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The Maize Subsector in Paraguay: A Diagnostic Overview

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Executive Summary

The maize sector in Paraguay is going through a period of perplexing changes. Despite recent production gains, average maize yields remain far below those which could be achieved with relatively simple changes in management practices and wider use of currently available improved germplasm. Citing the high cost of inputs, low producer prices for maize, and an uncertain market, most farmers in Paraguay produce maize only for their own use, planting limited area and using few or no purchased inputs.

This paper presents the results of a preliminary diagnostic study of the Paraguayan maize subsector carried out by researchers from the Departamento de Investigación y Extensión Agropecuaria y Forestal (DIEAF) of Paraguay and CIMMYT. The broad objective of the study was to identify the major factors behind low maize productivity and thus facilitate the long range research planning of the DIEAF Maize Program. More specific objectives included: 1) to review recent developments in Paraguay's agricultural economy in general and the maize subsector in particular; 2) to assess the current and future demand for different types of maize and their production potential; 3) to identify inefficiencies or bottlenecks in the marketing system for maize which may be lowering economic incentives for producers; 4) to distinguish between technical constraints to maize production (which are best addressed through research) and economic and/or institutional constraints (which are best addressed through policy reform); and 5) to explore the implications of the study's findings for the DIEAF Maize Program, and in particular to spell out the critical issues facing research policy makers.

Data for the study were collected in April, 1989. Following a review of secondary data sources, a two-week reconnaissance survey was carried out in Paraguay's major maize production zones involving interviews with maize producers, assemblers, transporters, wholesalers, retailers, feed processors, and consumers. The informal reconnaissance survey was followed by a more formal survey of marketing agents (designed to generate information on maize marketing margins), as well as a survey of large-scale and small-scale maize producers (designed to verify production practices used by commercial and subsistence farmers).

This preliminary diagnostic study has led to the following conclusions:

1. The maize subsector is poorly developed in Paraguay in the sense that current production levels are much lower than they could be.

2. The primary barrier to increased production is the low profitability of maize relative to alternative crops (soybeans, cotton, and manioc). However, additional research is needed to develop improved germplasm and to identify management practices that can help farmers increase yields with little additional investment in inputs. This research must be complemented by sound economic analysis designed to determine the profitability of current and potential future production technologies.

3. The relatively low profitability (and hence unattractiveness to farmers) of maize production results from: a) limited demand in the domestic market and b) low international maize prices, as well as high transport costs involved in delivering Paraguayan maize to the world market.

4. Systematic economic research has not been carried out at the farm level to determine the profitability for farmers of new technologies that could increase maize yields substantially in the short run.

5. Economic policy reforms alone offer limited prospects for solving the problem of low profitability. Efforts to stimulate increased production by supporting the producer price of maize and/or by providing guaranteed market outlets are likely to create an unsustainable drain on government resources.

6. The marketing system does not appear to pose a major constraint to increased maize production. The well-developed private sector grain marketing system, which handles primarily soybeans and wheat, could accommodate increased amounts of maize.

7. There is strong circumstantial evidence that Paraguay's informal domestic marketing system for maize responds rapidly to market signals and moves grain from production zones to consumption points rapidly and efficiently.

8. Prospects for growth in export demand for maize are dim. Substantial increases in international maize prices would be necessary for Paraguayan maize to compete on world markets, given current production and transportation costs. On the other hand, long term bilateral trade agreements at concessionary terms negotiated as part of a development assistance program might provide more realistic opportunities for the development of a limited export market for maize.

9. Prospects for growth in domestic demand for maize are favorable. Expansion of the poultry industry has been increasing domestic demand for feed maize at a rate of approximately 10% per year. Demand for feed maize could grow even further as the result of the recent sharp acceleration in beef exports, which can be expected to raise domestic beef prices, thereby inducing consumers to shift into additional consumption of poultry and pork. Increased production of maize-fed livestock for export is another potential future source of domestic demand, although the economic feasibility of this option remains unknown.

10. The public sector has an important role to play in supporting maize research for three main reasons:

a. maize is an important subsistence crop for the vast majority of the nation's smallholders;
b. the private sector is unlikely to invest significant resources into maize research because of the modest commercial importance of the crop; and
c. maize could conceivably become an important commercial crop in the future as the result of decreased profitability of competing crops.

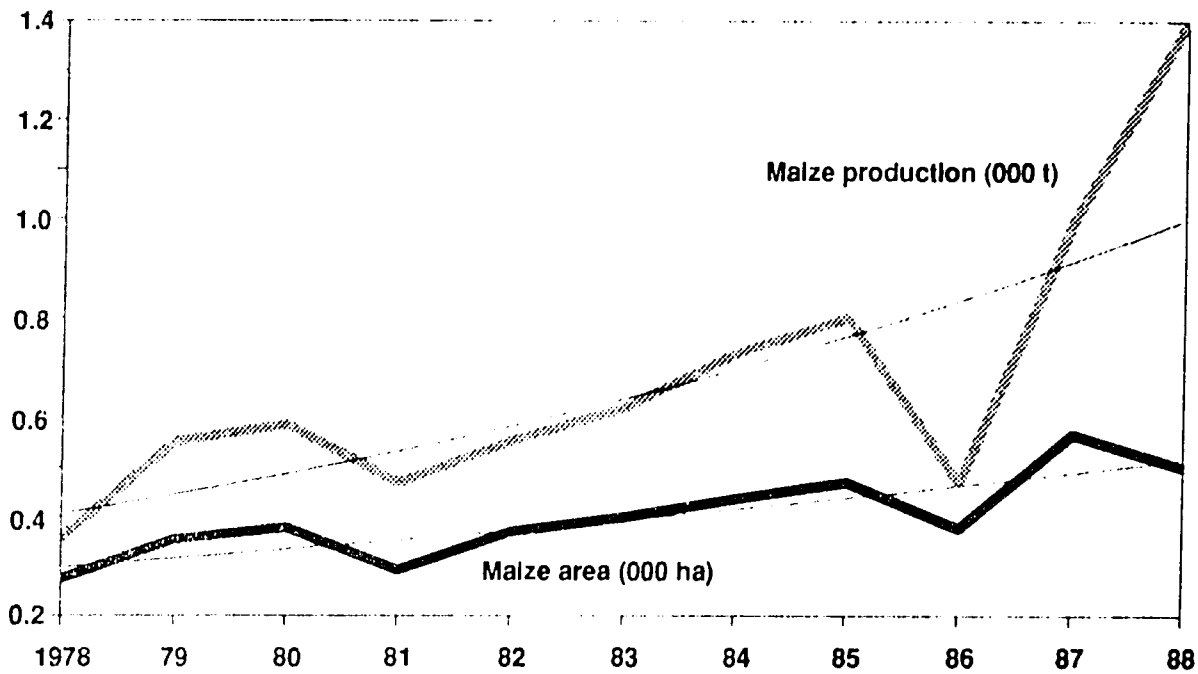
11. Three critical issues face agricultural research administrators:

a. the resource allocation to maize vs. other crops;
b. the resource allocation to different types of maize research (e.g., breeding vs. crop management vs. economics); and
c. the resource allocation to developing different types of maize germplasm (e.g., open pollinated varieties vs. hybrids, yellow vs. white maize, flints vs. dents).

Introduction and Objectives

During the past decade, the maize subsector in Paraguay has undergone considerable change. From 1979 to 1989, area planted to maize expanded over 200% as the crop moved into fertile growing areas along the southeastern border with Brazil, and yields rose 25% due to adoption of improved germplasm and management practices. These developments helped fuel a three-fold increase in national maize production (Figure 1).

Yet despite the progress achieved in raising production, there is still reason to be concerned about the performance of Paraguay's maize subsector. Even under generally favorable agroclimatic conditions, average maize yields remain far below those which could be achieved with relatively simple changes in management practices and wider use of currently available improved germplasm. While it is not unusual to encounter a discrepancy between yields on farmers' fields and on experiment stations, the case of maize in Paraguay is exceptional because the large yield gap cannot be explained by the usual factors. Many Paraguayan farmers possess the knowledge to increase their maize yields, yet they deliberately choose not to increase maize production, citing the high cost of inputs, low producer prices for maize, and an uncertain market. As a result, most farmers in Paraguay produce maize only for home consumption, planting limited area and using few or no purchased inputs.



Source: Ministry of Agriculture (1988).

Figure 1. Maize production trends in Paraguay, 1978-88.

This situation has created a dilemma for researchers in the Maize Program of the Departamento de Investigación y Extensión Agropecuaria y Forestal (DIEAF). Years of research have led to the development of improved germplasm and management practices which have the potential to increase maize yields significantly, yet most farmers appear unwilling to make the modest additional investments needed to adopt these technological innovations. Their reluctance has called into question the traditional assumption that the problem of low productivity in maize is essentially technical in nature and has emphasized the need to unravel the complex set of technical, economic, and institutional constraints which may be depressing maize production in Paraguay. A thorough analysis of these constraints would help focus research priorities for maize, both by directing attention to economic and institutional factors which may be constraining maize production and by accurately identifying farmers' technology needs.

Objectives of the study

This paper presents the results of a preliminary diagnostic study of the Paraguayan maize subsector carried out by researchers from the DIEAF Maize Program and CIMMYT. The broad objectives of the study were to identify the major factors contributing to low productivity levels in maize, with the aim of facilitating long range research planning of the DIEAF Maize Program.

More specific objectives included:

1. To review recent developments in Paraguay's agricultural economy in general and the maize subsector in particular.

2. To assess the current and future demand for different types of maize and their production potential.

3. To identify inefficiencies or bottlenecks in the marketing system for maize which may be lowering economic incentives for producers.

4. To distinguish between technical constraints to maize production (which are best addressed through research) and economic and/or institutional constraints (which are best addressed through policy reform).

5. To explore the implications of the study's results for the DIEAF Maize Program, and in particular to spell out the critical issues facing research policy makers.

Data collection activities

Beginning in November 1988, secondary data on maize production, marketing, and consumption were assembled and reviewed. Field data collection began in April 1989 with an informal reconnaissance survey focusing on Paraguay's major maize producing zones, particularly the states of Paraguarí, Itapúa, Alto Paraná, and Caaguazú. This reconnaissance survey was supplemented by two formal surveys. A questionnaire focusing on marketing activities and prices was administered to 25 purchasers of maize (e.g., first assemblers, itinerant traders, grain elevator operators, producer cooperatives, feed millers, poultry producers, exporters). A second questionnaire designed to elicit technical input-output coefficients and farm level prices was administered to a random sample of 15 maize producers, both smallholders and large scale commercial farmers. In addition, informal interviews were conducted with key participants from all levels of the maize subsector: producers, transporters, traders, extension agents, public sector researchers, private seed companies, government officials, agricultural input distributors, feed millers, and cooperatives.

The quality of the data used in this study warrants a brief comment. Primary data collected directly in the field are thought to be reasonably reliable, but caution must be exercised in interpreting secondary data on production, utilization, and trade, including official government statistics. Two main factors contribute to the unreliability of official statistics in Paraguay. First, the national crop reporting service lacks the resources necessary to carry out comprehensive data collection activities. The problem is somewhat less severe for commercial crops such as soybeans, cotton, and wheat, which tend to be 1) monocropped, 2) sold as cash crops, and 3) marketed through well-defined channels where quantities and prices can be observed and measured. In contrast, a large proportion of the maize crop is 1) produced in mixed stands, 2) retained for home consumption, and/or 3) marketed through informal channels. These factors make official maize statistics particularly unreliable. Second, even if the national crop reporting service were to receive more resources, data collection would still be hampered by the large amount of unregistered trade which characterizes the Paraguayan economy. Whenever Paraguay's price policies or exchange rates become misaligned with those of its neighbors, particularly Brazil and Argentina, large quantities of agricultural commodities are known to cross the border illegally, and these flows generally fail to show up in official statistics.

Agriculture in the Paraguayan Economy

General macroeconomic indicators

Agriculture has always played an important role in the Paraguayan economy, averaging around 33% of GNP during 1970-88. This percentage decreased temporarily during the heavy construction phase of the Itaipu hydroelectric project (1976-81), which gave a strong boost to the industrial and service sectors and helped propel the Paraguayan economy to the fastest growth rate in South America. Following a period of stagnation during the early 1980s, the economy has in recent years resumed a modest real growth rate based on a booming export-led agricultural sector (Table 1). This growth has been achieved in spite of the potentially destabilizing effects of recurring economic crises in Brazil and Argentina, two powerful neighbors to whom Paraguay's economic fortunes are closely linked.

Table 1. Paraguay macroeconomic indicators, 1970-88

Year	Real GDP* (1985=100) (billion (guaranis)	Real GDP per capita (000 guaranis)	GDP real annual growth (%)	Free exchange rate** (guaranis/US $)	GDP deflator (1985=100)
1970	559	243	6.5	126	29
1971	586	248	4.7	126	31
1972	617	254	5.5	126	34
1973	660	264	6.9	126	38
1974	715	278	8.3	126	47
1975	756	287	6.1	126	50
1976	814	299	7.3	126	53
1977	903	322	10.9	126	58
1978	1,005	340	11.3	136	64
1979	1,118	367	11.3	136	82
1980	1,246	396	11.4	134	100
1981	1,355	417	8.8	148	114
1982	1,340	399	-1.1	161	122
1983	1,301	375	-2.9	160	138
1984	1,534	375	17.9	320	166
1985	1,394	377	-9.1	593	208
1986	1,394	366	0.1	678	274
1987	1,454	371	4.3	797	334
1988	1,546	383	6.4	924	411

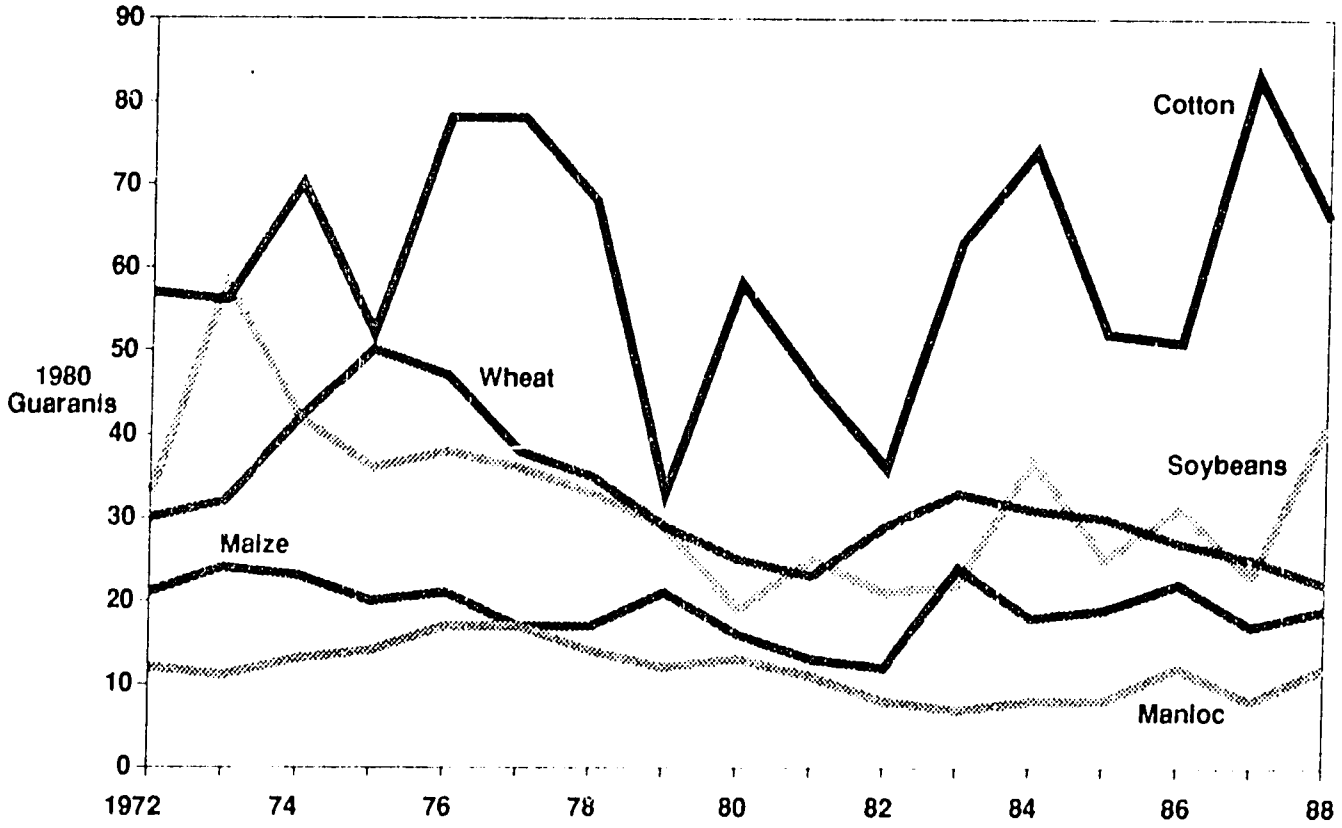
Source: * IMF, International Financial Statistics.
** Casa de Cambio Guarani, Asunción.
*** Banco Central de Paraguay.

