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Wheat Seed Marketing in Eastern
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WHEAT SEED MARKETING IN EASTERN BOLIVIA

By

Nicholas William Minot

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ABSTRACT

WHEAT SEED MARKETING IN EASTERN BOLIVIA

By

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This study begins with an analysis of the economic and organizational aspects of seed industries in less developed countries. Both theoretical arguments, based on the special economic characteristics of seed, and empirical evidence of seed industries are cited. It is argued that public sector efforts should be focused on a few activities and should facilitate private sector participation where possible. The conclusions are illustrated with a description of the successful reforms in a seed program in the eastern lowlands of Bolivia.

In addition, a diagnostic-prescriptive analysis of this wheat seed market is conducted, with particular attention to the problem of late delivery of certified seed. Using the results of a survey of the lowland wheat farmers, the study evaluates the economic and financial feasibility of a processing plant and storage facility which could provide seed earlier in the season. Given appropriate seed pricing policies, the investment provides an acceptable rate of return. Recommendations are made regarding equipment, capacities, plant location, and general seed marketing policies and procedures.

This work is dedicated
to my parents, the best
a guy could ever hope for.

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CHAPTER ONE

INTRODUCTION

1.1 Background

This study is based on research carried out by the author in 1984 under a contract between Chemonics International Consulting Division and the Bolivian Ministry of Agriculture and Campesino Affairs. The project, financed by the United States Agency for International Development, included a seed component with activities in several regions of Bolivia. Over the past four years, the project has fostered the rapid development of a seed industry to produce soybean, wheat, rice, and maize seed in the lowland area of the department of Santa Cruz. One of the tasks assigned to the author was to study the market for wheat seed in this area and to investigate the feasibility of a wheat seed processing plant and storage facility in the seed producing zone. As part of this study, the author conducted a survey of the lowland wheat farmers to determine various aspects of the demand for seed and the performance of the existing seed industry.

The wheat seed program in Santa Cruz is particularly noteworthy because it has facilitated the rapid expansion of wheat production in the lowlands raising the possibility that this region may reduce the sizeable imports of wheat. Furthermore, the program involves contract seed production by small-scale farmers in the highlands, thus illustrating the potential as well as the limitations of such a strategy.

Also of interest is the division of responsibilities among institutions in this seed program which constitutes a departure from the

system used elsewhere in Bolivia. Recent reforms have attempted to create a largely self-supporting seed industry and to promote a greater role for the private sector.

Following the completion of the assignment, the author attempted to place the experience of the Bolivian seed industry in a broader context by studying the patterns of seed industry organization in other less developed countries. Although there is a growing body of literature on the economics and organization of agricultural research, relatively little work has been done on the organizational aspects of seed programs. The present study attempts to address this deficiency in the literature.

1.2 Objectives of the study

This study has two overall objectives. First, it investigates the relationship between the institutional and policy environment of a seed industry and its performance. The goal is to develop guidelines to help identify the appropriate role of the public sector in different circumstances. In part, this involves theoretical arguments based on the technical characteristics of seed and the nature of its supply and demand. In addition, it draws on empirical evidence of the performance of seed industries in less developed countries as a function of the institutional and policy environment within which they operate.

Second, the study illustrates the complexity of the economics of seed production through an analysis of the wheat seed program in Santa Cruz, Bolivia. The analysis aims to solve several practical problems faced by the program, particularly the timing of the supply of wheat seed and the shortage of processing capacity in the region. It is hoped

that the practical issues considered can be placed in the context of the more general analysis of seed multiplication programs and their role in agricultural development.

1.3 Plan of the study

Following this introduction (Chapter One), the economic and institutional aspects of seed production and distribution are considered in Chapter Two. The special characteristics of seed as an economic product are discussed and the components of a seed industry described. Both theoretical and empirical evidence are then used to analyze the role of the public sector in developing an effective seed industry.

The analysis of the wheat seed market in the lowlands of Santa Cruz employs the description-diagnosis-prediction-prescription format for analyzing market structure and performance [Shaffer, 1970]. In general terms, Chapters Three and Four are descriptive and diagnostic, Chapter Five involves making projections, and Chapter Seven is prescriptive.

Chapter Three provides background information on Bolivia, its agricultural development, and its seed industry. The experience of Bolivian seed programs is used to confirm some of the patterns discussed in Chapter Two. The chapter also provides a descriptive foundation for more detailed consideration of the wheat seed market in the following chapter.

In Chapter Four, the market for wheat seed in the lowland Santa Cruz area is described. First, the national wheat situation and the patterns of wheat production in Santa Cruz are discussed. Then, lowland wheat seed consumption and wheat area are estimated. Finally, several problems with the supply of wheat seed are diagnosed, focussing on the problem of the late availability of certified seed. This chapter employs

data from a survey of lowland wheat farmers conducted by the author in July 1984. The methodology of this survey is explained in Annex B.

In Chapter Five, the survey data are used to make projections of the supply and demand for wheat seed. The temporal distributions of supply and demand are also estimated and used to project storage requirements.

Chapter Six presents various recommendations for improving the supply of wheat seed, focussing on the possibility of constructing a seed processing plant and storage facility. Capacity and equipment requirements are estimated, economic and financial feasibility studies carried out, and alternate sites for the plant are evaluated. In addition, recommendations are made for seed pricing and marketing.

In Chapter Eight, the results of the study are summarized and the conclusions reiterated. Lastly, the implications for further research are presented.

CHAPTER TWO

SEED INDUSTRIES IN LESS DEVELOPED COUNTRIES

Over the last twenty years, there has been increasing awareness of the importance of agricultural technology in economic development. In part, this comes from a greater understanding of the linkages between agricultural development and more general economic development [Johnston and Mellor, 1961; Nicholls, 1964; and Reynolds, 1983]. In addition, it is now widely accepted that technology generation and diffusion play a central role in agricultural development [Jorgenson, 1961; Schultz, 1964; and Mellor, 1966]. Efforts to develop new technology have been directed toward yield-increasing biological and chemical technology in response to the successes of the "green revolution" cultivars. The work of Hayami and Ruttan [1971] provided the historical and theoretical foundation for the idea that, where low wages prevail, agricultural development can and should pursue more labor-intensive yield-increasing technology relative to labor-saving mechanical technology.

One of the most important forms of yield-increasing agricultural technology is improved cultivars. However, in order to disseminate this technology, improved seed must be produced on a scale beyond the capability of most research stations. The feasibility of seed importation is limited by the low value/bulk ratio of seed and by the location-specificity of most cultivars. Thus, the development of an indigenous seed industry is a critical component of agricultural development strategies.

2.1 Definition and importance of seed industries

The traditional system, in which farmers save their own seed and exchange it among themselves, has served humankind for thousands of years and is probably still the dominant form of seed production. Seed selection in this system may be counter-productive if the poorest or latest-maturing portion of the crop is saved for seed.

There are several intermediate approaches to improving the seed supply. Ordinary grain may be processed and treated for use as seed. Another approach is to contract farmers to return 1.5 to 3 bags of seed for every bag received, with the remainder being marketed as grain. Neither system, however, involves the use of specialized seed growers who can provide the attention needed for quality seed production.

The development of seed industries, specialized sets of public and/or private institutions to produce and market seed, is a relatively recent phenomenon. In North America and Europe, seed industries evolved in response to the development of scientific breeding technology in the 19th century and the subsequent availability of new cultivars [Copeland, 1976: 214]. In many of the less developed countries, efforts to form seed industries began in the 1950s and 1960s, although only a minority can be said to have effective seed industries [Douglas, 1975].

A survey by the Food and Agriculture Organization (FAO) of 97 countries revealed that only 8% were at a "technically and/or economically advanced level." In 85% of them, "improved varieties are available but seed supply is inadequate," and in the remaining 7% improved cultivars were "not yet available" [Feistritz, 1972: 87]. Although almost all the industrialized countries had seed industries for cereals, industrial crops, pasture crops, and vegetables, the seed industries in less

developed nations were often limited to cereals and, less frequently, industrial crops. Of the 37 countries surveyed, all but three (Bolivia, Chad, and Niger) had "operational seed production and quality control schemes" in wheat, maize, or rice [Feistritzer, 1978]. A follow-up study by the FAO in 1979-80 confirmed these general patterns noting that, in most cases, seed programs in less developed countries were "fragmentary or pilot-scale operations" [Feistritzer, 1982].

Given the existence of improved cultivars, an effective seed industry contributes to agricultural production in several ways. Yields can be raised as a result of the greater genetic potential, higher germination rates, greater seed vigor, and lower incidence of disease. In addition, varietal purity contributes to uniform maturation and consistent product characteristics. This facilitates industrial processing (e.g. milling, canning, oil extraction, malting, ginning, and packaging) which becomes increasingly important in agricultural development.

These benefits are reflected at the farm level in the significant returns that can be obtained from a relatively small investment. More general benefits of increased agricultural production accrue to society through lower prices of agricultural goods, the generation or saving of foreign exchange if the commodity is traded, and so on. The gains are demonstrated by numerous studies which have found high rates of return to national investment in seed improvement [see Ruttan, 1982].

In addition, the generation of improved cultivars and dissemination through seed industries has several advantages with respect to equity and food security goals. Food security has been defined as:

the ability of food deficit countries, or regions or households within these countries, to meet target consumption levels on a year-to-year basis. [Valdes and Siamwalla, 1981: 2]

By facilitating the continuous introduction of new cultivars, a seed industry contributes to food security in the following ways:

- 1) It improves the ability of farming households with food deficits to raise consumption levels to the extent that higher yields raise income earnings or home production. Because improved seed is divisible, simple to adopt, and relatively inexpensive, it is more scale-neutral than other forms of technology, benefiting small farmers as well as large. Although the higher earnings last only until the new technology is reflected in crop prices, the effect on home production is more lasting [Dalrymple, 1979].
- 2) The benefits of improved seed reach even the landless agricultural laborers to the extent that it increases labor requirements, an important consideration in many Asian economies. Empirical evidence shows that the new cultivars increase or, at worst, do not decrease the demand for labor, in contrast to mechanical technology which tends to displace labor [Hayami, 1984].
- 3) Over the longer run, the lower per unit cost of production of marketed goods often results in lower consumer prices. When the commodity is a food crop, the benefits accrue disproportionately to the non-agricultural poor (i.e. food-deficit households) who spend a large portion of their income on food.
- 4) It has also been argued that the use of modern cultivars with greater responsiveness to nitrogen fertilizer and other purchased inputs makes the supply of agricultural goods more elastic with respect to price. Shifts in demand have less impact on prices, thus moderating the impact on real purchasing power for both consumers and producers.
- 5) Although the original "green revolution" cultivars were bred for high yields, breeding since then has placed greater emphasis on disease resistance and, more recently, drought resistance. With effective seed industries, these cultivars will help stabilize production levels, both at the household level and at the regional and national levels [see Herdt and Capule, 1983].
- 4) The existence of an effective seed industry facilitates the stockholding of seed in preparation for natural disasters when normal seed supplies may be consumed or damaged [see Feistritzer, 1975].
- 5) Lastly, an effective seed industry can contribute to the flexibility of the agricultural system by accelerating the diffusion of new cultivars developed in response to changing conditions.

The following section discusses the special characteristics of seed as an economic product. Next, the components of a seed industry are described. Finally, in section 2.4 the critical role of the public sector in facilitating the development of a seed industry is discussed.

2.2 Characteristics of seed as an economic product

The organization of the seed industry, like any industry, is greatly influenced by the inherent characteristics of the product and by the nature of its supply and demand. From an economic perspective, five characteristics of seed are particularly relevant.

First, for most crops, a seed "consumer" is automatically a seed "producer" as well. Thus, seed industries must compete with farm-level production of seed. Their ability to compete naturally depends on the cost and performance of saved seed relative to purchased seed. Some crop seeds are difficult to harvest, process, or store, requiring special machinery or skills. This introduces economies of scale which allow seed industries to produce more economically than the farmer. This is the generally the case for pasture seed because of its small size. Similarly, some oilseeds and vegetable seeds are difficult to process and do not store well [Delouche et al, 1973: 675].

When saving seed is simple and inexpensive, seed industries must supply seed with sufficiently superior performance to compensate for the greater cost of purchased seed. This is often the case for grains and some grain legumes which are easy to harvest (consisting of the agricultural product itself) and store well. Although hybrid seed cannot be reproduced at the farm-level, the seed must still offer superior performance to non-hybrid cultivars of the same crop. For many grains, even in developed commercial agriculture, seed is purchased every three to six

years, when the saved seed has degenerated or new cultivars become available.

A second important characteristic of seed is that the criteria which determine the value of the seed to the consumer are complex and varied. These criteria relate to the attributes of the seed itself and the genetically-determined performance of the plant. Important attributes of the seed are the germination rate, vigor, seed health, and cleanliness, while plant performance includes the yield under different agro-climatic conditions and cultural practices, maturation period, resistance to disease and pests, palatability and/or marketability of the product, quality and quantity of by-products such as stalks, and ease of cultivation and harvest. Because of the complexity of buyer criteria, seed production and marketing require knowledge of and responsiveness to consumer preferences.

Third, most of these components of seed quality are not readily apparent to the consumer at the time of purchase. Seed quality greatly determines the value of the seed to the consumer, but can only be evaluated directly at costs prohibitive to the individual buyer. While this is true of many products, it is a more serious obstacle given the the option of saving seed from one's own crop. Without an effective demand for quality seed, there is no incentive to produce it. Clearly, there is a role for an impartial arbiter of seed quality, both to provide the consumer with useful information and to protect, and thus promote, the producer of high-quality seed.

Fourth, the supply of and demand for seed are strongly seasonal and vary randomly from one year to the next according to the climate. This factor, in combination with the perishability of seed, highlights the

importance of proper storage from seed harvest to planting season. In addition, an agile marketing system is necessary to distribute the seed in a timely fashion. Seed delivered late may be as useless as undelivered seed.

Fifth, plant breeding generally has "public good" attributes so that the resulting benefits are difficult to "capture" by the responsible institution(s). This is because the development of new cultivars requires sizeable research costs, but, once developed, many are inexpensively reproduced. The seed can be multiplied and sold for just the cost of reproduction. This prevents the original "inventor" from selling the seed at a price that also covers the fixed costs of breeding (Annex A covers this topic in more detail).

2.3 Components of a seed industry

Seed production consists of seed multiplication, drying, processing, storage, marketing, and quality control. Each component will be described briefly, emphasizing the case of non-hybrid grain seeds. Although similar to grain production, the production of seed, as a living organism, requires special treatment to avoid physiological deterioration, mechanical damage, and seed mixture (overviews of seed production are provided by Copeland, 1976; Thompson, 1979; Delouche and Potts, 1971; and Feistritzer and Kelly, 1978; and Douglas, 1980).

Seed multiplication begins with a small quantity of physically and genetically pure seed provided by a breeding unit. This is multiplied (grown and harvested) several generations to obtain sufficient volumes of commercial seed. Although the number of required generations and the names of each generation vary, the original seed is usually called

"breeder" (or "pre-basic") seed, the next "foundation" (or "basic") seed, and then "certified" seed. Where four or more generations are necessary, a "registered" seed generation comes between foundation and certified seed, and sometimes there are multiple generations of certified seed. The multiplication factor from one generation to the next is between ten and forty for most seed-propagated crops. For seed production, more care is taken in weed and insect control, harvesting, threshing, and processing, especially for the initial multiplications. Isolation to prevent crossing (for cross-pollinated crops), roguing to remove off-type plants, and field inspection are also important parts of seed multiplication [Delouche and Potts, 1971].

Seed is often harvested earlier (thus, at high moisture levels) than grain to reduce field deterioration and exposure to weather and pests. However, high moisture content in harvested seed accelerates its deterioration. If the percentage moisture in the seed is above 13%, it must be dried down to this level within 24 hours of harvest to prevent deterioration. Generally, this must be done with artificial drying systems, that is by forcing heated air through a bulk storage bin. Solar drying is slow and leads to reduced germination rates [Thompson, 1979].

Seed processing includes cleaning, sizing, treating, and bagging. A variety of machines are used to remove inert material, non-seed organic material, seeds of weeds and other crops, and damaged or immature seeds. The air-screen cleaner, the most common, separates according to size and shape using vibrating screens and air flow. The screens are available with different sized and shaped holes and can be changed to clean seeds of different crops. Another cleaning machine is the gravity table, a machine with a vibrating surface that separates according to the density

of the particles. A third commonly used machine is the indented cylinder which uses a revolving cylinder with small indentations to separate according to the length of particles.

Other machines are available for separating according to texture, color, electrical properties, and so on. Different combinations of machines are used according to the type of seed, kinds of contamination, and the degree of cleanliness desired. Seed may be treated with fungicides and/or pesticides to disinfect and protect the seed through storage and later in the soil [Thompson, 1979 and Copeland, 1976].

The storage life of seed depends on the its species and cultivar, its quality, the relative humidity, and the ambient temperature. As mentioned before, cereal and some bean seeds are good storers while soybeans, peanuts, and most vegetable seeds are poor storers. In addition, Delouche et al [1973: 674] states that the quality of the seed entering storage is "one of the most important and over-looked considerations."

The relative humidity (RH) of the air surrounding the seed affects its moisture content and thus its rate of deterioration. In addition, the infestation and growth of fungi and insects are greater in warm, humid environments. Harrington's rule-of-thumb is that seed storage life is doubled for every 1% decrease in seed moisture and every 5.5° C. reduction in temperature [Harrington, 1959]. Cereal seeds last up to nine months at 30° C. 50% RH or 20° C. 60% RH. However, some tropical and sub-tropical environments do not meet these standards, and cereal seed storage will require dehumidification and/or air-conditioning, particularly for long-term storage [Delouche et al, 1973].

Marketing refers to the distribution of the right type of seed to

the right place at the right time for an "acceptable" price. Although often seen as mere logistics, successful seed marketing depends on two-way communication: disseminating information regarding seed performance, price and recommended practices and inputs; and collecting information regarding consumer preferences and farm-level problems [Delouche and Potts, 1971: 82-85]. As will be discussed later, this element is often one of the most troublesome for developing seed industries. Price, quality, acceptable cultivars, timeliness, and consumer confidence are critical problems, and deficiencies at any other stage in seed production is likely to be manifested in the marketing of the seed.

Quality control consists of both field inspection and laboratory testing and is carried out at various stages of seed production. Field inspections ensure that standards are met with regard to physical purity, plant health, weed and pest contamination, and so on. Seed testing involves laboratory tests of seed to determine its viability (rate of germination), vigor (speed and robustness of seedling growth), physical purity, cultivar purity, and seed health. Testing before cleaning can be useful to determine the types of contamination and the appropriate calibration of the machines. Testing before and after storage may identify the degree and causes of deterioration, thus guiding improvements in facilities and procedures.

Testing can provide the basis for a certification system to provide consumers with basic information regarding the seed. The simplest certification ticket identifies the species and cultivar of the seed, the lot number, and the period of certification validity and affirms that minimum seed quality requirements have been met. Information on germination rate, inert content, other crop seed content, weed seed content, and

purity may also be identified, either in the form of the tested value or the standards which have been met. The ticket also provides the net weight and, for treated seed, warns against animal or human consumption [Douglas, 1980: 123-129].

Although the technical characteristics of seed determine the necessary components of a seed industry, they do not address the important issue of the appropriate institutional arrangements for seed industries. This topic is reviewed in the following section with special emphasis on the role of the public sector.

2.4 Role of the public sector in seed industries

Clearly, the appropriate arrangement depends on the political, economic, and cultural conditions prevailing in a given country, as well as the crop in question. However, certain points can be made on the basis of the characteristics of seed mentioned in section 2.2 and on the basis of international experience in seed programs.

It is worth stressing that developing a seed industry is not always feasible or desirable. There must be 1) sufficient potential volume to justify the investments in equipment and training and 2) the possibility of offering seed with a significantly lower price and/or higher quality than the seed presently used. In practice, the existence of improved cultivars may be considered a prerequisite:

If the main thrust of agricultural improvement is based on the development or introduction of high yielding varieties or hybrids of food, feed, fiber or industrial crops, a seed program is essential. On the other hand, if the major improvement effort involves only land reclamation, market development, fertilizer procurement, etc., and varietal improvement is not provided for, then a seed program is of doubtful value. [Delouche and Potts, 1971: 7. Emphasis in original.]

Other things being equal, the following factors can be expected to contribute to the feasibility of a self-sustaining seed industry for a given crop: 1) the existence of a new cultivar with significantly superior performance; 2) a large cultivated area which allows economies of scale; 3) a high producer price so that even modest yield increases will justify the cost of the seed; 4) geographic concentration of the crop area, large farms, and good transportation infrastructure which reduce marketing costs; 5) a good supply system for fertilizer and other complementary inputs; and 6) a seed which is difficult to harvest, process, or store at the farm-level given the local climate. Naturally, the development of a seed industry may be desirable to meet other goals such as nutrition, equity, or food security, but the above factors influence the degree to which a seed industry could be self-supporting.

The role of the public sector in seed industries varies among regions. In the more developed countries, the role of the public sector is focused on a few activities, principally of plant breeding, seed certification, and legislation to promote private seed production and commerce. In Africa and the less developed parts of Asia and Latin America, public agencies are often directly involved in seed production, processing, and even marketing. The role of the public sector in plant breeding, seed multiplication, marketing, and certification will be discussed in turn.

2.4.1 Plant breeding

The public sector accounts for a large majority of agricultural research expenditure, especially in the developing countries. It comprises over 97% of the agricultural research expenditure in Africa and Asia and 95% in Latin America [Boyce and Evenson, 1975]. Private agri-

cultural research has been overwhelmingly oriented toward 1) commodity research for major export crops, funded by small groups of producers, processors, and/or exporters, 2) hybrid seed development, and 3) mechanical and chemical technology.

The relatively small magnitude of private research expenditure is understandable in light of the "public good" character of much agricultural research (see Annex A). The "product" of plant breeding and that of research are similar in some important respects.

While research and development related to new agricultural technology may be very expensive, difficult and time consuming, the copying and multiplication of such technology - once available - may be easy and inexpensive. Development of crop varieties with high yield capacity, disease and/or insect resistance or some other desirable characteristics may be difficult and costly. But once such a variety is made available to farmers, seed multiplication may be an easy task for the individual farmer. Thus, the ability of the research agency to benefit from the economic gains associated with the varietal development may be limited to initial sales... [Pinstrup-Anderson, 1982: 57]

In economic terms, the marginal costs of providing seed of a new cultivar to an individual consumer is less than the average cost of production. In addition, the ability to reproduce some seed relatively easily means that maintaining a monopoly, which would be able to charge a price covering average cost, is not possible. Competitors can reproduce the good and charge only the marginal cost. Thus, the market price will be less than the average cost to the inventor and the latter will not be able to cover the fixed research costs.

The result is that the private sector will underinvest in research to generate new seed cultivars and that public investment can yield significant economic returns. Although agricultural research has become an accepted function of the public sector, the evidence of high rates of return to public research indicates that there is still underinvestment

[see Ruttan, 1982: 237 and Pinstруп-Anderson, 1982: 100].

The concentration of private agricultural research on the three areas mentioned above is understood in light of these factors. Research in industrial crops may be worthwhile to a processing and/or exporting firm if it is able to control the marketing channels. This allows the firm to capture the returns to its research through lower producer prices. A hybrid seed firm is protected by the fact that the hybrid performance occurs only in the first generation, thus preventing others from reproducing the cultivars it develops. Similarly, the inventor of new machinery or agricultural chemicals enjoys protection through patent laws.

Legislation in Western Europe and, more recently, in the U.S. provides patent-like protection to plant breeders to allow them to capture more of the benefits. Although such legislation has been successful in accelerating private investment in plant breeding, there are some doubts regarding its usefulness in developing areas.

...without a patent system, the less-developed countries are still able to benefit from the public research institutes and also to use or even to "pirate" - quite legally - seed lines developed for the developed world. It is not clear how much new private research would be encouraged. [Barton, 1982: 1074].

Thus, such legislation would do more to impede the free flow of plant material than promote private research in most less developed nations.

In summary, the domestic private sector cannot be expected to play an important role in plant breeding in most less developed countries. Possible exceptions include the more technically advanced developing countries, particularly those in which crops with hybrid potential (e.g. maize) and industrial crops are important. In any case, the importance of public plant breeding is underscored by evidence, both theoretical

and empirical, that public investments in plant breeding and other forms of agricultural research produce significant economic returns.

2.4.2 Seed multiplication, drying, and processing

Although there is considerable variation among countries and crop, it is safe to say that predominantly public seed multiplication systems are common in less developed countries¹, particularly those in Africa. These programs tend to concentrate on staple cereal crops, principally wheat, maize, or rice, depending on the region [Feistritzer, 1978]. Often basic seed production is done on research stations or state farms while certified seed production is carried out on state farms and by contract growers.

Private firms are most commonly involved in producing seed for crops for which price controls are minimal and an annual market for seed is assured by the technical complexity of multiplication. Thus, private firms tend to produce hybrids seed, industrial crop seed, and, where the market is large, vegetable and forage seed, rather than cereal seed [Chahal, 1975: 268].

Hybrid maize has stimulated the development of private seed companies in a number of countries, such as Zimbabwe [Eicher, 1984], Uruguay [Rosell, 1975: 57], Brazil [Popinigis, 1982: 533], India [Walker, 1980], and Thailand [Brown et al, 1984]. The most frequently cited case is that of the Kenya Seed Company (KSC), which was formed in 1956 to produce

1. Examples are Bangladesh [Ahmed and Ahmed, 1983], Indonesia [Benjamin, 1981], Turkey [Gunay, 1975], Egypt [El-Gamal, 1975], Morocco [Besri, 1983], Niger [Hall, 1981], Burkina Faso [Potts et al, 1983], Mali [Giacich and Toure, 1982], Senegal [Bono and Lam, 1976], Ghana [Andrews and Vaughan, 1983], Nigeria [Joshua and Singh, 1982], Cameroon [Vaughan et al, 1980], Tanzania [USAID, 1985], Uganda [Kabeere, 1983], Zambia [Gray, 1975], and most other African countries [World Bank, 1981: 175].

grass seed. In the 1960s, it multiplied, distributed, and promoted publicly bred hybrid maize seed, leading to its rapid and widespread adoption among large and small farmers. The company has come to produce 13,000 MT of maize seed and almost 10,000 MT of sunflower, wheat, barley, grass, and bean seed. Although the government recently bought a majority share, the KSC continues to be run on commercial lines [USAID, 1980b; Hazelden, 1982; Douglas, 1980: 241-243; and Wortman and Cummings, 1978].

