huai River Valley who planted irrigated summer maize also expressed concern with the rapidly decreasing water table.

High seed costs were mentioned only in the rainfed spring maize systems in the Southwest and North regions. The relative absence of farmer-perceived problems with seed costs may reflect the fact that prices of hybrid maize seed in China are among the lowest in the world (Huang and Rozelle 2006). However, both the instability of seed prices, raised as a concern in the Northeast and Yellow-Huai River regions, and the price of seed and other inputs relative to the maize price, were issues of major concern to maize farmers.

4.3.2. Technology

Access to technology *per se* was not raised as a constraint to maize production in the Northeast or Yellow-Huai River Valley regions; however, farmers felt that access to information on improving crop management practices and maize productivity was lacking. Farmers in some of the surveyed North region rainfed spring maize areas also had infrequent access to technical experts who could demonstrate and provide information on new technologies. Concerns with technology access and the existence of suitable technologies were also frequently raised by farmers in the rainfed maize areas of the Southwest. Fewer seed companies are active in the Southwest than in other regions, and many of them are still relatively small and new within the context of the seed system that is now emerging as a result of recent policy changes.

Farmers recognized that currently cultivated OPVs had degenerated, but they did not have viable replacements. Similarly, new varieties suitable to replace currently sown local varieties in hilly and mountainous plots were also unavailable. As breeding priorities in China have been focused almost exclusively on hybrid varieties, resources allocated to the development of OPVs have been minimal.

4.3.3. Markets

Low, unstable maize prices were cited universally by farmers as an issue of great concern; however, the relative importance of marketing constraints depended largely on farmers' participation in maize markets. The primary concern of farmers in the Northeast was the limited number of outlets where they could sell their maize. Farmers in the Northwest and North rainfed spring maize systems also experienced limited maize marketing opportunities, which they attributed to restrictions imposed by government grain stations trying to control the activities of private traders. Farmers in some rainfed spring maize areas of the Southwest felt their marketing opportunities were limited by poor roads and infrastructure that prevented access to traders.

5. Priorities for Maize Research

5.1. Methodology for Research Prioritization

Research priorities may vary considerably depending on factors taken into consideration in shaping the prioritization process. The decision to incorporate information on certain factors and not others is a *de facto* assignment of weights. Weights play a significant determining role in the resulting ordering of priorities, and a shifting of weighting factors can dramatically alter an outcome (Pingali and Pandey 2001). The methodology utilized for the prioritization of maize research in China considers four separate means of assigning weights based on efficiency, poverty status, degree of marginality, and degree of maize substitutability. A weighted combination consisting of efficiency, poverty status, and marginality was also calculated using weights of 0.5, 0.3, and 0.2, respectively. In all cases the underlying foundation of the process remains the constraints identified and prioritized by farmers and scientists.

Five main factors determine the outcome of efficiency-based prioritization:

(1) farmer-scientist ranking of the importance of the constraint;

(2) yield gain associated with alleviation of the constraint;

(3) the probability that a solution to the constraint will succeed;

(4) the contribution of the maize system to national maize production; and

(5) the history of adoption of new technologies in the maize system or region.

Taking all factors into consideration, an efficiency index is calculated for each constraint and ordered by value. Constraints with the highest efficiency indices are prioritized.

The poverty-based prioritization of maize research utilizes a poverty-index weighting of the efficiency index to give more emphasis to problems experienced in areas with higher incidence of poverty. The poverty weights used reflect the share of rural poor population out of the total rural population for each maize agroecological region.

Marginality-based prioritization assumes a correlation between low maize yields and marginal status in the country, possibly resulting from limited access to technological information and poor infrastructure. It also identifies maize systems that are less served by private maize companies and require higher investment by the public research system. The marginality factor used to weight the efficiency index is the inverse of the average maize yield in the maize system.

A weighting factor based on the level of maize substitutability makes the assumption that the larger the share of maize area out of total crop cultivated area over a period of time, the more important the role of maize in the cropping system and the less likely it can or will be replaced by other crop alternatives.

5.2. Farmer-Scientist Constraint Prioritization

Constraints to maize production across the five maize agroecological regions and within maize systems in each region were discussed and prioritized in a two-day workshop attended by 45 maize scientists from both the public and private sectors. This included the Chinese Academy of Agricultural Sciences and its provincial branches in major maize producing provinces, Chinese Agricultural University, and other stakeholders in the maize research and production system. Information collected from farmers on maize production constraints as well as farmer estimates of yield and affected area were presented to the group for discussion. Based on their individual expertise and experience, workshop participants were assigned to one of five groups, each representing an agroecological region.

A key task for each group was to discuss and evaluate the constraints and yield losses elicited from farmers within the context of broader biophysical and institutional conditions of the maize system(s) and agroecological region. Another important objective of each group was to identify constraints that could be addressed through agricultural research and technology and to estimate the potential yield gains in the maize system from addressing the constraint. Each group reached a consensus on the priority ranking of each constraint by maize system based on both farmer and scientist assessment of its severity. They also estimated the maize area in the region affected by the constraint; the potential yield gain if the problem was addressed with available or achievable technology; and the likelihood of attaining that yield gain. The results of the ten highest-priority constraints in each maize system, as determined by farmers and maize scientists, are presented in Table 5.1.