Policies affecting the agricultural sector

Numerous policies relating to agriculture nominally were in effect during the Stroessner regime, but since many were not enforced, state intervention in the agricultural sector was in fact minimal. The new government which assumed office in mid-1989 has said that it is committed to maintaining and formalizing the laissez-faire approach to agriculture followed under the previous regime and has taken steps to dismantle many policies which proved unworkable. Four sets of policies can be identified which today influence agricultural decision making.

Producer price policy

Producer prices for the main commercial crops from 1972-88 are shown in Figure 2. Wheat prices were supported throughout most of the 1980s as part of a policy to increase self-sufficiency in wheat, but prices for all other crops were left free to respond to market forces. While none of the price series exhibits a strong upward or downward trend, all reflect a certain amount of variability. Table 2 presents coefficients of variation around trend (CVs) for these prices calculated over 1972-1988. Three features of the CVs are noteworthy. First, all of the CVs are modest in the sense that they are roughly equal to or less than the main international reference prices for these commodities during the same period. Second, the CV for wheat falls



Source: Calculated from Gabinete Tecnico price data.

Figure 2. Real producer prices of principal crops in Paraguay, 1972-88.

well within the range of CVs for the other crops, which is surprising considering the wheat price was the only price subject to government controls. Third, the CV for maize is the smallest, which would appear to contradict the view expressed by many producers that maize prices in Paraguay are particularly unstable.

Agricultural marketing policy

Farmer decision making in Paraguay is influenced by market opportunities. The government has enacted regulations governing the marketing of many agricultural commodities, especially export crops and wheat. The main objectives of these regulations are to define grades and to ensure quality standards. Marketing regulations do not attempt to legislate who may engage in marketing activities, and entry into the marketing industry is unrestricted.

Agricultural exports policy

For many years the government attempted to exercise control over agricultural exports, especially exports of soybeans and cotton. Private firms were required to report all foreign sales and were required to turn over a specified percentage of export earnings at a controlled exchange rate. This exchange rate was highly discriminatory and amounted to a tax on exports, creating strong incentives to smuggle commodities out of the country. Recognizing the unenforceability of the old system, the government that assumed office in mid-1989 abolished the system of multiple exchange rates and eliminated the requirement that a specified percentage of export earnings be turned over to the state. These reforms are expected to increase the efficiency of export marketing by obviating the need for private firms to engage in costly evasive behavior designed to conceal foreign transactions. If the cost savings are transmitted back to the producer, the result will be higher incentive prices for producers of export crops.

Exchange rate and monetary policy

Exchange rate and monetary policy are particularly important in an open economy such as Paraguay's, because they influence prices received by producers. During periods of high inflation and/or rapid exchange rate devaluation, producer prices can change substantially in a matter of days or weeks, introducing a strong element of uncertainty into agricultural decision making and often creating strong incentives for producers and exporters to smuggle commodities across borders to obtain more favorable prices.

Table 2. Coefficients of variation around trend for real producer prices of principal crops in Paraguay, 1972-88

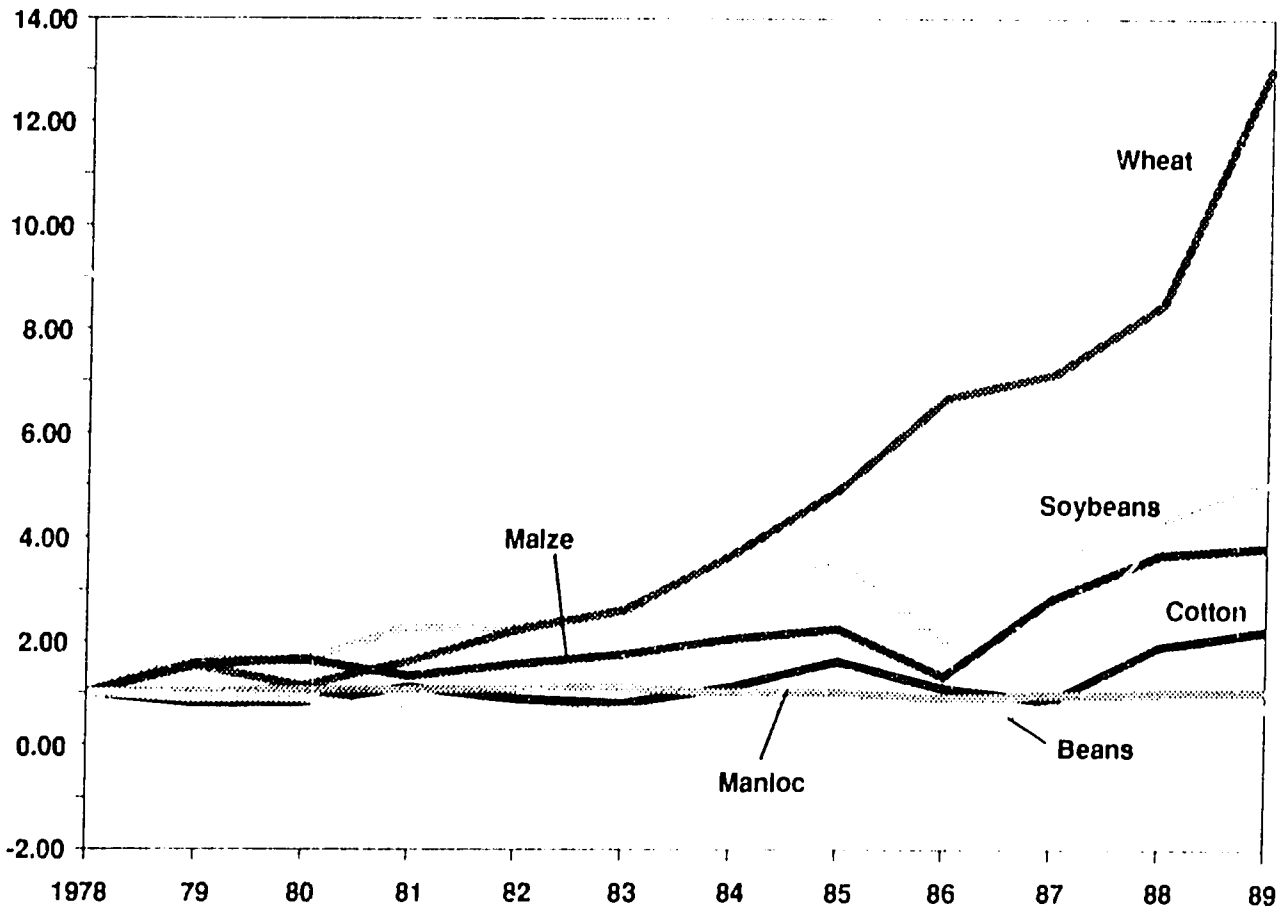
	Soybeans	Wheat	Maize	Cotton	Manioc
CV	28	20	18	25	23

Source: Calculated from DIEAF data.

Production of principal crops

Figure 3 presents indices of production for Paraguay's principal crops from 1978 to 1989. During this period, wheat production grew most rapidly, averaging 26% per year growth from a small initial base. The rapid increase in wheat production was due in large part to protectionist policies such as producer price supports and import restrictions, which made it profitable for commercial farmers to invest in improved technologies (e.g., high yielding varieties, fertilizer). Production of soybeans also experienced strong growth, increasing at an average rate of 13% per year in response to strengthening world prices, strong productivity gains, and the opening up of fertile lands along the Brazilian border. Despite a lack of government incentives, maize production increased substantially, averaging 10% annual growth. Production of cotton, the other major commercial crop, grew somewhat more slowly at an average annual rate of 7%.

In contrast to the strong growth achieved in the production of commercial crops, production of subsistence crops stagnated. From 1978 to 1989, production of manioc remained virtually unchanged, while production



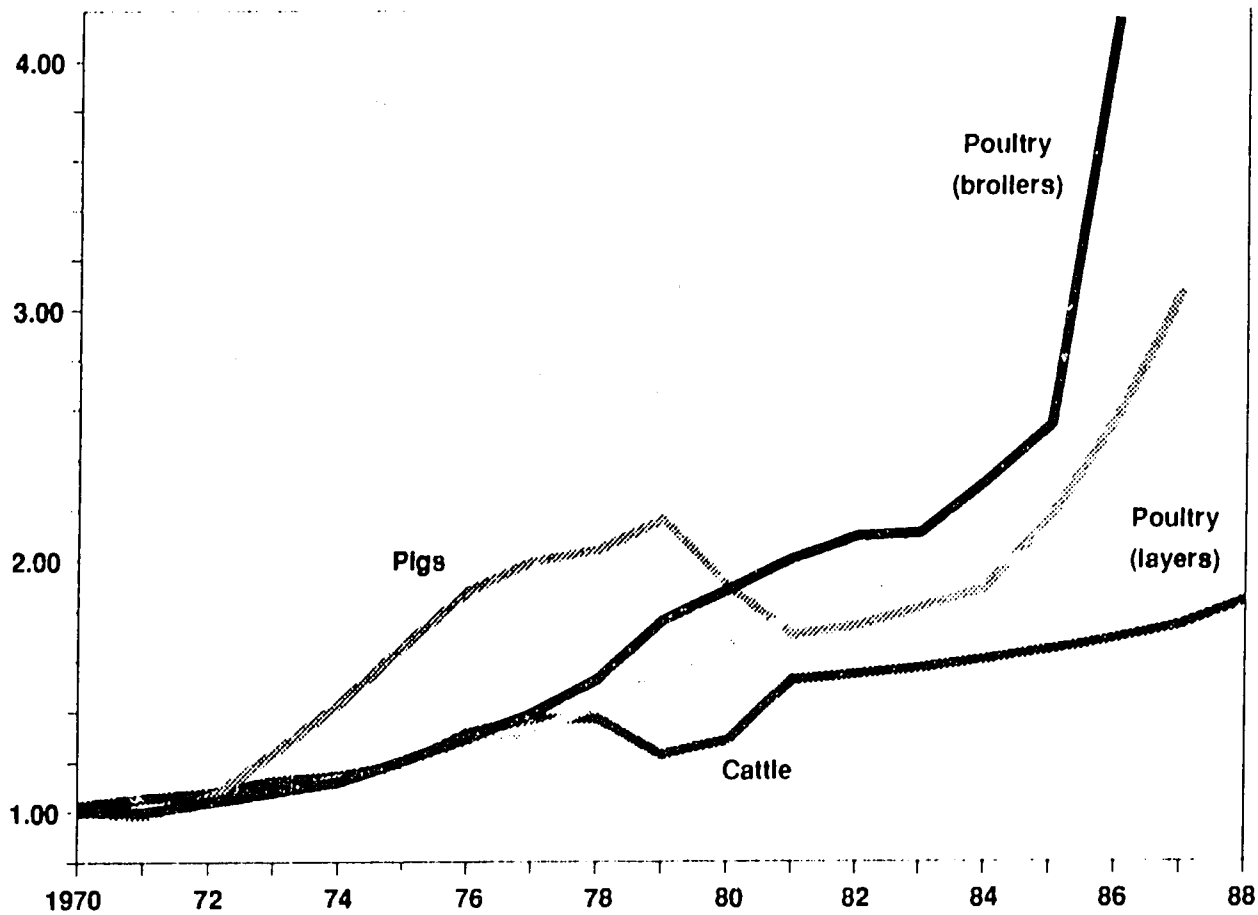
Source: Calculated from Gabinete Tecnico data.

Figure 3. Indices of production of principal crops in Paraguay, 1978-88.

of beans actually declined at an average annual rate of 3%. Although official production data for manioc and beans are somewhat less reliable than data for commercial crops (for reasons explained above), the divergent growth trends suggest increasing concentration on commercial crops at the expense of traditional staples.

Production of livestock

Figure 4 presents indices of livestock production in Paraguay during 1972-88. The livestock subsector is of interest to maize producers, because future growth in domestic demand for maize is likely to depend to a large extent on demand for maize-based livestock feeds. Currently, most feed maize produced in Paraguay is used by the poultry industry, which has expanded rapidly during recent years. The pork industry is also an important user of feed maize. In contrast, demand for feed maize from the beef industry has been modest, since most cattle in Paraguay are range fed. However, beef exports have accelerated sharply during the past year, and should this trend be sustained, derived demand for feed maize could become significant.



Source: Calculated from Gabinete Tecnico data.

Figure 4. Indices of production of livestock in Paraguay, 1970-88.

The Maize Subsector

Agroclimatic conditions

Maize production in Paraguay is concentrated in the *Region Oriental* (Eastern Region), where agroclimatic conditions are most favorable for maize (Figure 5). The climate in the *Region Oriental* is considered tropical-subtropical, with a mean annual temperature of 21.6° C, ranging from a mean monthly high of 31.9° C in January to a mean monthly low of 10.4° C in July (Encarnación weather station). Average annual rainfall varies between 1,300 mm and 1,700 mm and is distributed unimodally, with the rainy season beginning in September or October and continuing until March or April. Soils are highly variable and include sandy and calcarous alluvials, sandy latosols, latosols of basaltic origin, laterites, and red-yellow podzolics.

Maize production

Maize in Paraguay is grown by small scale semisubsistence farmers as well as by large scale commercial producers. Production technologies, cropping systems, and maize utilization patterns vary significantly between these two distinct groups of producers. Based on the predominant producer group, three zones can be distinguished within the *Region Oriental.* Zone A comprises primarily small scale semisubsistence production systems; Zone B comprises primarily large scale commercial production systems; and Zone C includes both small scale and large scale production systems (Figure 6).

Smallholders

Smallholders grow maize as a subsistence crop, either monocropped or in association with cotton, manioc, or beans. Land preparation is performed either manually or using animals, usually oxen or horses. Maize is hand planted in rows, with spacing between rows varying widely depending on the cropping mix (from less than 1 m apart when maize is intercropped with beans, to as much as 5 m apart when maize is intercropped with cotton). Little or no fertilizer is applied, and use of herbicides and pesticides is rare. Weeding is carried out manually or with animal drawn implements. Maize is generally harvested after cotton and/or manioc, which means that the maize crop is often left standing in the field for 2-3 months after grain maturity. In many regions, farmers bend over the stalk just below the ear during the final ripening stages to prevent rain from penetrating the husk and causing ear rot.