Industrial crops often provide more incentive for private seed firms because of the importance of high-quality raw materials, the technical complexity of farm-level seed production, the relative ease of seed distribution through the processing firm, and the geographic concentration of industrial crop production compared to staple crop production [Nelson and Kuhn, 1974: 160]. For example, private seed industries serve rubber and oil palm in Malaysia [Chin and Rafar, 1978]; tea, rubber, and coconut in Sri Lanka [Pinstrup-Anderson, 1982: 63]; and soybeans in Brazil [Popinigis, 1982: 536].

The private sector is sometimes involved in vegetable seed production because of the high value of the crop and the economies of scale in multiplication. In India, the private sector is involved "mainly in high profit margin crops such as flower seeds, vegetables, and F₁ hybrids" [Walker, 1980: 24]. The first private seed companies in Thailand, formed in the 1950s, produced vegetable seed [Brown et al, 1984]. Similarly, vegetable seed is produced by private firms in Tunisia and Algeria, while government agencies produce cereal seed [Douglas, 1980: 92]. More commonly, vegetable seed is imported due to its high value-bulk ratio, its geographic adaptability, and the technical sophistication required

for production.

Although not common, private production of cereal seed is sometimes undertaken, frequently by cooperatives and farmers' associations. Such organizations presumably have better knowledge of the demand for seed and may inspire greater trust among consumer/members than outside firms or public agencies. In a number of major developing countries, complex systems have evolved, combining diversified private seed enterprises as well as semi-autonomous and mixed organizations. Examples are Brazil [Popinigis, 1982], Colombia [Moncayo, 1975], Mexico [Tijerina, 1975], India [World Bank, 1982: 76], Thailand [Brown et al, 1984] and the Philippines [Sevilla and Guerrero, 1983: 1140].

On the basis of economic theory, the case for permanent public support of seed multiplication, drying, and processing is not as convincing as it is for plant breeding. Although the "product" is reproducible, a seed multiplication unit which receives subsidized breeder seed from a public sector research agency need not cover the costs of research, and so, competes on an equal basis with farm-level seed multiplication.

The empirical evidence concerning seed multiplication programs suggest several common problems. First, responsiveness and flexibility are important in seed production, but civil service regulations make it difficult to generate the incentive structure to promote this kind of institutional behavior. Even in the United States, this problem has been noted:

government agencies have not been successful in producing and selling seed due to the critical timing involved in performing the necessary roguing, detasseling or inspection functions. The seasonal nature of the job, with the corresponding necessity of long

hours and solid work peaks during these periods, is not compatible with the operation of a typical public agency. [USDA, 1967, cited in Delouche, 1978: 48]

Douglas [1980: 91] makes a similar point:

...government agencies often are unable to delegate decision-making authority to lower levels. For successful seed production, managerial decisions must be made promptly and on the spot.

Second, government seed multiplication programs generally depend on public funding. This can make the supply of seed less reliable, being subject to cut-backs in funding and conditioning any expansion of output on approval of greater budget allocations [Douglas, 1980: 91; World Bank, 1981: 60; Nelson and Kuhn, 1974: 158]. Shortages of subsidized government seed have been problems in Mali [Giacich and Toure, 1982: 502], Turkey [Gunay, 1975: 49], Uganda [Kabeere, 1983: 1090], and Indonesia [Benjamin, 1981], among others.

And third, seed multiplication generally requires considerable amounts of financial and managerial resources. It has been argued that direct involvement in seed multiplication diverts scarce public sector resources into activities that the private sector can perform. From this perspective, government efforts must be more focused on those few functions that must be done by the public sector such as research and seed certification.

On the other hand, private seed enterprises may not develop spontaneously, or may concentrate on a few crops as described above. Many observers argue that private seed enterprises are preferable in the long run, but that public sector involvement is necessary at least initially:

In most developing countries private enterprise in seed multiplication is lacking to the detriment of the country concerned. In these countries, the government has to take over the job of seed multiplication. [Schoorel, 1972: 97]

Similarly,

Increasing breeder's seed or basic seed is the responsibility of the plant breeder when the seed program is in its early stages... Producing seed for farmers is not an activity in which government agencies normally have an inherent advantage. This step can be taken over by private producers or shared by them with public institutions. However, potential private producers have to be found, stimulated, informed, and sometimes financed. [Wortman and Cummings, 1978: 350]

This "infant seed industry" argument can probably be defended on the basis of the need for simultaneous development of seed production capacity and public breeding and certification programs. Not knowing the government's commitment to seed production, private firms face greater risks to early involvement than do public agencies. In addition to the normal risks, the seed producer faces uncertainty regarding the ability of the public agency to provide adequate supplies of high-quality foundation seed, regarding the honesty and credibility of the seed certification service, and regarding seed and crop price controls. Once the need for some public seed production is accepted, the question turns to strategies which minimize the recognized weaknesses of public programs and which promote seed production by private entities.

One way to minimize the inherent weaknesses of public seed production programs is to contract out the actual multiplication to trained farmers. The idea that mechanized state farms can produce sufficient volumes more economically has not been demonstrated by experience. The India Seed Review in 1968 found that "the quantum of certified seed production required is so large that it cannot be produced on government farms alone" [cited in Delouche, 1978: 48].

A major World Bank project in Indonesia involved seed production on 2000 hectares of a state farm as well as continued use of contract farmers. The former suffered from weak management, numerous delays,

funding shortages, and low yields due to leveling operations, leading one observer to note:

It is now clear that the project design considerably over-emphasized the role that [government] estate production should play in the process. With regard to the seed-growing districts [of contract farmers], it is further established that these were indispensable if Java's seed requirements were to be covered. [Benjamin, 1981: 252]

As a result of this "costly lesson," all World Bank projects since have used contract growers instead of state farms [Russell, 1983]. Two seed specialists with wide international experience have noted:

Producing seed through farmer-contractors requires concentrated effort but is one of the best educational tools available to sell new technology. Contrary to most government workers' opinion it is also the least costly system in the long run. [Boyd and Jackson, 1981: 3]

However, the drawbacks of contract seed production are the logistical complexity and the difficulty of maintaining quality control. In Bangladesh, 20,000 contract growers are needed to produce just 8000 hectares of certified rice seed [Ahmed and Ahmed, 1983].

With regard to strategies to promote private seed production, there are various possibilities including technical and management training, subsidized credit, technical assistance, the use of government personnel or equipment, and direct government investment [Douglas, 1980: 83-92]. However, the core of any strategy to promote seed production by private entities must be 1) to build confidence in the competence and reliability of public plant breeding and certification services and 2) to allow private seed enterprises to compete fairly with public ones.

The latter entails resisting the temptation to control seed prices or sell seed at subsidized prices and making processing facilities and certification available to all on a fee basis. Chahal notes that this is frequently a problem and suggests the following approach:

if in the particular circumstances of a developing country, it is considered necessary that State must participate in production, marketing and distribution of commercial seed, it would be better to set up a separate organization either in the public sector or the joint sector to be run on commercial lines. [Chahal, 1975: 267].

This strategy has been adopted in the case of the State Seed Corporations in India which are "profit-responsible" [Walker, 1982]. Stripped of special subsidies, such corporations are forced to charge prices which cover costs, thus allowing private entities to compete on a fair basis.

Private seed firms often begin by multiplying foundation seed produced by public research stations. However, their position is precarious given the fact that their sales depend on the quality and reliability of public supplies of foundation seed. Nelson and Kuhn [1974: 164] recommend the staged involvement of seed enterprises in foundation seed production and breeder seed maintenance. Under this scheme, private seed firms are initially involved only in certified seed production. Later, the government provides incentives and technical support for these firms to take over foundation seed multiplication and, eventually, breeder seed maintenance.

In all of the relatively advanced seed industries mentioned earlier, the private sector has become increasingly involved in seed production and plant breeding, often following reforms designed to encourage private seed enterprises (Mexico, the Philippines, and India) and sometimes through the outright sale of public corporations (Brazil).

In summary, there are a variety of institutional arrangements for seed production depending on local conditions and the crop. Public seed production is common among new seed industries, but experience indicates

that public agencies are not well suited to seed production. Moreover, private seed firms can and do enter this field once research and certification agencies have demonstrated their reliability and once seed price structures reflect actual costs. Cooperatives and farmers' associations can play an important role in seed production for non-hybrid cereals if given proper incentives.

2.4.3 Seed marketing

As argued in section 2.2, seed marketing is more than the logistics of physical distribution. It also encompasses a two-way flow of information between the buyer and seller. The seller must disseminate information concerning the characteristics, price, and the time and location of availability and must gather information to determine buying patterns. Permanent direct public sector participation in the distribution of seed, like public seed production, is difficult to justify on the grounds of economic efficiency. The "infant industry" argument seems less applicable for seed marketing since rural distribution networks generally exist for a variety of commodities.

Nonetheless, the control of seed distribution by public agencies is common in less developed countries. In small or newly formed public seed programs, a division of the ministry of agriculture makes seed available to the extension service for distribution. Larger systems often involve a parastatal organization. Government control over seed distribution is particularly common in sub-Saharan Africa, where seed supply is managed by the public sector in 61% of the countries. Mixed systems account for another 28% and private distribution systems only 11%. Public distribution systems are almost universal among the Sahelian nations and least common in "middle-income" countries with a large-scale commercial agri-

culture sector, such as Kenya, Swaziland, and Zimbabwe [World Bank, 1981: 173].

The objectives of this kind of intervention are varied: to circumvent alleged exploitation by private traders (sometimes dominated by ethnic minorities), to facilitate the subsidization of improved seed to meet production goals, to meet equity objectives so that even remote farmers have access to seed, and simply to maintain public control over the means of production. However, the record of public seed distribution efforts is generally poor. As early as 1971, this problem was noted:

Considering all the various aspects and components of a seed program, government involvement has been least effective and most grossly inefficient in the distribution and marketing phases. Thus, private sector participation in distribution and marketing should be encouraged and assisted in all possible ways... [Delouche and Potts, 1971: 84].

This has apparently become a consensus view among observers [see Schoorel, 1972; Feistritz, 1972; Wortman and Cummings, 1978: 351; and Bunch, 1982]. Furthermore, it has been noted that open marketplaces in developing countries often have a wide range of consumer goods with the conspicuous exception of those goods sold exclusively by the public sector [World Bank, 1981: 65 and Hazelden, 1982: 526].

The problems of public distribution systems are similar to those of public seed production: 1) the organization and incentive structure common in public agencies does not facilitate responsive, independent decision-making, 2) market discipline is absent due to the monopsony of seed supply, and 3) public sector attempts to subsidize seed prices and to implement pan-territorial pricing introduce a number of difficulties to be discussed later. Innovation and flexibility are critical to effective seed distribution systems, especially given the seasonal demand and

complex demand criteria discussed in section 2.2. In a review of public input delivery systems in sub-Saharan Africa, the World Bank interpreted the problem as follows:

[Public agencies] have difficulties in adapting bureaucratic, financial, and administrative procedures to commercially oriented operations...pay scales and hiring and promotions procedures tend to be similar to those in government. This leads to reduced individual initiative, unwillingness to make quick and independent decisions, and consequent efficiency losses. The absence of competition in input supply also leads to a lack of innovation. Inputs are ordered in routine fashion without regard to location-specific requirements... Under the budgetary constraint that many countries experience, the actual amount that can thus be purchased remains far below the quantity desired at the subsidized price... Subsidization ties its operation to the budget year, causing delays in procurement and untimely delivery to farmers. [World Bank, 1981: 60-61]

Several examples are illustrative of these problems. Most of the examples are from African seed industries because parastatal seed distribution systems are particularly common in this region and because many of the recent seed projects (and evaluation reports) have been carried out there.

In Ghana, a Seed Multiplication Unit of the Ministry of Agriculture produced seed and distributed at grain prices by the extension service. A 1975 evaluation reported the following:

The results have been - at best - moderately successful. The extension workers usually had enough to do in regular work without the additional responsibilities as salesman and distributing agent. Some extension agents have conscientiously promoted good seed, and taken orders from many farmers, but have not been able to "deliver" because the distribution system did not get the seed in the area at the proper time - through no fault of the extension agent. As a consequence, the effectiveness of the extension agent is virtually destroyed. [Vaughan and Dougherty, 1975: 6]

The report argued that the subsidized price impeded the distribution of seed through cooperatives, farmer associations, and other private channels. Even the marketing parastatal was reportedly reluctant to begin seed marketing until "agreement on a reasonable profit can be reached"

[p. 7]. A 1983 report identified distribution as "probably the weakest link" in the program, yet the government was resisting a proposal to establish a mere 20% differential between seed and grain prices [Andrews and Vaughan, 1983: 19].

In Burkina Faso, a USAID project supports foundation seed production by the research organizations under contract to the National Seed Service. The latter then cleans the seed and sells it to the state Regional Development Organizations for final multiplication and distribution. Until 1981, the commercial seed prices were actually set below those of commercial grain so that seed sales were "in reality a combination of seed and grain sales" [Potts et al, 1983: 27]. Even under the new system, prices are set pan-territorially so that the relationship between seed and grain prices varies, and grain-deficit areas may have grain prices above the uniform seed price.

The distribution of seed and other inputs in Zambia occurs through the cooperative movement which is dominated by the governing political party. Hence, the allocation of seeds and other inputs has been used as a form of patronage to loyal party members [Bates, 1981: 111].

In Tanzania, the Ministry of Agriculture produces foundation seed on state farms established and equipped through a ten-year USAID seed multiplication project. TanSeed, a parastatal, produces certified seed by contracting individual farmers and the state farms and is the exclusive distributor of food crop seed. An evaluation report noted:

Delivery of seed is often late, frequently supply and demand do not coincide, and costs are very high. Currently the marketing margin is about 300 percent which makes seed - which are not subsidized - very expensive for farmers. [USAID, 1985: 8]

Part of the reason that the costs are so high is that TanSeed charges a

pan-territorial price and must cover the costs of transportation. An additional problem is that demand estimates have been based on optimistic "target" consumption figures given by District and Regional Development Offices. As a result, large volumes of seed have gone unsold, though less than 5,500 MT are produced annually [USAID, 1985]. The financial position of TanSeed is so precarious that in a recent year it was unable to pay its contract growers the agreed price.

A recent report called for the government to invite the Tanganyika Farmers' Association (TFA) to become part owner by buying part of the government's share (the TFA is a private entity which had earlier been forced out of seed production by the government). This would provide for the needed recapitalization of TanSeed and generate "incentives for efficiency and cohesive management" [Walker and Potts, 1982: 29].

In Kenya, the distribution of hybrid maize seed by the Kenya Seed Company was relatively uncontrolled. Seed was made available to over 6,000 registered retailers who paid in cash for the seed. The dealers knew their region and its likely demand well and had an incentive to provide seed on time, without ordering in excess. Sales rose from less than 1,000 MT in 1965 to over 10,000 MT in 1975, 90% of which was in 10 kg units, presumably bought by small farmers [Hazelden, 1982: 530]. Naturally, the rapid adoption rate was due to the truly superior cultivar, a product of ten years of painstaking breeding effort [see USAID, 1980b]. The point is that the distribution system was capable of delivering the product in ever increasing volumes.

The National Seed Corporation (NSC) of India was formed in 1961. Following its rapid growth in the 1960s with the introduction of the "green revolution" cultivars, the NSC became overextended and quality

declined. As a result, it was left with large amounts of unsold seed even though the supply was less than 10% of the estimated "requirements" [Thompson, 1981: 515]. Since then, foundation seed production and seed distribution has been opened up to the private sector. According to the World Bank [1978: 76]:

Initially, the companies tried to promote their products by demonstrations on farms; private retailers and cooperatives were encouraged through consignment arrangements, which left any unsold seed with the seed companies. Today, seed is being distributed in India by a network of more than 10,000 dealers throughout the country. Farmers have become quality-conscious and have developed preferences for brands of demonstrated quality. [World Bank, 1978]

Some 300 private seed companies, as well as 12 state seed corporations, now produce and distribute seed in India.

In summary, although government agencies are often involved in seed distribution, the typical organizational structure of public agencies is not conducive to the responsiveness, timeliness, and innovation needed for effective marketing. Furthermore, public distribution systems often institute price subsidies and pan-territorial pricing. These policies reduce the ability and incentive for both private and public entities to produce and distribute seed and, in the extreme, cause seed to be wasted in grain consumption. Some of the problems mentioned, such as the shortages, delays, and political favoritism, are consistent with patterns identified in the literature on subsidized fertilizer and credit [see Dalrymple, 1975; Bates, 1981; Adams and Graham, 1979].

Clearly, only some of the problems of seed marketing are due to the institutional arrangement of seed distribution systems. Poor seed quality, lack of truly "improved" cultivars, the shortage of trained personnel, shortage of spare parts, inadequate equipment, and other factors are also critical problems, each of which may manifest itself as a

problem of "farmer acceptance." Nevertheless, it is argued that the institutional structure of the seed industry influences its performance in addressing these problems.

2.4.4 Seed certification and legislation

As mentioned in section 2.3, consumer uncertainty regarding seed quality can be a serious problem. Not only does the consumer lose from imperfect information, but there is less incentive to produce quality seed. In economic terms, the returns to quality in the form of repeat purchases are not entirely captured by the firm, but distributed over the seed industry. Thus, in a free market the private firm is likely to underinvest in seed quality. This problem is illustrated by the situation in the United States during the 19th and early 20th centuries:

Although seed was sometimes available on the commercial market, the supply was sporadic, and often of questionable quality. Unscrupulous marketing gimmicks were sometimes used to take advantage of the customers' inability to identify seeds and their quality. This led to skepticism of the quality of seeds bought off the farm and created a climate of distrust against the development of a legitimate seed industry. [Copeland, 1976: 213].

The Indian seed industry in the early 1960s was described in quite similar terms:

...the seed companies often compromised on quality and tried to market mixed, wrongly labeled, or poor quality seeds. The unscrupulous gimmicks of such agencies not only created a climate of distrust among farmers, but the main objective of achieving higher yields, by the use of quality seeds was also defeated. [Siddiqui, 1983: 1065]

These problems have led to the establishment of services to provide impartial information on seed quality, usually in the form of certification. They are operated by public agencies and, in some cases, by non-profit associations and cooperatives. Since certification may be considered a form of simple grading, the following passage is relevant:

Grades are generally believed to increase resource mobility and reduce barriers to entry. When inputs or products can be bought by description, rather than by seller reputation or buyer inspection, the market is widened...Grades may help to insure that individuals in a market receive prices for their product commensurate with its quality. Grades help prevent "the clever and unscrupulous" from "outwitting the unwary and trusting." Second, total demand for a product may be increased... [Nichols et al, 1983: 76, 78]

Seed certification usually involves both field inspections and laboratory testing following established procedures and predetermined standards for each type of contamination, seed species, and class of seed (foundation, certified, and so on) [see Delouche and Potts, 1971: 65].

It is clear that seed certification or legislation is necessary only when seed is traded. It is not necessary in traditional agricultural systems in which farmers save their own seed or in vertically-integrated seed-and-commodity schemes which can rely on internal quality control. Some authors argue that government seed production makes certification unnecessary since quality can be maintained by decree [Potts et al, 1983]. In any case, new seed programs often involve a single agency for seed production and distribution, while quality control is maintained internally. The establishment of an independent service to certify seed quality is almost always an early step in this process of institutional specialization.

Public sector involvement in seed certification is justified more by the need for impartiality than by any external benefits to certification. Thus, there is no strong efficiency argument against charging user fees to cover the costs of certification. As argued earlier, self-supporting services avoid dependence on often unreliable public funding and improve responsiveness to market needs.

In practice, public participation in both seed production and seed certification creates two related problems. First, the credibility of

the certification service may be damaged by real or imagined political interference from the seed production agency, hence the value of maintaining the administrative and financial independence of the certification service. Second, the seed production unit may claim exclusive rights to the work of the certification service, especially if no fee is charged, thus impeding the development of private seed enterprises. A user-fee policy, to be applied to public and private producers, allows the certification service to expand to meet the demand, permits financial independence, and emphasizes its proper role as a "service" to seed producers, public and private.

Seed legislation establishes the legal basis for seed certification, defines the actual standards or the process for setting them, and regulates the trade of seed. The U.S. model follows the principle of truth-in-labeling [Rollin, 1975], whereas the European model restricts commerce to a list of officially approved cultivars [Kelly, 1975]. Several authors warn against premature establishment of seed legislation or the creation of overly strict quality standards which may inhibit the development of a seed industry [see Delouche and Potts, 1971: 76-81 and Douglas, 1980: 122-133]. For example, efforts to enforce the use of certified seed by prohibiting commerce in uncertified seed are neither practical nor desirable when the seed industry is incipient. Nevertheless, when designed in accordance with the current stage of seed industry development, seed legislation can play a useful role in facilitating seed commerce.

CHAPTER THREE

BOLIVIAN AGRICULTURE AND SEED INDUSTRY

This chapter describes the basic characteristics of the Bolivian agricultural economy, focusing on seed industry development. It is intended to provide a useful context for the following chapters which deal with the problem of improving the supply of wheat seed in the lowlands of the department of Santa Cruz.

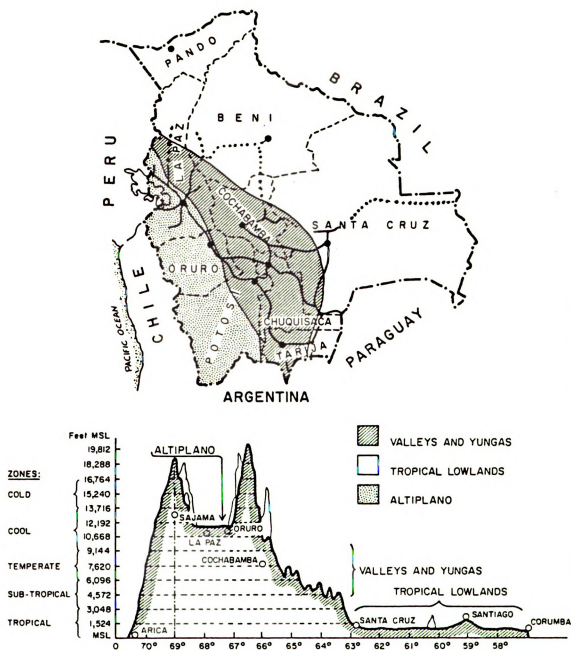
3.1 Geography, climate, and population

Bolivia is a landlocked country in South America, located between 9° and 23° S. and 58° and 70° W. Although it is within the tropics, as defined by latitude, the climate varies considerably from the permanently snow-capped peaks in the Andes Mountains to the tropical Amazonian forests. Bolivia is often divided into four geographic zones: the "Altiplano" (high plain), the "Valle" (Valleys), the Yungas, and the eastern lowlands (see Figure 3.1).

The Altiplano is a vast plain running north-south in the western part of the country, bordered by Andean mountain ranges on both sides. The plain lies about 4000 meters above sea level, while the mountain ranges reach altitudes of 6500 meters. The rainfall in this area ranges from 250 mm in the south to 650 mm in the north and the temperature is cool (8-12° C. annual mean) with overnight frosts during the winter. Lake Titicaca, located on the northern Altiplano, is the largest lake in South America and the highest navigable body of water in the world.

The Valleys and Yungas are an intermediate zone on the eastern

FIGURE 3.1: MAP OF BOLIVIA



SOURCE: Wennergren and Whitaker, 1975

slopes of the Andes, lying between about 800 and 3000 meters. The Yungas in the north consist of steeply descending mountain valleys with high rainfall (around 1100 mm). The Valleys in the south provide a more gradual descent to the east and are drier (around 700 mm).

The eastern lowlands, or "Oriente," form around 65% of the national territory. Most of this area is part of the Amazon River watershed though the climate varies considerably. Tropical rain forests receiving 2500 mm of rainfall and humid savannas are found in the north, whereas the southern part consists of semi-arid plains known as the Chaco which receives only 750 mm (Wennergren and Whitaker, 1975: 84-88).

The 1982 population of Bolivia was estimated at around 5.9 million, of which approximately 55% live in rural areas (World Bank, 1984: 218, 260). Although the overall population density is relatively low, considerable population pressure does exist as a result of the geographic distribution. The Altiplano and Valley regions contain around 78% of the rural population but only 25% of the land area. The population density is over 50 persons per square kilometer in the northern Altiplano, 10 per km² in the central Altiplano and the Valley areas, and less than one per km² in the lowlands (Whitaker and Wennergren, 1982: 237).

This concentration of population in the highlands, particularly in the northern Altiplano, reflects pre-Columbian patterns of population distribution. The pre-Inca Aymara and the Quechua-speaking Incas farmed throughout these areas before the arrival of the Spanish, whereas the lowlands were only sparsely inhabited by scattered groups of hunter-gatherers. Aymara- and Quechua-speaking Indians still populate the rural highlands, although a majority also speak Spanish. The impact of Indian populations is much less pronounced in the lowlands.

Rural-urban migration has been an important force in Bolivian population distribution. The total population of Bolivia grew 2.1% annually between two most recent censuses in 1950 and 1976, but the three major cities have grown at a much faster rate. La Paz in the Altiplano grew 3.5% annually, Cochabamba in the Valleys at 3.9%, and Santa Cruz in the lowlands at 7.2% [Romero, 1982: 312].

The high rate of growth of Santa Cruz highlights an important trend in rural-rural migration. It is estimated that between 200,000 and 350,000 have migrated to the lowlands around Santa Cruz, to lowland areas near Cochabamba, and to the Yungas near La Paz. This migration has been spurred by the opening of roads to these zones, population pressure on traditional highland farming areas, government colonization efforts, and the demand for labor from the growing commercial agricultural sector near Santa Cruz. The development of the Santa Cruz area will be discussed in subsection 3.2.2.

