

# **THE POTENTIAL FOR PRODUCTIVITY INCREASES IN COTTON AND MAIZE SYSTEMS: THE CASE OF NORTHERN MOZAMBIQUE**

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# **THE POTENTIAL FOR PRODUCTIVITY INCREASES IN COTTON AND MAIZE SYSTEMS: THE CASE OF NORTHERN MOZAMBIQUE**

## **1. INTRODUCTION**

Agricultural sector development in post-civil war Mozambique faces multiple challenges. Along with the physical destruction of road and communication infrastructure sustained during the war, agricultural product markets were severely disrupted and markets for inputs and credit almost totally disappeared. The relative political stability that has prevailed since the 1992 peace accords has encouraged a rapid recovery in agricultural production. Joint-venture companies have been promoted to facilitate the recovery of the cotton sector, a potential “engine” for broader farming system development. The government has adopted a market-oriented agricultural policy, and product and input markets are in the process of being liberalized.

To date, however, the recovery in agricultural production has come mainly from expansion of the cultivated area as rural populations resettle formerly abandoned land. Yields of major crops are low compared to regional and sub-Saharan Africa (SSA) averages. Maize is the staple food crop and cotton is northern Mozambique’s most important cash crop. Smallholder maize yields in northern Mozambique range from 0.8 to 1.0 tons/ha, 39-42% lower than yields in Tanzania, Zimbabwe, and Zambia (1.39-1.64 tons/ha) (Heisey and Mwangi 1997). Cotton yields in Mozambique are 170 kg/ha (fiber), compared to 326 kg/ha in Zimbabwe, 415 kg/ha in South Africa, and 237 kg/ha in Tanzania (CFDT 1996). The ginning out turn rate (GOR), which indicates the proportion of cotton fiber to seed and waste material, is also relatively low in Mozambique: Mozambique’s GOR is 33%, compared to 35% in Malawi and Zambia and 41% in Zimbabwe (Technoserve 1998).

Productivity growth has been constrained by farmers’ limited physical and financial access to improved varieties and inputs. Mozambique uses less than 2 kg of fertilizer per hectare of arable land compared to 33 kg/ha in Malawi and 51 kg/ha in Zimbabwe (Naseem and Kelly 1998). The use of higher-yielding improved varieties is also low relative to other countries. Seventeen percent of Mozambique’s maize area is planted to improved open-pollinated varieties; in Zimbabwe 96% of maize area is planted to hybrids, and in Zambia 5% of maize area is planted to OPVs and 72% to hybrids (Heisey and Mwangi 1997). Improved varieties of cotton are being tested at Mozambique’s National Cotton Institute, but most cotton produced today comes from older varieties that have been recycled year after year.

The widespread adoption of extensive production strategies implies significant environmental risks, and there are already anecdotal reports of deteriorating productivity associated with soil fertility decline. Increases in rural household incomes have been gradual because high internal transportation costs combined with strongly seasonal farmer marketing patterns result in low farm-gate prices. Recent estimates suggest that average rural household incomes in central and Northern Mozambique are little more than one U.S. dollar per person per week.

## 1.1. Objectives

Sustainable increases in agricultural production and rural incomes will require improvements in productivity through the increased use of improved inputs as well as expansion of cultivated area. In this paper we examine the potential for increasing productivity in cotton and maize farming systems in northern Mozambique from technical, policy and institutional perspectives. We address the following research questions:

- (1) What are the prospects for sustainable productivity increases in maize and cotton systems?
- (2) What are the most important sector-level constraints influencing technology availability and profitability? And
- (3) What are alternative policies and programs to address sector-level constraints affecting technology availability, profitability and sustainability of farm-level productivity increases?

## 1.2. Methods

This paper draws on empirical data and analysis from two multi-year studies. The first study looked at the role of joint-venture cotton companies (JVC) in facilitating technology adoption and productivity gains for cotton and maize, and the second examined the profitability of intensive maize in a subsector framework.

The first study<sup>3</sup> was carried out during the 1994/95 and 1995/96 cropping seasons in Montepuez District of Cabo Delgado Province, and Monapo and Meconta Districts of Nampula Province. Over five hundred rural households in JVC areas of influence were surveyed at four-month intervals, for a total of five rounds. Households were stratified by the level of technology used in cotton production and whether cotton was grown in large contiguous blocks or on dispersed family plots. The “high-input” package for cotton included herbicide, fertilizer, insecticide, and in some cases the provision of tractors (for land preparation and seeding) by JVCs. A subset of JVC high-input cotton growers also received improved maize seed, fertilizer, herbicide and use of tractors for “high-input” maize production. “Low-input” cotton program participants received only improved seed and insecticide from the JVCs.

The second study<sup>4</sup> was conducted during the 1996/97 and 1997/98 seasons in Nampula Province. In 1996/97, we surveyed 108 participants in the Direção Nacional de Extensão Rural/Sasakawa

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<sup>3</sup>For a complete description of the survey and results, see Strasberg, Paul J. 1997. *Smallholder Cash-Cropping, Food-Cropping and Food Security in Northern Mozambique*. Ph.D. dissertation. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

<sup>4</sup>The 1996/97 Mozambique results are reported in Howard, Julie A, José Jaime Jeje, David Tschirley, Paul Strasberg, Eric W. Crawford and Michael T. Weber. 1998. *What Makes Agricultural Intensification Profitable for Mozambican Smallholders?* MSU International Development Working Paper No. 69. East Lansing: Michigan State University.

Global 2000 (DNER/SG) high-input maize program. “High-input” program participants received improved maize seed, 12-24-12 and urea for the establishment of half-hectare demonstration plots on their own land. DNER also provided technical assistance to high-input program participants. During the 1997/98 season the sample was broadened to include a total of 208 farmers in three groups: (1) SG/DNER high-input program participants; (2) farmers participating in DNER’s low-input maize program who received regular technical advice from an extension agent but did not use purchased seed or fertilizer; and (3) a control group of farmers not participating in either program. We used crop cuts to estimate maize yields in both years.

In both studies, formal questionnaires were used to collect data on household characteristics, timing of agricultural practices and labor inputs; costs of production, and total production and sales. The research teams also carried out key informant interviews with research and extension personnel and private sector cotton, maize and input market participants to obtain additional information about constraints to technology development and diffusion.

We used several complementary analytical methods to address the research questions. Econometric yield models were estimated to quantify the effects of key inputs and field practices on productivity. Financial and economic budgets were constructed to assess the net gains from the use of cotton and maize technology from both the farmer’s and society’s perspective. We also used subsector analysis to identify major constraints to improved technology use.

## **2. AGROECOLOGICAL AND SOCIOECONOMIC CHARACTERISTICS**

### **2.1. Agroecological Characteristics**

Table 1 summarizes the key agroecological characteristics of the study areas. In all three zones, the relatively low risk of drought, temperature range and fair to good soil fertility offer good conditions for the production of cotton and maize (Geurts 1997). Eighty percent of the country’s cotton area is located in Nampula and Cabo Delgado Provinces (DEA 1998).

Although agroclimatic conditions are generally favorable for maize, yield potential varies: conditions are not as good in the more prevalent hotter lowland tropic areas (< 900 masl -- Regions 7 and 8) as in the mid-altitude areas (900-1,800 masl), which characterize parts of western Nampula Province and small areas along the country’s borders with Malawi, Zambia and Zimbabwe. In addition, most varietal improvement work in the region to date (at CIMMYT-Harare) has concentrated on varieties adapted to the mid-altitude zones that constitute the majority of maize environments in eastern and southern Africa (including the high-potential areas of neighboring Malawi, Zimbabwe and Zambia), not the lowland tropics that cover most of Mozambique.