Smallholders grow several distinct types of maize, which are known by their Guaraní language names (Table 3). However, since little of the maize produced by smallholders is marketed, and since no comprehensive survey of maize production patterns has been carried out, it is difficult to estimate the quantities grown of each type. By far the most common are *avati moroti* (white floury materials used for human consumption) and *tupi pyta* (yellow flint materials produced primarily for use as livestock feed). Smallholders also plant small amounts of *tupi moroti* (white flint maize used to prepare specialty dishes), as well as *sape pyta* and *sape moroti* (yellow and white dent materials grown for use as livestock feed). Most of the materials grown by smallholders are unimproved local varieties with low yield potential, high yield stability, and moderate resistance to local pests.

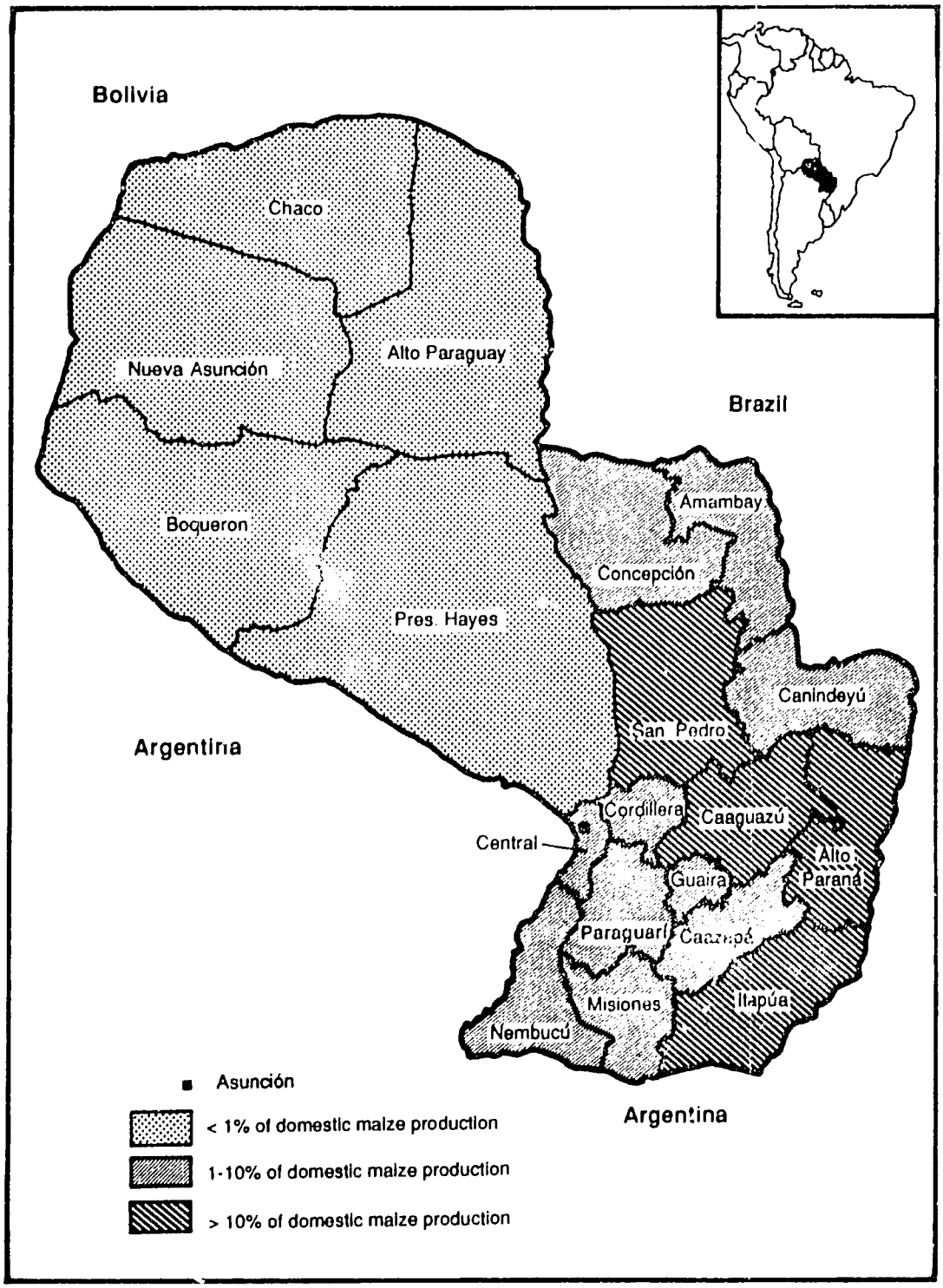


Figure 5. Distribution of maize production in Paraguay, 1986-87.

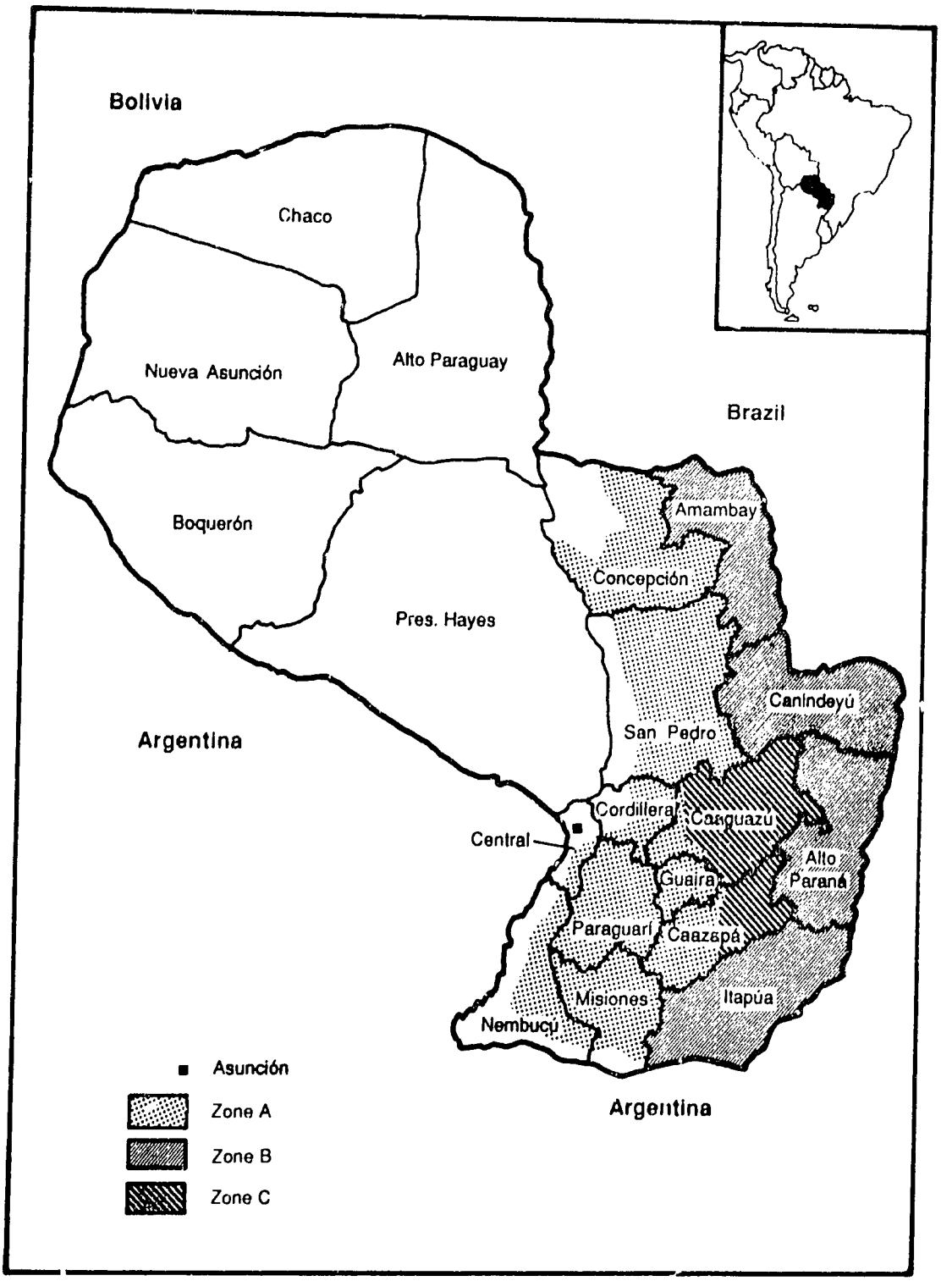


Figure 6. Maize production zones in Paraguay.

During the past few years, the DIEAF Maize Program has developed and released several varieties targeted for use by smallholders. One of these varieties, a yellow flint derived from Suwan 8027 and released under the name Guarani V-312 (also widely known as *carape pyta*), has enjoyed widespread acceptance by farmers as an alternative to traditional *tupi pyta* materials due to its higher yield potential and increased resistance to insect damage.

Large scale commercial producers

For large scale commercial producers, maize is a relatively minor crop grown primarily to feed their own livestock. Soybeans and wheat (grown in rotation) are the main commercial crops for large scale producers, very few of whom plant maize as a cash crop since this usually means reducing the area planted to soybeans. Land preparation is completely mechanized, and seed is drilled in rows using tractor drawn planters. Modest amounts of fertilizer are applied, primarily urea, diammonium phosphate, and compound fertilizer (NPK 18-46-0). Herbicide and pesticide use, while increasing, is still rare, and most weeding is carried out with tractor drawn implements. Even though many commercial farmers use combine harvesters on soybeans and wheat, the majority contract labor to harvest maize by hand because of the high cost of refitting the combines with maize harvesting attachments.

Commercial farmers grow both unimproved and improved maize materials, including hybrids. Seed availability can be a problem. Since Paraguay is not seen as a lucrative market for hybrid seed, few private companies have established seed production facilities within the country. Consequently, improved seed must often be purchased across the border in Brazil or Argentina. According to many farmers, however, Brazilian and Argentinian materials are not always well adapted to Paraguayan growing conditions.

Table 3. Characteristics of maize types grown in Paraguay

Local name	Color	Grain type	Grain produced by	Used for
Avati moroti	White	Floury	Smallholders	Human food
Tupi moroti	White	Flint	Smallholders	Human food
Tupi pyta	Yellow	Flint	Smallholders Commercial farmers	Animal feed Animal feed
Sapo pyta	Yellow	Dent	Commercial farmers	Animal feed
Sapo moroti	White	Dent	Commercial farmers	Animal feed

Maize utilization

It is difficult to formulate an accurate picture of maize utilization patterns in Paraguay, because few quantitative data are available indicating how farmers dispose of the maize crop. Casual observation suggests that much of the growth in maize demand in recent years has come from the livestock feed industry, especially the poultry feed industry, but no formal study of utilization patterns has been carried out. Published sources estimate that approximately 35% of total maize production is used for human consumption, 35% for on-farm feed, 25% for industrial uses (food and feed), 3% for exports, and 2% for seed, but it was not possible to determine how these figures were derived.

Despite the lack of reliable data, it is still possible to describe maize utilization patterns in general terms. Smallholders unquestionably retain most of their production for home consumption. Probably a greater proportion of the smallholder crop is fed to livestock than is consumed by humans, although it is difficult to say with certainty. A small portion may also be sold to generate cash, although maize is generally not a commercial crop for smallholders. In the absence of reliable data on household level grain transactions, it is not known whether a significant percentage of smallholders are net purchasers of maize.

Large scale commercial farmers plant almost exclusively yellow flint materials for use as livestock feed. Most of these farmers grow maize primarily to feed to their own animals, selling only excess production that they do not need. An unknown number of commercial farmers additionally produce maize as a cash crop, for sale either to local grain elevators or directly to feed manufacturers. Also, a few large scale farmers produce maize seed under contract to the national seed production company (SENASE), to the Ministry of Agriculture (MAG), or to one of the agricultural cooperatives.

Principal maize marketing channels

The field survey of maize markets carried out in April, 1989, revealed that the maize marketing system in Paraguay is more extensive than is generally believed. One reason Paraguay's maize markets remain poorly understood may be that most maize marketing activities take place outside the formal marketing channels which handle the country's main commercial crops. However, just because the grain elevators that purchase soybeans, cotton, and wheat handle very little maize does not mean that maize marketing does not take place. The survey revealed the existence of a complex, well-developed marketing system for maize involving a large number of intermediaries and comprising a large number of distinct marketing channels.

The participants in Paraguay's maize marketing system and the principal marketing channels are depicted in Figures 7a and 7b. To facilitate interpretation, separate diagrams are presented for the two most important types of maize, distinguished by color (yellow or white) and by use (feed or food). Figure 7a depicts the marketing channels that handle yellow maize used for animal feed. Figure 7b depicts the marketing channels that handle white maize used for food. Although the diagrams appear to depict separate marketing systems, in reality the two overlap considerably, as many intermediaries simultaneously handle both types of maize. For convenience, the following discussion is divided into marketing channels used primarily by large scale commercial producers and marketing channels used primarily by smallholders, although once again there is considerable overlap.

Maize marketing channels used by commercial producers

Commercial farmers almost exclusively produce yellow maize, which they sell to four main outlets: 1) local feed users, 2) grain elevators, 3) *camioneros* (itinerant traders) and 4) poultry operations located in the Asunción metropolitan area.

Local feed users include all individuals and firms located in the immediate production zone who purchase maize for feed, e.g., neighboring farmers, feed mills, and commercial poultry operations. Sales to local feed users may be made on a regular basis (in the case of farmers who regularly produce maize as a cash crop), or they may be sporadic (in the case of farmers desiring to dispose of an occasional unexpected surplus).