Table 5.1. Top ten maize production constraints prioritized by farmer groups and scientists.

		Rainfed			Irrigated		
Regions	Rank	Constraints	Potential yield gain (%)	Likelihood of success (%)	Constraints	Potential yield gain (%)	Likelihood of success (%)
Northeast							
Spring maize	1	Drought	30	15	-	-	-
	2	Poor knowledge/use of appropriate agronomic methods and crop management	20	50	-	-	-
	3	Poor nutritional content and grain quality of current varieties	0	80	-	-	-
	4	Ineffective agricultural extension (lack of funds)	10	70	-	-	-
	5	Corn borer	5	80	-	-	-
		Head smut	10	90	-	-	-
	6	Disarray of seed markets			-	-	-
	7	Low germination rate of certain varieties	1	100	-	-	-
	8	Stalk rot	1	50	-	-	-
	9	Lodging	1	80	-	-	-
	10	Frost	2	50	-	-	-
North							
Spring maize	1	Drought	30	35	Drought	35	20
	2	Head smut	15	90	Head smut	10	90
	3	Poor seed quality (e.g., germination rate and production quality)	7	98	Poor knowledge/use of appropriate agronomic methods and crop management	25	5
	4	Poor knowledge/use of appropriate agronomic methods and crop management	30	25	Low/decreasing soil fertility	10	5
	5	Corn borer	7	70	Poor seed quality	7	98
	6	Low soil fertility and soil erosion	20	5	Stalk rot	2	20
	7	Smut	1	70	Red spider mite	3	75
	8	Red spider mite	3	75	Corn leaf aphid	2	60
	9	Corn leaf aphid	2	60	Common smut	1	70
	10	Sugarcane mosaic virus	1	5	Sugarcane mosaic virus	2	5
Northwest							
Spring maize	1	Drought	35	10	Drought	30	40
	2	Poor knowledge/use of appropriate agronomic methods and crop management	30	50	Low rate of variety replacement	7	45
	3	Low soil fertility and soil erosion	25	5	Poor knowledge/use of appropriate agronomic methods and crop management	20	30
	4	Low rate of variety replacement	7	45	Head smut	8	90
	5	head smut	10	90	Low / decreasing soil fertility	10	5
	6	Low farm level investment in maize production	10	10	Low farm level investment in maize production	5	40
	7	Red spider	3	75	Lack of water-saving irrigation technology	0	30
	8	Smut	1	70	Red spider	2	75
	9	Low seed quality	1	98	Sugarcane mosaic virus	2	5
	10	Frost	2	15	Poor seed quality	1	98
					Common smut	1	70
Yellow-Huai River Valley							
Spring maize	1	Drought	30	30	-	-	-
	2	Poor knowledge/use of appropriate agronomic methods and crop management	30	30	-	-	-
	3	Low / decreasing soil fertility	30	50	-	-	-
	4	Poor seed quality	2	90	-	-	-
	5	*Turcicum* and *Maydis* leaf blights	2	80	-	-	-
	6	Stalk rot	1	60	-	-	-

Table 5.1. cont'd...