3.2 Bolivian agriculture

3.2.1 Agricultural production by region

Bolivian agriculture is marked by extreme variation in the types of crops and livestock grown, the degree of mechanization and use of purchased inputs, and the proportion of output which is marketed. However, rough characterizations can be made for each of the four geographic zones.

In the Altiplano, traditional small-scale farming dominates, with most of the holding less than 3-4 hectares. This is due to the land reform carried out following the Social Revolution of 1952 and continued population growth. Potatoes are the most important food crop, with barley, forages, quinoa (a high-altitude cereal), legumes, and vege-

tables also being grown. Sheep, llama, alpaca, and other livestock are raised as well, particularly in the southern Altiplano which is colder and more arid. Soil erosion, low soil fertility, overgrazing, and crop damage from hail and frost are serious problems, but the area continues to provide a precarious livelihood to many small farmers.

Although the climate of the Valleys is less severe, it is also characterized by highly fragmented land tenure and depleted soil fertility resulting from centuries of farming. Corn and potatoes are the staple crops, while wheat, barley, and fruits are also produced.

The Yungas, with its tropical humid climate, supports the production of coca, citrus fruits, coffee, and bananas. Although the soil is relatively fertile and urban markets close, steep slopes and unreliable roads impede all but the most profitable commercial crops. As a result, this area is sparsely populated [USAID, 1980a: 24-34].

Agriculture in the Oriente varies according to the climate. The tropical rain forests in the north yield Brazil nuts, rubber, and animal skins. The humid savanna and, to a lesser extent, the Chaco have become important producers of beef cattle. The beef is flown daily to the major urban centers. The most intensively farmed part of the Oriente is the area near the city of Santa Cruz. Sugar cane, soybeans, cotton, and other crops are produced by large-scale commercial farms. Rice, yuca (cassava), and maize are important small-farm crops, both for sale and for auto-consumption [CORDECRUZ et al, 1982b: 363-373]. This region is discussed in more detail in the following subsection.

3.2.2 Agricultural development in Santa Cruz

Only in the last 25 years has the department of Santa Cruz begun to fulfill the expectations held for the eastern lowlands. Like other nations bordering the Amazon basin, Bolivia has long seen the undeveloped forests and savannas as an immense storehold of natural resources waiting to be exploited.

The conviction that the United States' frontier phenomenon 'ought' to be transferable southwards into Latin America with equally dramatic results is one of the oldest and most persistent in the continent. [Fifer, 1982: 408]

Nevertheless, demographic and economic growth have been frustratingly slow or short-lived. In the 19th and early 20th century, the region experienced two successive boom-and-bust cycles, the first centered on cinchona bark, used to manufacture quinine, and the second on natural rubber [Fletcher, 1975 and Hiraoka, 1980].

With the loss of lowland territory to Brazil at the turn of the century and to Paraguay in the costly Chaco War of the 1930s, the geopolitical importance of populating this region became even more evident. Further incentive was provided by the Social Revolution of 1952, which involved comprehensive land reform, expropriation of the largest mines, and the abolition of semi-feudal relations in the countryside. Economic chaos, uncertainty concerning land expropriation, and possibly greater on-farm consumption meant substantially reduced volumes of marketed food. Furthermore, although over 320,000 titles to land were granted over the following two decades, many of the plots allocated were quite small. For example, in the department of Cochabamba over 20% of the land was redistributed, but more than 8,000 families received plots of less than 1.5 hectares of arable land. Colonization of the eastern lowlands to alleviate these problems became an explicit goal [Zondag, 1968 cited

in Stearns, 1973: 383; Weil, 1974; and Fletcher, 1975].

Many of government-sponsored colonies founded in the 1950s and 1960s were poorly designed. In addition to high costs (from US\$ 1500 to over US\$ 3000 per family), they were located far from markets and on poor soil, the colonists were miners and others without farm experience, and the selection of crops was regulated. As a consequence, settlement loans could not be repaid and the rates of abandonment were 50-85%. On the other hand, the numerous colonies which formed spontaneously tended to have lower abandonment rates and higher incomes. These colonies now account for 79% of the 65,000 lowland colonist families [see Edelman, 1967; Stearns, 1973; Henkel, 1982; and Fifer, 1982].

The government also promoted the establishment of foreign colonies, principally Japanese and Mennonite ones. Japanese and Okinawan colonists began arriving in 1953 under an agreement between the Bolivian, Japanese, and U.S. governments (they had been displaced by the construction of a U.S. airbase). Currently, there are about 430 such families in four settlements northwest and northeast of the city of Santa Cruz [CORDECRUZ, 1982a]. Credit and technical assistance from the Japanese government have facilitated agricultural mechanization to produce soybeans and wheat. The average income of the Japanese farmers is about five times that of Bolivian colonists [Kashiwazaki, 1983].

Similarly, the Mennonite colonists began arriving in 1954 from Paraguay. Since then, several waves have arrived from Paraguay, Mexico, and Canada. About 2,100 Mennonite families have settled in eleven colonies, most of which are southeast and northeast of Santa Cruz [CORDECRUZ, 1982a]. In spite of their social isolationism and cultural rejection of passenger vehicles and modern household appliances, they

are not reluctant to use heavy land-clearing equipment, tractors, and combines. They produce livestock, poultry, and dairy products as well as soybeans, maize, and wheat. Like the Japanese, they tend to have larger cultivated plots and higher average income than the nationals.

Although the Japanese and Mennonite farms tend to be larger than those of the Bolivian colonists, averaging 80 ha compared to 19 ha, the largest farms are the Bolivian "agricultural enterprises." The Land Reform Act of 1953 allowed for the retention of holdings of up to 2,000 hectares by "agricultural enterprises," defined as farms with large capital investments, wage labor, and modern technology. These farms produce sugarcane, cotton, soybeans, and wheat [Fifer, 1982].

Currently, most of the colonies, agricultural enterprises, and other farms are concentrated within 200 km of the city of Santa Cruz. Rice, maize, and yuca are produced by small farmers to the north of Santa Cruz, approaching the foothills of the Andes Mountains, where the rainfall is relatively high (about 2000 mm). Rice has become an important cash crop following its expansion in the late 1950s, partly due to the production of the Japanese colonies. Currently, rice is cultivated on 35,000 hectares in the department by about 16,000 growers [CORDECRUZ et al, 1982b: 61].

Large-scale production of sugar cane, the most important commercial crop in the department, is also concentrated to the north of the city. The volume produced grew considerably in the late 1950s and again in the early 1970s, reaching an area of 60,000 hectares and an output of around 1.9 million metric tons of refined sugar. The cane harvest provides seasonal employment to some 15,000 workers, the majority migrating from the highlands [CORDECRUZ et al, 1982b: 459-460].

Mechanized production of cotton, soybeans, and, recently, wheat is more common between Santa Cruz and the Rio Grande to the east where rainfall is lower (about 1000 mm). Cotton, only an experimental crop in the 1950s [Heath, 1959], experienced a boom in the early 1960s and again in the early 1970s, at which time its acreage expanded six fold in two years. Lower international prices and problems due to Bolivia's violation of an international trade contract have led to a decline in crop area to its 1970 level of about 7,000 hectares.

Soybeans have become the latest boom crop, stimulated by high international prices in the early 1970s. It has grown from covering 1900 hectares in 1972 to 40,000 hectares in 1981. This has allowed import substitution of vegetable oil [CORDECRUZ et al, 1982b: 523].

Following the expansion of soybean production in Santa Cruz, wheat production has also increased rapidly in the lowlands as a winter crop. This expansion has been facilitated by the fact that it can use the same lands and machinery as soybeans. Wheat production will be considered in more detail in the next chapter.

3.3 Seed industry in Bolivia

3.3.1 Overview of seed programs

Following the system employed by the FAO 1979-80 seed review, the Bolivian seed industry would be classified as having "fragmented or pilot scale operations" [Feistritzer, 1982]. For this reason, it makes more sense to speak of various seed programs rather than the Bolivian seed industry. Much of the fragmentation is due to the varied agro-climatic zones found in Bolivia and the weak transportation links between them. In addition, seed industry development has been slow due

to the predominance of small-scale semi-subsistence agriculture which limits the effective demand for purchased inputs such as seed. Furthermore, agricultural research in Bolivia has been hampered by inadequate support and duplication of effort.

Agricultural research and extension activities were initiated after World War II by the Servicio Agrícola Internacional (SAI), a joint U.S.-Bolivian organization. This structure was similar to other SAI units operating in most Latin American countries until the early 1960s [see Rice, 1974]. It established ten research stations in Bolivia between 1946 and 1964. Also paralleling the experience elsewhere in Latin America, the transfer of these functions to local agencies in the early 1960s and the reduction in U.S. technical and financial support severely weakened both research and extension. As a result, some of the research stations have discontinued research, while others have limited their activities and are forced to operate as commercial farms to generate revenues [Wennergren and Whitaker, 1975: 250-254].

A 1980 USAID report noted that IBTA, the research and extension agency, has "spread its research personnel and financial resources far too thinly among too many commodities and too many experiment stations." It also observed that researchers had insufficient contact with farmers and were isolated from farm-level problems [USAID, 1980a: 70-71]. In Santa Cruz in 1975, these problems led to the creation of the Center for Agricultural and Technological Research (CIAT) which has displaced IBTA in the department. CIAT enjoys support from the Regional Development Corporation of Santa Cruz (CORDECRUZ) and other local institutions.

In spite of the problems mentioned above, some improved cultivars have been released and disseminated. Cuban Yellow maize was released in

the 1950s and is now the principal yellow maize cultivar in the low-lands. Improved cultivars of rice are widely used in Santa Cruz. Wheat and certain types of potatoes are now dominated by cultivars introduced since 1960. The Mexican wheat cultivar, Jaral, has become widely used since its introduction in 1966. However, the use of improved cultivars does not indicate the existence of a sustained seed industry. Some cultivars have been disseminated by farmer multiplication with little or no renewal with certified seed [Wennergren and Whitaker, 1975: 114].

Attempts have been made to establish a wheat seed industry since the late 1960s when considerable attention was focused on wheat production by the newly formed National Wheat Institute, the USAID-Utah State University project, and the Ministry of Agriculture and Campesino Affairs (MACA). Although a locally-bred high-yielding cultivar, Coposu, was originally promoted, it became clear that farmers preferred Jaral for its superior disease resistance and the premiums offered by the mills for this semi-hard cultivar [Gardner, 1968 and 1970].

A Seed Department in MACA was formed in 1970 to control the marketing of seed, formulate and enforce seed regulations, and promote seed production and distribution. In spite of this limited mandate, it became directly involved in seed production using both its own land and that of contracted growers. The Seed Department then processed the seed in its own plants, first in Cochabamba and later in Warnes (Santa Cruz) and Betanzos (Potosi). It also certified and distributed its own seed.

Data on the volume of seed production are available for the first years. From 1970 to 1972, the volume of improved wheat seed sold rose from 177 MT to 384 MT, although in the latter two years several hundred tons of seed went unsold [Wennergren and Whitaker, 1975: 115].

Data are available on the proportion of crop area "under improved varieties" for the period 1975-81. They show that the crops with the highest proportions of improved seed area were those depending on imported seed: soybeans, cotton, and sorghum. On the other hand, the proportion of area under improved cultivars was generally less than 7% for wheat and maize and near zero for pasture, barley, and potatoes [Morales, 1984: 5].

Furthermore, these figures probably refer to land cultivated with up to fourth generation saved seed, rather than that cultivated with certified seed. Thus, they correspond to an annual production of only 100-200 MT.

In 1980, in an appendix to a report on Bolivian grain storage, a Kansas State University consultant noted the following:

The capacity of this program to produce good seed needs to be increased. At present the supply cannot be met [sic]. The multiplication program is operating in the red (not self-supporting). It is a well-organized program but needs more support to increase the supply of good seed. [Hugo et al, 1981: Appendix G]

It should be noted that this evaluation was based on a six-day trip accompanied by the director of the Seed Department. On the other hand, in conversations with the author, observers close to the seed program have contradicted this assessment. They report a variety of counter-productive policies within the Seed Department that have impeded the development of a more effective program.

First, the volume of seed produced has been severely limited by the reluctance of the Seed Department to promote or even permit other entities to use its processing facilities, in spite of the fact that budget allocations severely constrain the amount of seed it can directly produce. The Cochabamba processing plant, the largest and best equipped in Bolivia, was, as of 1982, "still operating at less than 25% of its capacity" [CORDECRUZ, 1982c: XXII-1].

A related problem is its uncooperative attitude toward private sector interest in seed production. The Seed Department recently refused to consider testing barley seed for a beer company even on a fee basis. The beer company had been interested in improving the quality of its raw material by initiating a private multiplication program.

Furthermore, MACA sought external aid to construct as many as five seed processing plants in those regions without facilities, paying little attention to promoting seed production where plants already existed. In Zudañez (Chuquisaca), USAID-financed processing equipment remained in its crates for over five years because the Seed Department would not run 100 meters of electrical lines to provide electrification for the facility. Serious problems were also reported in Santa Cruz, as described in the next subsection.

3.3.2 Seed programs in Santa Cruz

Until 1981, seed production in Santa Cruz was conducted by MACA and followed the pattern established in Cochabamba and other parts of Bolivia. MACA contracted the production of seed, cleaned it with its own processing facilities, and sold it to interested farmers. Seed growers were not provided any special seed, so the system was essentially one of supplying clean grain rather than varietally pure seed. Under this system, the CIAT Experiment Station at Saavedra had no incentive to produce breeder or foundation seed.

There is no information on the volumes of seed produced, but it is likely they were quite small. One source reports that no seed was produced in Santa Cruz in 1980 [Certificación, 1984a]. In part, this is due to the limited number of MACA personnel assigned to carry out this

function: one agronomist and two assistants. They were fully occupied by seed processing and were unable to devote much effort to field inspections or seed testing [CORDECRUZ, 1982c: XXII-2].

More seriously, several people acquainted with the program indicate that there were abuses of the system by MACA personnel. Specifically, it was reported that some seed growers were told their fields did not qualify for seed production and were paid grain prices for the harvest, yet the grain was processed and sold as seed. Another alleged practice was to falsify records to show that seed prices were paid to growers when in fact they were not and that sacks were sold as grain when in fact seed prices were charged. Thus, the need for government support was exaggerated for the private gain of MACA employees.

With this background, it is not surprising that the seed program made little progress in convincing farmers of the usefulness of purchasing "certified" seed. In fact, it contributed to the poor image of MACA, already mistrusted for its affiliation with the government. Since 1981, the institutional arrangement of the Santa Cruz seed program has changed significantly under the guidance of the USAID Agricultural Sector Project II. This project involved a technical assistance contract between MACA and Chemonics International, a U.S. consulting firm. In September 1980, Chemonics assigned Dr. Adriel Garay, a U.S.-educated Peruvian seed specialist, to the MACA office in Santa Cruz. Initially, he worked to strengthen seed testing procedures, showing in the process that the seed produced by the MACA program and even the imported soybean and cotton seed was often of poor quality.

In 1981, Dr. Preston Pattie, the project director, and Dr. Garay wrote a policy paper on seed program planning in Bolivia [Garay and

Pattie, 1981]. They made the following recommendations:

- 1) that seed production must be based on successive multiplication of varietally pure seed provided by the experiment station,
- 2) that greater effort be made to stimulate private sector seed production and distribution, such as by making processing facilities available on a fee basis,
- 3) that the construction of new processing facilities be dependent on progress in promoting seed production,
- 4) that, to the extent possible, MACA restrict its role to seed certification, and
- 5) that initial efforts to develop the seed program be regional.

Although well received among the local agricultural institutions [e.g. CORDECRUZ, 1982c], there was resistance from the Seed Department. In addition to eroding its control over seed production, the proposal would promote the involvement of the private sector, an idea with little acceptance in MACA and in the leftist government as a whole. Persistent lobbying, particularly by the organized commercial agricultural sector of Santa Cruz, eventually led to the removal of the national director of the Seed Department and his replacement by someone less hostile to the proposed reforms.

Several important changes were instituted in 1982. First, a Santa Cruz Regional Seed Board was formed to coordinate the seed program, establish quality control standards, and set foundation seed prices. It is composed of representatives of MACA, CORDECRUZ, CIAT, the Agricultural Chamber of the Oriente, and the professional association of agronomists [Zegarra, 1983: 77].

Second, a Regional Seed Certification Service was created as a branch of MACA, but with financial support from local institutions. This unit, composed of a small crew of young agronomists, works exclusively on seed certification and strives to "protect the good image of the

[new] Service with seed growers and farmers" [Zegarra, 1983: 79]. For field inspection and laboratory testing, it charges 3% of the final seed value, collecting from both public and private producers. USAID-Chemonics has worked closely with the Service, providing technical assistance and equipment and arranging training in seed technology at the International Center for Tropical Agriculture (CIAT) in Colombia.

Third, the Foundation Seed Unit was also established in 1982. Affiliated with the Saavedra Research Station, this unit is responsible for the production of high-quality foundation seed, generally through contracts with private growers.

And finally, the administration of the processing plant at Warnes was transferred to CIAT. To achieve this, it was argued that civil service regulations were not compatible with plant operation and that:

the functions of certification and processing [would] convert MACA into "judge and defendant." In addition, the very limited resources of MACA require that it concentrate its efforts on one single activity. [CORDECRUZ, 1982c: XXII-3]

The plant now processes seed as a service available to both public and private entities, charging prices which roughly cover costs. The plant's rated capacity has been expanded to about 3500 MT/year with equipment obtained through the USAID-Chemonics project.

Initially the program concentrated on two crops: soybeans and yellow maize. Soybean seed production has been carried out in both the summer (45%) and winter (55%) seasons for commercial soybean production in the summer. The program provides four Brazilian cultivars and has reduced Bolivian soybean seed imports from close to 100% to about 25% of consumption. Several private seed firms and the cooperative of Japanese farmers (CAICO) are active in soybean seed production while distribu-

tion is handled by ANAPO, the oilseed growers' association.

Maize seed production has also attracted the participation of a private seed enterprise. This firm buys foundation seed, multiplies the seed using contract growers, has it processed at the Warnes plant, and then distributes it. Two cultivars are currently offered.

Later, rice and wheat seed were incorporated into the program. These are still handled by CIAT because, as yet, no private entities have begun production. Wheat seed is produced by small-scale contract growers in a highland area of Santa Cruz. The elevation (1500-2500 meters) provides a climate more suitable for seed production and permits summer wheat cultivation (December-April). The harvested seed is brought to the Warnes plant for processing and is then immediately distributed in the lowlands for winter season wheat production (May-September). The wheat seed program is described more fully in Chapter Four.

Underlying the reforms instituted since 1981 are the explicit goals of generating self-financing public institutions, promoting private seed production and distribution systems, and coordinating these various institutions to provide high-quality seed to the farmer. The results of these reforms have been successful on several fronts. Certified seed production has expanded steadily, as shown in Table 3.1.

In addition to the eight private seed enterprises which have been formed since 1981, the program has also stimulated interest in privately operated seed processing plants. The cooperative of Japanese farmers (CAICO) has completed construction of a processing plant which is expected to concentrate on soybean seed. CAICO has also received technical assistance from the USAID-Chemonics project. Similarly, a private seed enterprise just completed a processing plant for maize seed. The

TABLE 3.1: CERTIFIED SEED PRODUCTION IN SANTA CRUZ (MT)

	Soybean	Wheat	Rice	Maize	TOTAL
1980		-	-	-	0
1981	500	-	-	100	600
1982	1300	162	200	100	1762
1983	1850	250	150	150	2400
1984	2100	396	700	800	3996

SOURCE: ANAPO for wheat seed (does not include seed stored in 1984).
Chemonics International for others.

construction of these plants has been stimulated by the rapid growth of the program, surpassing the processing capacity of the Warnes plant, and by the processing fees at Warnes which have been established to cover capital and operating costs.

Although there are no private entities currently involved in wheat seed production, one seed company bought a small quantity of seed in 1984 to determine the feasibility of entering wheat seed multiplication. This is made possible by the price structure of the public program which roughly covers costs, thus allowing private sector competition on an equal basis, and by the availability of certification services and processing facilities for hire. In addition, the development of private seed enterprises with experience in other crops facilitates diversification into wheat.

Naturally, much of the success of the seed program is due to the fact that the Santa Cruz area was "ripe" for the development of a seed industry. It had a large-scale commercial farming sector, fairly well developed agricultural institutions including growers' associations, and an important industrial crop (soybeans) for which the demand for pur-

chased seed was already established. However, it is also apparent that the reforms which explicitly promoted the participation of the private sector in seed production and distribution have been essential in realizing this potential. Furthermore, although promoted by the large-scale commercial sector, the seed program is also benefitting small farmers, both the wheat seed growers in the highlands and small rice and maize farmers in the lowlands.

CHAPTER FOUR

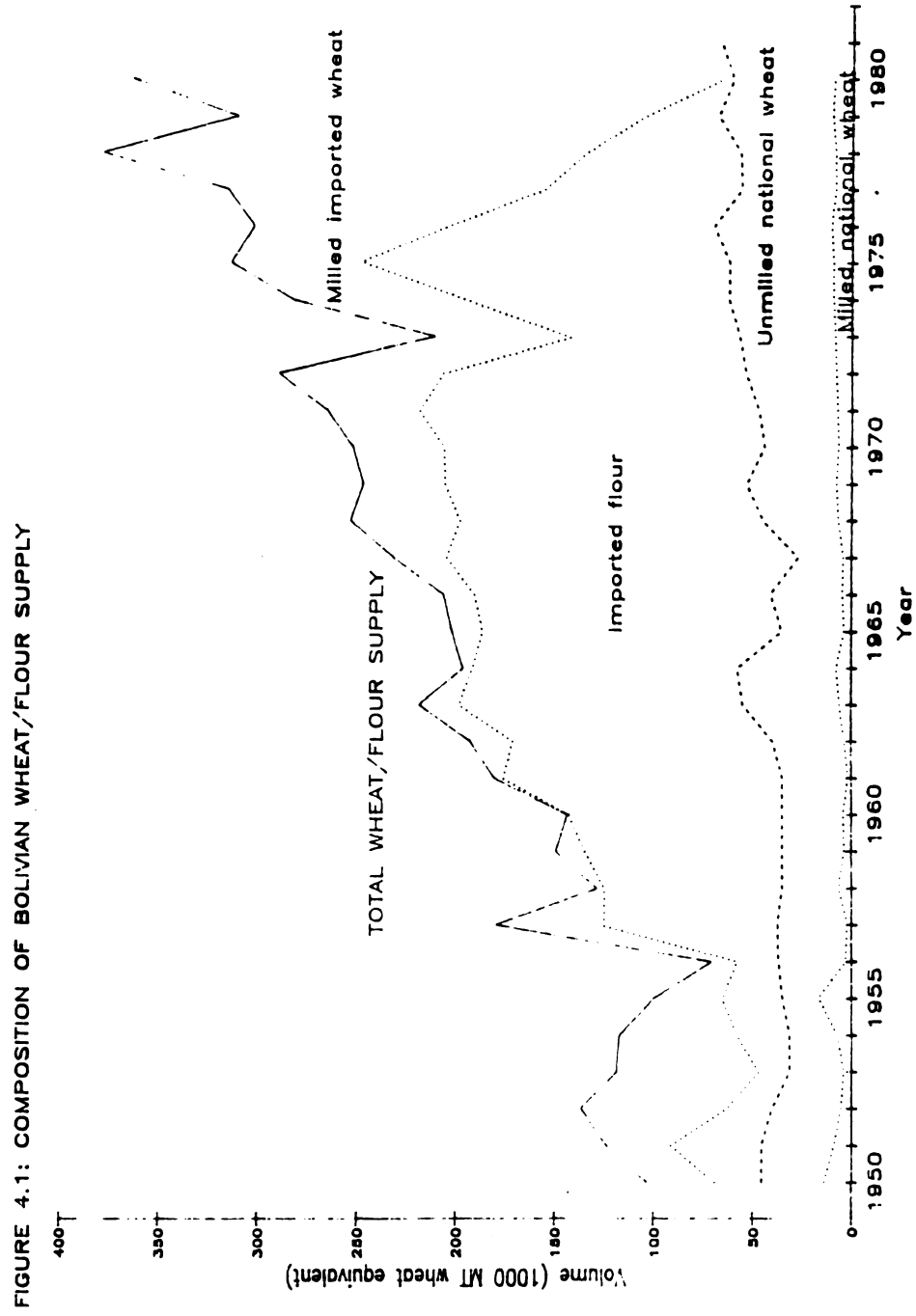
DESCRIPTION AND DIAGNOSIS OF THE LOWLAND WHEAT SEED MARKET

This chapter focuses on the wheat seed market in the lowlands of Santa Cruz, beginning with a review of the market for wheat grain in Bolivia. It is primarily descriptive and diagnostic, providing the groundwork for later chapters which generate projections of future trends and prescribe strategies for improving the supply of wheat seed.

The information in this chapter was gathered from secondary sources, interviews with Bolivian professionals, and a survey of lowland wheat farmers conducted by the author in July 1984. Using lists of farmers who purchased certified wheat seed, the survey was designed to weight the responses proportional to the volume of seed bought. The methodology of the survey is described in Annex B.

4.1 Wheat in Bolivia

In the 1930s, Bolivian wheat production constituted 60-70% of national consumption. Since that time, production has doubled but consumption has expanded eight-fold, so that imported wheat and flour now provide 85% of the total (see Figure 4.1). Large industrial mills, which supply the urban areas, obtain 90-95% of their wheat from imports. In contrast, most local wheat is consumed outside the cities, as flour from small-scale mills of less than 10 hp, in soups and "chicha," and as animal feed. Thus, it is not surprising that wheat policy has focused on raising national production to substitute for wheat and flour imports and to increase the local portion of wheat purchased by the large mills.



SOURCE: See Table 4.1.