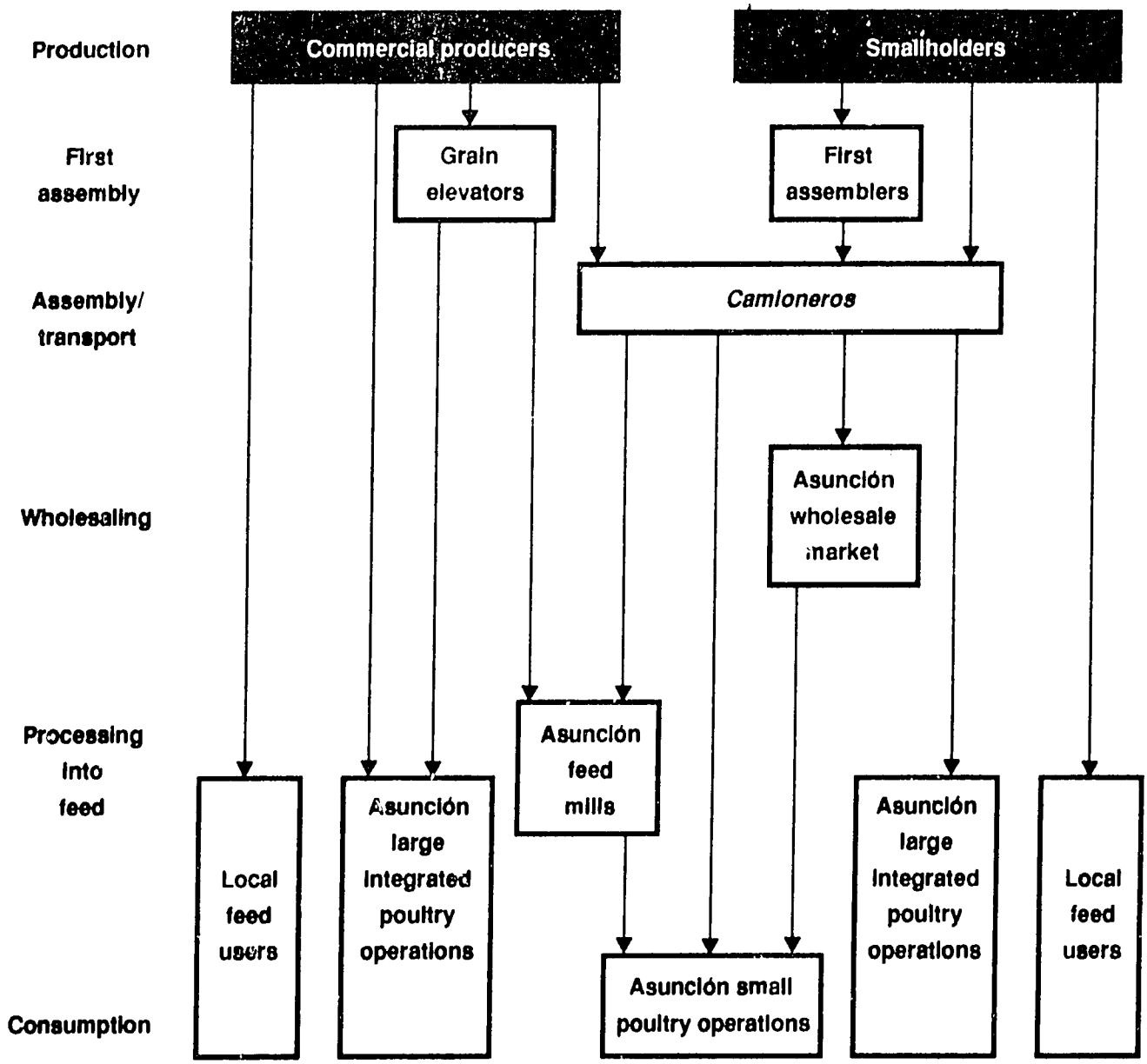


Figure 7a. Principal yellow maize marketing channels (feed use).

Grain elevators also purchase a portion of the maize marketed by commercial producers. Grain elevators handle primarily soybeans and wheat, but some are willing to purchase maize during slack periods since the same processing equipment and storage facilities used for soybeans and wheat can also be used for maize. Some elevator operators indicated that they make little profit on maize and claimed that they purchase the crop only as a favor to their regular soybean and wheat producing customers. Most of the maize purchased by grain elevators is resold in the Asunción area to feed mills or to large poultry operations. Very rarely, small quantities may be exported. Many elevator operators indicated they would be willing to handle greater quantities of maize if the market were more reliable, but they claimed that extreme price variability and highly variable demand makes maize a risky crop to handle. For this reason, elevator operators do not extend production credit for maize, purchasing the crop strictly on a cash basis. This is in sharp contrast to soybeans and wheat, for which production credit is regularly extended.

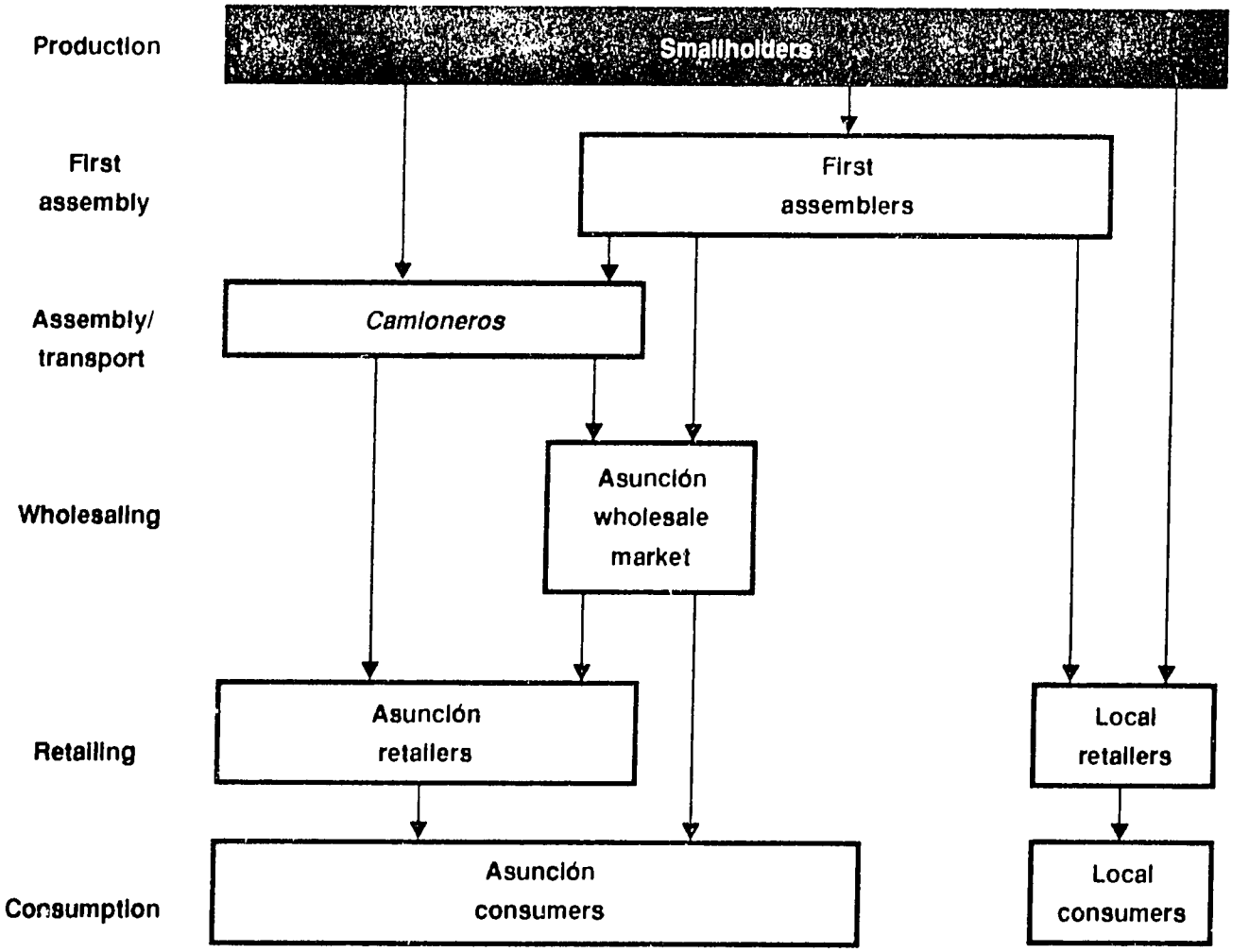


Figure 7b. Principal white maize marketing channels (food use).

A third portion of the maize marketed by commercial farmers is purchased by itinerant traders known as *camioneros*. These traders travel throughout the production zones during and after the harvest assembling small lots of maize from farmers and first assemblers. When a 10- to 15-ton truckload is completed, it is transported to Asunción for sale in the wholesale market, to one of the feed mills, or directly to poultry producers. Although *camioneros* deal primarily with smallholders, they also contact large scale commercial farmers in search of maize, since commercial farmers faced with the problem of disposing an unanticipated surplus are usually happy to have a *camionero* take it off their hands.

Commercial farmers also sell maize directly to poultry operations located in and around Asunción. This outlet is favored particularly by the small number of farmers who regularly grow maize as a cash crop. According to several farmers, the two main advantages of selling directly to poultry operations are that they offer a guaranteed market outlet and that they pay premium prices.

Maize marketing channels used by smallholders

Smallholders produce both yellow maize (for on-farm feed use or for sale) and white maize (for on-farm food use or for sale). Most of the maize marketed by smallholders is sold to three outlets: 1) first assemblers, 2) *camioneros*, and 3) local retailers.

First assemblers are traders who live within the production zones and who purchase small quantities of maize from local farmers. Most first assemblers do not specialize in maize trading; rather, they buy and sell maize (also other crops such as cotton and manioc) as one of several income generating activities. Many first assemblers are shopkeepers, and they frequently accept maize as payment for outstanding loans of food, dry goods, or money. Several first assemblers mentioned that they regularly provide production inputs on credit (e.g., seed, fertilizer, and cash). Almost all first assemblers are vehicle owners, since a vehicle is usually necessary to collect maize at the farm gate. First assemblers typically resell maize to *camioneros*, although a few deliver directly to the wholesale market in Asunción.

Smallholders also sell maize to *camioneros*. The chief advantages of selling to *camioneros* are that they take delivery directly at the farm gate and that they pay immediately in cash.

Some smallholders sell limited quantities of maize to local retailers--village shopkeepers who purchase maize directly from farmers. While these local retailers may own a vehicle used to transport grain, they are distinguished from first assemblers in that they do not transport grain over large distances (e.g., to Asunción) and in that they sell only to final consumers.

Maize destined for food use (virtually all white maize and some yellow maize) is either consumed within the immediate production zone or transported to an urban market, for example Asunción. *Camioneros* play a leading role in supplying urban markets with food maize, both white and yellow. Maize purchased from farmers, first assemblers, or grain elevators is trucked by *camioneros* to urban centers and sold to wholesaler-retailers in the wholesale market, who in turn resell to neighborhood retailers and consumers. In a few instances, *camioneros* sell directly to retailers without passing through a wholesale market such as the one in Asunción.

Maize marketing margins

Marketing margins for yellow maize were estimated based on the information obtained during the survey of marketing agents (Table 4).[3] Although the number of respondents was limited, marketing agents within each region gave remarkably consistent estimates of farm gate prices, transport costs between various production points and Asunción, and prices in the wholesale market. According to most respondents, buying prices, selling prices, and transport costs are well known to all market participants, with *camioneros* acting as the main brokers of information. This testimony, along with the highly consistent estimates of prices and costs, provides strong circumstantial evidence of a well-integrated maize marketing system characterized by a free flow of information.

While the estimated gross marketing margins are relatively large in percentage terms (marketing costs comprise 50% of the final retail price in Alto Paraná and 42% in Itapúa), this can be explained in terms of the dispersed structure of production and the high cost of storage. Since much of the maize which eventually enters the market consists of unanticipated surpluses produced by small scale producers located in isolated rural zones, maize must be assembled in extremely small lots over an extensive area poorly served by transportation infrastructure, resulting in high assembly costs. In addition, maize grain stored for any length of time in Paraguay's humid climate must be dried and fumigated monthly with insecticide. Given these unavoidable cost components, Paraguay's maize marketing system compares favorably with grain marketing systems in other areas of the developing world.[4]

Table 4. Estimated marketing margins for yellow maize in Paraguay, April 1989

	Production zone	
	Alto Paraná	Itapúa
	(guaranis/kg)	
Farm gate maize price	60	70
Transport to Asunción	+ 22	+ 15
Camionero's margin	+ 18	+ 15
Wholesale price (Asunción)	100	100
Wholesaler's margin	+ 10	+ 10
Retailer's buying price (Asunción)	110	110
Retailer's margin	+ 10	+ 10
Retail price	120	120

Source: Field surveys, 1989.

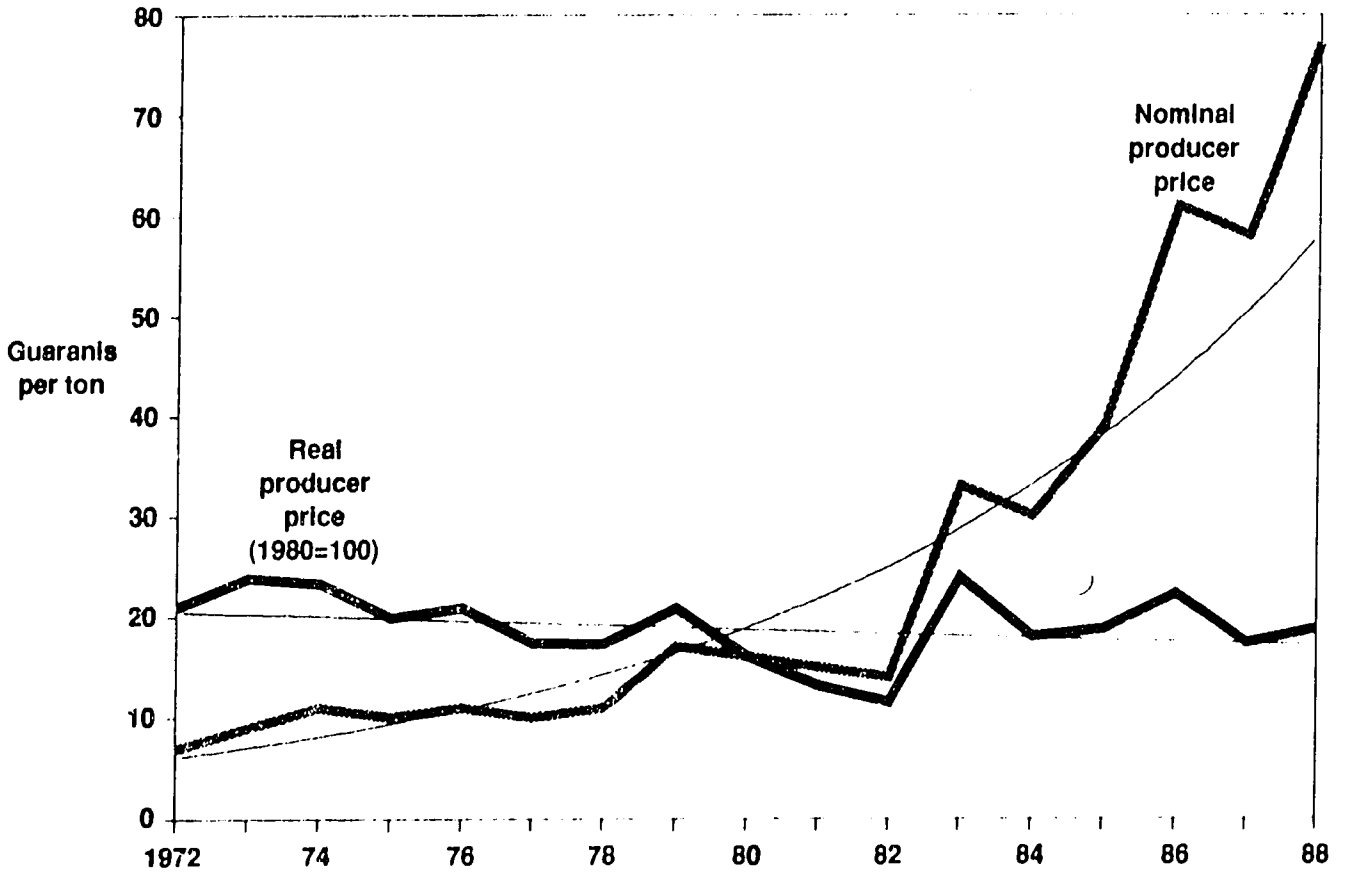
3 Because the market for white maize is limited and therefore difficult to observe, marketing margins for white maize were not formally estimated during this preliminary diagnostic survey.

4 See Ahmed, R., and N. Rustagi, "Marketing and price incentives in African and Asian countries: A comparison," in Eiz, D., *Agricultural Marketing Strategy and Pricing Policy: A World Bank Symposium* (Washington, DC: World Bank, 1985).

Maize prices

Maize prices in Paraguay are free to respond to market forces, since the government does not attempt to influence prices at either the producer, first assembler, wholesaler, or consumer levels. Maize prices therefore fluctuate in response to supply and demand conditions, both seasonally and from one year to the next.