Regions	Rank	Rainfed Constraints	Rainfed Potential yield gain (%)	Rainfed Likelihood of success (%)	Irrigated Constraints	Irrigated Potential yield gain (%)	Irrigated Likelihood of success (%)
	7	Corn borer	7	60	-	-	-
	8	Cutworm	3	80	-	-	-
	9	Lack of appropriate machinery	3	30	-	-	-
	10	Common smut	2	60	-	-	-
Yellow-Huai River Valley							
Summer maize	1	Drought	50	20	Drought	30	50
	2	Poor knowledge/use of appropriate agronomic methods and crop management	25	30	Poor knowledge/use of appropriate agronomic methods and crop management	25	30
	3	Low / decreasing soil fertility	30	50	Low / decreasing soil fertility	20	70
	4	poor seed quality	2	90	*Turcicum* and *Maydis* leaf blight	5	80
	5	*Turcicum* and *Maydis* leaf blights	5	80	Low level of mechanization	15	70
	6	Stalk rot	1	60	Poor quality seed	2	90
	7	Corn borer	5	60	Corn borer	5	60
	8	Lack of appropriate machinery	5	30	High winds	3	20
	9	High winds	2	20	Stalk rot	2	60
	10	Sugarcane mosaic virus	0.2	60	Maize rough dwarf virus	1	60
Southwest							
Spring maize	1	Drought	28	25	-	-	-
	2	Low / decreasing soil fertility	13	20	-	-	-
	3	Low farm level investment in inputs	10	10	-	-	-
	4	Poor maize nutritional and grain quality	1	50	-	-	-
	5	Limited maize marketing opportunities due to undeveloped markets	10	10	-	-	-
	6	banded leaf and sheath blight	6	30	-	-	-
	7	Overall level of insect and disease susceptibility in cultivated varieties	10	80	-	-	-
	8	Difficulties in purchasing seed for desired varieties (very few available outlets)	8	80	-	-	-
	9	Lack of planting technology	7	20	-	-	-
	10	Lack of information about new varieties	2	80	-	-	-
Southwest							
Summer maize	1	Low / decreasing soil fertility	20	60	-	-	-
	2	Low farm level investment in inputs	10	30	-	-	-
	3	Drought	25	65	-	-	-
	4	Overall level of insect and disease susceptibility in cultivated varieties	10	50	-	-	-
	5	Limited maize marketing opportunities due to undeveloped markets	10	30	-	-	-
	6	Ineffective agricultural extension (lack of funds)	9	20	-	-	-
	7	banded leaf and sheath blight	5	30	-	-	-
	8	Corn borer	10	80	-	-	-
	9	Poor maize nutritional and grain quality	1	50	-	-	-
	10	Poor transportation infrastructure	3	50	-	-	-
Southwest							
Fall maize	1	Drought	25	10	-	-	-
	2	Low farm level investment in inputs	10	10	-	-	-
	3	Low / decreasing soil fertility	20	20	-	-	-
	4	Poor maize nutritional and grain quality	1	50	-	-	-
	5	Limited maize marketing opportunities due to undeveloped markets	10	20	-	-	-
	6	Difficulties in purchasing seed for desired varieties (very few available outlets)	5	80	-	-	-
	7	Poor knowledge/use of appropriate agronomic methods and crop management	9	20	-	-	-
	8	Fake and low quality seed	2	80	-	-	-
	9	*Turcicum* leaf blight	3	60	-	-	-
	10	Poor transportation infrastructure	3	50	-	-	-

Note: Ranked in order of importance within a given maize production system.

Drought was considered a priority constraint to maize production in each maize system across the five agroecological regions. However, the manner in which drought affects yield may differ by maize system and region, e.g., spring drought delays sowing in the Northeast, while summer drought reduces yields in other regions. Yield gains that could potentially result from new technologies targeting drought were estimated at 20% to 35% across the different systems; however, the likelihood of success across systems varied more widely.

Other priority constraints differed largely by region. Poor knowledge of appropriate crop management practices was a highly prioritized constraint in the Northeast, Yellow-Huai River Valley, and Northwest regions. The poor grain quality and nutritional content of current varieties in the Northeast reflect their low starch content and high grain moisture content at harvest. This is especially true of the full-season hybrids that were promoted under the centrally planned economic system. The development of those varieties, many of which are still sown, reflected the predominant emphasis on yield alone. Head smut and low/decreasing soil fertility were identified as major constraints in the North and Southwest regions. Low levels of input use in maize production also ranked highly in the rainfed systems of the Southwest.

In estimating the likelihood of success when addressing the negative yield impacts of the identified constraints, scientists in the working groups were considerably more optimistic about achieving potential yield gains by addressing disease and insect constraints than by improving technology and information dissemination and addressing the impacts of drought through research and technology. They felt success in addressing the two latter constraints was very much a function of the specific maize system. Raising yields by improving soil fertility and increasing the investment in maize production inputs in the Southwest were considered much more difficult, given the role of local economic and environmental conditions and the relative inability to influence them through research and technology.

5.3. National Research Priorities

Twenty-five top priority constraints were identified at the national level based on the four alternative weighting indices (Table 5.2). Except for drought and low soil fertility in the irrigated summer maize system of the Yellow-Huai River Valley, all priority constraints identified using the efficiency index had to

Table 5.2. Top 25 constraints to maize production.