TABLE 4.1: BOLIVIAN WHEAT AND FLOUR PRODUCTION AND IMPORTS (1000 MT)

	National wheat production	Milled national wheat	Imported wheat (all milled)	Imported flour	TOTAL (wheat equiv.)
1950	45.70	13.60	33.90	17.30	103.63
1951	45.70	8.60	32.50	32.90	123.89
1952	40.00	5.00	73.70	16.40	136.48
1953	31.20	3.60	71.60	11.20	118.36
1954	31.20	7.20	58.80	19.40	116.94
1955	35.00	16.70	34.40	21.90	99.82
1956	37.00	2.70	13.20	14.80	70.76
1957	37.50	1.90	54.70	63.00	179.70
1958	35.00	6.60	3.40	64.90	128.54
1959	35.00	3.40	14.30	71.90	149.16
1960	35.00	4.00	.60	77.60	143.38
1961	35.00	1.40	4.50	101.50	180.47
1962	40.00	3.40	21.50	94.40	192.61
1963	55.20	6.00	20.00	103.00	218.26
1964	57.90	7.70	4.70	96.10	196.07
1965	35.00	3.50	15.60	108.90	201.85
1966	41.00	4.50	15.10	107.80	205.82
1967	27.00	4.00	26.60	127.80	231.10
1968	45.00	6.80	54.20	109.90	251.84
1969	53.00	8.00	40.60	109.80	246.10
1970	44.20	6.60	45.70	116.60	251.84
1971	47.10	7.10	46.30	123.30	264.65
1972	53.80	8.00	82.80	109.80	289.10
1973	57.00	8.60	68.20	61.50	210.62
1974	62.50	9.40	85.70	96.30	281.95
1975	61.80	9.30	65.40	133.80	313.03
1976	69.80	10.50	97.40	96.50	301.23
1977	55.60	8.30	160.00	71.50	314.91
1978	56.60	8.50	243.20	56.00	377.58
1979	67.80	10.20	204.30	27.00	309.60
1980	60.10	9.00	276.70	4.00	342.36
1981	66.60		266.40		333.00*
1982	66.00		170.00		236.00*
1983	40.30		331.30		371.60*
1984	68.50		360.00		428.50*

SOURCES: MACA-USAID, 1984; Torrico, 1979; and Hugo et al, 1981.

NOTE: Wheat equivalence calculated using a 72% conversion rate.

* 1981-1984 totals do not include flour imports.

4.1.1 Patterns in wheat production

The traditional wheat growing areas include the Valleys and, to a lesser extent, the Altiplano. For example, the departments of Cochabamba and Chuquisaca accounted for about 65% of the 96,000 hectares of wheat planted in 1982 [MACA-USAID, 1984]. In much of this highland producing area, wheat must compete with corn and potatoes. Except in a few areas, it is grown by small farmers who use only small amounts of purchased inputs. Fertilizer, for example, is generally reserved for potato cultivation. However, wheat production probably benefits from residual fertilizer in the soil.

In the lowlands of Santa Cruz, wheat production has increased markedly in the last six years. It has grown from 200 hectares in 1978 to around 8800 hectares in 1984 (see Table 4.2). Lowland wheat area now accounts for about 10% of national wheat area. In contrast to highland production, wheat in the lowlands is produced in the winter when the temperatures are low enough for this temperate climate crop. Another difference is that wheat in lowland Santa Cruz is grown on larger holdings (10-200 ha) and planting and harvesting are mechanized. It is frequently grown in seasonal rotation with soybeans, thus taking advantage of the fact that both crops use the same agricultural machinery.

Historically, most of the growth in Bolivian wheat production has been the result of increases in cultivated area. Yields average 700-800 kilograms per hectare, less than half the average for Latin American which is 1630 kg/ha [International Wheat Council, 1984]. In the lowlands, average yields are around 1000 kg/ha.

Perhaps the most intensive effort to promote wheat production in Bolivia occurred in the late 1960s and early 1970s. The United States

Agency for International Development (USAID) contracted Utah State University to provide technical assistance to the Ministry of Agriculture and Campesino Affairs (MACA). Although the first Utah State reports were pessimistic about the prospects for self-sufficiency in wheat [Dewey and McAllister, 1966 and Gardner, 1966a,b], recommendations were made for reducing wheat and flour imports. From 1966 to 1973 a wheat project within the Utah State contract focussed on varietal testing, fertilizer-response trials, and seed multiplication. Wheat area did not increase appreciably over this period, but yields did rise from around 550 kg/ha to around 800 kg/ha. This is probably the result of the adoption of new cultivars of wheat, in particular the Mexican cultivar, Jaral, introduced in 1966. Two Utah State economists calculated a negative ex poste rate of return to the project, arguing that USAID ignored indications that the sheep project provided superior returns [Wennergren and Whitaker, 1977].

Studies of the returns to crop production in the highlands have generally concluded that wheat is less profitable than competing crops at prevailing prices. For example, a Kansas State University report reviewed comparative return studies from 1964, 1971, 1973, 1978, and 1980 and concluded that:

...gross less variable costs are considerably lower for wheat than for corn and potatoes. Wheat yields would have to double for returns to equal those to corn, and to equal the returns to the cultivation of potatoes wheat yield would have to be eight times greater. [Hugo et al, 1981: 17]

Although conversations with farmers confirm that wheat is not a "preferred" crop, the fact that presumably rational farmers continue to grow it indicates that it must be more profitable than other crops in some situations.

This apparent paradox is probably explained by the fact that corn and potatoes are less profitable than wheat on low-fertility soil. Thus, wheat is relegated to areas with naturally poor soil and to land which has already been depleted by corn and potato production. A common rotation seems to be potato-corn-wheat-fallow [Gardner, 1966a]. Although no comparative rate of return studies have been done for lowland wheat production, very few crops are grown in the winter. Soybeans for seed and sorghum for on-farm animal feed are currently the only alternate uses for the land.

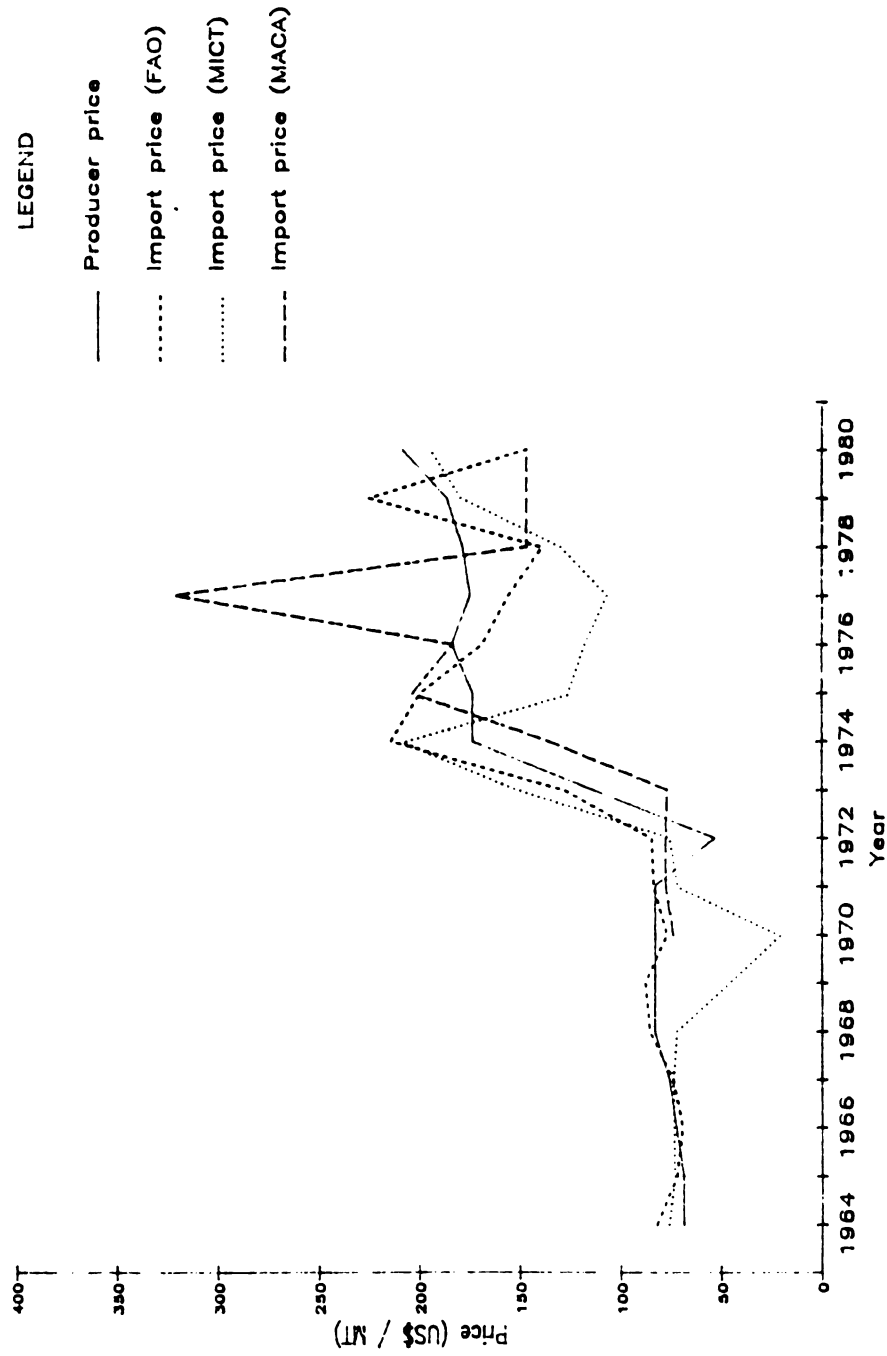
4.1.2 Wheat marketing and price policies

Wheat policy appears to pursue the goals of promoting wheat production to reduce imports and maintaining low consumer prices for wheat products. The history of wheat programs and regulations reflect the inherent conflict between the goals, the frequent changes in government (16 since 1964), difficulties in enforcement, and strong political pressure on the price of bread.

Pricing of wheat and wheat products in Bolivia is more complex than for any other commodity. Both consumer oriented and producer oriented policies have been implemented during the past twenty years... The price of bread is alleged to be one of the most politically sensitive factors in the country. [Gardner, 1974: 25]

Figure 4.2 compares Bolivian producer prices with various estimates of the price actually paid for wheat imports. The producer price is the average price paid to farmers at the farm gate. Although the estimates of import price vary widely, it appears that producer prices were roughly comparable to the import parity price until 1971 and again from 1976 to 1981. They were below import prices for the period in between. The comparative advantage of local wheat relative to imported wheat varies considerably among regions due to high transportation costs.

FIGURE 4.2: BOLIVIAN PRODUCER PRICES AND CIF IMPORT PRICES FOR WHEAT
(sources differ on import price)



SOURCES: FAO, (various); Hugo et al, 1981; and CORDECruz et al, 1982b.

In the early 1960s, several efforts were made to promote national wheat production. Supreme Decrees established that 1) all importation of wheat grain and flour had to be authorized by the government and would be used only to cover "deficits" in production relative to predetermined levels of consumption, 2) importers were required to sell one unit of national flour for every two units of imported flour, and 3) a tax was placed on imported wheat flour equivalent to about 12% of the wholesale price that year [Bedoya, 1970: 9-11]. The first measure would only constitute import protection to the degree that consumption levels were held below what they would be with free trade, which, of course, is politically difficult. The second measure was notoriously difficult to enforce in spite of the two subsequent decrees reiterating the policy. Furthermore, contraband wheat flour from Argentina diluted the impact of all three measures [Gardner, 1970: 7-8].

In the late 1960s, the National Wheat Institute (INT) was created and a system was established to provide producer support prices. Nonetheless, the incentive effect was minimal.

In the first place, studies indicate the wheat farmers are seldom paid the official support price. In addition, since the support price was implemented in 1968, it was never more than negligibly higher than the CIF price of Argentine wheat until 1973. [Gardner, 1974: 31]

In 1973 and 1974, the "support" prices were raised several times, generally lagging behind rising international prices (see Figure 4.2).

International prices fell below the support price (fixed in nominal terms from 1974 to 1980) for a few years, although it is unclear if the mills or the government were effective in enforcing the support price.

... millers are anxious to avoid purchasing domestically produced wheat at higher prices and appear to be successful in exercising various pretexts to reject the offerings of the limited domestic wheat which is for sale. [USAID, 1976: 12]

In an attempt to enforce the support price, the Wheat Marketing Division (replacing the disbanded National Wheat Insititute) operated a system of five purchasing and storage centers. In spite of sizeable subsidies from USAID PL 480 Title III funds, the centers suffered from poor location, faulty design (e.g. bulk storage instead of sack storage facilities), low volume and consequent high overhead rates (30-60% of sales). In addition, there were strong indications of graft [Hugo et al, 1981: 29-49]. Since then, at least three of the 616 MT storage facilities have been abandoned.

Over the period 1975-1980, there was a tremendous shift toward local milling: the volume of imported flour fell 96% (from 133,800 to 4,000 MT), national flour production more than quadrupled (from 53,800 to 232,300 MT), and the volume of imported wheat also quadrupled. The volume of national wheat milled remained constant at around 9,000 to 10,000 MT, so that its participation in national milling fell from 13% to 4% (see Table 4.1 and Figure 4.1).

Since 1981, the inflation rate has risen to unprecedented levels. Using 1981 as the base year (1981=100), the consumer price level in the second quarter of 1984 was 11,200 [Banco Central, 1984]. Combined with flour and bread price ceilings which can only be adjusted at great political cost, this has created downward pressure on real producer prices. Flour prices are far below market value, necessitating strict rationing of flour to the bakeries. In spite of the controls, large amounts of flour are smuggled into Peru.

Although the hyperinflation makes any calculation difficult, in July 1984 the producer price for wheat was US\$ 108/MT at the parallel exchange rate. This is only 75% of the F.O.B. price of Argentine wheat

and 60% of the C.I.F. price of U.S. wheat in Rotterdam. The price that the flour mills actually pay for imported wheat is even less since they are able to buy dollars at the official exchange rate, a 15-50% discount relative to the parallel rate. In addition, the government gives them a 90-day grace period in paying for imported wheat which amounts to a sizeable discount in real terms (over 50% at the 1984 inflation rate of 2100%). This distortion reduces their incentive to buy national wheat and imposes a real cost on the Bolivian economy.

4.1.3 Wheat production in Santa Cruz

In the 1960s, the possibility of wheat production in the lowlands of Santa Cruz was little more than an idea. In one of the first Utah State reports on wheat production, Gardner [1966b: 16] argued that:

The ideal way to take Bolivia out of the wheat import market would be to open up a vast new area of productive land somewhere in Bolivia where wheat could be grown as a specialized primary crop, rather than as crop of secondary importance relegated to left over lands. Such an area would be level enough to permit irrigation...

Regarding the Santa Cruz area, he mentioned that "reports, both hot and cold, regarding the potential for wheat production in this vast new agricultural area have been filtering out of that region" [p. 6].

In an annex to the same report, another author was less optimistic. In 1966, he visited a Mennonite colony that had experimented growing 100 hectares of wheat for home consumption the year before. Disease and lodging had been serious problems, and only 70 hectares had been worth harvesting. He concluded that:

The results are in full agreement with what I would expect whenever wheat is forced outside its major area of adaptation... Historically, such efforts have not met with success and I expect such effort will continue indefinitely with subsequent failures... In my opinion, Bolivia does not have the physical land area necessary to produce its total wheat needs. [Gardner, 1966b: 30, 31, 36]

In 1968, another study attempted to show that Bolivia might be able to produce 70% of its projected wheat needs by 1978 if it could increase yields by 124% and double wheat area. However, lowland production was not mentioned [Gardner, 1968]. Two years later, the same author reviewed the progress made since 1966 and acknowledged that "on the whole... yields have fallen below those levels that I thought possible to reach" [Gardner, 1970: 5]. He noted that:

The one great unknown in the total national wheat picture is what might happen in future years in the Department of Santa Cruz... One farm near Portachuelo has grown wheat for more than five years and this year has about 100 hectares planted. Many other farmers are experimenting with wheat... The advantages of wheat production in this area are tremendous, providing disease-free, high quality varieties are grown. The farms are large and mechanization already prevalent. Rice seeding and harvesting equipment may be used for wheat also. Perhaps the biggest advantage of all is that wheat can be double-cropped with rice or cotton, thus greatly reducing land costs. [Gardner, 1970: 31, 32]

At the time, experimental trials using ten cultivars of wheat had begun in the lowlands of Santa Cruz.

One of the earliest efforts to analyze the feasibility of wheat production in the lowlands was a 1971 study which looked at the issue of water availability. It assumed seasonal rotation with cotton and, looking at rainfall probabilities and evapotranspiration rates, concluded that "there seems to be a reasonable probability of producing a fairly good crop about six years out of ten" [Hargreaves, 1971: 4].

A 1976 USAID report on wheat policy commented on the situation and prospects for lowland wheat production:

wheat production in the Oriente has, to date, been largely experimental...some recent research results indicate favorable prospects for wheat husbandry in the Santa Cruz region in the winter months (May-Sept.), [but] any significant increase in the crop will require some form of irrigation... If there is a role for wheat in the crop rotation, it will be that of a winter double-cropping enterprise in combination with cotton, soybeans, or perhaps summer grown cereals. [USAID, 1976: 10]

The report noted that the Abapo-Izozog research project, located 150 kilometers south of the city of Santa Cruz, was the only major irrigation effort in the region. Since the project was only sustainable with substantial government subsidies, the report concludes that "it is unlikely...that any rapid expansion of wheat production will occur in this area" [p. 11].

The Center for Agricultural and Technological Research (CIAT) was formed in the mid-1970s to take over research and extension functions in Santa Cruz. In 1978, it began regular agronomic testing of wheat, using 1,888 lines and cultivars from the Cochabamba research station. A new cultivar, Saguyo, was identified which performed even better than Jaral, the most common cultivar by that time [CIAT, 1979].

In 1980, a "Departmental Plan for Wheat Production" was prepared which called for wheat area to expand to 80,000 hectares and for yields to be improved so that, by 1985, Santa Cruz would be producing more than the 1980 level of national wheat production [MACA et al, 1980]. This plan, like a similar one proposed a decade before [Romecin, 1970], never came close to fulfillment.

A 1981 Kansas State University (KSU) report made the following observations concerning lowland wheat production:

Mechanization of wheat is increasing... The Santa Cruz area is completely mechanized - large fields, large cultivation equipment, seeders, and combines...it is double cropped, being grown in the winter following cotton, maize, or soybeans. [Hugo et al, 1981: Appendix G]

Citing the Departmental Plan, the KSU report was more cautious:

there seems to exist an unjustified optimism, generated in certain quarters, in the belief that the Santa Cruz area can become the "breadbasket" of Bolivia through the implementation of large-scale agricultural projects. [Hugo et al, 1981: 69]

A key obstacle was believed to be the availability of seed.

Seed is a problem for wheat [in the lowlands of Santa Cruz]. Due to climate, quality of seed deteriorates from harvest one season to planting time the next season. Currently, seed is being obtained from Cochabamba for the area north of Santa Cruz. [Hugo et al, 1981: 200]

A related problem is that tropical production of wheat is vulnerable to disease, primarily seedborne diseases such as *Helminthosporium sativum*.

According to the data presented in Table 4.2, it appears that wheat area in the lowlands has expanded rapidly since 1978. It should be noted that the data are contradictory: one source assumes that departmental figures to refer to lowland production, another has 3272 MT for the 1980 lowland sales to the mills, and the MACA-USAID [1984] figures are possibly low for 1983 and 1984. The lowland figures for 1982-1984 in Table 4.2 are estimates based on data collected by the author.

The survey of lowland wheat farmers conducted by the author in July 1984 sheds some light on the patterns of wheat production. Among the 39 Santa Cruz farms surveyed, the area cultivated ranged from 15 to 2000 hectares with the median being 65 hectares. Differences were found among the Mennonite, Japanese, and Bolivian farmers as demonstrated in Table 4.3. The bulk of the Mennonite farms surveyed had less than 50 hectares while larger farms were more common among the Japanese and Bolivian wheat farmers. It should be noted that this sample over-represents large farms relative to the population of lowland wheat farms.

A brief overview of the summer cropping combinations is shown in Table 4.4. Soybeans were grown on 32 of the 39 farms in the sample. In only three of these farms was another crop grown on a larger area than soybeans. Soybeans were more likely to be grown with rice on the Japanese farms and with maize on the Mennonite farms. This difference may be

TABLE 4.2: WHEAT AREA AND PRODUCTION IN SANTA CRUZ

	Dept. of Santa Cruz (lowlands and V. Mesotermicos)			Dept. of Santa Cruz (lowlands only)		
	Area (ha)	Yield (kg/ha)	Production (MT)	Area (ha)	Yield (kg/ha)	Production (MT)
1970	1675	789	1322			
1971	1990	708	1408			
1972	2388	670	1600			
1973	4170	626	2610			
1974	5520	880	4860			
1975	6430	941	6050			
1976	6285	1091	6860			
1977	6785	1010	6855			
1978	7200	810	5830	200	900	180
1979	8000	950	7600	1680	952	1600
1980	8000	980	7840	1700	1600	2720
1981	8000	980	7840			
1982	5000	1000	5000	4800		
1983	6476	561	3636	6640		
1984				8829		

SOURCES: CORDECRUZ et al (1982b) for departmental figures.
 Hugo et al (1981) for lowland figures 1978-1980.
 Table 4.6 and assumption of a 75 kg/ha planting for
 lowland figures 1982-1984.

NOTE: MACA-USAID (1984) figures show departmental wheat area
 of 723 ha for 1983 and 1,578 ha for 1984. Lowland wheat
 production for 1982-1984 is not included for lack of
 reliable yield estimates.

TABLE 4.3: FREQUENCY DISTRIBUTION OF THE CULTIVATED AREA FOR SAMPLE FARMS

Cultivated area	Japanese	Bolivian	Mennonite	TOTAL
10 - 49 ha	1	1	13	15
50 - 99 ha	3	2	7	12
100 - 499 ha	4	4	1	9
500 - 999 ha	1	1	0	2
>1000 ha	0	1	0	1
TOTAL	9	9	21	39

SOURCE: Survey results, see Annex B for methodology.

TABLE 4.4: FREQUENCY DISTRIBUTION OF SUMMER CROP COMBINATIONS

Crops	Japanese	Bolivian	Mennonite	TOTAL
No crop	0	2	0	2
Soy alone	4	1	1	6
Soy-Maize	1	1	14	16
Soy-Rice	2	1	0	3
Soy-Maize-Rice	2	1	4	7
No Soy	0	3	2	5
TOTAL	9	9	21	39

SOURCE: Survey results, see Annex B for methodology.

TABLE 4.5: FREQUENCY DISTRIBUTION OF WINTER CROP COMBINATIONS

Crops	Japanese	Bolivian	Mennonite	TOTAL
Wheat alone	2	4	16	22
Wheat-sorghum	1	1	2	4
Wheat-Soy	2	2	0	4
Wheat-Sorghum-Soy	4	1	1	6
No Wheat	0	1	2	3
TOTAL	9	9	21	39

SOURCE: Survey results, see Annex B for methodology.

partly a result of the climate (the Japanese colonies are in a higher rainfall area than most of the Mennonite colonies) and partly the result of cultural factors.

In the winter season, wheat competed with soybeans for seed and, to a minor extent, sorghum and beans (see Table 4.5). The survey reveals that the Mennonites wheat farmers were less likely to grow other winter field crops, only occasionally growing one or two hectares of beans or 5-10 hectares of sorghum on the side. The Japanese in the sample were more likely to grow wheat with sorghum and winter soybeans, though wheat still dominated. The Bolivians were in an intermediate position.

The survey results also suggest that wheat production could be stimulated if wheat prices were higher. Growers were asked how many hectares they would have planted if the price of wheat had been 20% higher. Some 17 growers reported that they could not expand wheat acreage in the short run, generally because of the lack of available cleared land, and several others would not respond because of the hypothetical nature of the question. However, the average increase in wheat area, weighted according to the volume of CIAT seed purchased, was 38% over the current level. If accurate, this corresponds to a short- or medium-term supply elasticity of +1.8, higher than many estimates of agricultural supply elasticity [see Askari and Cummings, 1977].

Although this method is only speculative, the conclusion that lowland wheat production is relatively price elastic is supported by the observation that there are large tracts of land already under summer soybean cultivation which lie fallow in the winter. The availability of

fields and agricultural machinery for wheat production suggests that wheat area could be expanded with only moderate improvement in the economic incentives for wheat production.

4.2 Wheat seed in Santa Cruz

The three principal sources of purchased wheat seed in lowland Santa Cruz have been seed purchased from the traditional highland wheat regions, Proyecto Abapo-Izozog, and Proyecto Trigo of CIAT. The wheat growers' association (ANAPO) markets all CIAT wheat seed and some seed obtained from seed programs in the highlands. In addition, some seed is saved from harvest to planting by individual farmers. Each of these will be briefly discussed and the results summarized to estimate total wheat seed consumption.

4.2.1 Seed saved from the previous harvest

The sub-tropical climate in the lowland Santa Cruz area is the most serious obstacle to on-farm storage of seed from harvest to planting. The airport outside the city of Santa Cruz records an average of 1170 mm of rain annually, 24.6° C., and 69% relative humidity. However, the period of storage, roughly from October to June, corresponds to mid-summer when the rainfall rises to its maximum of 176 mm per month, the average temperature is 27° C., and the relative humidity averages 74% [CORDECRUZ, 1980]. These conditions do not allow "safe" storage of cereal seed for nine months [Delouche et al, 1973], but are close enough so that it should be possible some years.

The cost of saving seed is the forgone value of the grain (around \$b 650/kg) plus costs of storage, interest, and risk. Interest and risk are probably the major components and the total cost of saved seed may

be expected to be 15-50% above the grain price.