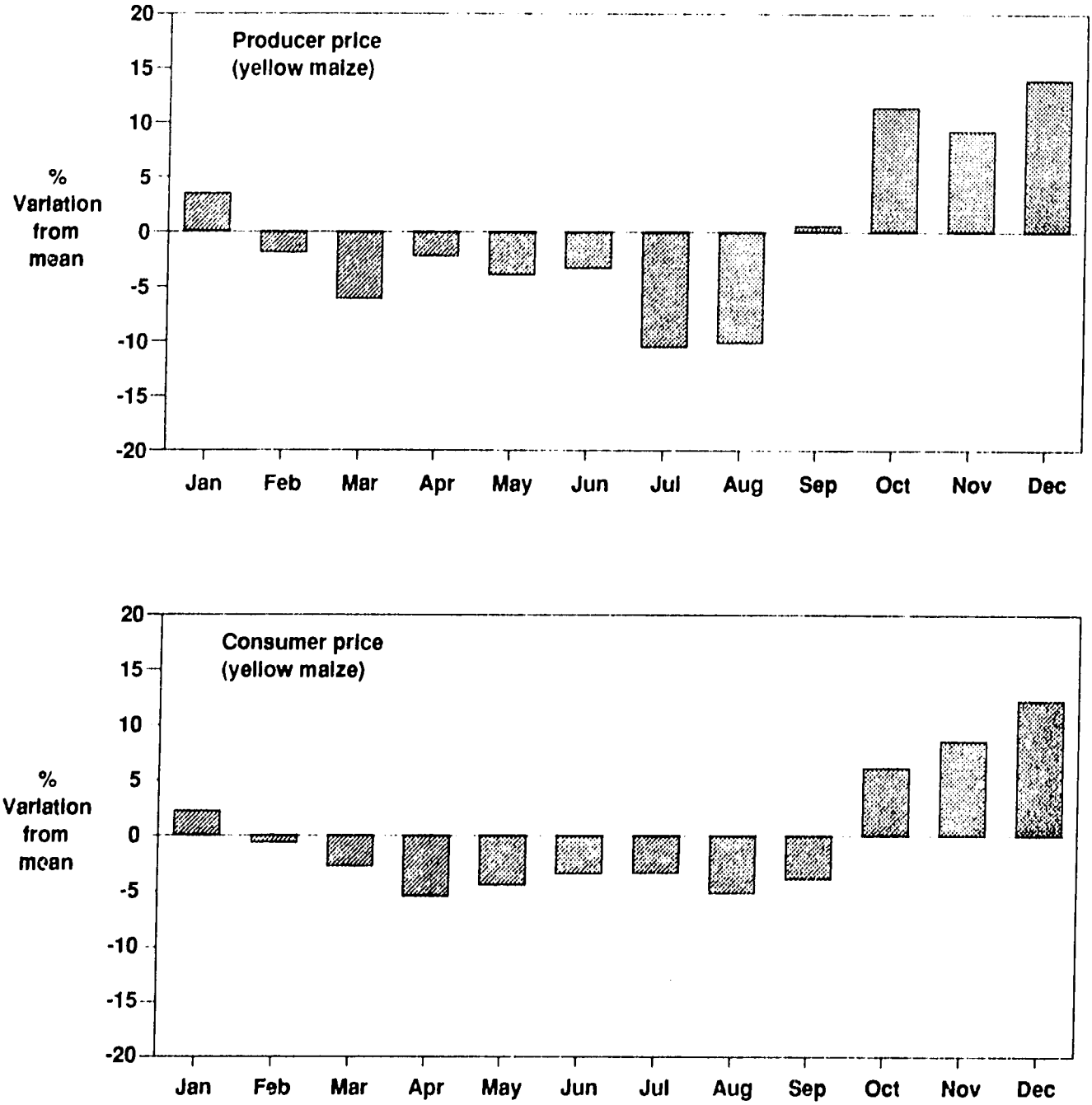
Average annual maize producer prices in Paraguay have been relatively stable over the long term. Since 1970, nominal producer prices have risen considerably, but real producer prices (i.e., adjusted for inflation) have moved around a relatively flat trend line (Figure 8). Year-to-year variability in real producer prices has been modest in percentage terms, exhibiting a coefficient of variation around trend of 18%. (In comparison, during the same period the international reference price of maize exhibited a CV of 23%.) Surprisingly, the CV for the producer price of maize was actually lower than the CVs for the producer prices of soybeans (28%), wheat (20%), cotton (25%), and manioc (23%). The empirical evidence thus indicates that maize prices have actually been more stable through time than prices of competing commercial crops.



Source: Calculated from MAG price date.

Figure 8. Long term movements in nominal and real producer maize prices in Paraguay, 1972-88

But if maize prices have been relatively stable from one year to the next, this is less true within each year. Monthly price data from MAG reveal a seasonal pattern in maize prices at both the producer and consumer levels (Figure 9). This pattern is consistent with the normal production cycle. Maize prices typically drop during the course of the harvest, reaching their lowest levels in the months following the completion of the soybean harvest when the bulk of the maize crop that has been left standing in the fields is harvested and brought to market (July and August). Maize prices then rise throughout the rest of the year as supplies

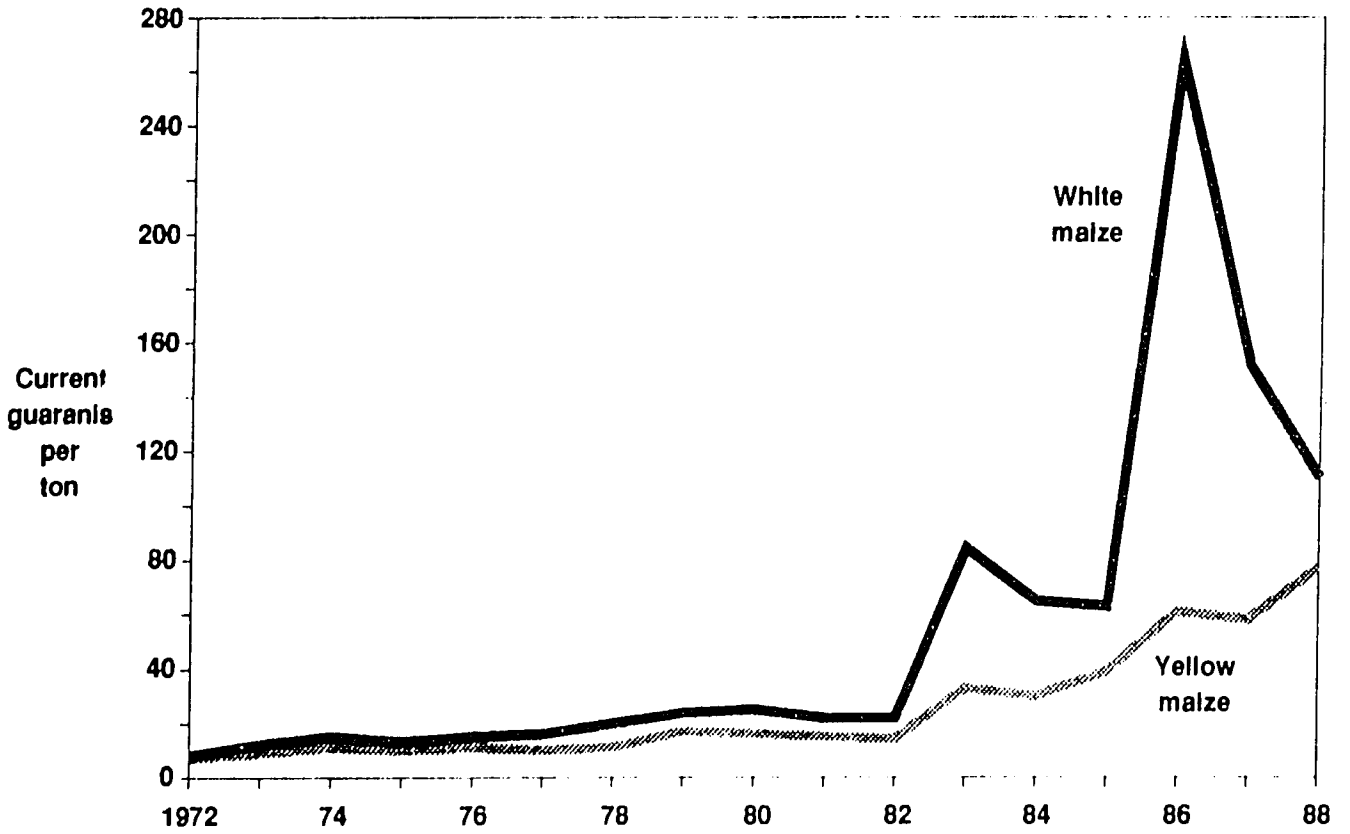


Source: Calculated from MAG price date.

Figure 9. Seasonal movements in maize prices, 1970-88.

become more scarce, peaking in the months immediately prior to the start of the harvest (December and January). Although price fluctuations at the producer and consumer levels are similar in absolute size, when expressed in percentage terms the seasonal variability in producer prices (25% difference between highest and lowest prices) is more extreme than the variability in consumer prices (18% difference), since producer prices are lower than consumer prices. By global standards this level of variability cannot be considered unusually high; seasonal fluctuations in maize prices of 50% or more are common throughout much of the developing world, particularly in humid tropical regions where storage problems are present.

Most of the maize marketed in Paraguay is yellow maize destined for use as animal feed. However, a small portion of marketed maize consists of white maize used in preparing special dishes (probably on the order of 10% or less). As shown in Figure 10, in recent years white maize has begun to command a significant premium in the market, especially when supplies are scarce (as in 1986, when drought decimated the white maize crop). Although little or no research has been done on the economics of white maize in Paraguay, presumably the price premium compensates producers for the lower yields of white maize. Marketing agents may also require additional compensation for the extra costs involved in handling white maize, which must be stored and transported separately from other grain types.

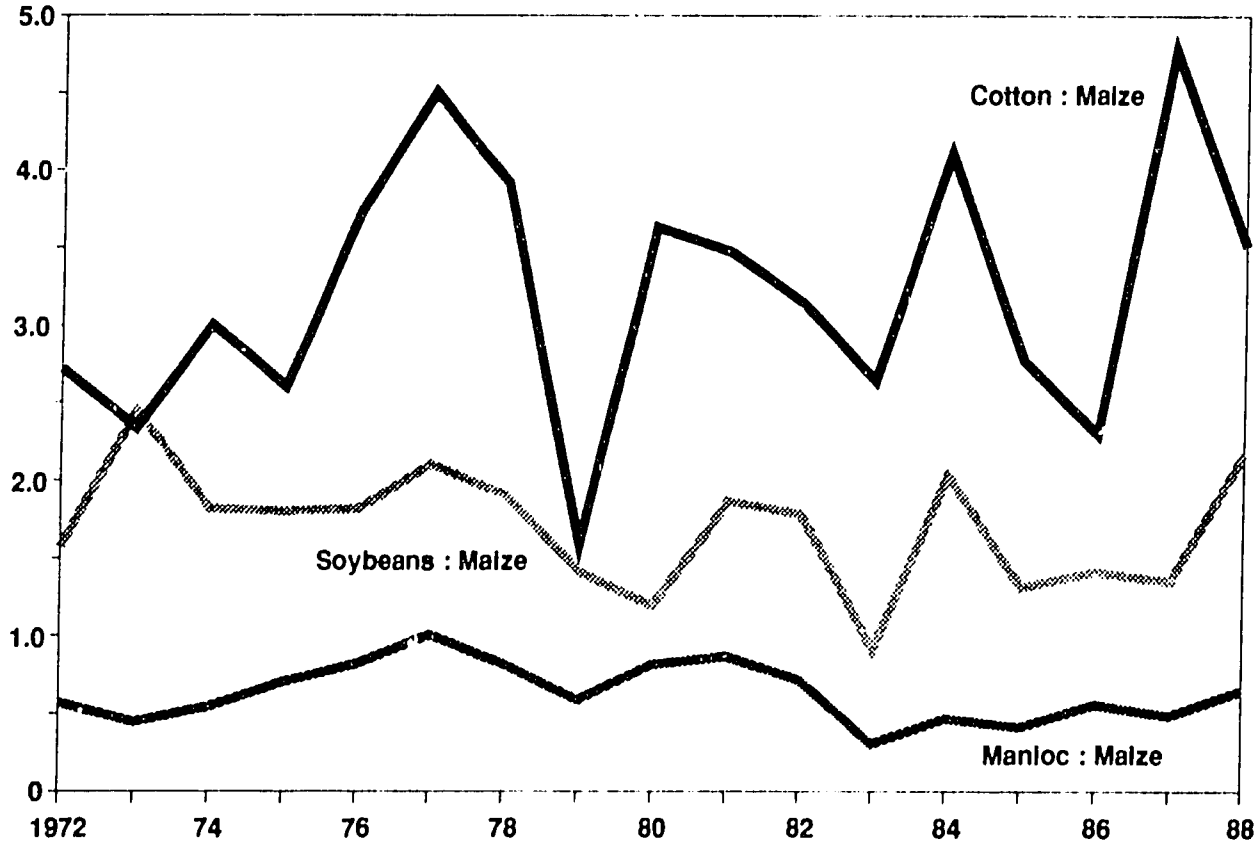


Source: Calculated from MAG price date.

Figure 10. Relationship between yellow and white maize prices in Paraguay, 1972-88.

How has the price of maize fared compared to prices of alternative crops? A comparison of maize producer prices with producer prices of the main alternative crops--soybeans, cotton, and manioc--fails to reveal a long term trend in relative price movements. Price ratios have varied from year to year (particularly the cotton-to-maize price ratio), but the overall trends are flat (Figure 11). This suggests that changes in relative prices have neither encouraged nor discouraged maize production during the past two decades. However, maize yields have increased more slowly than yields of soybeans and cotton, so the relative profitability of maize may have declined despite the lack of change in relative producer prices.

When considering producer price incentives in Paraguay, it is important to consider the effect of price signals emanating from neighboring countries. Paraguayan farmers naturally seek the most profitable market outlet for their crops, which in many years lies across the border in Brazil or Argentina. Two factors determine the relationship between producer prices in Paraguay and producer prices in Brazil and Argentina: the levels of producer prices in domestic currency terms in each of the three countries, and the exchange rates used to convert between the three currencies. During the past two decades, both the Argentinian and the Brazilian economies have experienced high inflation and rapid currency devaluations. These developments dramatically affected relative producer prices for maize between the three countries, creating strong incentives at times for farmers to seek market outlets in neighboring countries.



Source: Calculated from MAG price date.

Figure 11. Long term movements in ratios of producer prices of maize and competing crops, 1972-88.

In the absence of reliable data on the movement of nonregistered agricultural commodities across Paraguay's borders with Brazil and Argentina, it is difficult to say what the net effect of such trade has been on maize. However, it is well known that in some years when the producer prices differ greatly, the flow of agricultural commodities across the borders becomes substantial. Feed millers and poultry producers in Paraguay indicated that they do not hesitate to procure maize from Argentina and Brazil when it is not available from local sources.

Marketing constraints

In evaluating the efficacy of the maize marketing system, one additional factor should be noted. Many of the maize producers interviewed indicated that market outlets are frequently not available for maize during the post-harvest period. Because of high storage costs and limited storage facilities, few feed mills and poultry producers take advantage of low post-harvest prices to purchase large quantities of maize for long term storage. As a result, producers say they are often forced to retain surplus production for sale later in the year, when marketing opportunities once again become available. This can be costly, because the subsequent rise in maize prices does not always compensate producers for high storage costs (if they fumigate) or for storage losses (if they do not fumigate). Most of the producers interviewed contrasted the market for maize with the markets for soybeans and wheat, crops for which there is always fierce competition from commercial grain elevators.