Agroecological region	Maize production system	Constraints	Priority rank			
			Efficiency	Poverty	Marginality	Substitutability
Northeast	Rainfed Spring	Poor knowledge/use of appropriate agronomic methods and crop management	1	1	1	1
Northeast	Rainfed Spring	Head smut	2	2	2	2
Northeast	Rainfed Spring	Drought	3	3	3	3
Northeast	Rainfed Spring	Ineffective agricultural extension(lack of funds)	4	4	4	4
Northeast	Rainfed Spring	Corn borer	5	5	5	5
Northeast	Rainfed Spring	Poor nutritional content and grain quality of current varieties	6	6	6	6
Northeast	Rainfed Spring	Seed markets in disarray	7	7	7	7
Northeast	Rainfed Spring	Low germination rate of certain varieties	8	8	8	8
Northeast	Rainfed Spring	Stalk rot	9	9	9	9
Northeast	Rainfed Spring	Lodging	10	10	10	10
Northeast	Rainfed Spring	Frost	11	11	12	11
Northeast	Rainfed Spring	Soil insects (cut worm, mole cricket)	12	12	13	12
Northeast	Rainfed Spring	Army worm	13	13	14	13
Northeast	Rainfed Spring	Sugarcane mosaic virus	14	14	16	14
Northeast	Rainfed Spring	Maize rough dwarf virus	15	15	17	15
Northeast	Rainfed Spring	Grey blight	16	16	18	16
Northeast	Rainfed Spring	*Turcicum* blight/Maydis disease	17	17	19	17
Northeast	Rainfed Spring	Ear rot	18	18	22	18
Northeast	Rainfed Spring	Fake and low quality fertilizer and pesticides	19	19	23	19
Northeast	Rainfed Spring	Field rodents	20	20	24	20
Northeast	Rainfed Spring	Grain weevils(Corn earworms)	21	21	25	21
Yellow-Huai River Valley	Irrigated Summer	Drought	22		11	
Northeast	Rainfed Spring	Soil erosion	23	22		22
Northeast	Rainfed Spring	Storage rodents	24	23		23
Yellow-Huai River Valley	Irrigated Summer	Low/decreasing soil fertility	25		15	
Northeast	Rainfed Spring	Extreme heat and low humidity		24		24
Northeast	Rainfed Spring	Hail		25		25
Yellow-Huai River Valley	Irrigated Summer	Poor knowledge /use of appropriate agronomic methods and crop management			20	
Yellow-Huai River Valley	Irrigated Summer	Lack of appropriate machinery			21	

do with issues in the Northeast rainfed spring maize system. Addressing poor knowledge of appropriate crop management practices was the top national priority, with head smut and drought ranked second and third. Differences between final prioritization and farmer-scientist ranking of constraints in the Northeast rainfed spring maize system resulted from weighting factors in the efficiency index, particularly potential yield gain and likelihood of success.

The top 25 priority constraints resulting from national prioritization based on the poverty index target the Northeast rainfed spring maize system exclusively. Similarly, the top 25 priority constraints using the marginality index and those obtained using the substitutability index reflected and reinforced the results of the efficiency index.

The results reflect the importance at the national level of the Northeast rainfed spring maize system in terms of maize area and maize production. Based on the efficiency considerations of achieving the greatest and fastest impact on maize production, the focus on priority constraints in this system certainly makes sense. In terms of focusing research priorities on systems that are heavily dependent on maize production and have few alternative crops and cropping patterns, targeting the Northeast rainfed spring maize system is also logical. Moreover, although poverty in the Northeast region is not particularly visible compared with other parts of the country, there are nevertheless several counties with an annual per capita income below 1,500 yuan (US$ 182 at the official exchange in 2001 and 2002). Farmers in this region are also more dependent on maize as a source of income than in other regions.

Although we recognized the logic of including maize production as a weighting factor in setting national maize research priorities, since maize production in the Northeast region was quite large relative to other regions and systems, we did a similar prioritization exercise using indices that were not weighted by maize production. Results of that exercise are presented in Table 5.3.

The top national priority based on the efficiency index unweighted by maize production was head smut in the North rainfed spring maize system, followed by improvement of crop management practices in the Northeast spring maize system. Head smut and drought (present throughout the North and Northeast regions) were also included as top priorities. Prioritizing research based on poverty would focus efforts primarily on improving crop management practices, developing drought tolerant and disease resistant varieties, and increasing input use in the Northwest rainfed and irrigated spring maize systems. Results based on the marginality index unweighted by maize production primarily target drought, soil fertility problems, technology dissemination, and institutional and economic constraints in the rainfed fall, spring, and summer maize systems of the Southwest. Finally, prioritizing research efforts based on the importance of maize in the cropping system would continue to focus research on constraints to production primarily in the Northeast spring rainfed system, even without utilizing a production-weighted index. However, unlike the first set of substitutability index-based results, head smut and drought in the North rainfed spring maize system are also included among the priorities.

Research priorities based on the first set of four maize production-weighted indices predominantly targeted production constraints that can be addressed through new technologies or improved dissemination of existing technologies. The exceptions included improving seed markets and eliminating fake inputs from the market, both of which require market-oriented regulations. Similarly, constraints that could be mitigated with technical solutions were the top priorities according to the efficiency- and substitutability-based indices not weighted by maize production. Interestingly, the priorities resulting from the poverty- and marginality-based indices included policy-related economic, institutional, and infrastructural constraints that require attention outside the maize research and production community.

5.4. Regional Maize System Research Priorities

A similar priority-setting exercise was carried out for each maize production system using an efficiency-based approach weighted by farmer-scientist rankings, potential yield gain, and likelihood of success. Since maize production was constant across the maize system, the efficiency index was not weighted by production. The top 10 priorities for each maize system are shown in Table 5.4.