The survey results confirm the widely held impression that the practice of saving wheat seed from one season to the next is more common among Mennonite farmers than among the Japanese and Bolivian farmers. Only one of the nine Japanese respondents reported saving wheat seed. He had stored 900 kg (25% of his seed requirements) to supplement the seed from ANAPO. The germination rate was reasonable, and saving the seed allowed him to plant earlier than was possible with the seed from ANAPO. None of the other eight Japanese respondents used saved seed or even knew of others that had done so.

Similarly, only one of the nine Bolivian nationals interviewed had saved seed. In this case, the exception was the largest grower in the sample. He saved 46 MT of Jaral wheat seed in silos, relying only on ventilation during cool or dry days to preserve the seed. Along with 138 MT of seed from ANAPO, the saved seed was used to plant 2000 hectares of wheat. His intention was to save 184 MT of seed to meet all his needs for 1985. Other large-scale Bolivian growers, including one with sufficient storage capacity to save seed, were aware of these efforts but believed that seed storage was not worth the expense and risk.

On the other hand, seven of the twenty-one Mennonites surveyed had saved a portion of their seed requirements. However, six of these seven were found among the ten respondents located in the the two colonies farthest from the city of Santa Cruz: Valle Esperanza and Nueva Holanda. There was a consensus among the respondents in Valle Esperanza that around 50% of the colonies wheat seed requirements were met by saved seed (the question was not asked at the Nueva Holanda colony). On the other hand, various Mennonites in the nearer colonies independently

estimated that only 0 to 5% of the planted seed was saved from the previous year.

4.2.2 Seed from other departments

Until a few years ago, almost all wheat seed planted in the lowlands of Santa Cruz was obtained from the traditional highland departments, principally Cochabamba and Chuquisaca, where wheat is grown in the summer [Hugo et al, 1981]. Since the initiation of Proyecto Trigo, this source of seed has become less important although the trade continues through both formal and informal channels.

Informal channels consist of shipments from the highlands arranged by Santa Cruz merchants, truckers, and some Mennonite colonies. For example, one agricultural supply store (Servagro) sold about 45 MT of wheat seed in 1982 and a similar amount in 1983. In addition, survey respondents reported that several Mennonite colonies had arranged the purchase of 10 "truckloads" (60-90 MT) from the highlands in 1983 and at least two more this year (see Table 4.6). This seed is frequently just wheat grain bought in highland markets, though the Mennonite colonies generally clean it using home-made air-separators. It is purchased at grain prices, but transportation from the highlands adds 25-35% to this price (it is a 10-16 hour trip descending 2000 meters over mostly unpaved road). Among those surveyed, three farmers, all Mennonites, had bought Cochabamba seed from truckers or merchants.

More formal marketing is organized by the growers' association (ANAPO) which has purchased wheat seed from MACA in Cochabamba, Potosi, Chuquisaca, and Tarija (see Table 4.6). In previous years, these purchases were arranged to supplement overall production by Proyecto Trigo. This year, the purchases were used to supply farmers wanting to plant

early when CIAT seed was not yet available. The quality of this seed is often not much better than the grain referred to above. Varietal mixture and low germination have been problems, leading to the rejection of some 10 MT of "seed" in 1984. Although in previous years, this seed has been sold at a 15% discount below the price of CIAT wheat seed [ANAPO, 1982], in 1984 it was sold at the same price (around double the grain price). Growers were presumably willing to buy this inferior seed at the same price because it was available earlier in the season.

4.2.3 Seed from Proyecto Abapo-Izozog

Another source of wheat seed is the Proyecto Abapo-Izozog. This project is administered by the Ministry of Defense with financing from the Inter-American Development Bank. It consists of a varietal testing program and mechanized agricultural production, much of it irrigated, by several hundred colonist in an isolated arid region 100 kilometers south of the city of Santa Cruz. The project also produces wheat to sell to the mills in Santa Cruz using wheat seed of promising cultivars produced by the project [USAID, 1980a: 59].

Any excess seed is sold to farmers outside the project, generally Mennonite farmers also growing in this arid region. The wheat seed is cleaned with an air-screen cleaner owned by the project, but is neither tested nor certified. Although CORDECRUZ [1982c] recommended that the project specialize in seed production, the project technical personnel prefer to produce wheat and sell only excess seed. As a result, the supply has been quite irregular (see Table 4.6). In addition, the seed is neither varietally pure nor thoroughly cleaned. On the other hand, it is available early in the planting season and it is less expensive

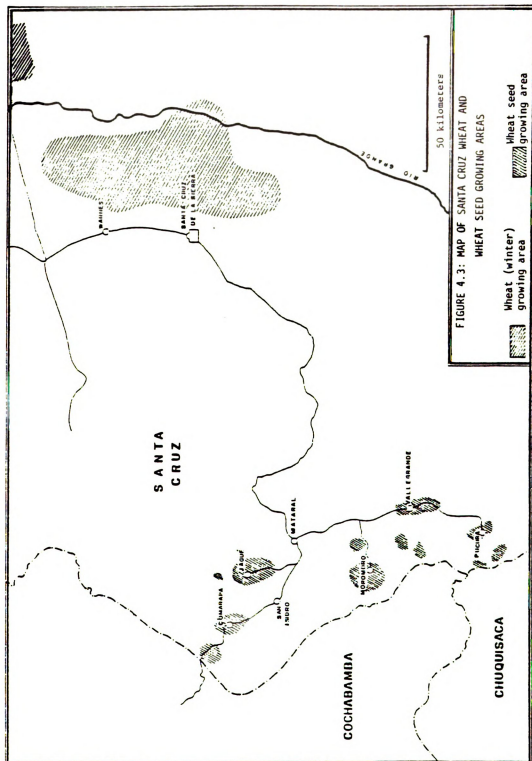
(about 40% above grain prices) than CIAT seed. In addition, it provides different experimental cultivars, generally ones adapted to the semi-arid conditions which prevail further to the south of the city of Santa Cruz.

4.2.4 Seed from Proyecto Trigo of CIAT

The CIAT wheat seed project, Proyecto Trigo, was initiated with financing from CORDECRUZ in the 1981-82 season. More recently, it received assistance from the PL 480 Title III program. Seed production is accomplished through contracts with farmers in the provinces of Vallegrande and Manuel Maria Caballero in the department of Santa Cruz. These provinces are in a highland region known as the Valles Mesotermicos (Mesothermal Valleys), where the altitude (1500-2500 meters) allows summer wheat production (see Figure 4.3).

The seed growers are small farmers averaging less than two hectares of wheat per family and located in twelve zones in the two provinces. Some of the zones (e.g. Comarapa and Vallegrande) are relatively flat and situated near major roads, but others (e.g. Higuera and Pampa Negra) are hilly and isolated, some lacking even unpaved road connection. CIAT provides these farmers with seed, technical assistance, and machinery for harvest and threshing where terrain and roads permit.

The small size of the farms and the fact that not all the harvest can be collected by CIAT mean that large numbers of growers must be contracted, over 500 this year. Since Proyecto Trigo has only two field agents and the collaboration of two extension agents, it is necessary to hire farmer-cooperators to help in the peak work periods, planting and harvest. Similarly, the agent from the Certification Service hired seven



local assistants to help inspect the fields.

The wheat seed is trucked to the Warnes seed processing plant outside of the city of Santa Cruz where it is dried, cleaned, and treated. ANAPO, the growers' association, markets the seed by issuing "purchase sheets" to farmers which allow them to obtain a certain volume of the cleaned seed from the plant. The purchase sheets are only issued for volumes up to one truckload so that large farmers do not dominate the early sales. Although the seed arrives daily during the lowland planting season, a backlog often develops. Farmers may have to wait for up to a week or return to the plant later in order to obtain seed.

The first year of the project (1981-82), 400 hectares of Saguayo and Quimori wheat seed were planted and 290 MT collected from the contract growers. Although this should have provided at least 250 MT of dried clean seed, that year ANAPO distributed only 162 MT of this CIAT seed [ANAPO, 1982]. It appears that the difference was not harvested in time for sale in the lowlands.

The second year (1982-83), the project planted over 1000 hectares, again with Saguayo and Quimori. However, only 310 MT of seed could be collected and 249 MT of dried clean seed sold [ANAPO, 1983]. This is due to several factors: 1) a drought occurred during planting, 2) heavy rains during harvest delayed the harvest and impeded the transport of seed to the lowland, 3) the price offered the contract growers was not competitive with that of local grain markets so "seed" was sold as grain, and 4) the project stopped collecting seed in the Valles when the planting season in the lowlands ended [CIAT, 1983].

In 1983-84, the third of the project, approximately the same area was planted, this time with Saguayo only. However, the climate was more

favorable and the price offered was 33% above the grain price, so it was possible to collect 649 MT of wheat seed. About 396 MT of seed were distributed by ANAPO and the rest stored in the Warnes plant for sale in 1985.

4.2.5 Estimation of total seed consumption

It is useful to employ the above information to estimate the total amount of wheat seed consumed in the lowlands of Santa Cruz and the current wheat area. These estimates will constitute baseline data from which to make projections.

Table 4.6 estimates the volumes of seed from each source. The figures for CIAT, Proyecto Abapo-Izozog, ANAPO, and Servagro were obtained from the respective institutions and are thus relatively accurate. However, the sale of seed from the highland departments "by others" and the volume of saved seed are speculative. The former is based on the assumption that the confirmed "truckloads" of seed brought from the highlands represent about 70% of the total shipments of that kind. The volume of saved seed is based on 1) the known volumes saved by the largest wheat farmer (0 in 1983 and 46 MT in 1984), 2) farmer estimates of the rates of seed saving in the Mennonite colonies (50% in the two most distant ones and 5% in the others), and 3) the seed consumption estimate from Table 4.7. According to Table 4.6, CIAT accounts for 45-59% of the seed supply and saved seed represents 9-14%.

Table 4.7 provides estimates of the wheat seed consumption and area for each of the three groups of producers: the Mennonites, Japanese, and Bolivians. First, the volumes of seed marketed through ANAPO to each group are presented. Next, the proportion of seed supplied

TABLE 4.6: SOURCES OF WHEAT SEED IN SANTA CRUZ (MT and percentage of total wheat seed consumption)

	1982		1983		1984	
CIAT Proyecto Trigo						
Production	162		250		649	
Stored for next year	0		0		253	
Sales in Santa Cruz	162	45%	250	50%	396	59%
Sales of seed from highlands						
By ANAPO	63	18%	20	4%	85	13%
By Servagro	45	13%	40	8%	0	0%
By others (estimated)	45	13%	90	18%	20	3%
Sales by Proyecto Abapo-Izozog	0	0%	53	11%	76	11%
WHEAT SEED SALES IN SANTA CRUZ	315	88%	453	91%	577	86%
Consumption of seed saved by farmers (estimated)	45	13%	45	9%	94	14%
WHEAT SEED CONSUMPTION IN SANTA CRUZ	360	100%	498	100%	671	100%

SOURCES: Volumes of CIAT seed production and sales from ANAPO annual sales lists. Other figures from interviews with technicians with from ANAPO, Proyecto Abapo-Izozog, and Servagro. Survey interviews were used for rough estimations of saved seed and volumes obtained from other departments by individuals.

NOTE: Various sources report different figures. CIAT seed production figures are generally higher, reflecting pre-processing weight and possibly including rejected or unsold seed. Wayar (1984) reports somewhat different figures.

by ANAPO for each group are estimated from the survey data. These were obtained by dividing the amount of seed purchased from ANAPO by the apparent seed consumption (area planted by respondents in 1984 multiplied by their reported planting densities) and the amount of ANAPO seed purchased. According to this method of estimation, virtually all the wheat seed used in 1984 by the Japanese farmers in the sample (98%) came from ANAPO. Bolivian nationals obtained 76% of their wheat seed from ANAPO and Mennonites only 51%. These proportions correspond roughly to the estimates made by farmers of the proportions supplied by ANAPO for the different groups.

Finally, survey data on the planting density is incorporated. The average seed density, weighted by the estimated wheat area, was 75 kilograms of seed per hectare, but this average figure masks important differences among wheat farmers. The planting density among the Japanese farmers ranged from 83 to 115 kg/ha, with an average value of 93 kg/ha. On the other hand, the Mennonites in the sample used 46-69 kg/ha, averaging 56 kg/ha. The Bolivian farmers used a wide range of planting densities with an average rate of 91 kg/ha. The differences are partly due to the higher rainfall in the region where the Japanese colonies are concentrated. However, this is not a complete explanation given that even the Mennonite colonies in this wetter region use the lower planting densities of their cultural group.

Seed consumption for each group is divided by the corresponding planting density to obtain total wheat area. This procedure was followed for each of the three groups of farmers (Japanese, Bolivian, and Mennonite) in order to correct for the under-representation of the Mennonites, who account for a larger portion of total wheat area than of CIAT

TABLE 4.7: ESTIMATED WHEAT AREA IN LOWLAND SANTA CRUZ, WINTER 1984

	Okinawa colonies	Bolivian nationals	Mennonite colonies	TOTAL
CIAT seed sold through ANAPO (MT)	65	220	111	396
Other seed sold through ANAPO (MT)	49	36	0	85
Total seed sold through ANAPO (MT)	114	256	111	481
Proportion of total supplied by ANAPO	.98	.76	.51	
Estimated total seed consumption (MT)	117	336	217	671
Planting density (kg/ha)	93	91	56	
Estimated planted area (ha)	1255	3706	3869	8829

SOURCES: Seed sales data from CIAT and ANAPO. Proportions supplied by ANAPO and planting density data from survey of wheat farmers.

NOTE: The average planting density was 75 kg/ha. CIAT seed accounted for 59% of the total seed consumed, while other seed sold through ANAPO comprised an additional 13%.

sales. According to these calculations, 8829 hectares of wheat were planted in 1984 using a seed supply composed of 59% CIAT seed, 13% Cochabamba seed sold through ANAPO, and 28% other seed.

It is worth noting that the survey sample was biased toward those farmers who buy seed through ANAPO. Thus, the estimated proportion of seed supplied by CIAT may be biased upward and the total wheat area biased downward. However, two types of independent confirmation of the estimated percentages indicate that these biases are not large. First, the aggregation of the volumes of seed from different sources yielded very similar results (the final results presented in Table 4.6 were adjusted to make the two tables consistent).

Second, the independent estimates of various farmers agreed roughly with the proportions in Tables 4.6 and 4.7. There seemed to be agreement that a large majority of lowland wheat seed (75-80%) was bought through ANAPO, that 10-20% was saved, primarily by the Mennonites, and that only a small remainder was purchased elsewhere.

4.3 Diagnosis of the wheat seed supply

In the course of the survey, qualitative information was gathered regarding the advantages and disadvantages of different sources of wheat seed in the lowlands. This information is useful in identifying the limitations of the CIAT wheat seed program.

The principal reasons for saving seed appeared to be the moderate cost and the option of planting early. The inconvenience of traveling to the city of Santa Cruz to purchase certified seed was presumably a factor as well, particularly for farmers in the more distant colonies. Several farmers complained of the long waiting period in the city to obtain CIAT seed.

With regard to the seed (and grain) purchased in the highlands, the general impression among those surveyed was that the this seed was not as clean nor as uniform as CIAT seed. The latter was deemed worth the higher price, and those who bought seed from Cochabamba said they would not have done so if the CIAT wheat seed had been available early in the planting season.

Of those surveyed, only two farmers, both Mennonites, were using seed from Proyecto Abapo-Izozog. One felt that it was of equal quality but cheaper than seed from ANAPO. The other claimed that it was less a matter of cost than availability early in the planting season.

Regarding the supply of CIAT wheat seed, the high price and single cultivar (Saguayo) were mentioned by various farmers, particularly among those preferring saved seed and seed from Proyecto Abapo-Izozog. However, the most common complaint by far concerned the late availability of CIAT wheat seed and the related problem of long waiting periods for its purchase. Each of these problems is discussed in turn.

The price of CIAT seed, at around double the price of wheat grain, is relatively high, and the survey results indicate that farmers do consider price when comparing seed. Given the policy that prices should cover costs, effort to reduce the price of wheat seed must be based on cost-reducing reforms. The price paid to the contract growers (about 33% above grain prices in 1984) is not very flexible given the experience of previous years. Since this item comprises 62% of the retail value of the seed, the scope for cost reduction is limited. However, the fact that the seed growing areas are disperse and often found in isolated zones contributes to the costs of transportation and technical assistance. The concentration of seed production in more accessible zones is one

strategy to reduce the costs of CIAT wheat seed production.

With respect to the single wheat cultivar available from CIAT, the survey provides information on varietal preference among wheat farmers: 48% of the sample, weighted according to volume of CIAT seed purchased, preferred the Saguayo cultivar offered by the CIAT seed program in 1984. Although Jaral was thought to be somewhat more drought resistant, Saguayo was preferred for its higher yield. Among those who did not prefer Saguayo were a number of farmers who had no preference, which is not surprising given the fact that a number of growers had only recently begun wheat production. Only three farmers expressed a clear preference for another cultivar, Jaral.

However, the importance of providing several cultivars is greater than indicated by these results. First, alternative cultivars would provide insurance against the possibility that Saguayo is stricken by some disease. Second, the continuous introduction of new cultivars is essential to maintain the demand for CIAT wheat seed, particularly if the practice of saving seed becomes more widespread.

The third and most serious problem is the timing of seed availability. Fully 61% of the sample, weighted according to the volume of CIAT seed purchased, reported that the date of planting on their farm had been delayed that year because of the late availability of CIAT seed. Among the growers who had alternate sources of seed, the other seed was generally planted first and the CIAT seed planted later. Many believed that this was the most critical problem with the CIAT seed.

Furthermore, respondents indicated that the "ideal" planting date was before the actual planting date. The average mid-point of the ranges given as "ideal," weighted according to the volume of CIAT seed pur-

chases, was the 29th of May. The average actual planting date, calculated the same way, was the 16th of June. Part of this difference may simply reflect less than "ideal" weather, but it is clear that late seed also played a role. The results of the survey also suggest that farmers would be willing to pay more for wheat seed available earlier. This issue is discussed further in Chapter Five.

Related to the problem of delayed availability is that of processing capacity. Not only does the processing capacity at the Warnes plant slow the process somewhat, but wheat seed processing is displacing the processing of soybeans. In late April of 1984, soybean seed processing had to be discontinued before finishing the seed harvest in order to start wheat seed processing. Overall in 1984, the Warnes plant processed 4000 MT in 1984, more than its rated capacity. This situation will be alleviated, at least in the short term, with the operation of the new processing plant in the Okinawa colony.

In summary, several conclusions have been reached in this diagnosis of the CIAT wheat seed program: 1) seed consumers are responsive to price and have alternative sources of seed, 2) the availability of just one cultivar is not an immediate problem to farmers, but research to identify alternate cultivars is essential for the long-run success of the program, 3) the most serious drawback of CIAT seed to farmers is its late availability, and 4) improved supply of CIAT seed would probably reduce the use of seed brought from Cochabamba and, to a lesser extent, the use of saved seed and seed from Proyecto Abapo-Izozog.

CHAPTER FIVE

PROJECTIONS FOR THE SANTA CRUZ WHEAT SEED MARKET

In this section, information gathered in the wheat farmer survey and from secondary sources will be used to estimate future trends in the wheat seed market in Santa Cruz. Particular emphasis will be placed on generating projections which will be useful in the feasibility study and recommendations presented in Chapter Six.

Based on the description of the current supply of wheat seed in the previous chapter, the future of the supply of wheat seed is considered, looking at each source of seed in turn. Then, projections of total and CIAT wheat seed purchases are made by predicting the area of wheat production, the planting density, the proportion of seed which will be purchased, and the proportion supplied by CIAT. And third, projections are made concerning the potential demand for CIAT wheat seed if it can be made available early in the lowland planting season.

5.1 Projected supply of wheat seed

In this subsection, factors that may limit the future supply of seed from different sources will be considered. The emphasis will be on the supply of CIAT seed though other sources will be discussed briefly.

The supply of CIAT wheat seed is limited by the amount of suitable area in the seed producing region, low yields, and the "leakage" of seed to other buyers (see subsection 4.2.4). This year, Proyecto Trigo organized seed production on 1065 hectares in 12 zones within the Valles Mesotermicos. This yielded 649 MT of cleaned seed, implying a collection

rate of 0.61 metric tons of cleaned dry seed per hectare. However, this rate varies, being greater in the province of Caballero (0.83 MT/ha) than in the province of Vallegrande (0.47 MT/ha) [Certificacion, 1984b]. CIAT plans to concentrate seed production in the more accessible zones and those with higher yields. By improving technical assistance, supervision, and yield, they expect to raise the collection rate. It seems feasible to raise the average collection rate to 0.8 MT/ha.

It has been estimated that there are potentially 2250 ha for wheat seed production in the Valles, but reaching this acreage would require expansion of almost all 12 production zones [Certificacion, 1984b]. Counting only the six most important and most accessible zones, the same estimation shows about 1500 potential hectares. If this area were planted with seed and a net collection rate of 0.8 MT/ha achieved, then about 1200 MT of clean wheat seed could be produced by Proyecto Trigo within several years, almost twice the 1984 level of production and three times the 1984 CIAT sales. This is considered the upper limit for wheat seed production in the highland region of Santa Cruz.

With regard to Proyecto Abapo-Izozog, it is doubtful that this will become an important or even consistent supplier of wheat seed. First, as mentioned earlier, the project personnel are not interested in dedicating themselves to becoming seed producers and will continue to sell only their surplus. They do not anticipate any surplus for 1985, though they may resume wheat seed sales in 1986. Second, the continued operation of the project depends on sizeable government subsidies and donor financing. Thus, termination of the project and its seed sales within the next five years is a distinct possibility.

The wheat seed from the highlands (Cochabamba and Chuquisaca) faces

no similar constraint on the supply side. Grain sales will probably continue to act as the residual source of seed, making up for shortfalls and lateness in the supply of higher-quality seed. Similarly, although MACA/Cochabamba expressed an interest in an advance agreement with ANAPO to provide 460 MT of wheat seed for the lowlands in 1985, ANAPO was not interested. Indeed, unless the quality of this MACA seed improves, it will serve as a residual supply for ANAPO. If, however, MACA/Cochabamba can establish more effective quality control measures, it may serve as an important supplement to CIAT seed when the latter reaches its maximum output.

The future "supply" of saved seed is the least predictable. On the one hand, one might expect the use of saved seed to grow as new wheat farmers learn techniques in seed storage and germination testing. On the other hand, if the early availability of CIAT seed is improved, it would eliminate one of the main advantages of saving seed.

5.2 Projected demand for wheat seed

The demand for CIAT seed and for purchased seed in general can be projected by making assumptions about the total acreage of wheat production, planting density, the proportion of purchased seed, and the proportion supplied by CIAT.

5.2.1 Area of wheat production

Of the three components mentioned above, the area of wheat production is, perhaps, the most difficult to project. First, it is necessary to determine what region is the relevant market for CIAT seed.

It is argued that the Valles Mesotermicos (the highland Santa Cruz region) should not be considered a significant market for wheat seed in

the medium term. Currently, none of the seed CIAT produces is bought by highland wheat farmers. This is due to the fact that 1) the seed is sold from Warnes, five hours from the highlands (see Figure 4.3), 2) there has never been any surplus from the winter planting sales until this year, and 3) small-scale semi-subsistence farmers tend to keep input purchases to a minimum. It is possible that the construction of a processing and storage plant in this region and the release of significantly superior varieties may change this, but even so, the demand would constitute a minor share of the total. Thus, this source of demand is not included in these projections.

On the other hand, commercial lowland wheat farmers produce substantially more wheat and are forced by climatic conditions to purchase a large portion of their seed. Thus, it is likely that the bulk of future demand for wheat seed will come from the lowlands. Thus, this study will focus on the projection of demand for wheat seed in the lowlands of Santa Cruz.

Given that the relevant market is the Santa Cruz lowlands, the next task is to project wheat area in this region. As noted in section 4.1, lowland wheat area has grown rapidly, rising from 1,680 hectares in 1979 to an estimated 8,829 hectares in 1984 (see Table 4.2). If these figures are accurate and comparable, they correspond to an annual growth rate of 39%. This rapid growth is confirmed by the high proportion of farmers surveyed who had begun growing wheat in the past few years.

It is commonly believed among agricultural specialists in Bolivia that wheat production in Santa Cruz has the potential for continued growth, especially if timely supply of wheat seed can be assured. One source reports that "around 120,000 hectares [in Santa Cruz] are appro-

priate for cultivation of this cereal" [CIAT, 1982: 2]. This figure, however, probably includes vast tracts of forest not yet cleared. As such, it represents the technical potential in the long run without regard for the economic feasibility of cereal cultivation on this land. More realistically, the Five-Year Agricultural Plan [Certificacion, 1984a] projects a growth from 18,700 to 31,000 hectares over 1985-1989. This represents a 15% annual growth rate, though the first year of the projection is probably too high.

The results of the survey confirm this expectation of continued expansion of wheat production in the lowlands. In spite of the fact that the largest grower, comprising one half of the wheat area covered in the interviews, did not plan to expand production in 1985, the total planned acreage for 1985 was 18% greater than the 1984 area. Although this may represent the optimistic goal of the interviewed farmers assuming the weather is favorable, this rate does not include the growth due to farmers growing wheat for the first time.

For the purpose of projecting the demand for wheat seed, it seems reasonable to estimate an annual growth rate between 0 and 15% over the next ten years. The upper limit for lowland wheat acreage, at least in the medium run, may be estimated relative to the area dedicated to summer soybean production. As mentioned above, wheat is most commonly grown in seasonal rotation with soybeans. Perhaps three-quarters of the soybean area could be used. Since the soybean area was 40,000 hectares in 1982 [MACA-USAID, 1984], this implies an upper limit of around 30,000 hectares.

Thus, in Table 5.1, high, medium, and low projections are made assuming annual growth rates of 0%, 4%, and 15%, respectively, and an

upper limit of 30,000 hectares. These constitute relatively conservative estimates of future lowland wheat area.

5.2.2 Planting density for wheat production

The second factor which determines the demand for seed is the planting density. The survey results indicate significant differences between the three groups, with the Mennonites using the least seed per hectare (see Table 4.7). The average, weighted by estimated total wheat area, is 75 kilograms per hectare. This figure was used to project total wheat seed consumption in Table 5.1.