**Table 1. Agroecological Characteristics**

	Region 7	Region 8	Region 10
Location	Montepuez District, Cabo Delgado Province; Ribaué District, Nampula Province	Monapo and Meconta Districts, Nampula Province	Malema District, Nampula Province
Altitude	200-1,000 meters	coastal	> 1,000 meters
Avg. rainfall	1,000-1,400 mm	800-1,200 mm	> 1,200 mm
Avg. temperature during cropping season	20-25EC	>25EC	15-22.5EC
Soils	Sandy to heavier clay	Sandy, heavier soils in low-lying areas	Heavy
Dominant crops	Maize, sorghum, cassava, cowpea, groundnut, cotton	Cassava, maize, cotton	Maize, cotton

Source: MAP 1996

## 2.2. Characteristics of Survey Households Compared to the General Population

Extension programs, whether public or private, often introduce new technologies to farmers with better resources and skills first, and expand the program to others after the yield response and profitability of the technologies have been demonstrated. To assess the extent to which this is true of the cotton and maize programs in Mozambique we compared selected characteristics of our survey participants with those of typical agricultural households located in the same provinces and covered in the 1996 National Survey of Smallholder Agriculture in Mozambique (TIA 1996).

Our analysis suggests that participants in the high-input cotton and maize programs have higher resource levels than participants in low-input programs, non-program participants or provincial averages (Table 2). High-input cotton program households had almost three times (6.1 ha) and low-input cotton households twice as much land (4.5 ha) as average households in Nampula and Cabo Delgado Provinces (2.1 ha). Households not producing cotton for JVCs also had more land (3.5 ha) than average. The differences were not so great in the maize program: high- and low-input maize program farmers had about 20% more land per household than the provincial average (2.5 vs. 2.1 ha/household). Landholdings of farmers not participating in SG or DNER maize programs matched the provincial averages (2.1 ha).

Farmers participating in high-input cotton and maize programs also had more family labor resources: household sizes were 15-22% higher than provincial averages (5.3-5.6 persons/household compared to 4.5-4.7 persons on average in Nampula and Cabo Delgado Provinces). Low-input program household sizes were also slightly higher (5.0-5.1) while non-program households were about the same as provincial averages (4.6-4.7). High- and low-input maize program households were much more likely to have a literate household head than the typical households described by the TIA data. Heads of high-input maize and cotton households had more years of schooling (2.5-

3.6 years) than low-input or non-program participants (2.0-2.8 years).

As discussed above, there is very little use of fertilizer, improved seed and pesticide in Mozambique. The TIA survey indicates that less than 1% of farmers in Nampula and Cabo Delgado Provinces used fertilizer for any crop and 5.9-15% used insecticides (for export crops such as cotton) during 1995/96. Country-wide, less than 20% of farmers used improved maize seed. As expected, 100% of farmers participating in high-input cotton and maize programs used fertilizer, insecticide (in the case of cotton) and improved seed (for maize) since these inputs form part of the technology package. But our data also suggest that improved input use is also slightly higher than average among maize survey farmers who did not receive purchased technology through a program. Possibly the input programs are helping to create a demand for fertilizer beyond the direct program participants, and/or the survey farmers' higher resource levels allow them to purchase inputs on their own. Among maize farmers, 2.8% of low-input participants and 2% of non-program participants reported using fertilizer (compared to the provincial averages of 0-0.3%). With regard to improved seed, 12.7% of low-input and 19% of non-program farmers said they used improved maize varieties.

**Table 2. Selected Characteristics of Survey Households Compared to the Broader Population of Agricultural Households**

	Cotton <sup>a</sup>			Maize <sup>b</sup>			Provincial <sup>c</sup>	
	High-Input	Low-Input	Non-Participant	High-Input	Low-Input	Non-Participant	Nampula	Cabo Delgado
Average farm area (ha/household) <sup>d</sup>	6.1	4.5	3.5	2.5	2.5	2.1	2.1	2.1
Mean household size (persons/household)	5.3	5.0	4.7	5.6	5.1	4.6	4.7	4.5
Average hectares cultivated per capita (or adult labor equivalent)	2.1 <sup>e</sup>	1.7	1.6	0.5 <sup>f</sup>	0.5 <sup>f</sup>	0.5 <sup>f</sup>	0.5 <sup>f</sup>	0.6 <sup>f</sup>
Percent of literate household heads				62.0	57.1	49.1	40.0 <sup>g</sup>	40.0 <sup>g</sup>
Mean years of school completed	2.5	2.0	2.0	3.6	2.4	2.8	n/a	n/a
Mean livestock units per household <sup>i</sup>				2.4	2.8	2.0	n/a	n/a
% using chemical fertilizer	100.0	n/a	n/a	100.0	9.3	5.4	0.3	0.0
% using insecticide	100.0	100.0	n/a	n/a	n/a	n/a	15.0	5.9
% using improved maize seed				100.0	12.7	19.0	<20	<20

<sup>a</sup> Source: Strasberg 1997

<sup>b</sup> Source: DEA/DNER/MSU 1997/98 Survey

<sup>c</sup> Sources: DEA 1998, World Bank 1999 and Dominguez and Chidiassamba 1997

<sup>d</sup> Includes fallow land but excludes land with fruit trees.

<sup>e</sup> Average hectares cultivated per adult labor equivalent.

<sup>f</sup> Average hectares cultivated per capita.

<sup>g</sup> Average for Mozambique. Source: World Bank 1999

We conclude from the above discussion that participants in the cotton and maize programs have better resource endowments than the general farm population and a tendency to use higher levels of improved seed and fertilizer -- in the case of maize, even without program participation -- than their neighbors. These findings have implications for the expansion of cotton and maize technologies to farmers who are more resource constrained and less accustomed to using improved inputs than the current participants.

### **3. THE POTENTIAL FOR PRODUCTIVITY CHANGE IN COTTON**

Mozambique's cotton development strategy is based on a system of legal monopsony rights which are granted by the government to large JVCs. In exchange for monopsony cotton buying rights in a specific geographic area, the JVC agrees to supply participating smallholders in their concession area with inputs and extension services for cotton and other crops, and to purchase seed cotton from farmers at official price levels. Vertical coordination of input supply and cotton marketing through the concession system offered an attractive way to boost cotton production and smallholder incomes, with little investment required from the financially-strapped government. Following the war and the dismantling of government parastatal marketing agencies, JVCs were often the sole provider of agricultural inputs, credit, and marketing services to liquidity-constrained smallholders.

#### **3.1. Joint Venture Companies and Agricultural Technologies**

Smallholder cotton production takes place either on smallholders' own "dispersed" fields or on larger contiguous areas ("blocks," often land from former Portuguese estates) that are divided into parcels and cultivated by individual farmers. Block fields are one strategy used by JVCs to address the problem of poor rural roads and the high cost of operating in remote areas. It is much cheaper to provide services and monitor production on block fields compared to the smaller dispersed "family sector" plots. "Block" farmers may also have access to additional services from JVCs, i.e., land preparation and seeding by tractor.

The JVCs differ markedly in the quality of extension services, chemicals and the support to non-cotton crops they provide to smallholders in their concession areas. While the majority of smallholders working under contract to JVCs continue to use low-input cotton technology (featuring hand tillage, planting and application of chemical insecticide), in recent years the Montepuez JVC, Lomaco, has experimented with more intensive techniques in both cotton and food crop production. Beginning in the early 1990s, Lomaco began providing a select group of farmers with herbicide, fertilizer and tractors for use in both cotton and maize production. In contrast, the Nampula Province JVCs have focused their production and extension efforts exclusively on cotton, providing neither inputs nor extension advice for food or other cash crops.