Each maize system is affected by its own unique combination of abiotic, biotic, institutional, and socioeconomic constraints; however, drought appears as a common constraint across all systems. Several disease and insect problems are also common to multiple maize systems. Poor crop management and the need for improved technology dissemination were identified as important constraints to production across the country. Finally, while socioeconomic and institutional constraints appeared in each maize system, their impacts on limiting maize production and productivity were considered to be highest in the Southwest region.[3]

[3] Research priorities are a moving target, an example of which was the recent increase in the incidence of gray leaf spot caused by *Cercospora zeae-maydis* in the southwest corner of Yunnan province. Starting in 2002, the disease has spread at an alarming rate, likely due to the introduction of temperate maize hybrids into subtropical ecologies.

Table 5.3. Top 25 constraints to maize production (no weighting by output).

Efficiency Index

Agroecological region	Maize production system	Constraints	Rank
North China	Rainfed Spring	Head smut	1
Northeast	Rainfed Spring	Poor knowledge/use of appropriate agronomic methods and crop management	2
North China	Rainfed Spring	Drought	3
North China	Irrigated Spring	Head smut	4
Northeast	Rainfed Spring	Head smut	5
Northeast	Rainfed Spring	Drought	6
North China	Irrigated Spring	Drought	7
Northeast	Rainfed Spring	Ineffective agricultural extension (lack of funds)	8
Yellow-Huai River Valley	Irrigated Summer	Drought	9
North China	Rainfed Spring	Low seed quality (low germination, poor seed production quality)	10
North China	Rainfed Spring	Poor knowledge/use of appropriate agronomic methods and crop management	11
Yellow-Huai River Valley	Rainfed Summer	Low/decreasing soil fertility	12
Yellow-Huai River Valley	Rainfed Spring	Low/decreasing soil fertility	13
Yellow-Huai River Valley	Irrigated Summer	Low/decreasing soil fertility	14
Northeast	Rainfed Spring	Corn borer	15
North China	Irrigated Spring	Low seed quality (low germination, poor seed production quality)	16
Yellow-Huai River Valley	Rainfed Summer	Drought	17
Northeast	Rainfed Spring	Poor nutritional content and grain quality of current varieties	18
Yellow-Huai River Valley	Rainfed Spring	Drought	19
North China	Rainfed Spring	Corn borer	20
Yellow-Huai River Valley	Rainfed Spring	Poor knowledge of appropriate agronomic methods and crop management	21
Northeast	Rainfed Spring	Seed markets in disarray	22
Yellow-Huai River Valley	Irrigated Summer	Poor knowledge of appropriate agronomic methods and crop management	23
Yellow-Huai River Valley	Rainfed Summer	Poor knowledge of appropriate agronomic methods and crop management	24
Yellow-Huai River Valley	Irrigated Summer	Lack of appropriate machinery	25

Poverty Index

Agroecological region	Maize production system	Constraints	Rank
Northwest	Rainfed Spring	Poor knowledge of appropriate agronomic methods and crop management	1
Northwest	Irrigated Spring	Drought	2
Northwest	Rainfed Spring	Head smut	3
Northwest	Irrigated Spring	Head smut	4
Northwest	Irrigated Spring	Poor knowledge of appropriate agronomic methods and crop management	5
Northwest	Rainfed Spring	Drought	6
Northwest	Irrigated Spring	Low rate of new variety replacement	7
Northwest	Rainfed Spring	Low rate of new variety replacement	8
Northwest	Rainfed Spring	Low soil fertility and soil erosion	9
Northwest	Irrigated Spring	Low farm level investment in maize production	10
Northwest	Irrigated Spring	Low/decreasing soil fertility	11
Northwest	Rainfed Spring	Red spider	12
Northwest	Rainfed Spring	Low farm level investment in maize production	13
Northwest	Irrigated Spring	Red spider	14
Northwest	Irrigated Spring	Lack of water-saving irrigation technology	15
Northwest	Rainfed Spring	Smut	16
Northwest	Rainfed Spring	Low quality seed	17
Northwest	Irrigated Spring	Sugarcane mosaic virus	18
Northwest	Irrigated Spring	Low quality seed	19
Northwest	Irrigated Spring	Smut	20
Northwest	Irrigated Spring	Fake fertilizer and pesticides	21
Northwest	Rainfed Spring	Fake seed, fertilizer and pesticides	22
Northwest	Rainfed Spring	Frost	23
Northwest	Irrigated Spring	Frost	24
Northwest	Rainfed Spring	Cutworm	25

Table 5.3. Cont'd...