5.2.3 Proportion of wheat seed supplied by CIAT

The estimates in Table 4.6 indicate that over the past three years, 86-91% of the seed consumption has been purchased seed. As mentioned above, there is no strong reason to expect that this proportion will change significantly except for random fluctuation due to weather conditions which affect the possibility of seed storage. Thus, it is assumed in Table 5.1 that purchases will be 86% of seed consumption.

CIAT seed currently supplies 59% of the total wheat seed consumption in the lowlands (see Table 4.6). Without substantial change in the nature of Proyecto Trigo, this percentage is unlikely to change except for random fluctuations of the nature described above.

If, however, CIAT seed can be made available in sufficient quantities early in the planting season, this proportion will probably rise, principally through the elimination of ANAPO purchases of seed from outside the department. Since farmers paid the CIAT seed prices for this seed in 1984, the demand has been demonstrated. By supplying this share, CIAT would come to provide 72% of the total seed consumption. Although

TABLE 5.1: PROJECTED WHEAT AREA, SEED CONSUMPTION, AND SEED SALES IN LOWLAND SANTA CRUZ

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Wheat area (ha)												
High projection		10153	11676	13428	15442	17758	20422	23485	27008	30000	30000	30000
Medium projection	8829	9182	9549	9931	10329	10742	11172	11618	12083	12566	13069	13592
Low projection		8829	8829	8829	8829	8829	8829	8829	8829	8829	8829	8829
Seed consumption (MT)												
High projection		762	876	1007	1158	1332	1532	1761	2026	2250	2250	2250
Medium projection	671	689	716	745	775	806	838	871	906	942	980	1019
Low projection		671	671	671	671	671	671	671	671	671	671	671
Proportion supplied by purchased seed	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86	.86
Seed purchases (MT)												
High projection		655	753	866	996	1145	1317	1515	1742	1935	1935	1935
Medium projection	577	592	616	641	666	693	721	749	779	811	843	877
Low projection		577	577	577	577	577	577	577	577	577	577	577
Proportion supplied by CIAT seed	.59	.63	.66	.69	.72	.72	.72	.72	.72	.72	.72	.72
CIAT seed sales (MT)												
High projection		480	578	695	834	959	1103	1200	1200	1200	1200	1200
Medium projection	396	434	473	514	558	580	603	627	652	679	706	734
Low projection		423	443	463	483	483	483	483	483	483	483	483

SOURCE: High projection assumes 15% growth up to 30,000 hectares. Medium assumes 4% growth and low assumes no growth. Proportion of purchased seed assumed constant and CIAT share assumed to rise from 59% to 72% (see Table 4.6), with upper limit of 1200 MT. Survey results used for 1984 wheat area (8829 ha) and planting density (75 kg/ha).

other sources of seed may decline as well, particularly grain purchases from the highlands, the projections in Table 5.1 assume that the proportion supplied by CIAT rises to only 72%, subject to the maximum of 1200 MT estimated in section 5.1.

5.3 Temporal distribution of supply and demand

While timeliness is clearly a problem in the supply of CIAT wheat seed, more specific information is needed in order to resolve the problem. It is necessary to quantify the demand for "early seed" in the lowlands. In this section, projections are made of the proportion of annual CIAT seed production which would have to be stored until the following year to meet this demand. This is done by comparing the temporal distribution of the supply and the demand of CIAT wheat seed.

From the results of the survey, it is possible to construct two indices of the temporal distribution of demand, that is the proportion of seed which would be planted each week of the planting season if seed were available. The first index is derived from the "ideal planting date" reported by the wheat farmers in the survey. If a range of dates was given, the midpoint date was used and the results were weighted according to the volume of seed purchased. The resulting distribution is expressed as a percentage of the total demand and presented as Alternative A in Table 5.2.

The second index is based on the actual date of planting in 1984 among those respondents who were not delayed in planting by the availability of seed. Some of these managed to obtain CIAT seed early, others used other sources of seed such as saved seed, and still another group could not plant until late in the season due to weather and other factors. This temporal distribution was calculated as above and is

presented as Alternative B in Table 5.2.

In evaluating these two indices of the distribution of seed demand, it should be noted that the "actual date" index reflects the demand that particular year (1984) when the lowland planting was somewhat delayed by the weather. Thus, it does not reflect the long-run expectations of farmers as does the "ideal date" index. On the other hand, the "ideal date" index probably includes some assumption of ideal weather which would allow them to plant early. For the latter reason, Alternative B is considered more realistic than Alternative A. More information on this topic will be available after the 1985 lowland planting season when the seed stored from 1984 will allow farmers to plant as early as desired.

The temporal distribution of the supply of CIAT wheat seed can be estimated from the dates of arrival of the seed at the Warnes Processing Plant in 1983 and 1984, the only years for which such data are available. In order to take into account the time between the arrival of the seed at Warnes and its availability at the farm, two weeks were added to these dates.

For several reasons it is believed that the 1984 data are more representative of future trends than those for 1983. In addition to the more typical weather, the supply distribution for 1983 was truncated after mid-July when the project stopped accepting seed. In the future, the project will follow the 1984 policy of guaranteeing purchase from all registered seed farmers. Thus, the average distribution of supply was estimated giving two thirds weight to 1984 and one third to 1983. It is displayed in Table 5.2, again expressed as percentages of total supply.

TABLE 5.2: TEMPORAL DISTRIBUTION OF THE DEMAND FOR WHEAT SEED AND THE SUPPLY OF CIAT WHEAT SEED (% of annual supply or demand)

	May				June				July		TOTAL
	1	2	3	4	1	2	3	4	1	2+	
Supply at farm level, 1983	0	1	3	17	13	38	9	5	12	2	100
Supply at farm level, 1984	0	0	1	8	10	10	9	21	15	26	100
Supply at farm level, weighed average	0	0	2	11	11	19	9	16	14	18	100
ALTERNATIVE A:											
Demand according to "ideal" planting date	1	10	15	20	28	23	1	1	1	0	100
Withdraw from storage	1	10	13	9	17	4	0	0	0	0	54
Add to storage	0	0	0	0	0	0	8	15	13	18	54
ALTERNATIVE B:											
Demand according to actual planting date	0	6	17	17	17	11	6	6	3	17	100
Withdraw from storage	0	6	15	6	6	0	0	0	0	0	33
Add to storage	0	0	0	0	0	8	3	10	11	1	33

SOURCES: The supply data from arrival of seed at the Warnes plant plus 15 days to be available for planting. Two alternative measures of demand from the survey of wheat farmers. The difference between supply and demand indicates the amount to be stored (if excess supply) or withdrawn from storage (if excess demand). See text for more detail.

The differences between supply and demand each week reflect the changes in the level of stocks necessary to equate the two. Excess demand early in the season indicates the need to withdraw seed from storage, while excess supply late in the season is used to replenish the stocks. The sum of either represents the proportion of the total which would be saved from one year to the next to balance weekly supply and demand.

If the demand is distributed as in Alternative A, then 54% of the total production could be stored from one year to the next. If Alternative B is a more realistic description of the demand, implying a later demand pattern, the gap between supply and demand is smaller, constituting 33% of the total. Given the greater confidence placed on Alternative B, it can be affirmed 33% is a reasonable, if conservative, estimate of the proportion of seed which should be saved to meet the demand for "early seed."

It is worth noting that the indices of demand do not incorporate any price differential between early and late seed. Given the possibility that early seed would carry a premium, it is relevant to ask if farmers would actually pay higher prices for early seed. Among the survey respondents, fully 61% (weighted by volume of CIAT seed purchased) reported being willing to pay 15% more for earlier wheat seed, while 31% said they would pay 30% more for such seed. Although answers to hypothetical questions are not very reliable, the results demonstrate that timely delivery of seed has a significant economic value to the lowland wheat farmers.

5.4 Synthesis of volume and storage projections

Table 5.1 provides high, medium, and low projections of CIAT seed sales under the assumption that wheat seed can be made available early in the lowland planting season. In Table 5.2, it was estimated that at least 33% of the annual volume of seed production would have to be stored to meet this demand for "early seed." In Table 5.3, these projections are combined to estimate the volumes to be produced, stored, and sold each year. In addition to the results assuming Alternative B (33% of the seed is stored), the table includes for the purpose of comparison the results assuming Alternative B (54% stored).

The "sales" in Table 5.3 are equal to the corresponding figures in Table 5.1. "Direct sale" refers to seed produced and marketed in the lowlands the same year, as is currently done. It is 46% of the sales in Alternative A and 67% in Alternative B. "Stored seed" refers to the volume of seed put into storage that year for sale the following year. Thus, it is calculated as a percentage (33% or 54%) of the sales the following year. And finally, "production" is the sum of direct sales and seed produced for storage. All figures are expressed as net weights of wheat seed, that is, after drying and cleaning.

According to Table 5.3, CIAT wheat seed production in 1990 may reach 1200 MT, the estimated maximum production in the Valles Mesotermicos, or it may be as low as 483 MT. The estimates of the volume of seed stored range from a high of 648 MT, if production reaches its maximum and 54% is stored each year, to a low of 159 MT. The medium projection of Alternative B, believed to be the most probable of the six scenarios, show CIAT wheat seed production rising to 492 MT by 1990 and the volume of stored seed reaching 252 MT.

TABLE 5.3: PROJECTED PRODUCTION, STORAGE, AND SALES OF CIAT WHEAT SEED (MT)

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Alternative A: 54% of seed is stored												
High projection												
Direct sales	396	227	266	320	384	441	507	552	552	552	552	552
Stored	253	312	375	450	518	596	648	648	648	648	648	648
Production	649	539	641	770	901	1037	1155	1200	1200	1200	1200	1200
Sales	396	480	578	695	834	959	1103	1200	1200	1200	1200	1200
Medium projection												
Direct sale	396	181	217	236	257	267	278	289	300	312	325	338
Stored	253	255	278	301	313	326	339	352	366	381	396	412
Production	649	436	495	538	570	593	616	641	667	693	721	750
Sales	396	434	473	514	558	580	603	627	652	679	706	734
Low projection												
Direct sale	396	170	204	213	222	222	222	222	222	222	222	222
Stored	253	239	250	261	261	261	261	261	261	261	261	261
Production	649	409	454	474	483	483	483	483	483	483	483	483
Sales	396	423	443	463	483	483	483	483	483	483	483	483
Alternative B: 33% of seed is stored												
High projection												
Direct sale	396	227	387	466	559	642	739	804	804	804	804	804
Stored	253	191	229	275	316	364	396	396	396	396	396	396
Production	649	417	617	741	875	1006	1135	1200	1200	1200	1200	1200
Sales	396	480	578	695	834	959	1103	1200	1200	1200	1200	1200
Medium projection												
Direct sale	396	181	317	344	374	389	404	420	437	455	473	492
Stored	253	156	170	184	191	199	207	215	224	233	242	252
Production	649	337	486	528	565	588	611	636	661	688	715	744
Sales	396	434	473	514	558	580	603	627	652	679	706	734
Low projection												
Direct sales	396	170	297	310	324	324	324	324	324	324	324	324
Stored	253	146	153	159	159	159	159	159	159	159	159	159
Production	649	316	450	470	483	483	483	483	483	483	483	483
Sales	396	423	443	463	483	483	483	483	483	483	483	483

SOURCES: Tables 5.1 and 5.2. See test for details. Stored seed listed in year of harvest.

CHAPTER SIX

STRATEGIES TO IMPROVE THE SUPPLY OF WHEAT SEED

In the previous chapter, projections of CIAT wheat seed sales, production, and storage were made. In this chapter, these projections are used to make recommendations for the improvement of the supply of wheat seed in the lowlands of Santa Cruz. Specifically, this chapter provides recommendations for a seed processing plant in the Valles Mesotermicos and analyzes the economic and financial feasibility of the investment.

Both the economic and financial analyses compare the flows of costs and benefits over the assumed ten-year life of the plant (1986-1995) given the medium projection of wheat seed demand and Alternative B from Table 5.3. The financial analysis considers only the costs and benefits perceived by the economic agent making the investment, relying on market prices to value the inputs and outputs. The economic analysis includes the costs and benefits to all those affected by the investment through the use of "shadow prices" which reflect the scarcity value of inputs and outputs [Gittinger, 1982]. In both cases, the Bolivian peso (Bs) of June 1984 is the numeraire. At that time, the official rate was Bs 2000 per U.S. dollar and the parallel rate was Bs 3250/US\$.

A sensitivity analysis is used to test the robustness of the results under somewhat different assumptions regarding the fees charged, volumes processed, and so on. In addition, a preliminary evaluation of alternate sites is made. And finally, recommendations are made for seed marketing and price policies to complement the proposed investments.

6.1 Preliminary considerations

Two issues must be briefly discussed before proceeding: 1) the justification for considering a combined processing and storage facility rather than either facility by itself and 2) the assumptions regarding the ownership and operation of the plant.

Regarding the first issue, the case for a combined facility seems convincing for several reasons. First, a processing plant in the Valles without storage capacity is inferior to a combined facility because the incremental benefits with the addition of a storage room are greater than the additional costs. This conclusion is based on the assumptions that a 20% premium could be charged for early seed and that the climate in the Valles Mesotermicos is cool and dry enough to allow 12 months storage of treated wheat seed at ambient temperatures. The profitability of seed storage is demonstrated subsection 6.2.3.

On the other hand, a storage facility in the Valles without processing capacity would mean that the seed would have to be dried and cleaned at Warnes and shipped back to the Valles for storage. Additional transportation costs alone would constitute around 13% of the retail value, making this an unacceptable choice. Alternatively, the seed could be dried in the Valles, stored until the following year, and cleaned at Warnes just before the winter planting in the lowlands. In addition to the problems associated with storing uncleaned seed over long periods, the Warnes plant runs at full capacity in March and April with the summer crop of soybean seed. Thus, this option also seems inferior to the combined facility.

Regarding the ownership of the plant, one frequently discussed option involves the participation of regional public institutions such

as CIAT and/or CORDECRUZ as well private entities such as ANAPO, with the goal of eventual transfer to complete private ownership. If public agencies are involved, the plant would probably be operated as a semi-autonomous administrative and financial unit like the Warnes plant. This study assumes that seed processing and storage would be performed as a service to other institutions and individuals on a fee basis. More detailed treatment of this issue is beyond the scope of the present study, though it is clearly one of the central issues which need to be resolved by local institutions over the next year.

6.2 Capacity and equipment requirements

This section discusses the appropriate capacity and equipment to dry, clean, treat, and store wheat seed in the Valles Mesotermicos. It is based on data collected by the author and consultation with the seed specialists working on the project.

6.2.1 Seed drying

Drying the wheat seed serves two purposes in Proyecto Trigo. First, as mentioned earlier, it is necessary to dry wheat seed down to around 13% moisture to prevent the deterioration of the seed. Second, drying breaks the dormant period of the seed which follows harvest. Dormancy is a survival mechanism which normally prevents the seed from germinating at an inappropriate time [see Copeland, 1976: 121-148]. In 1983, when the weather delayed the shipment of the seed to Warnes, dormancy was not a problem, and only 50% of the seed needed to be dried. In 1984 the seed was delivered promptly and 90% needed to be dried to break its dormancy.

It seems advisable that the processing plant in the Valles be able to dry 100% of the seed processed at that plant within the two month

period of harvest. Direct sale seed will need drying to break its dormancy, and seed to be stored should be well dried to extend its storage life.

The type of drier used with good results at the Warnes Plant consists of three chambers, each measuring about 3 x 4 meters. Up to one meter deep of grain (approximately 8 MT of grain) is loaded onto a fine-mesh screen floor in the chamber. A heater (350,000 BTU/hour) and centrifugal blower (9 hp) force warm air up through the screen and seed, drying it in 24-28 hours. Thus, the total capacity is about 1.0 MT/hour.

6.2.2 Seed cleaning and treatment

The seed technologists working on the project determined that the wheat seed processing plant in the Valles should have the following equipment at a minimum: an air-screen cleaner, a chemical treater, a platform balance to bag the seed, a portable industrial sewing machine, and two elevators large enough to load the air-screen cleaner and the platform balance. The chemical treater is necessary to extend the life of the seed to be stored and to protect seed for direct sale from deterioration until germination in the sub-tropical lowland. The Warnes plant currently applies 1.5 liters of Buzan (a fungicide) and 250 cc of Malation (an insecticide) per metric ton of wheat seed.

The seed for direct sale to the lowlands that winter would have to be processed during the period of winter planting (May and June). On the other hand, the seed to be stored until the following winter planting can be processed any time from July on provided that the seed was dried soon after harvest. For this reason, it is helpful to consider separately the processing capacity for the seed to be shipped immediately and the seed to be stored until the following season.

The capacity of the processing plant is, in effect, that of the air-screen cleaner. Two standard air-screen cleaners are the Clipper 27 and the Crippen A-334. The former is one of the smallest industrial air-screen cleaners (a capacity of 0.4 MT/hour), and is in use in various places in Bolivia. The latter is somewhat larger (0.7 MT/hour) and more flexible in operation. This is the model used at the Warnes Processing Plant.

The cumulative capacities by month for seed for direct sale and that to be stored are compared in Table 6.1. It is assumed that the plant can run double-shifts for the two months of processing seed for direct sale and single-shifts for the months of processing seed to be stored. The calculations further assume six hours of effective operation per shift, and up to ten months operation per year. Thus, the Clipper 27 can process 211 MT of seed for direct sale and 422 MT for storage, while the Crippen A-334 will clean 370 MT for direct sale and 739 MT of seed to be stored.

These capacities are employed in Table 6.2 which shows the proportion of capacity utilization for each of the two models of air-screen cleaner, for Alternatives A and B regarding the percentage of seed to be stored, and for each of the three projections of wheat seed demand: high, medium, and low. From this table, it appears that the Crippen A-334 would be more likely to meet the processing requirements of the CIAT wheat seed project. Given that the price difference between the two models is not large and the fact that the greater flexibility of the Crippen would facilitate its use to process other crop seeds, this model is considered more appropriate and will be included in the analysis.

TABLE 6.1: CUMULATIVE MONTHLY PROCESSING CAPACITY BY TYPE OF AIR-SCREEN CLEANER AND TYPE OF SEED BEING PROCESSED (MT)

Type of air-screen cleaner	Clipper 27	Crippen A-334
Cumulative capacity for direct sale seed (assumes 44 shifts/month)		
May	106	185
June	211	370
Cumulative capacity for seed to be stored (assumes 22 shifts/month)		
July	53	92
August	106	185
September	158	277
October	211	370
November	264	462
December	317	554
January	370	647
February	422	739
March	[equipment maintenance]	
April	[equipment maintenance]	
ANNUAL CAPACITY	634	1109

SOURCES: Based on a 0.4 MT/hr capacity of the Clipper 27 and a 0.7 MT/hr capacity of the Crippen A-334. Also assumes six hours/shift of effective operation, and up to ten months operation per year.

**TABLE 6.2: CAPACITY UTILIZATION OF TWO AIR-SCREEN CLEANERS UNDER
DIFFERENT ASSUMPTIONS REGARDING CIAT SEED SALES AND STORAGE**

	1986	1987	1988	1989	1990
CLIPPER 27 AIR-SCREEN CLEANER					
Alternative A: 54% storage					
High projection					
Direct sale	1.26	1.52	1.82	2.09	2.40
Stored	.89	1.07	1.23	1.41	1.54
Medium projection					
Direct sale	1.03	1.12	1.22	1.27	1.32
Stored	.66	.71	.74	.77	.80
Low projection					
Direct sale	.97	1.01	1.05	1.05	1.05
Stored	.59	.62	.62	.62	.62
Alternative B: 33% storage					
High projection					
Direct sale	1.83	2.21	2.65	3.04	3.50
Stored	.54	.65	.75	.86	.94
Medium projection					
Direct sale	1.50	1.63	1.77	1.84	1.91
Stored	.40	.44	.45	.47	.49
Low projection					
Direct sale	1.41	1.47	1.54	1.54	1.54
Stored	.36	.38	.38	.38	.38
CRIPPEN A-334 AIR-SCREEN CLEANER					
Alternative A: 54% stored					
High projection					
Direct sale	.72	.86	1.04	1.19	1.37
Stored	.51	.61	.70	.81	.88
Medium projection					
Direct sale	.59	.64	.69	.72	.75
Stored	.38	.41	.42	.44	.46
Low projection					
Direct sale	.55	.58	.60	.60	.60
Stored	.34	.35	.35	.35	.35
Alternative B: 33% stored					
High projection					
Direct sale	1.05	1.26	1.51	1.74	2.00
Stored	.31	.37	.43	.49	.54
Medium projection					
Direct sale	.86	.93	1.01	1.05	1.09
Stored	.23	.25	.26	.27	.28
Low projection					
Direct sale	.80	.84	.88	.88	.88
Stored	.21	.22	.22	.22	.22

SOURCES: Projected volume of seed divided by the processing capacity.
Assumes a maximum of 88 shifts (two months, double shifts) to process seed for direct sale and 176 shifts (eight months, single shifts) to process seed to be stored for following year.
See Tables 5.3 and 6.1.

6.2.3 Seed storage

A principal reason for locating the processing and storage facility in the Valles Mesotermicos near the seed-producing zones is that the climate is more favorable for seed storage without the use of equipment for air-conditioning and dehumidification. The altitude of this region is above 1500 meters so that the average temperatures are relatively low, 17-18° C., compared to those in the lowlands, around 25° C. Rainfall in the Valles Mesotermicos is also lower: 500-700 mm annually compared to 1200 mm annually in much of the area near the city of Santa Cruz. The average humidity is around 68-70%, somewhat lower than the range of 69-75% found in the lowlands. To confirm the suitability of this climate for seed storage without climate-control equipment, several bags of seed are currently being stored in the Valles Mesotermicos and will be tested after a year.

There are various criteria involved in the determination of the optimal storage capacity. If the uncertainty regarding future volumes of seed to be stored is disregarded and the objective is to maximize the return on the investment, the storage capacity should be such that the marginal cost of expanding the facility equals the additional revenue resulting from the expansion. The marginal cost is roughly calculated as the estimated construction cost (\$b 315,000 per square meter) plus 17% for services (see Table 6.6) and 10% for operating costs, totaling \$b 405,000 per square meter. This is presented in Table 6.3.

An additional square meter of storage space provides two forms of revenue. First, the storage fee provides revenue. Since the premium for early seed is assumed to be 20% and risk and financial costs would be around 15% of the value of the seed, it is assumed that the facility

could charge a 5% storage fee, or \$b 69,000/MT per year the additional capacity is used. If 1.25 MT can be stored on each square meter, then this is equivalent to \$b 86,700/m² for each year of use.

The second source of revenue is the processing fee net of variable costs for processing, since expanding the storage capacity allows the processing plant to employ excess capacity. Based on calculations presented in section 6.3, the net processing revenue is \$b 117,000/MT or \$b 146,000/m² of additional storage space.

The flow storage and processing revenue must be discounted and summed over the years that the additional capacity is used. This introduces diminishing marginal returns since the larger the capacity, the longer the time before an additional square meter is used. Table 6.3 employs the medium projection of Alternative B and a 10% discount rate. Under these assumptions, it is profitable to continue adding storage

TABLE 6.3: MARGINAL COST AND REVENUE AS A FUNCTION OF STORAGE CAPACITY

Storage capacity (MT)	200- 207	208- 215	216- 224	225- 233	234- 242	243- 244
Marginal revenue from storage fees (\$b 1000)	87	87	87	87	87	87
Marginal revenue from processing fees (\$b 1000)	146	146	146	146	146	146
Total marginal revenue per m ² per year (\$b 1000)	233	233	233	233	233	233
Years which additional capacity is used	5-10	6-10	7-10	8-10	9-10	10
Sum of discount factors for those years @ 10%	2.98	2.35	1.79	1.28	0.81	0.39
Marginal revenue per m ² (\$b 1000)	694	547	417	297	189	90
Marginal cost per m ² (\$b 1000)	405	405	405	405	405	405

SOURCE: Discount factors from Gittinger [1982: 434]. See text for details.

space up through the 224th metric ton of capacity (179 m² of space). Any further increase in storage area would not be used until the eighth year, a delay which reduces the present value of marginal revenue below marginal cost. Naturally, a change in the storage fee, the net processing revenue, the discount rate, or the volume projections would change the profit-maximizing storage capacity.

This analysis does not, however, incorporate the uncertainty regarding the demand for storage and the consequent risks associated with over-capacity and under-capacity. Since the expansion of the facility is possible, the risk of under-capacity is probably not critical. The risk of over-capacity seems moderate too due to the fact that the volume projections and assumption of a ten-year useful life are relatively conservative. Thus, it is recommended that the storage capacity be an even 225 MT (180 square meters).

6.2.4 Other equipment and facilities

The processing plant will also need facilities and equipment for a small office and seed testing laboratory. The office is necessary for the plant manager and to store records of volumes processed, receipts, expenses, payroll, and results from seed tests. The laboratory for seed testing is needed to adjust the processing to the particular condition of the incoming seed, to diagnose various stages in processing, and to confirm the quality of out-going seed. The laboratory equipment includes samplers for extracting seed from bags or bins, scoops, a scale, testing screens with different sized holes, a humidity tester, and a hygrophograph.

6.3 Financial analysis of costs and revenues

This section compares the private costs and revenues of a plant equipped with three drying chambers, a Crippen A-334 air-screen cleaner, a chemical treater, a 225-metric ton storage area, an office and laboratory. It employs the medium projection and Alternative B from Table 5.3, subject to the upper limits imposed by the processing and storage capacity. In 1988, the plant reaches full capacity for the two months of processing seed for direct sale (370 MT), at which point the Warnes Plant must again participate in the processing of wheat seed. In 1993, the volume of seed to be stored reaches the storage capacity (225 MT).

6.3.1 Revenue

The gross revenue of the plant is calculated in Table 6.4. The revenue per metric ton processed is calculated according to the fees charged by the Warnes plant in 1984 for drying, air-screen cleaning, and chemical treating. The revenue per metric ton of stored seed is equivalent to 5% of the retail price of seed in 1984, as described in subsection 6.2.3. The volumes of stored seed, and the consequent revenues from their sale, are listed in the year of sale. As noted above, the volumes processed and stored follow Table 5.3 subject to the limits imposed by the processing and storage capacities.