#### **3.2 Cotton Yields and Yield Determinants**

In this section we review our findings on yields from different cotton technology packages. Section 3.2.1 compares cotton yields by production technology and agroecological zone. We then turn to an exploration of key factors affecting cotton yields. The results from our cotton yield determinants analysis are summarized in Section 3.2.2.

##### *3.2.1. Yield Results*

Table 3 presents mean seed cotton yields by production technology for 1993/94 and 1994/95. Yields for high-input cotton in Region 7 (Montepuez) were significantly higher than yields for low-input cotton produced in Montepuez or Region 8 (Monapo/Meconta). High-input block yields in

1993/94 averaged 1099 kg/ha, 153% higher than low-input dispersed yields in Montepuez (434 kg/ha) and 68-99% higher than low-input block (656 kg/ha) and dispersed (551 kg/ha) yields in Monapo/Meconta. The yield differences between high- and low-input cotton were even more striking the following year. In 1994/95, Montepuez high-input block yields were 1442 kg/ha and high-input dispersed yields were 1179 kg/ha. These yields were 107-153% higher than low-input dispersed yields in Montepuez (569 kg/ha) and 70-188% higher than low-input block and dispersed yields in Monapo/Meconta (501-693 kg/ha).

Table 3 also shows (for 1994/95) the wide variability of cotton yields within each technology type and agroecological zone, especially for low-input users. In Region 8 (Monapo/Meconta) low-input yields in the highest yield tercile were two to five times higher than yields in the lowest tercile, and in Region 7 (Montepuez), highest tercile yields (low-input cotton) were four times higher (1010 kg/ha) than mean yields in the lowest tercile (200 kg/ha). For high-input users in Montepuez, highest tercile yields were only 89-156% greater than mean yields in the lowest tercile.

**Table 3. Mean and Tercile Cotton Yields by Zone and Cotton Production Technology**

	Cotton		Cotton (1994/1995)		
	Mean Yields		Yield Tercile		
	1993/1994	1994/1995	1	2	3
<b>Region 7 -- Montepuez</b>			---Kg/ha---		
High-input block	1099	1442	1045	1483	1976
High-input dispersed	---	1179	649	1227	1661
Low-input dispersed	434	569	200	501	1010
<b>Region 8 -- Monapo/Meconta</b>					
Low-input block	656	693	337	627	1080
Low-input dispersed	551	501	155	448	917

Source: 1994/1996 MAP/MSU Smallholder Survey

### 3.2.2. Factors Affecting Yields

The above analysis suggests that yields are higher for cotton produced with high compared to low levels of inputs, and that yields are extremely variable for both high- and low-input users, especially the latter. We used econometric modeling to try to isolate the most important factors affecting yield levels and variability. The cotton model itself and detailed results are presented in Appendix 1.

The overall performance of the model indicates a high degree of explanatory power, with an adjusted R-square greater than 0.67 in both specifications. The signs of all variables are as expected and each of input and labor-related variables included in the model are statistically significant at the .10 level or lower.

The model provides convincing evidence that high-input technology is linked to higher yields. On average, high-input block users get 781 kgs and high-input users on dispersed fields get 598 kgs more cotton per hectare than their neighbors using low-input technologies. Timely field preparation

and planting are also important and are significant constraints for the majority of farmers who have no access to tractors. Among non-mechanized farmers in Region 7 (Montepuez) and Region 8 (Monapo/Meconta), only 54 and 32% of farmers (respectively) planted on the recommended date. The model indicates that a one-week delay in seeding results in an average loss of 51-115 kgs, roughly 9% of total yield. The intensity of weeding also affected yields. Many farmers complain of a shortage of labor -- in fact, the dominant reason mentioned by non-cotton growers for not growing cotton was the shortage of labor -- and cotton weeding conflicts with other important farm activities, e.g., maize weeding. However, each additional day of weeding labor in cotton results in a yield increase of from 1.6 to 4.1 kgs. Adequate pest control is also important. Low-input cotton typically receives three insecticide treatments, but the model shows that a fourth insecticide application increases average yields by 89 kgs (17%).

### **3.3. Financial and Economic Analysis**

#### *3.3.1. Financial Profitability from Smallholder and JVC Perspectives*

Farm-Level Financial Profitability. We constructed enterprise budgets to analyze the profitability of smallholder cotton from both farmer and JVC viewpoints. At the farm level, the enterprise budgets attempt to capture the financial costs and revenues faced by farmers on a per hectare basis during the 1994/95 season. First, cotton yield was valued at the harvest farmgate price to get an estimate of gross revenue. Next, the costs of purchased inputs, hired labor, weeding, herbicide and fertilizer applications, and tractor use were subtracted from gross revenue to get the net income per hectare, or net returns to land. In the financial analysis no monetary value is assigned to family labor inputs, but returns per day of family labor are estimated by dividing the net income per hectare by the number of days of family labor.

A summary of the financial results is presented in Table 4. Our analysis indicates that cotton production is very profitable for smallholders, especially high-input users. Returns per labor day for Montepuez high-input cotton growers were \$1.91-\$2.41 per day, two to four times greater than low-input cotton growers in either Montepuez and Monapo/Meconta (\$0.62 to \$0.93/labor day), and far above estimated mean daily wage rates of \$0.47-0.49 (Strasberg 1997). The key factor behind these differences is labor-saving herbicide use: high-input farmers who applied herbicide used much less weeding labor than non-herbicide users. Total family labor days ranged from 42-65 adult equivalent days for high-input farmers. Low-input farmers used 72-142 labor days. While the gains were not as dramatic, net income for high-input cotton growers (\$102 to \$105/ ha) was also greater than for low-input cotton growers (\$65 to \$93/ha).

Sensitivity analysis was conducted to examine the impact of input and product price changes on net income measures. The base year for the budgets is 1994/95. In the following year, 1995/96, insecticide prices rose as a result of changes in the Japanese KRII aid program. JVCs raised the price of insecticide applications to \$7.82 per insecticide application per ha, compared to \$3.09 (Montepuez) and \$0.21 (Monapo/Meconta) in 1994/95. Minimum seed cotton prices also increased during the same period, from \$0.115 to \$0.339 per kg. Holding input prices constant and raising the output price increased returns to labor, unsurprisingly.

But when input prices also rise, returns to labor are unchanged from the 1994/95 base case. In order for returns to labor to rise under the new price regime, labor productivity will have to improve, perhaps through the increased use of labor-saving inputs, tractorization, or the adoption of labor-saving agronomic practices.

**Table 4. Mean Seed Cotton and Economic Indicators by Zone and Production Technology, 1994/1995**

Indicators	Region 7: Montepuez				Region 8: Monapo/Meconta		
	High-input block	High-input dispersed	Low-input dispersed	No cotton	High-input block	Low-input block	No cotton
Seed cotton yield (Kg/ha)	1,442	1,179	569	---	693	501	---
Total input cost excluding labor, cotton, (US\$/ha)	95	53.13	12.67	---	3.83	3.71	---
Hired labor, cotton (US\$/ha)	25.76	23.82	9.97	---	9.92	3.83	---
Net returns to family labor, cotton, (US\$/day)	2.41	1.91	0.78	---	0.93	0.62	---
Annual net income per capita from farm and non-farm sources (US\$)	191	119	82	58	101	83	61

Source: 1994/1996 MAP/MSU Smallholder Survey

The analysis also suggests that per capita income (from all farm and off-farm sources) is much higher for cotton growers who participate in JVC programs than for their non-cotton producing neighbors, and among cotton growers, high-input users had higher incomes than low-input farmers. Per capita incomes for cotton producers working with JVCs in Region 7 (Montepuez) were \$82-191, compared to \$58 for non-cotton producers. In Region 8 (Monapo/Meconta), income for JVC program participants was \$83-\$101 per capita, compared to \$61 for non-participants. Per capita incomes were 22-133% higher for high-input users compared to low-input users (Table 4).