Marginality Index

Agroecological region	Maize production system	Constraints	Rank
Southwest	Rainfed Fall	Drought	1
Southwest	Rainfed Fall	Low/decreasing soil fertility	2
Southwest	Rainfed Spring	Low/decreasing soil fertility	3
Southwest	Rainfed Fall	Low/decreasing soil fertility	4
Southwest	Rainfed Fall	Farm level cash flow shortages (low input use)	5
Southwest	Rainfed Fall	Difficulties in purchasing seed for desired varieties (very few available outlets)	6
Southwest	Rainfed Fall	Few marketing opportunities for farmers to sell maize due to undeveloped market	7
Southwest	Rainfed Spring	Drought	8
Southwest	Rainfed Fall	Poor maize nutritional and grain quality	9
Southwest	Rainfed Summer	Drought	10
Southwest	Rainfed Summer	Poor knowledge of appropriate agronomic methods and crop management	11
Southwest	Rainfed Fall	Poor knowledge of appropriate agronomic methods and crop management	12
North China	Rainfed Spring	Poor knowledge of appropriate agronomic methods and crop management	13
Southwest	Rainfed Fall	Fake and low quality seed	14
Southwest	Rainfed Fall	*Turcicum* leaf blight	15
Southwest	Rainfed Fall	Poor transportation infrastructure	16
North China	Rainfed Spring	Head smut	17
Southwest	Rainfed Fall	Storage rodents	18
Southwest	Rainfed Fall	Maydis disease	19
North China	Rainfed Spring	Drought	20
Southwest	Rainfed Spring	Leaf blight	21
Southwest	Rainfed Fall	Corn borer	22
Southwest	Rainfed Fall	Soil erosion	23
Southwest	Rainfed Spring	Low quality seed	24
Southwest	Rainfed Summer	Low quality seed	25

Substitutability Index

Agroecological region	Maize production system	Constraints	Rank
Northeast	Rainfed Spring	Poor knowledge of appropriate agronomic methods and crop management	1
Northeast	Rainfed Spring	Head smut	2
Northeast	Rainfed Spring	Drought	3
Northeast	Rainfed Spring	Ineffective agricultural extension (lack of funds)	4
Northeast	Rainfed Spring	Corn borer	5
Northeast	Rainfed Spring	Poor nutritional content and grain quality of current varieties	6
Northeast	Rainfed Spring	Seed markets in disarray	7
Northeast	Rainfed Spring	Low germination rate of certain varieties	8
Northeast	Rainfed Spring	Stalk rot	9
Northeast	Rainfed Spring	Lodging	10
Northeast	Rainfed Spring	Frost	11
Northeast	Rainfed Spring	Soil insects (cut worm, mole cricket)	12
Northeast	Rainfed Spring	Army worm	13
Northeast	Rainfed Spring	Sugarcane mosaic virus	14
Northeast	Rainfed Spring	Maize rough dwarf virus	15
Northeast	Rainfed Spring	Grey blight	16
Northeast	Rainfed Spring	*Turcicum* blight / Maydis disease	17
Northeast	Rainfed Spring	Ear rot	18
Northeast	Rainfed Spring	Fake fertilizer and pesticides	19
Northeast	Rainfed Spring	Field rodents	20
Northeast	Rainfed Spring	Grain weevils	21
North China	Rainfed Spring	Head smut	22
Northeast	Rainfed Spring	Soil erosion	23
North China	Rainfed Spring	Drought	24
Northeast	Rainfed Spring	Storage rodents	25

Table 5.4. Top ten constraints to maize production by production system.

Northeast Region Constraint	Rainfed spring maize
Poor knowledge and use of appropriate agronomic methods and crop management	1
Head smut	2
Drought	3
Ineffective agricultural extension (lack of funds)	4
Corn borer	5
Poor nutritional content and grain quality of current varieties	6
Seed markets in disarray	7
Low germination rate of certain varieties	8
Stalk rot	9
Lodging	10

North Region Constraint	Irrigated spring maize	Rainfed spring maize
Head smut	1	1
Drought	2	2
Poor seed quality	3	3
Poor knowledge/use of appropriate agronomic methods and crop management practices	4	4
Low / decreasing soil fertility	5	6
Red spider mite	6	7
Stalk rot	7	
Corn leaf aphid	8	9
Smut	9	8
Sugar cane mosaic virus	10	10
Corn borer		5
Soil erosion		6

Northwest Region Constraint	Irrigated spring maize	Rainfed spring maize
Drought	1	3
Head smut	2	2
Poor farmer knowledge/use of appropriate agronomic and crop management practices	3	1
Low rate of variety replacement - few varieties appropriate for local conditions are released	4	4
Low farm level investment in inputs	5	7
Low / decreasing soil fertility	6	
Red spider mite	7	6
Lack of water saving irrigation technology	8	
Sugarcane mosaic virus	9	
Poor seed quality	10	9
Low soil fertility and soil erosion		5
Common smut		8
Fake agricultural inputs (fertilizers, pesticide, seed)		10

Yellow-Huai River Valley Constraint	Irrigated summer maize	Rainfed summer maize	Rainfed spring maize
Drought	1	2	2
Low / decreasing soil fertility	2	1	1
Poor farmer knowledge/use of appropriate agronomic and crop management practices / low productivity	3	3	3
Appropriate machinery unavailable	4	8	9
Turcicum leaf blight	5	4	6
Corn borer	6	6	5
Poor seed quality	7	5	4
High wind	8	9	
Stalk rot	9	7	7
Maize rough dwarf virus	10		
Cutworm			8
Common smut			10
Sugarcane mosaic virus		10	