This alleged marketing constraint could not be verified during the reconnaissance surveys. A formal longitudinal survey of producer grain transactions would be necessary to determine whether or not reliable market outlets do in fact disappear during the post-harvest months. If the allegation is correct, however, the implication is that the maize producer prices reported above are not always available, and that maize therefore is a more risky crop than soybeans and wheat.

Profitabillity of Maize and Other Principal Crops

Importance of profitability analysis

Researchers in Paraguay have been dismayed by farmers' apparent lack of interest in adopting improved maize production technology. Trials carried out both on-station and in farmers' fields have demonstrated that maize yields can be raised significantly with relatively simple innovations, such as the adoption of improved germplasm, use of fertilizer, improvements in weed control, or more timely harvesting (Table 5). Despite this experimental evidence, farmers apparently have been reluctant to change their practices. The problem does not seem to be one of lack of information, since the same farmers use improved practices on other crops.

When questioned directly, farmers attribute their lack of interest in maize to its low profitability relative to soybeans and cotton. Maize prices are said to be relatively low and highly variable, and demand for maize is said to be limited in the absence of a well-developed export market. Many farmers describe having encountered difficulties in finding a buyer for maize, especially during the post-harvest period, and some claim to have sold maize at a loss in order to avoid losing the entire crop from spoilage.

These assertions by farmers indicate the critical importance of determining the profitability of maize in Paraguay compared to alternative crops. Enterprise budgets were therefore developed to estimate the relative profitability of maize vs. alternative crops. The purpose of the profitability analysis was to determine current profitability rankings and to estimate the likely effect of possible future changes in technology and prices.

Table 5. Maize yields (kg/ha) obtained with improved technologies (single-factor effects)

Variety	Farmer practice	Nitrogen fertilizer	Timely planting	Weed control
Local	1,299	--	--	-
Improved open-pollinated variety	1,689	3,370	2,195	2,450
Hybrid	2,338	5,610	4,910	4,020

Source: DIEAF Maize Program.

Enterprise budgets

Two sets of enterprise budgets were developed to assess the profitability of maize compared to alternative crops. One set of budgets represents the cropping choices facing large scale commercial farmers (maize vs. soybeans, with winter wheat included for comparison). The second set of budgets represents the cropping choices facing smallholders (maize vs. cotton vs. manioc).

Technical coefficients for the large scale producer budgets were obtained from the crop budgets published by the Colonias Unidas cooperative. Technical coefficients for the smallholder budgets were obtained from the crop budgets published by the extension service (SEAG). All technical coefficients were verified and where necessary adjusted by means of farmer interviews conducted in two representative maize production zones (Itapúa and Alto Paraná). Prices of machinery and purchased inputs were obtained by visiting input distributors located in the major production zones. Additional information on land rental charges, machinery costs, animal traction costs, and wage rates were obtained through interviews with farmers, extension agents, and researchers. The complete enterprise budgets appear in Appendices A and B.

Profitability measures

Large scale commercial producers

Of all the crops produced by large scale commercial farmers, soybeans are by far the most profitable, generating net returns to land and farmers' management of G 148,131/ha. Maize trails at a considerable distance, generating net returns of G 96,357/ha. For purposes of comparison, wheat generates a modest G 26,617/ha. (However, it should be recalled that wheat is grown during the cool winter months when no other field crops are grown.) It is interesting to note that in absolute terms maize is hardly unprofitable; in fact, maize generates nearly four times as much net revenue per hectare as wheat. However, since maize is grown during the summer cycle when it must compete with soybeans for land and other resources, it remains *relatively* unattractive to commercial farmers.

In view of the low relative profitability of maize, the question logically arises of why commercial farmers even grow maize in Paraguay. During the informal reconnaissance survey, most large scale producers readily acknowledged that maize is rarely viewed as a viable commercial crop; rather, maize is planted as a source of feed to be used on the farm. Only a few commercial farmers holding contracts for seed production (at a guaranteed price significantly above the usual post-harvest price) considered maize an attractive commercial crop.

Smallholders

Of all the crops produced by smallholders, cotton is most profitable, generating net returns to land and farmers' management of G 169,278/ha. Manioc follows in profitability, generating net returns of G 142,367/ha. Maize produced using animal traction technology (the most common maize production technology) generates negative net returns of G -19,882/ha, which explains why so few smallholders plant maize as a cash crop.

Sensitivity analysis

Effects of changes in producer prices

Given the open nature of the Paraguayan economy, movements in world commodity prices are transmitted rapidly to the domestic producer price level. In recent years, this openness has enabled Paraguayan producers to benefit from favorable prices for the main export crops, soybeans and cotton. However, the openness of the economy at the same time implies a risk, because Paraguayan producers are vulnerable to possible downward movements in world commodity prices.

How much would output prices have to change before the current profitability rankings would be altered? Producer prices for maize, soybeans, cotton, and manioc were varied to determine the robustness of the current profitability rankings under possible changes in prices. No assumption is made about the causes of these price changes, which could originate from numerous sources (e.g., changes in world market conditions; changes in the cost of transporting Paraguayan commodities to world markets; changes in supply and demand conditions inside Paraguay; changes in supply and demand conditions in Brazil or Argentina; changes in official producer price policies in Paraguay, Brazil, and/or Argentina; and macroeconomic policy developments affecting the exchange rates between the guarani, the austral, and the cruzeiro).

Table 6 shows the profitabilities of maize, soybeans, wheat, cotton, and manioc (measured as net returns to land) assuming a range of percentage changes in maize producer prices. Maize being a low value crop, its price must increase significantly in percentage terms for maize to overtake competing crops in absolute profitability. In the case of large scale producers, the maize producer price would have to rise 17.5% above current levels for maize to equal soybeans in profitability. In the case of smallholders, an even larger change in relative prices would be necessary to affect the position of maize in the current profitability rankings. The maize producer price would have to increase 18% simply for maize to become profitable under animal traction production technology, and it would have to increase 245% and 270% over current levels for maize to equal manioc and cotton in profitability.

Effects of changes in production technology: Full budget approach

The relative profitabilities of Paraguay's major crops would also be affected by technological change leading to higher productivity. Using the previously developed enterprise budgets, technical change can be modeled in two ways: through enhanced yield at a given level of production costs, or as reduced production costs at a given level of yield. These two approaches are equivalent, although they permit us to think about the problem slightly differently, depending on the type of innovation under consideration. For example, a crop breeder might think about the yield increases at a given level of production costs which might be achieved with improved germplasm, whereas an agronomist might think about the cost savings at a given yield level which might be achieved through more efficient crop management practices.

How much would maize productivity have to rise before the current profitability rankings would be altered? Increased productivity in maize was modeled by increasing maize yields at the current level of production costs. Table 7 shows the relative profitabilities of maize vs. competing crops assuming a range of percent-

age changes in maize yields.[5] Since some production costs vary as a function of yield (e.g., harvesting costs, post-harvest transport and processing costs), net profitability is not as sensitive to changes in yields as to changes in prices. As expected, maize yields would have to change significantly in percentage terms for maize to overtake competing crops in absolute profitability. In the case of large scale commercial farmers, maize yields would have to increase 27% for maize to equal soybeans in profitability. In the case of smallholders, maize yields would have to increase 285% and 315% for maize to equal manioc and cotton in profitability.[6]

Table 6. Sensitivity of maize profitability (guaranis/ha) to price changes

a) Large scale producers

Net returns at:	Maize	Soybeans	Wheat
25% price decrease	21,358		
10% price decrease	66,358		
5% price decrease	81,358		
Current price	96,358	148,310	26,617
5% price increase	111,358		
10% price increase	126,358		
25% price increase	171,358		

Maize price would have to increase 17.5% for maize net returns to equal soybean net returns.

b) Smallholders

Net returns at:	Maize	Cotton	Manioc
25% price decrease	-48,007		
10% price decrease	-31,132		
5% price decrease	-25,507		
Current price	-19,882	169,278	142,368
5% price increase	-14,257		
10% price increase	- 8,632		
25% price increase	8,243		

Maize price would have to increase 245% for maize net returns to equal manioc net returns.
Maize price would have to increase 270% for maize net returns to equal cotton net returns.

5 The sensitivity analysis reported in Table 7 assumes no change in the price of maize, i.e., perfectly elastic demand. While this assumption is realistic if domestic demand continues to increase rapidly and/or if exports occur, the assumption would not hold if production increases saturate a limited domestic market and lead to lower prices.

6 Although these yield increases seem large when expressed in percentage terms, they represent an increase to a yield level only slightly above yields currently achieved by commercial farmers.

Effects of changes in production technology: Partial budget approach

Simply varying yield at a given level of production costs is not always a very realistic way to model technological change, since technological innovations usually involve changes not only in yields, but also in production costs. For farmers, the important question is whether the expected yield increase justifies the additional investment required to adopt a new technology. This is certainly the case in Paraguay, since most of the yield enhancing technological innovations identified by researchers (e.g., use of improved germplasm, increased use of nitrogen fertilizer, chemical weed control) involve additional expenditures.

Table 7. Sensitivity of maize profitability (guarnais/ha) to yield changes

a) Large scale producers

	Maize	Soybeans	Wheat
Current yield	4 t/ha	2.5 t/ha	2 t/ha
Net returns at:			
Current yield	96,358	148,310	26,617
5% maize yield increase	106,228		
10% maize yield increase	116,098		
15% maize yield increase	125,959		
20% maize yield increase	135,836		
25% maize yield increase	145,693		

Maize yield would have to increase 27% for maize net returns to equal soybeans net returns.

b) Smallholders

	Maize	Cotton	Manioc
Current yield	1.5 t/ha	1.8 t/ha	18 t/ha
Net returns at:			
Current yield	-19,882	169,278	142,368
5% maize yield increase	-15,485		
10% maize yield increase	-11,088		
15% maize yield increase	- 6,691		
20% maize yield increase	- 2,294		
25% maize yield increase	2,103		

Maize yield would have to increase 285% for maize net returns to equal manioc net returns.
Maize yield would have to increase 315% for maize net returns to equal cotton net returns.

A better method for evaluating the profitability of a technological innovation is the partial budget approach, in which the marginal returns achieved though use of a new technology are compared to the marginal costs of adopting the technology. Partial budgets are conventionally calculated using data obtained from on-farm trials, so that the profitability of the new technology can be established under farmer's actual conditions.[7]

Beginning in 1986, the DIEAF Maize Program initiated on-farm research designed to evaluate the profitability in farmers' fields of improved maize production technologies. Trials were planted in 10 locations distributed across all three maize production zones (A, B, and C) to assess the profitability of improved technologies previously identified through experiment station research (e.g., improved varieties, inorganic fertilizer, optimal plant density, and chemical weed control). Preliminary analysis of the trial data generated mixed results. Use of the improved variety Guarani-312, especially when combined with optimal plant spacing, was found to be profitable in some but not all locations. Fertilizer use was found to be unprofitable, as the unfertilized treatment generated the highest net returns (Table 8). Chemical weed control was found to be extremely profitable, as evidenced by high marginal rates of return to the incremental investment in herbicides and labor to apply them (Tables 9a and 9b).

Table 8. Profitability of fertilizer use on maize in on-farm trials, Santani and Chore zones, 1987

Treatment N - P - K	Adjusted yield (kg/ha)	Gross returns (guaranis/ha)	Costs that vary (guaranis/ha)	Net returns (guaranis/ha)
0 - 0 - 0	3,677	55,155	0	55,155
0 - 30 - 0	3,888	58,320	14,010	44,310 *
0 - 60 - 0	3,645	54,675	26,520	28,155 *
0 - 90 - 0	3,911	58,665	39,030	19,635 *
40 - 0 - 0	3,533	52,995	18,180	34,815 *
40 - 30 - 0	3,555	53,325	30,690	22,635 *
40 - 60 - 0	3,852	57,780	43,200	14,580 *
40 - 90 - 0	4,055	60,825	55,710	5,115 *
80 - 0 - 0	3,632	54,480	34,860	19,620 *
80 - 30 - 0	3,587	53,805	47,370	6,435 *
80 - 60 - 0	3,515	52,725	59,880	-7,155 *
80 - 90 - 0	3,681	55,215	72,390	-17,175 *
120 - 0 - 0	4,046	60,690	51,540	9,150 *
120 - 30 - 0	4,100	61,500	64,050	-2,550 *
120 - 60 - 0	4,275	64,125	76,560	-12,435 *
120 - 90 - 0	3,897	58,455	89,070	-30,615 *
120 - 90 - 50	3,618	54,270	105,470	-51,200 *
160 - 120 - 50	3,645	54,675	134,660	-79,985 *

* Dominated treatment.

Source: DIEAF Maize Program.

Table 9a. Profitability of improved weed control practices in on-farm trials, cooperative prices, Santani and Chore zones, 1987

Treatment	Adjusted yield (kg/ha)	Gross returns (guaranis/ha)	Costs that vary (guaranis/ha)	Net returns (guaranis/ha)
No weed control	4,082	285,740	0	285,740
Herbamina 720 (l)	4,677	327,390	7,400	319,990
Tordon 101 (l)	4,280	299,600	7,850	291,750 *
Herbamina 720 (h)	4,824	337,680	8,200	329,480
Tordon 101 (h)	4,917	344,190	9,750	334,440
Gesaprim + 2-4-D (l)	5,537	387,590	11,875	375,715
Gesaprim + Tordon (l)	4,783	334,810	11,925	322,885 *
One weeding	4,395	307,650	12,000	295,650 *
Gesaprim + 2-4-D (h)	5,362	375,340	12,563	362,777 *
Gesaprim (l)	5,462	382,340	13,252	369,090 *
Gesaprim + Tordon (h)	4,867	340,690	13,350	327,340 *
Gesaprim (h)	5,576	390,320	16,000	374,320 *
Two weedings	4,934	345,380	17,000	328,380 *
Primextra (l)	4,700	329,000	18,020	310,980 *
Weeding + weeding	4,932	345,240	19,500	325,740 *
Primextra (h)	4,212	294,840	21,275	282,565 *

(l) = Low level; (h) = high level; * = dominated treatment.

Source: DIEAF Maize Program.

Table 9b. Marginal rates of return for nondominated weed control treatments in on-farm trials, cooperative prices, Santani and Chore zones, 1987

Treatment	Costs that vary (guaranis/ha)	Marginal costs that vary (guaranis/ha)	Net returns (guaranis/ha)	Marginal net returns (guaranis/ha)	Marginal rate of return (%)
No weed control	0	--	285,740	--	---
Herbamina 720 (l)	7,400	7,400	319,990	34,250	463
Herbamina 720 (h)	8,200	800	329,480	9,490	1,186
Tordon 101	9,750	1,550	334,440	4,960	320
Gesaprim + 2-4-D	11,875	2,125	375,715	41,275	1,942

(l) = Low level; (h) = high level

Source: DIEAF Maize Program.

7 For a more complete description of the partial budget approach to evaluating new technologies, see *From Agronomic Data to Farmer Recommendations: An Economics Training Manual* (CIMMYT 1988).

Policy Implications

Even without incorporating risk considerations, the enterprise budgets support the view of many researchers that low maize production in Paraguay can be attributed not only to technological constraints, but also to insufficient economic incentives for producers. Before turning to a discussion of how research might help overcome some of the major remaining technological constraints, it is important to consider policy changes which could increase the expected profitability of maize production and thereby stimulate farmers to adopt improved germplasm and management practices.