**Profitability for the JVC.** Table 5 shows the profitability of alternative cotton production technologies from the JVC perspective, taking into account the costs of supporting smallholder cotton production, collecting seed cotton, ginning and marketing. All high- and low-input cotton technologies are profitable assuming the JVC faces an output price equivalent to the ten-year world average, and assuming that current yields, GORs, and the current smallholder-JVC cost sharing

structure are maintained. High-input cotton production is more than twice as profitable as low-input production: profits from block and dispersed high-input cotton are \$127/ha and \$115/ha, respectively, compared to \$56/ha for low-input cotton (Table 5). If output prices remain the same, but yields increase to third tercile levels and the GOR rises to 40%, JVC profits increase by \$86/ha in the low-input dispersed case, \$165/ha for high-input dispersed cotton, and rise by \$203/ha for high-input block cotton (Table 5).

**Table 5. JVC Profits in Smallholder Cotton, by Production Technology**

Production Technology	Profit (US\$/ha)	
	Actual Yield and GOR <sup>1</sup>	Improved Yield and GOR <sup>2</sup>
High-input block	127	330
High input dispersed	115	280
Low-input dispersed	56	142

<sup>1</sup> Assumes 10 year average world prices, mean yields, ginning ratio (GOR)=34%.

<sup>2</sup> Assumes cotton yields rise to third tercile levels and GOR increases from 34% to 40%.

Source: 1994/96 MAP/MSU Smallholder Survey

### 3.3.2. Profitability from Society's Perspective

In this section we consider whether investments in alternative cotton technologies are profitable for society as a whole. In practice, this involves adjusting financial prices to economic prices, in two steps. First, taxes and subsidies, which were included in the financial analysis, are excluded in economic analysis because they represent transfers of funds within the economy from one group to another group, via the government, without affecting total national income. The second step in the economic analysis is to calculate the appropriate values for traded items (e.g., imported inputs, import substitutes, and exports). Traded items are expressed in terms of their world price equivalents. In addition, the values of traded items are converted from foreign currency into domestic currency using the economic foreign exchange rate rather than the official exchange rate.

The results of the economic analysis, summarized in Table 6, show that investments in cotton production in general, and for high-input cotton in particular, are clearly profitable from society's point of view. Net social returns for low-input cotton were \$74/ha in Region 7 (Montepuez); social gains from high-input cotton were \$188-204/ha, 150-176% higher. In Region 8 (Monapo/Meconta), net social returns were \$42/ha for low-input maize and more than twice as high for high-input block cotton, \$97/ha.

**Table 6. Net Social Returns in Smallholder Cotton, by Cotton Production Technology, 94/95**

Production Technology	Net Social Returns (US\$/ha) <sup>1</sup>
<b>Region 7: Montepuez</b>	
High-input block	204
High input dispersed	188
Low-input dispersed	74
<b>Region 8: Nampula</b>	

High input block	97
Low-input dispersed	42

<sup>1</sup>Assuming cotton prices at the 10-year world mean.

Source: 1994/96 MAP/MSU Smallholder Survey

#### 4. THE POTENTIAL FOR PRODUCTIVITY CHANGE IN MAIZE

Unlike cotton, until very recently maize in northern Mozambique was primarily a subsistence crop or sold in small amounts to the parastatal marketing agency or the local market. There is no parallel “engine of development” for maize like the JVC concession system for cotton to assure the provision of inputs, extension assistance and guaranteed markets for maize output. By the mid-1990s -- with the end of the government-enforced minimum price policy for maize, local procurement by the parastatal marketing agency, and the closure of the parastatal input marketing agency -- maize producers in northern Mozambique faced a nearly complete input and output market vacuum. It is against this very different backdrop that we now examine the impact of several different programs intended to increase maize productivity by providing improved inputs and technical assistance to smallholders.

##### 4.1. Current Maize Yields and Technology Use Among Smallholders

The main source of improved maize technology for Mozambican smallholders has been the free distribution of improved OPV maize seed by non-governmental organizations (NGOs) as part of war rehabilitation efforts in the 1990s. CIMMYT estimates that approximately 17% of total maize area in Mozambique is now planted to improved varieties. A number of OPV and hybrid seed varieties suited to different agroecological regions and incorporating disease resistance and other characteristics have been developed by INIA and SEMOC (Appendix 2 lists the names and characteristics of 19 maize varieties that are currently approved for distribution within Mozambique). Emergency programs distributed only a few selected OPVs because of the weak formal seed distribution system and the belief that smallholders could not afford to purchase hybrid maize seed every year.

The improved OPVs are deteriorating over time, however. The relief programs were phased out in the mid-1990s; farmers are replanting the varieties they received and no longer renewing improved seed stocks regularly. This has resulted in a “Catch-22” situation in the Mozambican seed industry: (1) creating a demand for purchased seed among smallholders has been difficult after many years of free distribution, and (2) because of the weak demand for purchased seed, very few of the officially released varieties are available on a regular basis from SEMOC.

Fertilizer was not part of starter packs distributed by relief agencies in Mozambique. Mozambique has one of the lowest fertilizer consumption rates in sub-Saharan Africa, and fertilizer use by Mozambican smallholders is virtually unknown except in greenbelt vegetable areas and among tobacco outgrowers. By contrast, NPK rates on total maize area range from 26 kg/ha in Malawi to 70 kg/ha in Zambia.

## 4.2. DNER/SG and Lomaco Maize Programs

In the mid-1990s DNER, NGOs and the for-profit private sector began new programs intended to increase smallholder maize production through the use of improved technology. The programs made improved seed and fertilizer available to farmers on credit and/or provided training in improved husbandry practices. In the following section we focus on the results of three such programs implemented in northern Mozambique from 1993-98: the Lomaco high-input maize program, the DNER/SG high-input maize program and the DNER low-input maize program.

Participants in the Lomaco high-input maize program in 1993/94 and 1994/95 were a subset of smallholders who were already growing high-input cotton for the company (discussed in section 3). The high-input maize package included herbicide application and mechanized land preparation, seeding, and application of 12-24-12 fertilizer at the rate of 150 kgs/ha. Lomaco purchased all of the maize produced by the growers for sale to NGOs providing food aid to families in southern Mozambique. The costs of land preparation, herbicide, seed and fertilizer were deducted from the amount paid to farmers at the time of marketing. Other cotton producers working with Lomaco produced “low-input” maize and received no purchased inputs or technical assistance for maize from the company.

Farmers who participated in the DNER/SG program in 1996/97 and 1997/98 received improved Manica or SEMOC-1 OPV seed, and 50 kg each of DAP and urea (200 kg/ha) on credit for use on a half-hectare demonstration plot on their own land. All operations were carried out by hand. DNER/SG helped farmers contact potential maize buyers, but farmers were responsible for marketing the maize and repaying the input credit plus interest at the rate of 25% per year.

Participants in DNER’s low-input maize program in 1997/98 formed extension groups that met regularly to receive technical advice on planting, weeding and pest control but did not use purchased seed or fertilizer or receive any outside marketing assistance.