Southwest Region Constraint	Rainfed spring maize	Rainfed summer maize	Rainfed fall maize
Drought	1	1	1
Low / decreasing soil fertility	2	2	2
Low resistance of available varieties to disease and insects	3	3	
Corn borer	10	5	
Limited maize marketing opportunities due to undeveloped markets	7	6	5
Ineffective agricultural extension		7	
Banded leaf and sheath blight	8	8	
Maydis leaf blight		9	
Poor maize nutritional and grain quality	6	10	6
Low farm level investment in inputs	4	4	3
Difficulties in obtaining seed for desired varieties (very few available outlets)	5		4
Lack of agronomic and crop management technology	9		7
Lack of variety options			
Low seed quality (e.g., germination rate, poor seed production quality)			8
Turcicum leaf blight			9
Poor transportation infrastructure			10

6. Discussion and Conclusions

The identification of regional and maize system constraints highlighted differences in impediments to maize production in the surveyed regions of China, but also revealed many common problems encountered by maize farmers. Although national level priorities target issues in specific maize systems, the potential spillovers to other regions and systems of addressing many of the priority constraints are substantial. Drought was identified as a key constraint in both the national priority setting exercise and the individual maize system priority setting exercises. Other constraints, such as poor on-farm crop management, lack of technology and information dissemination, and poor seed quality, may be more efficiently and effectively tackled at a national level. Participating farmers and scientists discussed a range of possible solutions to eliminate or minimize the effect of the constraints they prioritized.

Some of the constraints can largely be addressed through technological solutions, although the mere availability or development of technological solutions does not guarantee either their accessibility to farmers or their on-farm use. Research and development efforts can be targeted towards improving both yield potential and on-farm yields by reducing the impacts of abiotic and biotic constraints. Given adequate funding and resources for maize breeding, scientists participating in the workshop felt confident that most disease and insect problems described by farmers could be addressed. In the past, disease and insect resistant varieties developed through breeding have been used successfully to control these problems.

The use of biological insect control has also been successful. Improved crop management, including intercropping and crop rotations that have been adapted to local growing environments, offers another potential solution. However, appropriate market conditions for diverse crops must also be in place for technologies to be accepted by farmers. A fourth technological solution is the increased use of pesticides by farmers, but this solution is also heavily dependent on other factors such as market and industry conditions, as well as farmer income and opportunity costs.

Abiotic stresses such as drought, frost, and hail pose difficult technological challenges, but the development of stress tolerant varieties can greatly reduce losses due to these constraints. Additional efforts to increase the adoption of no till agricultural methods and the use of technologies such as plastic sheeting for mulch were also suggested as a means to better control and improve the growing environment. Again, these solutions involve the availability of the necessary inputs and machinery, and access to them. Scientists in the workshop encouraged further collaborative research between agronomists and farm machinery specialists, as well as the support of farmer-operated machinery services.

Concerns with seed quality included the technical aspects of seed production as well as the activities of organizations and individuals involved in marketing the seed. As such, successful solutions to this constraint should promote better management and better quality control of both the production process and seed markets. Recommendations included enforcing the existing seed production and marketing regulations more effectively, as well as creating additional regulations for the seed multiplication process, and subsequent seed storage and delivery mechanisms.

New technologies should be targeted not only towards increasing yields, but also towards improving grain quality for feed and industrial use. These value-added improvements would enhance the income-generating ability of maize farmers by expanding the potential marketing outlets. Some level of government investment in the development of the maize processing industry was believed to be a necessary element for the successful expansion of alternative uses for maize.

The current ineffectiveness of the agricultural extension system was highlighted as a major impediment to improved maize production and productivity. Both farmers and scientists recognized the need for improving the dissemination of new and existing technologies. An urgent call was made for government reform of the agricultural extension system consisting of additional investment in the system, including the improvement of salaries, benefits, and living conditions of agricultural extension workers. Additional support for farmer associations was also proposed as a means of addressing problems with technology extension.

The Southwest rainfed spring/fall/winter maize systems deserve special attention due to their dependence on maize, which is consumed by farmers directly as a staple food and is a source of income through livestock and sales. The concerns of farmers in these systems that maize varieties suitable for their growing environment were not readily available stood out as a unique situation of technology needs not being fully addressed. This issue should not be confused with market, institutional, or infrastructural factors resulting in the unavailability of seed, although those constraints were also raised by farmers in these systems. A wider range of technological options needs to be made available to these farmers.

A subset of the identified priority constraints requires broader government policy interventions and investments that do not directly involve science and technology development. To increase the low level of investment in inputs and improve maize profitability, participants recommended reducing transactions costs and farmers' tax burden as well as expanding small-scale credit programs targeted specifically at farmers. Increased public investment in farmer education and training is also necessary.

Although many maize production areas coincide with areas of low per capita income, increased maize production and productivity will not provide the means to solve the problems of poverty. Investment to improve infrastructure and increase off-farm employment opportunities in poverty areas must also be made.