6.3.2 Investment costs

Investment costs are composed of the costs of imported equipment and the local costs of construction and installation. Equipment costs are detailed in Table 6.5. The main cost items are the air-screen cleaner, the chemical treater, and the generator. The calculations in this analysis assume that reliable electrical power will not be avail-

TABLE 6.4: GROSS REVENUES OF SEED PROCESSING PLANT

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Volume processed (MT)	486	528	554	561	569	577	585	594	595	595
Revenue per MT (1000 \$b)	135	135	135	135	135	135	135	135	135	135
Volume in storage (MT)	0	170	184	191	199	207	215	224	225	225
Revenue per MT (1000 \$b)	69	69	69	69	69	69	69	69	69	69
GROSS REVENUE (1000 \$b)	65804	83296	87789	89222	90861	92500	94139	95982	96187	96187

SOURCES: The volumes from Table 5.3 (medium projection, 33% stored), subject to limits of capacity (225 MT storage and 370 MT for seed for direct sale); processing revenue according to fees charged by the Warnes plant; and storage revenue assuming a fee of 5% of the retail value of the seed.

TABLE 6.5: COSTS OF IMPORTED EQUIPMENT FOR PROCESSING PLANT

Description	Quantity	Unit price (US\$)	Cost (US\$)
I. Plant equipment			
Generator (10 KW)	1	8515	8515
18-foot elevators	2	2500	5000
Blower/heater	1	3000	3000
Two-wheeled trolleys	2	175	350
Air-screen machine A-334	1	10000	10000
Chemical treater	1	6500	6500
Weighing and bagging machine	1	750	750
Bag sewing machine	1	900	900
Subtotal			35015
II. Laboratory equipment			
Aluminum scoops	2	10	20
Testing screens	10	15	150
Humidity tester	1	300	300
Higrothermograph	1	735	735
Subtotal			1205
Purchase value			36220
Packaging, transportation, and insurance (40% of the purchase value)			14488
TOTAL (US\$)			50708
TOTAL (\$b 1000 at official rate of \$b 2000/US\$)			101416
TOTAL (\$b 1000 at parallel rate of \$b 3250/US\$)			164801

SOURCES: Equipment list from discussions with project technical staff and prices from project documents.

able at the site. This constitutes a conservative assumption in that power from a utility would probably be less expensive. Although Table 6.5 shows conversion of the dollar cost to local currency value using both the official and parallel exchange rate, only the former is used in this financial analysis. This is the rate that would be paid to import the equipment and thus reflects the private cost. The parallel rate is used in the economic analysis presented in section 6.4.

Rough estimates of the construction and installation costs are made in Table 6.6 by using the expected dimensions of different components of the plant and unit prices. These were estimated by the project technical personnel with experience in the design and construction of seed processing plants, both in Bolivia and elsewhere. Some laboratory equipment was also included as a local currency investment item.

6.3.3 Operating costs

Operating costs include personnel, energy, maintenance and repair, and miscellaneous costs. Personnel costs are calculated assuming the need for a full-time plant manager and nightwatchman, as well as varying use of laborers. Although the Warnes Plant often operates with only three workers per shift, four are assumed in this case because of the lower level of automation. For example, no horizontal conveyor belts like those at Warnes are planned. Eight person-months are assumed for the two months of double-shift processing of seed for direct sale. Four workers handle the processing of seed for storage for as many months as the volume demands (see Table 6.1). One worker remains during the months without processing activity for cleaning and maintenance. Lastly, three person-months are included to handle the sale of stored seed in April. The results are presented in Table 6.7 and summarized in Table 6.9.

TABLE 6.6: CONSTRUCTION AND INSTALATION COSTS FOR PROCESSING PLANT

	Dimensions		Unit	Cost
	(m)	(m ²)	price (1000 \$b)	(1000 \$b)
A. Building area				
Receiving and drying	14x10	140		
Processing	10x10	100		
Storage area (225 MT)	10x18	180		
Subtotal		420	315	132300
B. Covered outdoor areas				
Receiving area	5x3	15		
Dispatching area	5x3	15		
Subtotal		30	140	4200
C. Offices	4x6	24	525	12600
D. Unpaved access road		500	12	6000
E. Security fence	180		7.5	1350
F. Installation				
Electricity and telephone	15% of A + C			14490
Sanitation and water	5% of A + C			7245
Special	2% of A			2646
G. Equipment				
Laboratory equipment			600	
Feed chute			5000	
Equipment instalation			1200	
Subtotal				6800
H. Other	10% of A - G			18763
TOTAL CONSTRUCTION AND INSTALLATION COST				206394

SOURCES: Based on discussions with and estimates by project technical staff.

TABLE 6.7: PERSONNEL COSTS OF SEED PROCESSING PLANT (\$b 1000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Plant manager	3510	3510	3510	3510	3510	3510	3510	3510	3510	3510
Workers	4054	4249	4371	4400	4433	4467	4500	4543	4548	4548
Night watchman	1540	1540	1540	1540	1540	1540	1540	1540	1540	1540
TOTAL	9104	9299	9421	9450	9483	9517	9550	9593	9598	9598

SOURCES: Based on the monthly salaries of \$b 250,000 for the plant manager and \$b 110,000 for the others plus 16.7% for social security and other labor costs. These calculations assume full-time employment of the plant manager and nightwatchman. They also assume eight workers during double-shift processing of seed for direct sale, four workers during the single-shift processing of seed to be stored, three workers during the sale of seed, and one worker during the remaining time. Time required for each type of processing calculated from the seed volumes and monthly capacity in Tables 5.3 and 6.1.

The energy costs per metric ton of processed seed are determined in Table 6.8. As mentioned, it is assumed that the plant will have to generate its own electrical power to operate the machinery. In this table, "usage" is defined as the energy requirements per metric ton of seed processed. It is the product of the power capacity of the unit and the number of hours of operation per ton of processed seed. A 10 KW generator appears to be sufficient to meet the electrical needs of the plant. Energy costs are summarized in Table 6.9.

Maintenance costs are roughly calculated at 2% of the construction and installation cost and 5% of the CIF cost of the imported equipment. Although maintenance on some items such as the generator will probably be more than 5%, maintenance for others such as the air-screen cleaner and the platform balance will likely be less. The costs of other items not included or not foreseen is assumed to be 10% of the rest of the operating costs. These costs are included in Table 6.9.

6.3.4 Comparison of costs and revenues

Operating and investment costs are summarized in Table 6.9. Also included in the table are the estimated costs for chemicals to treat the seed, as described in subsection 6.2.2. However, these costs are charged to the institutions having the seed processed apart from the normal processing fees. This item is not counted here with costs, nor with the gross revenues in Table 6.4.

Table 6.10 combines the gross revenues from Table 6.4 and the costs from Table 6.9. The difference between the two is the net revenue, which is negative the year the plant is constructed and positive thereafter. One measure of project worth is the net present value: the sum of the

TABLE 6.8: ENERGY COSTS PER METRIC TON OF PROCESSED SEED

Electricity	Capacity		Operation	Usage
	(hp)	(kw)	(hr/MT)	(kwh/M)
Blower	9.00	6.71	.94	6.31
Elevator for uncleaned seed	.75	.56	1.40	.78
Air-screen cleaner	3.00	2.24	1.40	3.13
Elevator for cleaned seed	.75	.56	1.00	.56
Chemical treater	1.00	.75	.25	.19
Elevator for treated seed	.75	.56	1.40	.78
Bag sewing machine	.05	.04	.10	.00
Electrical consumption	15.30	11.41		11.76

Diesel	Usage Operation		Usage	Cost
	(l/hr)	(hr/MT)	(l/MT)	(\$b/MT)
Heater for seed drier	7.90	1.00	7.90	5530
Generator (10 KW)	7.00	1.40	9.80	6860
Energy cost per metric ton				12390

SOURCES: Equipment specifications and technical relationships from technical project staff. Diesel price of \$b 700/liter which includes transportation of fuel to region.

NOTE: An electrical capacity of 10 KW would be sufficient since not all the equipment is operated simultaneously.

TABLE 6.9: COSTS OF SEED PROCESSING PLANT (1000 \$b)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Operating costs										
Personnel	9104	9299	9421	9450	9483	9517	9550	9593	9598	9598
Energy	6022	6542	6864	6951	7050	7149	7248	7360	7372	7372
Maintenance	9199	9199	9199	9199	9199	9199	9199	9199	9199	9199
Chemicals (not added)	41662	45263	47492	48092	48778	49463	50149	50921	51006	51006
Other	2432	2504	2548	2560	2573	2586	2600	2615	2617	2617
Investment costs										
Construction	206394	0	0	0	0	0	0	0	0	0
Imported equipment	101416	0	0	0	0	0	0	0	0	0
TOTAL COSTS	334567	27544	28032	28159	28305	28451	28596	28766	28785	28785

SOURCES: Tables 6.5 through 6.8.

NOTE: Chemical costs are paid by the customer as part of fee for processing. They are not included in the total here, nor in the calculation of revenues in Table 6.4.

TABLE 6.10: FINANCIAL ANALYSIS OF SEED PROCESSING PLANT (\$b 1000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Gross revenue	65804	83296	87789	89222	90861	92500	94139	95982	96187	96187
Total costs	334567	27544	28032	28159	28305	28451	28596	28766	28785	28785
Net revenue	-268762	55752	59756	61063	62556	64049	65542	67216	67402	67402
Net revenue discounted at 10%	-268762	50684	49385	45878	42727	39769	36997	34492	31443	28585
Net present value with 10% discount rate	= 91 million Bolivian pesos at June 1984 prices									
Internal rate of return	= 17.7 %									

SOURCES: Tables 6.4 and 6.9.

discounted net revenues for each year of the life of the investment where the discount rate represents the opportunity cost of capital. In mathematical form, this can be expressed as follows:

$$NPV = \sum_{t=0}^T \frac{Y_t}{(1+r)^t}$$

where NPV is the net present value, Y_t is the net revenue in year t , r is the discount rate, and T is the expected life-span of the investment. Using a discount rate of 10%, the net present value is 91 million pesos at June 1984 prices.

Another measure of project worth is the internal rate of return, that is the discount rate at which the net present value becomes zero. In this case, the internal rate of return is 17.7%, indicating that the investment is profitable since the opportunity cost of capital is generally assumed to be around 10%.

6.4 Economic analysis of costs and benefits

A complete economic analysis would value the various inputs and outputs of the investment at their social cost or shadow price. Using the financial analysis as a base, there are various ways to adjust market prices to more accurately reflect "true scarcity values." Five examples come to mind: it could be argued 1) that a lower shadow wage rate should be used to reflect the existence of rural unemployment, 2) that a higher seed price would better reflect the benefits of early seed that accrue to farmers, 3) that the benefits of import-substitution of wheat are only partially reflected in the price of wheat, 4) that the

valuation of seed processing is excessive given the possibility of leaving the Warnes plant with excess capacity, and 5) that the official exchange rate does not reflect the "scarcity value" of foreign exchange.

This analysis will focus on the only two examples which tend to make the economic return lower than the financial one: the valuation of imported equipment given foreign exchange shortages and valuation of seed processing given the possibility of creating excess capacity at the Warnes Plant. Each will be discussed briefly.

With the construction of several new seed processing plants in the region, it is relevant to ask if the Warnes Plant will be left with excess capacity. A small foundation seed processing plant to be located on the CIAT experiment station in Saavedra (about 100 km north of the city of Santa Cruz) will process foundation seed starting in 1986, however this will reduce the load on the Warnes Plant only marginally. The cooperative of Japanese colonists, CAICO, has recently constructed a processing plant in the Okinawa I colony which is expected to process soybean seed. A third new processing plant, owned by a private seed company, is nearing completion between Warnes and Santa Cruz. This plant will process the maize seed produced by that company.

Nonetheless, it is doubtful that the Warnes plant would be left with unused capacity with the construction of a wheat seed plant in the Valles. Currently, wheat seed processing is done from late April to mid-July. It is necessary to cut off the arrival of soybean seed in order to begin wheat seed processing. Thus, the construction of the wheat seed plant would allow expansion and greater flexibility in the soybean production.

Second, maize seed is harvested in May and June, but it is not

processed until July because of the greater perishability of the newly harvested wheat and soybean seed. With the wheat seed processing plant, maize could be processed earlier. Third, as explained above, it is not economical for the wheat seed plant in the Valles to have the capacity to process all the wheat seed being produced. Some of the direct sale seed would have to be processed at the Warnes plant beginning in the third year of the project, earlier if the high projection is assumed. In sum, the Warnes Plant will not be left idle and the revenue received in processing fees by the new plant will reflect the true economic benefit.

With regard to the valuation of foreign currency in Bolivia, it should be noted that it is very difficult to obtain U.S. dollars at the official rate since they are strictly rationed by the government. However, a parallel rate is established by private money-changers operating on the sidewalks and in "Casas de Cambio" in the major cities. Since one can buy and sell freely at this rate, it may be considered a more accurate indicator of the value of foreign currency.

In June 1984, the reference month for all prices in this study, the parallel rate was \$b 3250 per U.S. dollar. If this exchange rate is used to convert the dollar costs of the imported equipment to local currency costs, the net present value of the investment using a 10% discount rate is four million Bolivian pesos and the internal rate of return is 10.3% (see Table 6.11). While certainly lower than the financial rate of return, this lower-limit estimate of the economic rate of return indicates that the investment is at least modestly profitable from the perspective of the Bolivian economy as a whole.

TABLE 6.11: ECONOMIC ANALYSIS OF SEED PROCESSING PLANT (\$b 1000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Gross revenue	65804	83296	87789	89222	90861	92500	94139	95982	96187	96187
Total costs	401438	31030	31518	31645	31791	31937	32083	32253	32272	32272
Net revenue	-335634	52266	56270	57577	59070	60563	62056	63730	63915	63915
Net revenue discounted at 10%	-335634	47515	46504	43259	40345	37605	35029	32703	29817	27106
Net present value with 10% discount rate	=	4 million Bolivian pesos at June 1984 prices								
Internal rate of return	=	10.3 %								

SOURCES: Tables 6.4 and 6.9.

6.5 Sensitivity analysis

Since all projections involve some uncertainty, it is helpful to determine the sensitivity of the results to changes in the assumptions regarding prices, volumes, the life-span of the investment, and so on. Thus, the internal rates of return for both the financial and economic analysis were calculated under a variety of altered assumptions, and the results presented in Table 6.12.

If the life-span of the project is reduced from ten years to eight years, the economic rate of return drops below the lowest estimates of the social opportunity cost of capital, but the investment remains profitable from a private point of view. If the life-span is twelve years, a clear possibility, both rates increase with the economic rate of return rising to 13%.

With respect to the volume of seed, if the high projection from Table 6.5 is used and the processing capacity turns out to be 10% greater than estimated in Table 6.1, the rates of return rise somewhat. This increase in profitability is modest because the storage capacity and processing capacity are still limiting factors. On the other hand, if the low projection is assumed along with a 10% reduction in capacity (though this is not constraining), the rates of return are significantly lower, but the investment is still financially profitable.

Referring again to Table 5.3, if 54% of the seed production each year is saved until the following planting season (Alternative A) and the medium projection is accurate, then the rates of return diminish only marginally. Storage capacity is a limiting factor from the second year, but the processing capacity for direct sale is not as constraining because more of the seed is being stored. If these volume and storage

TABLE 6.12: SENSITIVITY ANALYSIS: FINANCIAL AND ECONOMIC INTERNAL RATES OF RETURN UNDER VARYING ASSUMPTIONS

	Financial internal rate of return	Economic internal rate of return
Original assumptions	18%	10%
Life span of project		
8 years	13%	5%
12 years	20%	13%
Volume of seed		
High projection, 10% higher processing capacity	24%	15%
Low projection, 10% lower processing capacity	11%	4%
Proportion of stored seed		
54% (Alternative A)	15%	8%
Fee for seed processing		
10% higher	22%	14%
10% lower	13%	6%
Fee for seed storage as % of retail value		
No fee	11%	4%
2.5% fee	14%	7%
7.5% fee	21%	13%
10% fee	24%	16%
15% fee	29%	21%

SOURCE: Tables 6.4 through 6.11. High and low volume projections and change in the proportion of stored seed from Table 5.3. Note that the same processing equipment and storage capacity are assumed. Economic rate of return is conservative and should be considered the lower limit.

assumptions were combined with a larger storage facility, the rates of return would be higher than under the original assumptions in this study because of the added revenue from seed storage.

The fee for processing has a modest effect on the financial and economic return. It should be noted that with a 10% reduction in processing fees, the economic rate of return drops to an unacceptable level.

And finally, various levels of storage fees, expressed as a percentage of the retail value of the seed, are tested. In general, the results can be summarized by saying that the financial return remains acceptable even without a storage fee, but that the economic return is below the opportunity cost of capital for all fees less than that originally assumed, 5%. Naturally, any reduction of the premium on early seed below that assumed here (20%) would have to be reflected in the storage fee. It is worth noting that in order to maximize the return, the capacity of the storage facility should be larger (smaller) than 225 MT if the premium on early seed is greater (less) than 20%.

Finally, it should be reiterated that the economic rate of return was very conservatively calculated, adjusting only the rate of exchange used to value the imported equipment. If other shadow prices were adopted, as mentioned in section 6.3, then the economic rates of return would be higher than calculated in Tables 6.11 and 6.12.

6.6 Evaluation of alternate sites for the processing plant

The criteria for the location of the plant should include the availability of labor, electrical service, and water, the suitability of the climate for seed storage, and the costs of transporting the seed from the seed growing zones and to the lowlands. A site somewhere in the

Valles Mesotermicos is indicated by the relatively cool climate and the fact that little additional transportation would be required. In fact, these costs may be lower due to the fact that drying and processing reduce seed weight by about 10%. Four population centers are considered in this evaluation: Vallegrande, Mataral, San Isidro, and Comarapa.

With respect to the availability of labor, the two largest towns in the Valles Mesotermicos are Vallegrande (5700 inhabitants) and Comarapa (2600 inhabitants), while San Isidro and Mataral have somewhat less than one thousand each (see Table 6.13). Although these levels of population may not be constraints in themselves, a tomato processing plant being constructed by CORDECRUZ in San Isidro will open in 1985, employing around 30 people. This may create a short-run labor shortage.

Regarding the availability of electrical service, Vallegrande and Comarapa have systems with capacities of 380 KW and 300 KW, respectively, while the other two have smaller systems (see Table 6.13). Small-scale hydro-electrical projects by the Italian government will increase the capacity of each by 200 KW within a few years. The project in Comarapa, which involves connecting San Isidro to its electrical system, is more advanced and should be in operation in 1985. Although this will provide surplus electrical capacity during the daytime, there will be little or no surplus in the evening, needed for the months when double-shift operations must occur. For this reason, a generator may be necessary even in Comarapa and San Isidro. The operating costs of the plant would be somewhat lower with this service, but the need for a generator is probably not avoided.

All four centers have municipal water systems. The system in Mataral is run by diesel pump and is consequently more expensive than the

others. However, the plant does not use water in the industrial processes, so that this factor does not affect costs in a significant way.

Meteorological data are not available for all four centers, but the information available does not indicate any major differences between the sites in terms of their suitability for seed storage. The only significant difference is that Mataral appears to have a lower rainfall than the two other sites for which data are available (see Table 6.13).

Perhaps the most important impact of site location on the costs of operating the plant concern the costs of assembly and distribution of wheat seed. Table 6.14 estimates the additional transportation costs per 100 MT of seed for each possible plant site. The branched road system (see Figure 4.3) means that locating the plant on any branch will require seed produced along other branches to detour from its route in order to be dried and processed. This additional distance which seed must be transported, twice the length of the detour, is listed for each combination of plant site and production zone. The proportions of seed coming from each production zone are based on the pattern this year. The cost of transportation was approximately \$b 10/quintal/kilometer or \$b 217/MT/kilometer. The cost is the product of the additional distance, the volume, and the transportation cost.

Note that locating the plant in Mataral, being located along the route to the lowlands from each production zone, involves no additional transportation. On the other hand, the other three sites would involve additional transportation costs of \$b 690,000 to \$b 1,484,000 for each 100 MT of seed processed at the plant. Assuming only 400 MT of seed are processed each year for ten years and using a discount rate of 10%, the net present value of these additional costs would be around \$b 18 mil-

TABLE 6.13: CHARACTERISTICS OF ALTERNATE SITES FOR THE PROCESSING PLANT

	Comarapa	S. Isidro	Mataral	Vallegrande
Population	2597	<1000	<1000	5715
Altitude (meters)	1814	1550	1400	1980
Rainfall (mm/yr)	576	-	501	695
Temperature (OC.)	17.8	-	-	16.8
Relative humidity (%)	68%	-	-	70%
Electrical capacity				
Current (kw)	300	-	30	380
Projected (kw)	500	500	30	580
Water system	Gravity	Gravity	Pump	Gravity
Transport costs	High	Medium	Low	High

SOURCES: CORDECRUZ et al (1982c), CORDECRUZ (1980), and discussions with CORDECRUZ personnel. Note that the projected capacities of Comarapa and San Isidro are of the same system since the two are to be connected by electrical lines.

TABLE 6.14: ADDITIONAL TRANSPORT COSTS PER 100 MT OF SEED FOR DIFFERENT PROCESSING PLANT SITES

Plant site	Seed production zones	Additional distance (km)	Volume (MT)	Cost (1000 \$b)
Comarapa	Vallegrande, Moromoro	100	54	1172
	Jague, Tablacucho	60	24	312
	Comarapa	0	22	0
	Total cost			1484
San Isidro	Vallegrande, Moromoro	50	54	586
	Jague, Tablacucho	20	24	104
	Comarapa	0	22	0
	Total cost			690
Mataral	Vallegrande, Moromoro	0	54	0
	Jague, Tablacucho	0	24	0
	Comarapa	0	22	0
	Total cost			0
Vallegrande	Vallegrande	0	30	0
	Moromoro	40	24	208
	Jague, Tablacucho	100	24	520
	Comarapa	100	22	477
	Total cost			1205

SOURCES: Based on the proportions of seed from each zone this year, and an estimated transportation cost of \$b 217/MT/km at June 1984 prices. Note that one kilometer of detour generally implies two kilometers of additional distance.

lion to \$b 40 million. By means of comparison, the price of the generator is about \$b 17 million at the official exchange rate.

In summary, Mataral has a clear advantage with respect to the costs of transportation which is perhaps the most important site-related factor. In addition, its central location would facilitate publicity about the wheat seed project. The disadvantage of this site is the inferior electrical service which makes the installation of a generator necessary. On the other hand, it is very possible that generators would have to be installed in the other three sites as well in order to be able to operate in the evening. This issue deserves more research, particularly regarding the availability of surplus electrical capacity and the relative costs of generating electricity and using municipal electricity.

6.7 Wheat seed price and marketing policy

In this section, recommendations are made for the improvement of wheat seed pricing and marketing policies to complement the proposed investments. Seed pricing, for both contract seed growers and seed consumers, is considered first.

The price paid to contract growers is initially set according to CIAT estimates of the costs of production plus a 20% incentive premium. However, there have been some problems with this system. As mentioned earlier, in 1983 many seed growers found it profitable to sell their "seed" as mere grain. In 1984, by contrast, the newly formed seed growers' association refused to accept the price initially offered and a higher price was reached through negotiations.

The sale price of the wheat seed is fixed before the winter plant-

ing season by CIAT in cooperation with ANAPO representing the lowland wheat growers. The criteria used are the costs of producing the seed, principally the price paid to the seed growers and the processing fees, and the relation between the seed and grain prices.

The practice of fixing prices according to the "cost of production" is widespread in Bolivia, not just in this seed program, but in national agricultural price policy. Although useful in some contexts, there are several weaknesses of this system. First, the costs of production vary among producers and are not easy to calculate even for a representative producer. The use of family labor and fixed assets such as land are difficult to value. Second, the hyperinflation in Bolivia makes any cost estimate out of date within a month. And third, the cost of production does not always reflect a price that buyers are willing to pay or that producers would accept.

In general terms, it is recommended that prices be set taking into account a broader set of considerations than merely the "cost of production." Prices set by the institutions of the seed program should incorporate the likely supply (demand) of seed which can be bought (sold) at a given price.

In addition, pricing arrangements must be realistic given the high and unpredictable nature of inflation in Bolivia. All prices used in the agreement with contract seed growers should be set relative to the grain price or simply in kind using the seed as a medium of exchange.

For example, the 1984 agreement established that seed growers would receive seed to plant and only repay the "loan" at harvest either in kind or at an amount fixed in pesos. When the real value of the cash price fell 75% in real terms, CIAT revoked the second option causing

considerable resentment among the seed growers. Repayment for inputs and the collection price for seed itself should be set relative to wheat grain prices. Furthermore, the grain price referred to should be one of relevance to the other party: the mill price in Santa Cruz is less relevant to seed growers than the price in highland markets.

With respect to the sale of wheat seed in the lowland, a central problem is the use of a single fixed price all season. This generates excess demand early in the lowland planting season and excess supply toward the end. This creates the potential for favoritism, or at least arbitrariness, in the allocation of the early seed. Most importantly, it does not offer any incentives to find ways to delay lowland planting or provide early seed from other sources, such as stored seed.

An alternative approach would be to charge a premium for seed which has been stored from the previous year. This would be in line with the strategy of pricing according to the "cost of production," yet it raises a problem. As can be appreciated in Table 5.2, the sale of stored seed and seed harvested that month overlap for a period of three to four weeks. The simultaneous sale of stored seed and lower-priced "fresh" seed is clearly unfair, as well as creating the same kind of temptations mentioned above.

The third approach, that of charging a premium for early seed regardless of its origin, seems the most reasonable. In this way, the allocation of early seed would follow the criteria of economic "urgency" as reflected in the price lowland farmers are willing to pay. The smaller and more frequent the price changes, the smaller tendency of sales to fluctuate, falling just before a price change and rising just after one. On the other hand, the frequency of changes is limited by the

associated administrative problems.