### 4.2.1. Yield Results

Table 7 presents yield results by agroecological zones for the three programs and control groups. Yields for farmers participating in Lomaco’s high-input maize program in Region 7 (Montepuez) were 125% higher than low-input groups in 1993/94 (1.8 vs. 0.8 tons/ha). The differences were even greater (233%) the following year: Lomaco high-input plot yields were 2 tons/ha, compared to 0.6 tons/per hectare for the low-input groups. Differences were statistically significant for both years. In Region 8 (Monapo/Meconta) mean yields for low-input maize groups were 0.3 ton/ha in 1994/95 and 0.4-0.5 tons/ha in 1995/96, below the regional average (northern Mozambique) of 0.8-1.2 tons/ha.

Maize yield results for DNER/SG high-input farmers in 1996/97 varied from 0.8 tons/ha in Region 7 (Ribae) to 2.4 tons/ha in Region 8 (Monapo/Meconta) and 2.9 tons/ha in Region 10 (Malema). In 1997/98, yields in high-input and low-input plots exceeded non-program plot yields in all 3 agroecological zones. However, yield differences between high- and low-input plots were

significant only in Region 8 (Monapo/Meconta), 2.7 compared to 2.0 tons/ha. In Region 7 mean yields for high- and low-input plots were both 1.3 tons/ha. In Region 10 low-input plots yielded 1.9 tons/ha compared to 2.0 tons/ha for high-input plots.

The means reported in Table 7 mask the extreme yield variability in among survey participants in all years, even within the high-input groups where participants were ostensibly using the same types and quantities of inputs. Table 8 shows mean yields by yield tercile and agroecological region for selected high-input and non-program participants. Differences

**Table 7. Maize Yield Results from High- and Low-Input Programs**

<u>Year</u>	<u>Region 7 -- Ribaue and Montepuez Districts</u>				<u>Region 8 -- Monapo and Meconta Districts</u>			<u>Region 10 -- Malema District</u>		
<b>MAIZE-COTTON PROGRAMS (hi input maize programs in bold)</b>										
	<b>Hi Maize/Hi Cotton Block</b>	Hi Cotton, Lo Maize Dispersed	Lo Cotton, Lo Maize Dispersed	No Cotton, Lo Maize	Lo Maize/Lo Cotto n-Block	Lo Maize/Lo Cotto n-Dispersed	No Cotton, Lo Maize	n/a	n/a	n/a
93/94 <sup>a</sup>	<b>1.8</b>	n/a	0.8	0.8	0.3	0.3	0.3			
n	(48)			(96)						
94/95 <sup>a</sup>	<b>2.0</b>	1.0	0.6	0.6	0.5	0.4	0.4			
n	(48)			(96)						
<b>DNER/SG MAIZE PROGRAMS (hi input maize programs in bold)</b>										
	<b>DNER/SG Hi-Input Maize</b>	DNER Lo-Input Maize	Non-Maize Prog. Part.		<b>DNER/SG Hi-Input Maize</b>	DNER Lo-Input Maize	Non-Maize Prog. Part.	<b>DNER/SG Hi-Input Maize</b>	DNER Lo-Input Maize	Non-Maize Prog. Part.
96/97 <sup>b</sup>	<b>0.8</b>				<b>2.4</b>			<b>2.9</b>		
n	(16)				(24)			(21)		
97/98 <sup>c</sup>	<b>1.3</b>	1.3	1.1		<b>2.7</b>	2.0	1.7	<b>1.9</b>	2.0	1.2
n	(34)	(27)	(21)		(32)	(34)	(30)	(13)	(10)	(7)
97/98 optimal conditions					4.1	2.8	2.5			
n					(11)	(11)	(11)			

<sup>a</sup>Strasberg 1997

<sup>b</sup>Howard, Jeje et al. 1998

<sup>c</sup>Howard, Jeje et al. (forthcoming)

**Table 8. Maize Yield Variability**

<u>Year</u>	<u>Region 7 -- Ribaue and Montepuez Districts</u>		<u>Region 8 -- Monapo and Meconta Districts</u>		<u>Region 10 -- Malema District</u>	
<u>Yield</u>	<u>High-Input</u>	<u>Non-participant</u>	<u>High-Input</u>	<u>Non-participant</u>	<u>High-Input</u>	<u>Non-participant</u>

Terciles	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
94/95 <sup>a</sup>	0.9	1.9	3.2	0.2	0.4	1.2													
96/97 <sup>b</sup>	0.5	0.7	1.4				1.2	2.4	3.7				1.2	2.8	4.7				
97/98 <sup>c</sup>	0.6	1.3	2.1	0.7	1.0	1.5	1.3	2.5	4.1	1.0	1.7	2.5	1.3	1.9	2.4	0.5	0.8	2.6	

<sup>a</sup>Strasberg 1997

<sup>b</sup>Howard, Jeje et al. 1998

<sup>c</sup>Howard, Jeje et al. (forthcoming)

between first and third tercile yields in the high-input case vary from 85-291% (Region 10); for non-participants the differences range from 114 to 500% (Region 7). Third tercile yields achieved by high-input farmers were quite impressive in some regions: Region 8 high-yielders got 3.7-4.1 tons/ha (1996/97) and in Region 10 mean third tercile yields were 4.7 tons/ha (1996/97).

#### 4.2.2. Factors Affecting Yield

The yield results presented in the previous section leave us with three puzzles. First, the results presented in Table 7 show that high-input maize outyielded low-input maize and non-program participants in the cotton-maize program groups, but the relationship was less clear in the maize program analysis. In all three regions, yields of DNER/SG high-input and DNER low-input maize were higher than maize yields for non-participants. Only in one region (8) were differences between the DNER/SG and DNER yields statistically significant, however. This is curious since both improved varieties and fertilizers were used on the DNER/SG plots, and only improved management (no purchased inputs) was used on the DNER low-input plots.

Second, the tercile analysis presented in Table 8 showed that yield variability was extremely high in all maize/cotton and maize groups, even within groups where program participants were ostensibly using the same types and levels of inputs. Third, the highest tercile yields for the high-input groups represented only 18-60% of on-station yields reported for Manica and SEMOC-1 varieties (Appendix 2).

We try to answer these puzzles by using econometric models to isolate the most important factors affecting maize yields in the maize-cotton and maize programs. The following section interprets the econometric findings from three models: (1) maize grown in maize-cotton programs in 1994/95, (2) maize in the DNER/SG maize program in 1996/97; and (3) maize grown by DNER/SG high-input, low-input and non-program participants in 1997/98. The models themselves and detailed results are presented in Appendix 3.

Maize yields in Lomaco maize-cotton programs, 1994/95. For the cotton-maize groups, the most important factor affecting maize yields was participation in the high-input maize program itself, i.e., the use of improved maize varieties, 12-24-12 fertilizer, herbicide and mechanized land preparation and planting. The analysis also suggests that participation in the high-input cotton program has a positive effect on maize yields, even when farmers are not provided with improved inputs for use on maize. Farmers who spent more time weeding also had higher maize yields, and maize yields were also positively associated with good soil fertility and adequate rainfall (Strasberg 1997).

Maize yields in the DNER/SG maize program, 1996/97<sup>5</sup>. In this model, planting density was the most important single factor influencing yields -- the higher the plant density, the higher the yield. This suggests that yields could be increased, *ceteris paribus*, by increasing planting density from the observed mean of 35,659 plants/ha (the recommended plant density for high-input maize is 50,000 plants/ha). Here, as in the Lomaco model, the positive and significant coefficient on the labor variable suggests that general labor availability -- possibly, as in the previous case, at such peak times as weeding -- represents a production constraint for some households. Unlike the LOMACO high-input maize scheme, the DNER/SG program did not provide herbicides for participants.