Producer price policy

The enterprise budgets clearly support the claim made by farmers that maize is unprofitable compared to competing crops at current yields and prices. Sensitivity analysis shows that the low relative profitability of maize could be reversed by a significant increase in the producer price of maize. Such an increase could come about in several ways: 1) by an increase in the international price of maize; 2) by an increase in the producer price of maize in Brazil or Argentina; 3) by rising domestic demand for maize, combined with effective import restrictions; 4) by government intervention in the market to support maize producer prices in Paraguay; or 5) by government intervention in the market to increase marketing efficiency. These five alternatives imply very different types of producer price policies.

The first three alternatives--waiting for an increase in the international price of maize to be transmitted to the producer level, waiting for an increase in the producer price in Brazil or Argentina, or relying on rising domestic demand to push up producer prices--would imply a continuation of the government's current laissez-faire approach to producer price policy, in which supply and demand forces are allowed to determine producer prices for maize. The chief advantages of such an approach are that it allows agricultural production decisions to be determined by market signals, leading to more efficient allocation of resources in the economy, and that it is easy (and inexpensive) to administer. On the other hand, the disadvantage of a laissez-faire approach is that when international maize prices are low and domestic demand remains limited, Paraguayan maize producers will have no incentive to increase production, even though maize production might be desirable for nonefficiency reasons (e.g., diversification, national food security).

Alternatively, the government could abandon its laissez-faire approach and adopt a more active role in setting maize producer prices. Since improved technologies for maize are already available (and known to farmers), government intervention in the market to support maize producer prices would almost undoubtedly stimulate increased production, assuming prices were supported at a high enough level. However, the efficiency of such a strategy would have to be questioned. To begin with, the sensitivity analysis indicates that producer prices would have to rise substantially in order for maize to displace other crops (a minimum of 17% in the case of commercial farmers, and much more in the case of smallholders). This means that price supports would be costly to defend, especially since a significant rise in the producer price of maize in Paraguay would probably attract imports of maize from neighboring provinces of Brazil and Argentina. Furthermore, assuming that the government would have to purchase maize at the support price,

It is not at all clear how it would dispose of this grain. Since domestic demand is satisfied at current production levels and exports appear to be unprofitable given present production costs, any additional production elicited by price supports would have to be disposed through subsidies. Thus, any attempt by the government to stimulate maize production through direct price supports would be expensive and ultimately unsustainable.

However, the government could attempt to influence maize producer prices indirectly by increasing marketing efficiency, with the hope that cost savings would be transmitted to producers in the form of higher prices. Specific measures to increase marketing efficiency might include improving transportation infrastructure in maize production zones (to decrease assembly costs), investing in improved maize storage facilities (to reduce storage costs), and supporting market information services (to reduce information costs). Because such a strategy would not entail continuing direct support to maize producers over the longer term, it appears more feasible from a budgetary point of view and warrants careful consideration.

Market development activities

Direct grain exports

Many large scale producers assert they would be willing to plant maize as a commercial crop if a market outlet were assured. Several farmers suggested that market development activities be initiated for maize in much the same way as they were for soybeans. Paraguay's soybean industry emerged during the 1970s with the help of a comprehensive market development program that included government price supports, guaranteed market outlets, and extension of subsidized credit to producers while they learned how to grow what was then still a new and unfamiliar crop. These measures, designed to protect the "infant industry" during its early years, were gradually phased out as soybeans became established; today, price supports and guaranteed market outlets are no longer necessary (although exporting firms continue to provide generous levels of production credit at favorable rates).

Unfortunately, the type of market development program that succeeded in launching the Paraguayan soybean industry is unlikely to work for maize. Paraguay is a low cost producer of soybeans by global standards, so that once the learning phase was over and yields rose, Paraguayan soybeans could compete in world markets without the help of subsidies. In contrast, given current international prices and production costs, Paraguayan maize does not enjoy such a clear cost advantage in world markets. The export parity price for maize (i.e., the price at which Paraguayan producers would be competitive in world markets) now stands at around G 60,000/t, or approximately US$ 60/t (Table 10).

The export parity price of G 60,000/t compares to an estimated production cost of G 51,000/t for large scale commercial farmers and G 88,000/t for smallholders (calculated from the enterprise budgets as total cost of production per ton, exclusive of charges for land and farmer's management). While these figures suggest that commercial farmers in Paraguay are able to produce maize at a cost that is competitive with world prices, two factors must be taken into account in assessing the likely competitiveness of Paraguayan maize in international markets.

First, the estimated production cost figures do not include any charges for land or farmer's management. When charges for these factors of production are added, the cost of production rises above the export parity price. The enterprise budgets indicate that even when commercial farmers receive G 75,000/t for maize, returns to land and farmer's management used in maize production are lower than returns to the same resources used in soybean production.

Second, the calculation implicitly assumes that the quality of Paraguayan maize would be acceptable in world markets. Currently this is not the case, given the variable quality of Paraguayan maize and the frequent mixing of different grain types. Improving the quality of Paraguayan maize would presumably entail additional processing and handling costs which have not been taken into account in the present analysis.

Table 10. Estimated export parity price of maize in Paraguay, 1989

	US $/t	G/t
Maize price		
f.o.b. Rosario (Argentina)	115	115,000
Transport and handling		
Asunción to Rosario (Argentina)	-35	- 35,000
Maize price		
f.o.b. Asunción	80	80,000
Exporter's margin		
Asunción	- 7.5	- 7,500
Storage (including fumigation)	- 5.0	-5,000
Drying	- 5.0	- 5,000
Transport		
Farm gate to Asunción	- 2.5	- 2,500
Maize price at farm gate		
(Export parity)	60	60,000

Source: Author's calculations.

Meat exports

One major reason for the low export parity price of maize is that Paraguay is a landlocked country with limited access to the sea. This means that the high transport cost involved in delivering Paraguayan maize to world markets must be absorbed by Paraguayan producers if their grain is to be competitively priced. One possible strategy for overcoming this problem would be to export livestock fed on maize rather than the maize itself. While transport costs involved in gaining access to world meat markets would still be considerable, the high unit value of livestock products would reduce the size of transport costs as a percentage of total value, thus lessening the problem.

The potential for increasing exports of livestock--specifically, livestock fed on maize--was not evaluated as part of the present study. While Paraguay has traditionally been an exporter of range-fed beef, exports of maize-fed livestock (beef, pork, or poultry) have been negligible. Assessing the likely profitability of developing an export market for maize-fed livestock would require a detailed feasibility study focusing not only on world market opportunities, but also on production cost issues that at present remain somewhat speculative.

Marketing regulations

One way to increase the producer price of maize--and thus the profitability of maize production--might be to improve grain quality. Many industrial users of Paraguayan maize express dissatisfaction with grain quality. Major criticisms concern the inconsistent color (caused by mixing of different grain types), variable moisture content, and high levels of foreign matter. Although the government publishes grain quality standards, these are not strictly enforced. Excessively moist grain is sometimes discounted by assemblers, but producers generally accept the lower price since they are usually in a hurry to dispose of surplus maize before the beginning of the soybean harvest and in any event lack on-farm drying facilities. Feed millers in turn discount moist grain purchased from assemblers, but the assemblers can absorb the discounted price because they paid a lower price for the grain in the first place (leaving their margin largely unaffected). Few assemblers find that it pays to dry maize before reselling.

As long as most marketed maize is used in the domestic feed industry, quality considerations are not critical, since feed producers are able to use grain of variable quality. However, should efforts be initiated to develop an export market, grain quality will become extremely important if Paraguayan maize is to compete with maize produced in neighboring Brazil and Argentina. This would require the establishment and enforcement of strict quality standards concerning grain type, color, humidity level, and cleanliness. However, the exporting firms themselves could be expected to enforce quality standards, since it would be strongly in their interest to do so. Thus, while grain quality standards could become increasingly important in the future as the maize market develops, extensive government participation in such activity would probably not be necessary.

Seed production and control of germplasm

The current system for producing and distributing maize seed poses a constraint to the dissemination of improved germplasm in Paraguay. Since the market for maize seed is limited, neither the public nor private sector has made a concerted effort to develop effective seed production and distribution capacity. As a result, producers cannot always obtain sufficient quantities of seed, and they frequently plant seed of poor quality or inappropriate characteristics.

Large scale commercial farmers plant primarily open pollinated varieties (OPVs) using seed saved from the previous harvest. They may also purchase maize seed from private seed companies or from SENASE, the national seed company. A small number of commercial farmers (accounting for approximately 20% of total maize area) plant hybrids using seed purchased from private seed companies (e.g., Cargill, CEIBA-GEIGY, Pioneer, Dekalb). Since many of these companies do not maintain research and production facilities in Paraguay, they sell materials developed primarily for use in Brazil and Argentina--materials which are not always appropriate for Paraguay. Many large scale commercial farmers claim that hybrid seed is frequently unavailable in Paraguay, with the result that they regularly travel to Brazil to purchase hybrid seed. This expense of course adds to maize production costs.

Most smallholders plant unimproved materials using seed saved from the previous harvest. Smallholders who plant improved materials obtain seed from SENASE, which sells certified seed produced on MAG experimental stations or grown by private farmers registered as seed producers. Maize has never been a top priority for SENASE, which concentrates on commercially more important crops, and sufficient quantities of maize seed are not always produced. Often when maize seed is unavailable from SENASE, private traders appear in the production zones selling seed that is supposedly certified and treated with fungicide. Farmers have learned through bitter experience to mistrust these traders, many of whom sell low quality seed or seed of unknown origins (often unimproved local materials) that has been dusted with red powder to give the appearance of having been treated with insecticide.

The shortcomings of the seed production and distribution system serve to undermine the efforts being made to develop and disseminate improved maize materials. Farmers have difficulty obtaining improved seed, and even when they do manage to obtain improved seed, often this seed is not what it is supposed to be. Many farmers describe having purchased "improved" seed that turned out to be of extremely poor quality, and they understandably express reluctance to engage in further experimentation with unfamiliar new varieties.

If improved maize materials being developed in the national breeding program are to be disseminated successfully to farmers, especially to smallholders who cannot afford to incur the additional costs involved in travelling long distances to buy reliable seed, measures will have to be taken to improve the seed production and distribution system. Seed production activities currently being carried out by SENASE, MAG, and private producers (including cooperatives) will have to be better coordinated to ensure matching of supply and demand. Of critical importance will be the implementation of an effective seed certification procedure, so that farmers can be assured that they are actually obtaining the materials they require.

Implications for Research

This preliminary diagnostic overview of the maize subsector in Paraguay supports the view of many researchers that low maize yields are caused by a combination of technical and economic constraints. Some of the economic constraints probably can be alleviated by policy reforms (e.g., lack of grain quality standards), while others probably cannot (e.g., low international maize prices). Meanwhile, the remaining technical constraints will require technological solutions generated by the research system. Three key issues can be distinguished which will need to be addressed by research managers before a long term research agenda for maize can be formulated.

Importance of maize vs. alternative crops

In considering maize research in Paraguay, perhaps the most basic issue facing policy makers concerns the appropriate level of funding which should be allocated to maize vs. alternative crops. The issue is not a simple one, considering the political importance of maize as a subsistence crop grown by smallholders. In terms of commercial importance, maize is still a minor crop in Paraguay, which might suggest that it be assigned relatively low priority in the research agenda. However, at least five arguments can be made in favor of allocating public sector research resources to maize:

1. Maize is a very important crop for the vast majority of the nation's smallholders, grown for use both as food and as feed.[8] Even if maize is not a major commercial crop, increasing the productivity of resources devoted to maize production will allow smallholders to free up land, labor, and/or capital to devote to other productive activities on and off the farm. Given the government's desire to improve the welfare of the rural population by raising incomes and improving nutritional status, maize is an obvious candidate for government research support.

2. Because of its relative lack of commercial importance, maize is unlikely to receive serious attention from private sector research firms, at least in the short run. While private companies have been quick to invest research resources into export crops, they have largely ignored maize due to the limited prospects for an immediate return on their investment. Therefore, if the public sector does not engage in maize research, little research is likely to get done unless maize increases in importance as a commercial crop (either for domestic feed use or for export). This is not to say that public sector investment will necessarily be unprofitable; on the contrary, the payoff over the long run may be considerable.

8 Little or no empirical work has been done in Paraguay to quantify the nutritional importance of maize in rural diets. Therefore, the percentage of calories contributed by maize remains subject to speculation.

3. Currently maize is a minor commercial crop, but it could conceivably become more important in the future. At present, Paraguayan maize is not able to compete on a regular basis with maize produced in Argentina and Brazil, not only in global maize markets but sometimes even in the domestic market. However, the situation could change. Productivity increases made possible by technological change could lead to significantly lower production costs, which along with improvements in grain quality could make Paraguayan maize competitive on world markets. Achieving such productivity increases will involve the adoption of new technologies, including hybrid materials which have yet to be developed.

4. Limited export possibilities may become available sooner than anticipated. The idea has been raised of negotiating long term bilateral trade agreements involving maize and other commodities with countries which have expressed a desire to support Paraguay's economic development (e.g., Japan, Taiwan). In addition to opening up new markets for Paraguayan products, an important advantage of such an arrangement would be to allow diversification away from Paraguay's current dependence on only two main export crops--soybeans and cotton. The likelihood of concluding long term bilateral trade agreements involving maize would depend in part on the cost of production, which can be influenced by research investments.

5. Maize may eventually gain in importance for agronomic reasons. Because the soybean-wheat rotation is still relatively new in many areas of Paraguay, little is known about the long term effects of this rotation on soil structure and fertility. However, there are signs that continuous cropping with soybeans and wheat may be leading to soil compaction problems and declining levels of soil organic matter. Should these problems intensify, maize may eventually provide an alternative crop which will enable farmers to break the continuous soybean-wheat rotation in order to improve soil structure and organic matter content.

Importance of different types of maize research

Within the DIEAF Maize Program, an important research planning issue concerns the proportion of resources which should be devoted to different types of research. The choice can be framed in terms of the emphasis given to crop improvement research (i.e., plant breeding) vs. crop management research (i.e., agronomy, pathology, pest control) vs. economics research. The issue is particularly pressing because given the modest resources of the Maize Program, it is impossible to fund all types of research at desirable levels.

Crop improvement research

Crop improvement activities currently carried out in Paraguay consist primarily of screening imported germplasm obtained from both public and private sector breeding programs (i.e., CIMMYT, national programs, private seed companies). In addition, a modest breeding effort is being made to adapt selected materials for release within Paraguay as products of the national research system. In planning for the future, Maize Program administrators must decide whether the resources allocated to crop improvement activities should be expanded, maintained at current levels, or decreased.

What economic criteria can be invoked to help determine the optimal level of investment in crop improvement research? Recent theoretical work on the economics of plant breeding programs is of possible relevance in addressing this question. Brennan[9] has developed a simple model to determine the economic relationship between costs and expected returns from a plant breeding program, with particular emphasis on small countries like Paraguay. Brennan's work has showed that the expected returns to investment in a plant breeding program depend on four key parameters: the amount of production likely to be affected by the program, the expected yield gain, the distribution though time of costs and returns, and the total cost of the program (which depends on the type of research carried out, the availability of facilities, the availability of skilled breeders, etc.). Brennan's work indicates that as the amount of expected production changes, increasingly sophisticated (and expensive) breeding programs are justified (Table 11).

The crop improvement activities currently being carried out by the DIEAF Maize Program place it somewhere between the second and third stages in this sequence--the primary emphasis is on screening imported materials, with limited attention to adaptive breeding. Given that maize production in Paraguay is currently estimated at around 1 million tons, these types of activities would appear to be consistent with Brennan's estimate for threshold production levels. Although development of new lines is difficult to justify, work on nonconventional hybrids--a much more modest undertaking--is currently being considered. Such work would benefit greatly from the close links which have been established between the DIEAF Maize Program and CIMMYT, since inbred lines developed at CIMMYT headquarters in Mexico would provide a ready source of improved germplasm to feed into the national breeding program. It is interesting to note that work on nonconventional hybrids recently has been launched in Guatemala and El Salvador, two countries which resemble Paraguay in the size and structure of their maize subsectors.