It is recommended that the sale price of wheat seed in the lowlands drop each week on a fixed day and by a fixed, round-number amount in order to keep the system as clear as possible. Furthermore, the price should fall by at least 20% from mid-May to mid-June in such a way so that the average price is approximately equal to that charged this year.

Another advantage to such a price structure is that it would make a similar system possible for the seed growers in the highlands. Because the administrative problems are greater here, perhaps only two or three adjustments in price would be feasible. This would, for the first time, provide an economic incentive for the early harvesting and delivery of wheat seed.

Another marketing issue to resolve is the actual disbursement procedure. Currently, farmers obtain permits to buy a specific quantity of wheat seed, usually no more than a truckload, from the ANAPO headquarters in the city of Santa Cruz. The seed is actually obtained at the Warnes Plant, about 20 minutes north of the city of Santa Cruz. Because the seed is continually arriving, being processed, and being sold it is difficult to monitor the availability of seed at Warnes. Many farmers are forced to make several trips to the plant, perhaps staying in the city for up to a week waiting for seed.

There are various alternative procedures for marketing the seed coming from the new processing plant in the Valles Mesotermicos. One approach would be to allocate seed among buyers at the new plant and have it delivered directly to the farm or colony. This alternative is the least costly in terms of transportation and handling but the most complex in terms of the administrative and communication requirements.

Coordinating the dispatch of seed from the plant with the purchases made in Santa Cruz would be impractical except perhaps in the case of bulk orders from a colony, cooperative (such as CAICO), or one of the largest farmers. However, it is likely that farmers would resist buying seed never having seen it.

A second alternative is to transport the seed to a transshipment point in the city of Santa Cruz, an small storage area, perhaps rented by ANAPO or CIAT. The seed would be sold from this place. This system is convenient for farmers lodged in the city waiting for seed and reduces transportation expenses for the seed going to the farms south of the city. However, it requires the establishment of a separate short-term storage area and a distinct record-keeping system from that at the Warnes Plant which may continue processing some wheat seed. Unless a suitable site is already available, this alternative would probably be impractical.

The third alternative, that of continuing to use the Warnes Plant as a retail outlet, is perhaps the most convenient, at least in the short run. Although the simplest for CIAT, it is somewhat inefficient in requiring seed to be delivered north of the city for sale only to have some brought to farms south of the city.

One way to combine the strengths of each of these systems would be to make some seed available at the new plant and other seed available from the Warnes plant. The price difference would correspond to the transportation and handling costs of delivery to the Warnes Plant. In this way, if a colony or large farm finds it more cost-effective to purchase direct from the plant, this is possible.

Even more flexibility could be achieved with the abolition of the

rule that only farmers can buy CIAT seed. If a merchant has an unused storage area and feels farmers might pay for the convenience of buying seed in the city, he can experiment at his own risk. Another possibility is that seed might be brought to the more distant colonies for resale by merchants or members of the colonies. This diminishes the sizeable transaction cost that farmers in these distant colonies face.

This proposal would be resisted by many working in the agricultural sector because of the danger of "exploitation." However, attempts to establish "fair" mark-ups would eliminate the very flexibility sought: only relatively simple marketing which can be covered by the allowable mark-up will be undertaken. A better method might be to try to ensure that publicity about the price charged by CIAT at the Warnes Plant exists wherever the seed is sold. Perhaps seed merchants could be "licensed" by CIAT and required to post announcements of Warnes prices (furthermore the Warnes price could be listed on the certification ticket itself). This would be easy to monitor among the few agricultural supply merchants in the city. In the colonies, the colony administrators could provide effective enforcement, though abuse seems unlikely among the Mennonites in any case.

In summary, it is recommended that CIAT continue selling wheat seed from the Warnes Plant, but also sell it from the new plant in the Valles Mesotermicos at a lower price. Further, it is recommended that the seed be available to selected merchants for resale in the city or to farms, ideally with some system to ensure that buyers are aware of the Warnes price and are therefore making an informed choice.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

7.1 Conclusions regarding seed industries in less developed countries

With the recognition of the importance of agricultural technology in economic development has come a growing body of literature on the economic and organizational aspects of agronomic research. Much less attention has been paid to the problem of developing effective seed industries necessary to multiply and disseminate the new cultivars. This is unfortunate given the importance of the stage in the process of technology generation and diffusion and the serious deficiencies in most seed industries in the less developed countries. The present study attempts to address this issue.

Chapter Two of this study identifies several important characteristics of seed as an economic product and relates them to the institutional requirements of seed industries, focussing on the role of the public sector. With regard to the characteristics of seed, several conclusions were reached:

- 1) Seed consumers are also seed producers so that a seed industry must offer seed with higher quality or lower price than the farmer's own saved seed. The ability to do this varies with the climate and crop. Seed that is difficult to store, process, or clean gives a natural advantage to a specialized seed industry.
- 2) The determinants of quality are complex and vary among farmers. Thus, knowledge of and responsiveness to farmer demand are crucial to successful seed marketing.
- 3) Seed quality is not readily apparent to the consumer. In the absence of a trusted source of information, the demand for even high-quality seed will be minimal.

- 4) The supply and demand for seed are strongly seasonal and vary from year to year and seed is perishable. This highlights the importance of careful seed handling and agile, timely marketing.
- 5) And finally, the returns to most forms of plant breeding can not be captured by the research institutions. Thus, breeding has public good attributes.

With these institutional requirements for effective seed production and distribution, the role of the public sector in each component of a seed industry was considered. As mentioned above, plant breeding has public good attributes, thus justifying public investment. This theoretical argument is confirmed by the high rates of return which have been estimated for plant breeding. Private breeding has been stimulated by the development of hybrids and by "breeders' rights" legislation in some countries, but for most less developed countries, the public sector must continue to play a dominant role.

In the case of seed production, there is less justification for permanent direct government participation, nor are public agencies well suited for this kind of activity. Nonetheless, public seed production is common in less developed countries, particularly in Africa. Although the "infant industry" argument is plausible, seed policies often inhibit the development of private seed enterprises. The most effective role for the public sector is to stimulate private involvement in seed production through the 1) elimination of subsidized seed prices, 2) the provision of processing and certification services available to all on a fee basis, and 3) the development of a research program which can generate new cultivars adapted to local conditions and provide reliable supplies of quality foundation seed. Additional assistance to private seed enterprises may take the form of technical assistance, credit, and technical and management training.

For various reasons, seed production by private firms is more likely for industrial crops, hybrids, vegetables, and pasture crops than for the major cereals. In the latter case, farmers' associations and cooperatives may be a more feasible alternative to government seed production. Where public seed production is necessary, experience has demonstrated that the use of contracted seed growers is less costly in the long run than the use of mechanized state farms.

Compared to other components of a seed industry, public seed marketing is the least justifiable in terms of economic theory and has the worst record. Seed marketing requires a degree of responsiveness and flexible marketing system rarely found in public agencies due to the incentive structure (salary rather than commission), centralization of decision-making power, and civil service regulations. Insufficient supply, lateness of delivery, high costs, and even political bias in distribution have been problems. Subsidized seed prices and pan-territorial price exacerbate these problems and may cause seed to be consumed as grain.

Seed certification and other efforts to regulate seed marketing are clearly necessary public functions. The non-transparency of seed quality, combined with the option of saving seed, mean that impartial information on seed quality will greatly facilitate the development of a seed industry. Clearly, the service must be independent and available to all seed producers, public and private, on a fee basis.

In Chapter Three, the description of the experience of the the certified seed program in the Santa Cruz region of Bolivia confirms some of the generalizations made above. The reforms of 1982 weakened the public sector monopoly on seed production and allocated different func-

tions among MACA, the local research organization (CIAT), and the growers' associations. They also established "realistic" prices for seed and made certification and processing available to public and private entities. In addition to rapid growth in seed production, the reforms have simulated the creation of private seed enterprises and private processing facilities. Wheat seed is produced by CIAT using contract growers, but at least one seed enterprise is considering seed production for this crop.

7.2 Conclusions regarding wheat seed marketing in eastern Bolivia

Partly as a result of the availability of quality seed, lowland wheat area has grown to around 8,800 hectares in just a few years. The survey carried out by the author seems to indicate that CIAT certified seed has accounted for 45-60% of wheat seed consumption, saved seed an additional 9-14%, and other uncertified seed the remainder. The main shortcomings of CIAT seed from the point of view of the lowland wheat farmer are its unavailability early in the planting season. In spite of some complaints about the high price of CIAT seed, a majority of those interviewed said that the lateness of CIAT seed had delayed their planting and claimed they would pay 15% more for seed available earlier.

The projections made indicated that wheat area in the lowlands may grow to 13,600 ha by 1995, with high and low projections being 8,800 ha and 30,000 ha, respectively. If the problem of lateness can be solved, the annual demand for CIAT seed could easily reach 730 MT by that time.

A comparison of the temporal distribution of wheat seed supply and demand showed that around 33% (and possibly up to 54%) of the annual production would have to be stored from one year to the next in order to satisfy the early demand for seed.

7.3 Recommendations regarding wheat seed marketing in eastern Bolivia

Using the projections referred to above, a feasibility study of a processing plant and storage facility in the highland seed growing region was carried out using June 1984 local prices. Both financial and economic internal rates of return were calculated. On the basis of this analysis, the following recommendations were made regarding equipment and capacities.

- 1) The drying capacity should be sufficient for to dry 100% of the annual production of wheat seed in two months. Given the projections made here, a three-chambered drier with a total capacity of 24 MT with forced heated air flow should be adequate. This would dry about 1.0 MT/hr.
- 2) The processing plant should have an air-screen cleaner, a chemical treater, a balance platform bagger, an industrial sewing machine, and two elevators. Of the two models of air-screen cleaner, the Crippen A-334 seems more appropriate to the needs of the plant. Its capacity is approximately 0.7 MT/hr.
- 3) Assuming a 20% price premium on early seed, a 5% storage fee, and a ten-year life span of the plant, the storage facility should have capacity sufficient for its seventh year of operation. Given the projections made here, this would indicate the need for 225 MT of storage capacity. It is assumed that twelve month wheat seed storage in this region is safe. This assumption is currently being tested.
- 4) Basic laboratory equipment and space for a laboratory are needed. In addition, a small office would be included in the plant design.

Given these equipment and capacity recommendations, the projections of demand made earlier, the assumption of a 5% storage fee, and the processing fees currently charged in Santa Cruz, the financial rate of return to the plant is 17.7%. The economic rate of return is 10.3%. The latter was conservatively estimated in that only the exchange rate was adjusted to reflect true scarcity value. Market prices were not adjusted to reflect the benefits to farmers, consumers, and plant workers as a result of the plant. Thus, it appears that investment in the plant would

provide a substantial financial return and an adequate economic return.

A sensitivity analysis was used to estimate the impact of changes in assumptions on these rates of return. For example, a 12-year life span would raise the economic rate of return to 13%, but the absence of a premium for early seed would result in an unacceptably low economic rate of return.

An evaluation of alternate sites for the plant indicated that electricity and transportation costs were the most significant factors in plant location. Mataral has a clear advantage in terms of transportation costs, but more research is needed to determine if the inferiority of the public services, particularly electricity, makes this an undesirable site. Much depends on whether a generator would be needed at the other sites as well.

And finally, several recommendations were made regarding the pricing and marketing of CIAT wheat seed. First, it was suggested that the price schedule of wheat seed involve a downward staircase pattern with fixed adjustments each week. This would provide incentives for storage by CIAT and others, encourage later planting among those that are able to do so, and allow a similar (but simplified) scale to be established in the highland seed growing area.

Second, it was recommended that non-farmers be permitted to buy moderate quantities of wheat seed. The price of resale would not be controlled, but notice of the initial price could be included on the certification ticket to ensure that the eventual buyer is making an informed decision. This would facilitate the marketing of CIAT wheat seed by private traders in the more distant colonies.

7.4 Implications for further research

Much of the available literature on seed programs in developing countries is oriented toward the technical issues in individual programs. There is a need for more comparative studies and for more attention to the economic and institution-building aspects of seed programs.

There are several areas of particular interest:

Adoption of improved varieties: What is the relative importance of price, availability, performance, and other factors in seed purchasing decisions?

Seed programs serving small farmers: What is the experience with such programs? What special measures are important in serving small farmers?

Effective public seed production: Where public seed production is considered necessary, what institutional forms, pricing structures, and personnel arrangements have proved useful in dealing with the special requirements posed by seed production? How can such systems take advantage of private marketing channels?

Types of public assistance: What forms of public assistance have been most effective in promoting private sector participation? What is the experience with mixed or joint enterprises and what problems arise?

Seed industry reform: Various countries have undergone privatization in seed production. How is this accomplished and what have the results been?

Promoting private cereal seed production: Are the obstacles to private cereal seed production related to controlled producer prices, subsidized public programs, and other policy variables? Or are the problems more fundamental such as the ease of on-farm saving of seed, limited effective demand, and geographic dispersion? What is the experience with other private entities such as cooperatives and farmers' associations?

Historical perspective: Looking at the more advanced seed industries in the developing countries (Brazil, Colombia, Thailand, the Philippines, India, and so on), how has the private sector become involved over time?

Research on these and other related topics would contribute to the design of systems for technology generation and diffusion in less developed countries.

ANNEXES

ANNEX A

SEED AS A "PUBLIC GOOD"

Although frequently used in economic literature, the term "public good" is variously defined. According to one definition, a public good has the property that "if more of it is provided for one member of a group of people, more is necessarily provided for all members" [Sugden and Williams, 1978: 159], examples being national defense and flood control. It is also defined as a good "whose availability to a single consumer is not reduced by having made it available to another consumer" [Pearse and Nash, 1981: 120], such as information or a half-empty train. These contrasting definitions correspond to Schmid's distinction between "high exclusion cost" and "joint-impact" goods.

In the latter case, "even though people could be excluded from use of the output, this would be a mistake as long there is someone who places any value on the product, since it costs nothing to allow another user" [Schmid, 1983: 10]. Thus, in order to ensure allocative efficiency, the price would have to be zero, preventing the producer from recovering the costs of production.

A monopolistic producer of a joint-impact good may be able to cover costs, but only by raising the price above marginal cost which results in a non-Pareto optimal level of consumption. This is because 1) rational consumers equate the ratios of marginal utility to price for different goods, and 2) since the price of the joint-impact good is greater than the marginal cost, the ratio of marginal utility to marginal cost is greater for this good than for ordinary goods. Therefore,

allocating more resources to supplying the joint-impact good could increase the utility of some without decreasing the utility of any.

In a competitive unregulated market, the problem is different. Competition drives the price down to the marginal cost which, being below the average cost, does not allow producers to cover costs even if the social benefit justifies the cost.

In the case of information, seed, and inventions, there are often high fixed costs of developing the good, but once developed it can be produced relatively cheaply. Thus, the average costs of production are greater than the marginal costs, making it a joint-impact good. Furthermore, in the case of relatively simple inventions, most non-hybrid seed, and all information, it is relatively easy for other firms to duplicate the "product." This fact introduces high exclusion costs which make monopoly impossible. Duplicating firms will reduce the price of the good to their marginal cost of production which does not allow the original producer to cover its average costs (which include the costs of research and development).

The point is not that the researcher/inventor/breeder should always be able to cover costs, since some joint-impact goods are not worth producing. Rather, the point is that, in a private unregulated market, even some goods whose social benefits would exceed the costs of development and production will not be created because the original producer captures only a small portion of the benefits. The incentives of this producer are reduced because of the gains captured by those duplicating the good. The result is that potential researchers/inventors/breeders who are aware of this pattern will not enter the market, and those that do will produce a sub-optimal level of these kinds of goods.

There are two important policy implications. First, the public sector can play an important role in creating legal-economic institutions which allow producers of this type of good to capture a greater portion of the returns and thus to cover costs when the product is indeed socially useful. This is the idea behind patent legislation and breeders' rights legislation.

Second, in cases where such protection is not practical, there is an opportunity for the public sector to make investments with significant social returns. Because public agencies do not have to cover costs, they can provide goods (such as information and plant cultivars) whose benefits, though not captured by the agency itself, justify the investment.

ANNEX B

METHODOLOGY OF WHEAT FARMER SURVEY

The survey of lowland wheat farmers was conducted to provide information concerning 1) the prevalence of the problem of late seed, 2) the temporal aspects of supply and demand, 3) current levels of seed consumption and cultivated wheat area, 4) the proportion of wheat seed supplied by the CIAT seed program, and 5) factors influencing demand for wheat seed.

Sample Selection

It was decided to draw a sample of approximately forty wheat farmers in the Santa Cruz lowland area. Unfortunately, no complete and usable list of wheat farmers could be obtained. The two flour mills in the city of Santa Cruz had lists of the farmers from whom they purchased wheat. However, these lists lacked identification of the farmers' colonies or towns making it impossible to locate them. The oil-seed growers' association (ANAPO), which also represents wheat growers, had a membership list, but this list had the same problem and included many soybean growers who do not produce wheat.

It was necessary to draw the sample from wheat seed sales lists from 1983 and 1984 provided by ANAPO. As described in Chapter 4, ANAPO markets all of the CIAT seed and some seed obtained from other programs in the highlands. The 1983 list includes both CIAT seed sales and the small volume of non-CIAT seed while the 1984 list appears to include only the former. CIAT seed constituted 97% of the sales included on the

lists. Names selected from the buyer lists for both years in order to include farmers who obtained seed from other sources one or the other year. The list for 1984 was current as of July 5, thus excluding late-season sales accounting for about 30% of the 1984 total. However, over 90% of these late-season sales went to the largest wheat farmer, who was included in the survey.

Since the purpose of the survey was to study the nature of the demand for wheat seed, the sample selection was done in a manner such that the probability that a given farmer would be chosen was directly proportional to the sum of volumes of CIAT seed purchased by that farmer in 1983 and 1984 (reference to the 3% non-CIAT seed will be omitted for the sake of brevity). Greater representation is given to the larger buyers to reflect the fact that their decisions and preferences have larger influence on the demand for this wheat seed.

The method involved assembling a list of all of the seed buyers in one list with the individual volumes purchased. Then a list of the cumulative volume of seed purchased was prepared so that each name corresponded to a range of the total amount purchased. For example, a grower who bought 10 46-kilogram bags might correspond to the 4538th through 4547th bags of wheat seed. Next, bags were sampled randomly from the total number and the name of the grower corresponding to each sampled bag was selected for the survey. In other words, if the 4541st bag were sampled, the hypothetical grower mentioned would be selected for the survey.

It was determined that selecting 64 bags would yield approximately 40 names of growers, since the larger buyers of seed would be selected more than once. Bags were sampled from the cumulative list at intervals

of 193 bags (the total volume of seed sold divided by 64), starting from a bag randomly chosen from the first 193 bags. Since each farmer's seed purchases were grouped together on the list, this procedure guaranteed that all farmers who purchased 193 bags or more would be included in the sample, while the probability of smaller buyers being selected was proportional to the volume purchased. In mathematical terms:

$$P_i = \begin{cases} X_i/193 & \text{if } X_i < 193 \\ 1 & \text{if } X_i \geq 193 \end{cases}$$

where P_i is the probability of the i th grower being selected and X_i is the number of 46-kg bags of wheat seed bought by the i th grower from CIAT in 1983 and 1984.

This procedure resulted in the selection of 25 names of Mennonite farmers and 10 names of Bolivian nationals. The Japanese farmers coordinated their purchases through their cooperative, CAICO, so that the ANAPO lists identified the buyer only as "CAICO." Nevertheless, nine bags of seed bought by CAICO were selected by this procedure. A list of the Japanese growers and the volumes purchased by each in 1984 were provided by CAICO, permitting the selection of nine names through the same procedure described above. Thus, 44 names of wheat farmers were selected to be interviewed.

Questionnaire preparation and the interviews

The survey questionnaire was prepared by the author in consultation with technical personnel from ANAPO and the Certification Service. It included closed-ended questions regarding the area and yield of summer and winter crops, previous experience and future projections for wheat production, the preferred and actual dates of planting, planting den-

sity, sources of seed, varietal preference, hypothetical supply response to wheat price increases, and hypothetical demand response to seed available at an earlier date (see Figure B-1). In most interviews, open-ended questions were also asked to obtain additional information regarding the practices of neighbors, degree of satisfaction with seed from different sources, and so on.

The interviews were conducted during July 10-21 1984, corresponding to the end of the winter planting of wheat. The author conducted all interviews with the exception of three carried out by a Bolivian member of Chemonics' Santa Cruz team.

Of the names selected, all nine of the Japanese and nine of the ten nationals were interviewed (we were informed that the missing one had not planted wheat either year). Among the Mennonites, two of the names corresponded to the same grower. Of the 24 remaining Mennonites, only 18 were reached. Among those not reached, one lived four hours further than any other, another did not speak either Spanish or English, and the rest could not be found at their houses, in spite of various attempts. For three of these six missing Mennonites, neighbors who grew wheat were chosen as substitutes. Thus, 39 interviews were conducted as part of the random sample.

In addition, a number of other "key" growers were interviewed, including several Mennonite colony leaders and a number of growers that had saved sizable sums of seed from one year to the next. The responses of these farmers were not tabulated with the sampled farmers, but were used to gain a qualitative understanding of wheat seed use.

FIGURE B-1: EXAMPLE OF SURVEY QUESTIONNAIRE

CIEMONICS INTERNATIONAL en cooperación con CIAT y ANAPO
ENCUESTA DE TRIGUEROS (Julio 1984, Sta Cruz)

Nombre			Miembro de ANAPO: si
Localización			no
GENERAL	HA	TM	USO DE SEMILLA DE TRIGO
Cultivado en verano 1983-84			Densidad de siembra
Soya			Semilla de trigo sembrado en 1984
Maíz			Fuente Var. Precio Problemas etc.
Arroz			
TOTAL			
Cultivado en invierno 1984			Semilla de trigo sembrada en el pasado
Soya			Fuente Var. Problemas etc.
Trigo			
TOTAL			
PRODUCCION DE TRIGO			Leyenda
Cultivado 1983			100 no colonia/coop S=Seguayo
Cultivado 1982			200 colonia/coop J=Jiral
Sembrará 1985			10 no sabe Q=Quimori
Trigo que se sembraría con un precio			20 CIAT-ANAPO
20% mayor			30 ANAPO
Fecha de inicio de siembra			40 guardado
Fecha determinada por			50 comerciante 1 Uniformidad
☐ el clima			60 transportista 2 Rendimiento
☐ disponibilidad de semilla			70 agricultor 3 Enfermedades
☐ disponibilidad de equipo			1 Santa Cruz 4 Costo
Fecha ideal para siembra			2 Vallegrande 5 Disponible tarde
COMENTARIOS:			3 Comarapa 6 Difícil obtener
			4 Sucre 7
			5 Cochabamba 8
			6
			Variedad preferida y por qué
			Cuanta semilla guardará para 1985
			Para cubrir costos de almacenamiento
			pagaría 15% mas para semilla lista 15 abril si no
			pagaría 30% mas para semilla lista 15 abril si no
			Encuestadores: Lic. Nicholas Minot
			Lic. Dexter Vargas

FIGURE B-2: PHRASING OF SURVEY QUESTIONS

I am working with ANAPO to identify problems with the supply of wheat seed, particularly since some farmers have complained about its lateness. I would like to ask you several questions about your wheat crop and the wheat seed you use.

How many hectares of soybeans do you have planted now in the winter? Of wheat? Of other crops?

How many hectares of soybeans [maize, rice, other crops] did you have planted last summer? What yield did you obtain?

How many hectares of wheat did you plant last year [1983]? What yield did you obtain?

How many hectares of wheat did you plant the year before [1982]? What yield did you obtain?

How many hectares of wheat do you plan to plant next year if the weather and prices [in dollars] are the about same as they are this year?

Returning to this years wheat crop, around what date did you begin planting wheat this winter?

Was that date determined by the weather, the availability of seed, availability of machinery, or some other factor?

What would consider the best or ideal planting date for wheat?

How much wheat seed do you use per hectare?

Where did you obtain your seed this year? What cultivar was it? How much did it cost? What was your impression of this seed, what problems or advantages did it have? And in previous years?

What cultivar do you prefer? Why?

How much seed, if any, do you plan to save to be planted next winter?

Now I would like to ask two hypothetical questions. First, how much wheat would you plant if, other things being equal, the price of wheat were 20% higher (or X pesos per quintal)?

Second, would you pay a price 15% higher for CIAT seed available in April or whenever you needed it? Would you pay 30% more for this seed?

[In some cases, further questions were asked about the respondent's impression of seed use in his colony/region, the techniques used for saving seed, problems with the supply of CIAT seed, and so on.]

Interpretation of the results

Much care must be taken in interpreting the results of the survey for two reasons. First, as mentioned earlier, the sample was selected from a list of farmers who bought CIAT seed. Thus, it is representative of wheat farmers who purchase seed from CIAT but not necessarily of all wheat farmers in the lowlands of Santa Cruz.

Second, as described above, there was a deliberate bias in the sampling procedure. Simple averages of the responses of the sampled growers will not reflect the "average CIAT wheat seed customer," but rather will be biased toward the larger CIAT seed buyer who are found in the sample to a disproportionate degree. Nor do simple averages represent growers in proportion to the volumes purchased since all growers who bought more than 193 bags of wheat seed would be included and weighted equally. Weights are needed to ensure that growers are represented in proportion to the volumes purchased.

Although not intuitively obvious, it can be shown that using the actual volumes of seed purchased as weights would cause large buyers to be over-represented, even relative to their seed purchases. On the other hand, if the number of bags sampled of each grower is used as the weight, then each is represented proportional to the volume of CIAT wheat seed 1983 and 1984. This will be referred to as weighting according to the volume of seed bought from CIAT even though the actual weights used are different.

In spite of these complications, the survey reached the buyers of a large majority of the seed sold in 1983 and 1984. The 39 growers actually contacted and tabulated in the quantitative results accounted for 91% of the CIAT seed purchases.

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