Although weather, pests and program implementation were not significant variables in the econometric model, comments by farmers provided additional insights about how these factors affected production on DNER/SG plots during the 1996/97 season. According to farmers, the unseasonal and heavy rains that delayed planting and other operations, flooded fields and caused maize ears to rot in the field were the primary factor affecting yields. Forty-seven percent of households reported abnormal rainfall. An additional 17% reported insect and wild animal damage (from termites, stalkborers, rabbits, monkeys and rats) that reduced yields (Howard, Jeje et al. 1998).

Successful program implementation, including timely delivery of inputs and extension assistance, is also critical if participating farmers are to achieve target yields. During the survey participants were asked open-ended questions about possible problems related to program implementation. It is worth noting that 74% of households overall cited no particular implementation problem. Of the remaining 26%, the most significant complaint was that seed and fertilizer arrived late, forcing farmers to plant later than they would have liked. This problem appears to have been particularly severe in Region 7 (Ribau), where more than 35% of households commented on late input delivery. Poor seed quality and lack of and/or improper extension advice were other types of implementation problems cited by participants: 14% of Region 8 (Monapo/Meconta) farmers felt they had received inadequate extension assistance (Howard, Jeje et al. 1998).

Maize yields in the DNER/SG, DNER, and non-participant groups, 1997/98. In this model plant density was again the most important factor affecting yields. As expected, plant density is greater in the high-input group, but it is still well below the recommended level of 50,000 plants/ha (when improved varieties and fertilizer are used). The positive association between number of plants and yield holds for almost all groups and regions (Howard, Jeje et al., forthcoming). There are many possible explanations for low plant density, including poor spacing at planting time, poor quality seed which results in poor germination, soil fertility problems, pest attack and inadequate weeding. More agronomic research is needed to isolate specific problems in each region and design low-cost, practical solutions.

Pest and weather-related damage significantly reduced yields in the sample. The most common complaint was termites, which attack the maize plant at all stages. Damage from the wind, drought,

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<sup>5</sup>This model includes observations from DNER/SG program participants in Manica Province. Half of the 143 observations are from Manica Province; the remainder are from Nampula.

flooded fields and rats were other major problems mentioned by farmers. Our analysis also indicates that soil type is important: farmers who planted in red soils had significantly higher maize yields than farmers who planted in black, gray or white soils. Finally, the results suggest that maize yields were higher for those who participated in DNER extension groups than for non-program participants.

The econometric analysis still leaves us with this unanswered question -- why didn't the DNER/SG high-inputs package perform better? Why didn't the analysis clearly show a yield impact from the improved variety-fertilizer package in this case, as we were able to show for the high-input package in the Lomaco maize-cotton program?

There are several possible explanations for the relatively poor performance of the DNER/SG hi-input package compared to the low-input group. First, in Regions 7 and 10, planting and fertilizer application by farmers were delayed by the late arrival of the inputs. Improved maize varieties received through the DNER/SG program were planted from 2 to 5 weeks later than local varieties used with the DNER program or by non-program participants, usually the same week or the week following the arrival of the improved seed and fertilizer (Howard, Jeje et al. forthcoming). In Table 7 we present yield data for an "optimal conditions" scenario -- in this case, for sample farmers in the highest yield tercile in Region 8 (Monapo/Meconta) where inputs were delivered on time and weather conditions were favorable. These yields under "optimal conditions" were 4.1 tons/ha, 46% higher than yields obtained by low-input extension program participants (2.8 tons/ha). Average yields for non-program participants in the highest tercile were 2.5 tons/ha.

Second, our data suggest that farmers spent 36-49% fewer labor days (adult-equivalent family plus wage labor) on the DNER/SG plots than on DNER low-input or non-program plots (Howard, Jeje et al., forthcoming), although it is often argued that planting in lines and applying fertilizer usually requires more labor than traditional low-input practices. It is admittedly difficult to collect good labor data using an end-of-season single recall method. However, allowing for these potential problems, we still find it striking that DNER/SG participants in all regions consistently reported using less labor on DNER/SG plots than on other maize plots. Our survey indicated that most farmers did not repay their input loans in Nampula Province. In fact, if farmers do not repay the loans the use of improved seed and fertilizer may be very profitable, even if they plant late, are less than meticulous about weeding, and achieve yields well under the target. We devote the next section to a discussion of the farm-level profitability of improved technology use, under a variety of assumptions regarding yields, output prices and loan repayment.

#### *4.2.3. Financial Profitability*

A summary of results from the financial profitability analysis for the different groups is presented in Table 9. Detailed budgets by program group and year are presented in Appendix 4.

### Maize-Cotton Programs 1994/95

*Farm-level profitability.* For farmers selling maize in June 1995, net income varied from \$22.61/ha for low-input maize grown by non-cotton producers in Region 8 (Monapo/Meconta) to \$71.69/ha for low-input maize grown by farmers producing high-input dispersed cotton in Region 7 (Montepuez) (Table 9). Average returns to high-input maize in Region 7 were \$54.14/ha. Although yields for high-input maize were 100-233% higher than low-input maize in Region 7, costs of production were also much higher (\$113.12/ha for high input maize compared to \$3.09-\$4.24 for low-input maize), significantly reducing net earnings (Appendix 4). Returns to low-input maize were 39-217% higher in Region 7 (Montepuez) than Region 8 (Monapo/Meconta) (Table 9). Net income per family labor day followed the same pattern, varying from \$0.36/day for the low-input maize, no cotton scenario in Region 8 to \$1.98/day for low-input maize grown with high-input dispersed cotton in Region 7 (Table 9).

*JVC profitability.* Lomaco management's decision to invest in smallholder maize (beginning in 1991) was driven largely by the emergency demand for domestic maize. As part of war relief efforts, donor programs signed forward contracts with JVCs for the delivery of maize at fixed and favorable prices above prevailing market rates. Eliminating the maize price risk the firm faced allowed it to pay smallholders the government minimum maize price in force at that time and remain profitable. Strasberg (1997) showed that, had Lomaco faced world prices instead of the prices offered by donor agencies, the firm would have **lost** from \$20/ha to \$119/ha depending on market assumptions. Unsurprisingly, after donors discontinued the forward contracting program following the 1994/95 season Lomaco ended the high-input block maize scheme.

#### High-Input Maize Program 1996/97

In the 1996/97 season there were large differences in net income per hectare and per labor day between high-input maize program participants in Regions 7, 8 and 10 because of the wide disparity in yields (0.8 - 2.9 tons/ha). Region 7 farmers selling in June **lost** \$61.97/ha on average; farmers in Regions 8 and 10 achieved profits of \$32.32/ha and 53.27/ha on average. Net income per labor day ranged from losses of \$0.73 in Region 7 to gains of \$0.48 and \$0.60 per day in Regions 8 and 10, respectively (Table 9).

Maize prices rose through the marketing year in 1997/98, and Region 8 and 10 farmers who stored maize and sold very late in the year (December) were able to increase profits by 150-255%, to \$80.74/ha (Region 8) and \$188.95 (Region 10). Region 7 farmers still lost money at December prices, but losses were reduced from (negative) \$61.97 to (negative) \$32.41. For those farmers who sold earlier in the year (between July and December), the modest price gains and resulting increase in revenue were offset by the loss of maize to storage pests except in Region 10, where profits increased by one-third from June levels (Table 9).