Table 11. Approximate threshold production levels needed to justify different maize breeding activities.

Maize production (000 t)	Maize breeding activity justified
< 168	Breeding program not justified
168 - 284	Screening of imported materials justified
285 - 1,000	Adaptive breeding justified
1,000 - 1,610	Development of nonconventional hybrids justified
> 1,610	Development of new lines justified

Source: Brennan (forthcoming).

9 Brennan, J.P., "Economic criteria for the establishment of a plant breeding program," (CIMMYT Economics Working Paper, forthcoming, 1991).

Crop management research

Crop management research currently being carried out in Paraguay includes land preparation trials, fertilizer trials, weed control trials, insect control trials, date of planting trials, spacing trials, and intercropping trials. This work is being done both on experiment stations and farmers' fields. As in the case of crop improvement research, Maize Program administrators are faced with deciding whether the resources allocated to crop management research should be expanded, maintained at current levels, or decreased.

Although little formal analysis has been done on the economics of crop management research, presumably the returns are determined by the same key parameters which apply to plant breeding. Given that research facilities are already in place at Caacupé and Encarnación and that competent scientists are currently available to carry out both types of research, the cost structures of breeding and crop management research in Paraguay are likely to be similar. This means that the economics of plant breeding and crop management research are likely to differ, if at all, in terms of two key parameters--expected yield gains, and distribution through time of research costs and returns.

How are expected yield gains from plant breeding likely to compare with expected yield gains from crop management research for maize in Paraguay?

In view of the low yields currently achieved in farmers' fields, considerable yield gains could be expected in the short run through relatively simple changes in management practices (e.g., use of fertilizer, weed control, planting density). This would argue in favor of continued attention to crop management research. On the other hand, some researchers have pointed out that the improved management practices are already well known, and that additional research is not required--what is required is improved economic incentives which would make it profitable for farmers to use technology which is already "on the shelf."

Similarly, in view of the continuing widespread use of unimproved materials, it is logical to assume that considerable yield gains could also be achieved in the short run through dissemination of improved germplasm. This would argue in favor of continued attention to crop improvement research. On the other hand, it has been suggested by some researchers that improved germplasm has already been developed, and that additional research is not required--what is required is an effective seed production and distribution system capable of delivering the improved varieties to farmers.

In considering these issues, it is important to remember that available data on current farmer practices, including data on the use of improved germplasm, are highly unreliable. There would thus appear to be a clear need to conduct a comprehensive farm level survey to improve the knowledge base in this area.

Economics research

The DIEAF Maize Program does not include economists among its full time staff. Perhaps for this reason, economics research has never been considered a priority. Given the lack of knowledge about the profitability of the new technologies being developed, this would appear to be a serious shortcoming. While appointment of a full time economist to the Maize Program staff is probably not justified, it is certainly worth considering how economists working elsewhere within DIEAF could be involved more actively in the Maize

Program's plan of work. At the very least, economists should participate in farm survey work designed to determine current production practices and identify key constraints, which will help breeders and crop management researchers better to orient their technology development efforts. In addition, economists should participate in the planning and implementation of on-station as well as on-farm trials, so that economic analysis can be performed on the experimental data to determine the profitability of the new technologies being developed.

Importance of different types of maize germplasm

The third key planning issue concerns the proportion of resources used for crop improvement work which should be devoted to different types of germplasm--hybrids vs. OPVs, yellow materials vs. white materials, flints vs. dents. In order to ensure that DIEAF resources are utilized efficiently, the final allocation of resources should be determined both by demand-side factors (what is the demand for each type of germplasm?) and supply-side factors (who are the potential alternative suppliers of the various types of germplasm?).

Demand for different types of maize germplasm is difficult to estimate with precision, since no comprehensive farm level surveys have been carried out to determine what farmers are currently planting. Direct sampling at the farm level will probably be necessary, since secondary sources of information (e.g., commercial seed sales data) are likely to be incomplete given the large amounts of seed that are imported informally from Brazil and perhaps Argentina. Casual observation suggests that farmers currently plant a wide range of germplasm types, but it is difficult to know whether this diversity really reflects farmers' preferences for different types of germplasm. Many farmers indicated that seed of preferred varieties is often unavailable, forcing them to plant whatever seed they can obtain.

Despite this complaint expressed by farmers, the supply of different types of germplasm is difficult to estimate in the absence of reliable data on seed production and sales. However, to the extent that private seed companies have a commercial interest in working in Paraguay, logically their primary focus will be on large scale commercial farmers, who regularly buy maize seed. This implies that the private sector will tend to focus on types of germplasm produced for the commercial market, i.e., primarily yellow flint materials suitable for feed use, both OPVs and hybrids. Private companies will have little interest in developing and promoting the white floury maizes planted by smallholders for home consumption, implying that there may be a role for the public sector in continuing to work with these materials.

In deciding the proportion of resources to allocate to different germplasm types, researchers may want to consider the potential advantages of concentrating on a limited set of materials. Commercial buyers in Paraguay often cite the inconsistent quality of maize grain offered for sale in the market, which frequently consists of mixtures of different grain types. The research system could conceivably contribute to the standardization of grades by restricting the number of varietal releases.

Summary and Conclusions

This preliminary diagnostic overview of the maize subsector in Paraguay has led to the following conclusions:

1. The maize subsector is poorly developed in Paraguay in the sense that current production levels are much lower than they could be.

2. The primary barrier to increased production is the low profitability of maize relative to alternative crops (soybeans, cotton, and manioc), rather than a lack of improved technology. However, this is not to say that technical constraints to production have all been overcome. Additional research is needed to develop improved germplasm and to identify management practices that can help farmers increase yields with little additional investment in inputs. This research must be complemented by sound economic analysis designed to determine the profitability of current and potential future production technologies.

3. The relatively low profitability of maize results from: a) limited demand in the domestic market, and b) low international maize prices (as well as high transport costs involved in delivering Paraguayan maize to the world market). As a result of these two factors, maize producer prices in Paraguay are low, making commercial maize production relatively unattractive.

4. Improved germplasm and management practices have been identified which have the potential to increase maize yields substantially in the short run, but these are not being adopted by many farmers. Systematic economic research has not been carried out to determine whether adoption of these new technologies would be profitable for farmers.

5. Economic policy reforms alone offer limited prospects for solving the problem of low profitability. Efforts to stimulate increased production by supporting the producer price of maize and/or by providing guaranteed market outlets are likely to create an unsustainable drain on government resources.

6. The marketing system does not appear to pose a major constraint to increased maize production. The well-developed private sector grain marketing system which handles primarily soybeans and wheat could accommodate increased amounts of maize. Grain exporters claim it would be easy to expand their maize trade, especially during the slack season between the end of the soybean marketing season and the beginning of the wheat marketing season.

7. Much of the domestic demand for maize is currently handled by an extensive informal marketing system comprising a large number of market participants and marketing channels. Preliminary analysis of seasonal and spatial price spreads provides strong circumstantial evidence that this informal marketing system works well, responding rapidly to market signals and moving grain from production zones to consumption points rapidly and efficiently.

8. Prospects for growth in export demand for maize are dim. Substantial increases in international maize prices would be necessary for Paraguayan maize to compete on world markets, given current production and transportation costs. On the other hand, long term bilateral trade agreements at concessionary terms negotiated as part of a development assistance program might provide more realistic opportunities for the development of a limited export market for maize.

9. Prospects for growth in domestic demand for maize are favorable. Expansion of the poultry industry has been increasing domestic demand for feed maize at a rate of approximately 10% per year. Demand for feed maize could grow even further as the result of the recent sharp acceleration in beef exports, which can be expected to raise domestic beef prices, thereby inducing consumers to shift into additional consumption of poultry and pork. Increased production of maize-fed livestock for export is another potential future source of domestic demand, although the economic feasibility of this option remains unknown.

10. The public sector has an important role to play in supporting maize research for three main reasons:

    a. maize is an important subsistence crop for the vast majority of the nation's smallholders;

    b. the private sector is unlikely to invest significant resources into maize research due to the modest commercial importance of the crop; and

    c. maize could conceivably become an important crop in the future as the result of decreased profitability of competing crops.

11. Three critical issues face agricultural research administrators:

    a. the resource allocation to maize vs. other crops;

    b. the resource allocation to different types of maize research (e.g., breeding vs. crop management vs. economics); and

    c. the resource allocation to different types of maize germplasm (e.g., OPVs vs. hybrids, yellow vs. white maize, flints vs. dents).

Recommended Follow-up Research Activities

This preliminary diagnostic survey of the maize subsector in Paraguay has identified a number of important gaps in the knowledge base. Since it is difficult to identify research priorities without a clear understanding of farmers' circumstances, DIEAF Maize Program researchers must decide which of these gaps, if any, warrant immediate attention. Three possible follow-up research activities would appear to be needed most urgently: a maize producer survey, a maize marketing survey, and economic analysis of experimental data.

Maize producer survey

Basic descriptive information on the maize subsector in Paraguay is still lacking. Reliable data are not available on the numbers and physical distribution of maize producers, area planted to different types of maize germplasm, sources of seed, maize production practices and yields, critical production constraints, and the role of maize in the farming system. In addition, the profitability of maize production under different technology levels remains largely unknown. Without this basic information, it will be difficult to develop a list of research priorities for the DIEAF Maize Program, since the relative importance of different research activities will remain essentially speculative.

Much of the missing information could be obtained through a survey of maize producers. The goal of such a survey would be to generate baseline descriptive data on maize production practices, including distribution of production, numbers and types of producers, use of different types of germplasm, sources of seed, maize production practices and yields, prices of inputs and outputs, and utilization of maize (food vs. feed use, including grain and fodder).

Maize marketing survey

Despite turning up considerable evidence that the maize marketing system in Paraguay is extremely well developed, this preliminary diagnostic survey has not been able to generate reliable estimates of the quantities of grain moving through the various marketing channels. Nor has it been able to determine the reliability of market outlets for maize. Many producers who market at least part of their production claim that they often cannot find buyers during the months immediately following the harvest. If true, this would obviously have important implications for the profitability of maize production, since maize would therefore be more risky than alternative crops whose markets are guaranteed (e.g., soybeans and cotton).

These questions about the size and reliability of the maize market could be resolved through a post-harvest marketing survey focusing on producer grain transactions. Such a survey would generate information on quantities sold of different types of maize and prices received by farmers, leading to an improved understanding of the true commercial importance of maize in Paraguay. This would presumably help to resolve the critical question of whether the main constraints to maize production are technical or economic in nature.

Economic analysis of experimental data

DIEAF researchers have done an impressive job of identifying improved maize production technologies and testing these technologies on the research station as well as on farmers' fields. Although statistically significant yield increases have been associated with a number of new technologies, many of the experimental data have not been subjected to rigorous economic analysis. In cases where preliminary economic analysis has been carried out, the results frequently have been inconclusive. Additional economic analysis is needed to establish whether adoption of the yield increasing improved technologies would actually be profitable for farmers. Without this information, it is risky to formulate recommendations to be passed along to the extension service.

Depending on the availability of detailed input-output data (e.g., variable labor inputs associated with different treatments), it may be possible to perform economic analysis using results of past trials. Alternatively, if input-output data from past trials are unavailable, it will be necessary to collect such data during several additional cycles of trials before economic analysis can be performed.

Appendix A

Enterprise Budgets for Maize, Soybeans, and Wheat

Table A1. Enterprise budgets for maize, soybeans, and wheat (commercial farmers), 1989

	Maize	Soybeans	Wheat
Yield (kg/ha)	4,000	2,500	2,000
Producer price (G/kg)	75.0	190.00	140.00
GROSS RETURNS (G/ha)	300,000.00	475,000.00	280,000.00
FIXED COSTS			
Tractor (G/ha)	11,626.88	12,024.38	10,335.00
Implements (G/ha)	772.20	798.60	686.40
Combine harvester (G/ha)	0.00	13,240.00	13,240.00
VARIABLE COSTS			
Tractor:			
Fuel/lubricants (G/ha)	18,259.02	18,883.26	16,230.24
Repairs/maintenance (G/ha)	13,162.50	13,612.50	11,700.00
Implements:			
Repairs/maintenance (G/ha)	526.50	544.50	468.00
Combine harvester.			
Fuel/lubricants (G/ha)	0.00	3,412.51	3,412.51
Repairs/maintenance (G/ha)	0.00	22,500.00	22,500.00
Seed (G/ha)	14,000.00	33,750.00	25,000.00
Fertilizer (G/ha)	24,000.00	27,200.00	56,900.00
Herbicides (G/ha)		55,000.00	
Insecticides (G/ha)		34,650.00	16,500.00
Fungicides (G/ha)			23,250.00
Transport -- purchased inputs (G/ha)	360.00	480.00	960.00
Transport -- production (G/ha)	24,000.00	15,000.00	12,000.00
Labor:			
Skilled (G/ha)	4,387.50	5,137.50	4,500.00
Unskilled (G/ha)	63,375.00	24,750.00	750.00
Cost of capital (6 months)	29,172.69	45,885.65	34,950.74
TOTAL FIXED COSTS (G/ha)	12,399.08	26,062.98	24,261.40
TOTAL VARIABLE COSTS (G/ha)	191,243.21	300,805.92	229,121.49
TOTAL PRODUCTION COSTS (G/ha)	203,642.29	326,868.90	253,382.89
NET RETURNS (G/ha)	96,357.71	148,131.10	26,617.11

Appendix B
Enterprise Budgets for Maize, Cotton, and Manioc

Table B1. Enterprise budgets for maize, cotton, and manioc (smallholders), 1989

	Maize	Cotton	Manioc
Yield (kg/ha)	1,500	1,800	18,000
Producer price (G/kg)	75.00	330.00	22.00
GROSS RETURNS (G/ha)	112,500.00	594,000.00	396,000.00
FIXED COSTS			
Team of oxen (G/ha)	712.80	1,069.20	237.60
Implements (G/ha)	859.89	1,289.83	286.63
VARIABLE COSTS			
Team of oxen:			
Feed (G/ha)	9,000.00	13,500.00	3,000.00
Implements:			
Repairs/maintenance (G/ha)	293.14	439.71	97.71
Seed (G/ha)	5,250.00	7,000.00	0.00
Fertilizer (G/ha)			
Herbicides (G/ha)			
Insecticides (G/ha)	5,000.00	19,600.00	
Fungicides (G/ha)			
Contract services:			
Harvest cotton (G/ha)		180.000.00	
Transport -- purchased inputs (G/ha)	0.00	0.00	18,000.00
Transport -- production (G/ha)	9,000.00	10,800.00	0.00
Labor:			
Skilled (G/ha)	37,500.00	70,500.00	12,000.00
Unskilled (G/ha)	44,812.50	74,400.00	60,750.00
Cost of capital (6 months)	19,954.02	46,123.15	16,892.59
TOTAL FIXED COSTS (G/ha)	1,572.69	2,359.03	262.11*
TOTAL VARIABLE COSTS (G/ha)	130,809.66	422,362.86	55,370.15*
TOTAL PRODUCTION COSTS (G/ha)	132,382.34	424,721.89	55,632.27*
NET RETURNS (G/ha)	19,882.34	169,278.11	142,367.73*

* Total costs and net returns of manioc adjusted to reflect a six-month cycle.