Since the survey took place, liberalization and market reform have decreased the implicit and heavy tax burden imposed on maize farmers through government grain procurement policies (Huang and Rozelle 2006). Other recent policy interventions have directly eliminated the burden of explicit agricultural taxes and reversed a long-standing history of agricultural taxation to one of direct subsidies to farmers who produce grain in order to increase grain production and improve rural incomes. Subsidies are now in place for purchasing seed of designated high quality "special use" varieties, including maize varieties (Gale et al. 2005). However, it is still too early to quantify the impact of any of these new policies.

For the past three decades, farmers in China have operated in a constantly changing policy and market environment that has drastically impacted all aspects of maize production and utilization. Regular technological advances have also contributed greatly to the current state of maize production. In China a challenging and unique mix of government intervention and liberalization of agricultural and market policies continue to influence maize production. Addressing the complex set of identified priority constraints to future maize production in China will necessarily involve a combination of science and policies to tackle the broader issues of markets, infrastructure, and farmer capacity.

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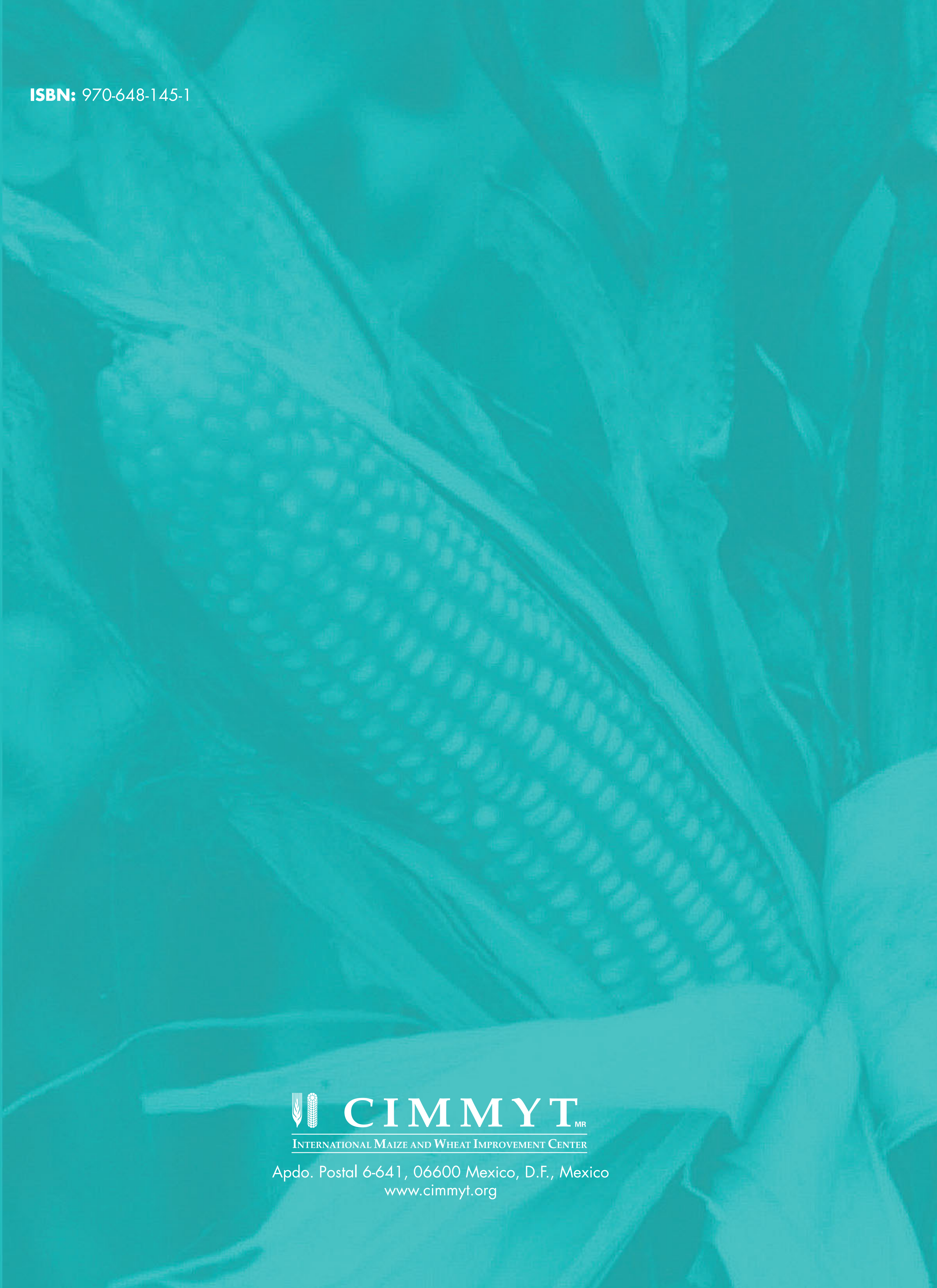

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INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER

Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico
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