#### High- and Low-Input Maize in 1997/98

The 1997/98 analysis shows that for farmers who sold in September, net income/ha ranged from losses of \$5.68 per hectare for high-input program participants in Region 7 (Ribau) to gains of \$138.40/ha for low-input extension program farmers in Region 8 (Monapo/Meconta). As in the 1994/95 case, the cost of inputs for farmers in the high-input program was much higher than for other farmers --\$110.98/ha, including interest payments, compared to \$1.38-\$4.50/ha for low-

input farmers. In Region 8 (Monapo/Meconta), the input costs offset the yield and revenue gains from the use of high inputs. Average profits for high-input farmers were \$100.37/ha, compared to \$138.40/ha for low-input farmers and \$119.50/ha for non-participants. In Regions 7 (Ribau) and 10 (Malema) where yields from high-input plots were similar or lower than for low-input maize, net income/ha was significantly lower for high-input program participants (ranging from losses of \$5.68/ha in Region 7 to gains of \$17.88/ha in Region 10) (Table 9).

Farmgate prices rose 48-59% between September and November. Farmers who held their maize for later sale increased net income/ha by 47%- 480% or more (Table 9). Net income/ha rises by another 6-10% if farmers use storage insecticide, reducing grain losses from insect damage by half. In all regions, however, net income/ha remained lower for high-input program farmers than for low-input participants and farmers who did not participate in either program.

As noted earlier, in two districts high-input farmers planted 2-5 weeks late because of tardy input delivery. Under optimal conditions -- represented by the highest yield tercile in Monapo/Meconta District (where inputs were delivered on time), profits from high-input plots (\$225/ha) were slightly higher than for the extension group (\$216/ha) and non-program participants (\$209/ha), if farmers sell in September. High-input maize is more attractive if farmers hold maize for sale in November. Farmers earn \$366/ha from the high-input plots, compared to \$311/ha from low-input extension plots and \$295/ha from non-program plots (\$295/ha) (Table 9).

In follow-up interviews we carried out in our survey villages after the 1996/97 and 1997/98 marketing seasons, many DNER/SG participants in Nampula Province indicated that they had not repaid their input loans and did not plan to do so. The reasons why farmers did not feel obligated to repay are unclear. However, the analysis presented in part 5 of Table 9 suggests that non-repayment is a profitable strategy for individual farmers. In every region, net income/ha was higher or comparable and net income/labor day was higher for DNER/SG farmers who did not repay their loans than for farmers in other groups. For example, DNER/SG farmers selling in September and not repaying their loans earned \$1.80/labor day in Region 7, compared to \$1.14/day for low-input participants and \$0.79/day for non-program participants. DNER/SG participants in Region 8 earned \$2.94/day, compared to \$1.40/day and \$1.10/day for low-input and non-program participants. Similarly, in Region 10 DNER/SG farmers earned \$2.86/day if they did not repay, compared to \$1.08 (low-input) and \$0.87 (non-participant) for other farmers. These profitability results, combined with survey evidence that DNER/SG farmers consistently used fewer labor days per hectare than farmers in other groups, lead us to tentatively conclude that at least some DNER/SG farmers used the purchased inputs as a substitute for labor: that is, they may have devoted less time to weeding and other crop activities, reasoning that they would get an "acceptable" yield in any case because of the combination of improved seed and fertilizer application. The financial analysis suggests that this was a rational strategy if farmers were not expecting to have to repay the input loan. Setting a precedent of loan defaults will lead to other problems as Mozambique moves from pilot input programs to working with the private sector to set up a sustainable input delivery system, however.

**Table 9. Summary of Results from Farm-Level Maize Enterprise Budgets**

<b>MAIZE-COTTON PROGRAMS 1994/95</b>	<b>Region 7 (Montepuez)</b>				<b>Region 8 (Monapo and Meconta)</b>				
	<b>Hi Maize/Hi Cotton Block</b>	<b>Hi Cotton, Lo Maize-Dispersed</b>	<b>Lo Cotton, Lo Maize-Dispersed</b>	<b>No Cotton, Lo Maize</b>	<b>Lo Maize/Lo Cotton-Block</b>	<b>Lo Maize/Lo Cotton-Dispersed</b>	<b>No Cotton, Lo maize</b>		
<b>Maize grain yield (tons/ha)</b>	<b>2.0</b>	1.0	0.6	0.6	0.5	0.4	0.4		
<b>1. June 1995 prices</b>									
June farmgate price (\$/kg)	<b>0.08</b>	0.08	0.08	0.08	0.07	0.07	0.07		
Net income (\$/ha)	<b>54.14</b>	71.69	47.12	45.49	32.63	23.86	22.61		
Net income/labor day (\$/ae day)	<b>1.32</b>	1.98	0.83	0.69	0.59	0.35	0.36		
<b>2. December 1995 prices</b>									
December farmgate price (\$/kg)	<b>0.22</b>	0.22	0.22	0.22	0.21	0.21	0.21		
Net income (\$/ha)	<b>379.33</b>	206.61	126.88	127.63	96.78	69.62	70.07		
Net income/labor day (\$/ae day)	<b>11.88</b>	5.25	2.28	1.86	1.80	1.11	1.10		
<b>MAIZE PROGRAMS 1996/97</b>	<b>Region 7 (Ribaua)</b>			<b>Reg. 8 (Monapo/Meconta)</b>			<b>Region 10 (Malema)</b>		
	<b>Hi-Input Maize</b>	<b>Lo-Input Maize</b>	<b>Non-Prog. Part.</b>	<b>Hi-Input Maize</b>	<b>Lo-Input Maize</b>	<b>Non-Prog. Part.</b>	<b>Hi-Input Maize</b>	<b>Lo-Input Maize</b>	<b>Non-Prog. Par.t.</b>
1 USD = 11,500 mt									
<b>Maize grain yield (tons/ha)</b>	<b>0.8</b>			<b>2.4</b>			<b>2.9</b>		
<b>3. June 1997 prices</b>									
June farmgate price (\$/kg)	0.06			<b>0.06</b>			<b>0.06</b>		
Net income (\$/ha)	<b>(61.97)</b>			<b>32.32</b>			<b>53.27</b>		
Net income/labor day (\$/ae day)	<b>(0.73)</b>			<b>0.48</b>			<b>0.60</b>		
<b>4. Average July-December 1997 prices</b>									
Avg. July-December price (\$/kg)	<b>0.073</b>			<b>0.068</b>			<b>0.073</b>		
Net income (\$/ha)	<b>(62.15)</b>			<b>29.53</b>			<b>72.20</b>		
Net income/labor day (\$/ae day)	<b>(0.73)</b>			<b>0.44</b>			<b>0.81</b>		
<b>5. December 1997 prices</b>									
December price (\$/kg)	<b>0.12</b>			<b>0.098</b>			<b>0.12</b>		
Net income (\$/ha)	<b>(32.41)</b>			<b>80.74</b>			<b>188.95</b>		
Net income/labor day (\$/ae day)	<b>(0.38)</b>			<b>1.21</b>			<b>2.12</b>		

⋮

⋮

	Region 7 (Ribaua)			Reg. 8 (Monapo/Meconta)			Region 10 (Malema)		
	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.
<b>MAIZE PROGRAMS 1997/98</b>									
1 USD = 12,000 mt									
Maize grain yield (tons/ha)	1.3	1.3	1.1	2.7	2.0	1.7	1.9	2.0	1.2
<b>5. September 1998 prices</b>									
September price (\$/kg)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Net income (\$/ha)	(5.68)	106.07	85.91	100.37	138.40	119.50	17.88	116.62	100.85
Net income/labor day (\$/ae day)	(0.09)	1.14	0.79	1.34	0.86	0.64	0.38	1.08	0.87
Optimal conditions: net income (\$/ha)				225	216	209			
Optimal conditions: net income/labor day (\$/ae day)				2.7	1.4	1.1			
If loan credit is not repaid: net income (\$/ha)	109.88			220.53			134.45		
If loan credit is not repaid: net income/labor day	1.80			2.94			2.86		
<b>6. November 1998 prices</b>									
November price(\$/kg)	0.14	0.14	0.14	0.13	0.13	0.13	0.14	0.14	0.14
Net returns to land (\$/ha)	55.60	167.58	136.44	188.63	203.62	177.37	103.81	207.34	158.86
Net returns to family labor (\$/ae day)	0.91	1.80	1.25	2.52	1.26	0.94	2.21	1.92	1.37
If storage insecticide is used: net income	61.22	178.01	144.96				112.79	221.00	168.74
If storage insecticide is used: net income	1.00	1.91	1.33				2.40	2.05	1.45
Optimal conditions: net income (\$/ha)				366	311	295			
Optimal conditions: net income/labor day (\$/ae day)				4.4	2.0	1.5			

#### 4.2.4. Economic Profitability

In this section we summarize the results of the economic analysis, which considers profitability from the viewpoint of society instead of the individual farmer. We address two questions: (1) if the alternative to increased domestic production is to import grain at commercial rates, is society better off producing maize locally using improved technologies instead of importing? And (2) if grain is produced for export, is society still better off producing maize with improved technology?

Mozambique's geography greatly influences the domestic and international competitiveness of its maize. The large consumption centers of Maputo and Beira are located far south, close to South Africa, more than 2000 kilometers by road from Nampula and Cabo Delgado Provinces. If there is a maize deficit in Southern Africa, maize from Mozambican producers competes with maize imported from the U.S. When there is a maize surplus in the region, Mozambican maize competes with South African maize to supply Maputo and Beira.

The results of our economic analysis of the maize-cotton programs in 1994/95 and the high-input maize program in 1996/97 are summarized in Table 10. In 1994/95, assuming a maize deficit in Southern Africa, the high-input maize program generated a net loss of \$16/ha to society. Net gains from low-input maize production were \$26/ha. In 1996/97, again assuming a maize deficit in southern Africa, whether society gained or lost from the investment in high-input maize depended on the assumptions about transport costs. If transport costs are assumed to be high (\$0.05 ton/km), net losses ranged from (negative) -\$131/ha in Region 7 (Ribau) to (negative) -\$50/ha in Region 10 (Malema). If transport costs are lower (\$0.03/ton/km), high-input maize in Region 7 still results in net losses of (negative) -\$74/ha, but there are substantial gains in the other two regions, \$59/ha in Region 8 (Monapo/Meconta) and \$142/ha in Region 10. When southern Africa has a maize surplus (northern Mozambican maize competes with South Africa in the domestic market) and transport costs are high, all regions in Northern Mozambique show net losses from high-input maize ranging from (negative) -\$193/ha in Region 8 to (negative) -\$165/ha in Region 7. With lower transport costs high-input farmers break even in Region 10 because of their relatively high yields, but losses in the other two regions range from (negative) 109/ha (Region 7) to (negative) \$45/ha (Region 8). The findings from 1994/95 and 1996/97 suggest that high internal transport costs make it difficult generally for high-input maize from Mozambique to compete with South African maize in the Maputo and Beira markets except when maize yields are relatively high--2.3 tons and above.

However, as regional trade barriers have come down neighboring Malawi has become an increasingly important market, and there is evidence that maize is also being exported to eastern Zambia. Farmers in northern Mozambique can export maize to Malawi at very competitive prices, given the proximity and the low-cost railway link, and the market may be relatively stable because of Malawi's structural deficit in maize. Break-even prices (CIF Malawi border) range from \$87 to \$245 per ton. US producers could supply maize to Malawi at approximately \$185/ton, but these varieties are likely to be less preferred by consumers. In the future it may also be possible for northern Mozambican farmers to export to Kenya and Tanzania through the ports of Pemba and Nacala. The 1994/95 analysis shows that the break-even price for maize FOB Northern Mozambican ports varies from \$91-\$131/ton, depending on whether on-farm yields are 2.0 or 3.1

tons/ha. This is likely to be quite competitive with U.S. maize (\$161/ton CIF Mombasa), even after coastal shipping charges of \$30-\$40/ton. In general, developing the regional market will reduce the risk of adopting high-input technologies by increasing the probability of remunerative prices even during years of regional surplus.

**Table 10. Summary of Economic Analysis Results**

	<u>Region 7 (Montepuez)</u>		<u>Region 8</u>
	<u>Hi</u>	Low-	<u>(Monapo and</u>
<u>MAIZE-COTTON PROGRAMS 1994/95</u>	<u>Maize/Hi</u>	Input	<u>Meconta)</u>
	<u>Cotton</u>	Maize	Low-Input
	<u>Block</u>		Maize
-----	-----	-----	-----
<u>Maize grain yield (tons/ha)</u>	<b>2.0</b>	1.0	0.5
<u>Maize Deficit in Southern Africa</u>			
a. Net Income: Import Parity (\$/ha):	<b>(16)</b>	26	0
b. Break-Even Export Price, FOB Northern Mozambique (\$/ha); mean yield=1985 kg/ha	<b>131</b>		
c. Break-Even Export Price, FOB Northern Mozambique (\$/ha); mean yield=3185 kg/ha	<b>91</b>		
<b><u>HIGH-INPUT MAIZE PROGRAMS 1996/97</u></b>			
	<u>Region 7</u>	<u>Region 8</u>	<u>Region 10</u>
	<u>Ribaue</u>	<u>Monapo/</u>	<u>Malema</u>
		<u>Meconta</u>	
DNER/SG Yields (tons/ha)	0.8	2.4	2.9
<u>Maize Deficit in Southern Africa</u>	(numbers in parentheses are negative)		
a. Net Income: Import Parity Hi Transport Cost (\$/ha)	(131.0)	(89.0)	(50.0)
b. Net Income: Import Parity Lo Transport Cost (\$/ha)	(74.0)	59.0	142.0
<u>Maize Surplus in Southern Africa</u>			
c. Net Income: Import Parity Hi Transport Cost (\$/ha)	(165.0)	(193.0)	(174.0)
d. Net Income: Import Parity Lo Transport Cost (\$/ha)	(109.0)	(45.0)	0.0
-----	-----	-----	-----
<u>Break-Even Export Price (\$/ton)</u>			
e. Break-Even Export Price Lo Trans. (FOB Malawi) (\$/ton)	245	110	87
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## 5. COMPLEMENTARY PUBLIC AND PRIVATE STRATEGIES TO FACILITATE STRUCTURAL TRANSFORMATION THROUGH TECHNOLOGY DEVELOPMENT AND DISSEMINATION

The analysis presented in parts 2-4 of this paper suggests that there is considerable potential to increase smallholder yields and incomes through the intensification of cotton and maize production. Currently, however, the financial and economic returns from cotton intensification are much higher than maize, and the use of purchased inputs on maize is much riskier in terms of yields and financial returns.

In this section we examine the constraints and opportunities for expanding the use of improved inputs, and increasing the profitability of cotton and maize intensification, from two viewpoints. In section 5.1. we discuss the issue from a technology perspective. Since our analysis indicates that

profits can increase with yields, what improvements in farm-level production technology are needed to increase cotton and maize yields, and what institutional changes will be required to make improved technology more accessible to farmers?

Profits are also affected by the level of development and other characteristics of the input and output markets, which are reflected in the prices faced by farmers and the reliability of the input source or commodity outlet. In section 5.2., we examine potential policy, institutional and investment options to (a) reduce the price of improved seed, fertilizer and pesticides at the farmgate and (b) increase the price farmers receive for their output. In addressing these issues we consider the lessons that can be learned from comparing the cotton and maize sectors.

## **5.1. Improvements in Farm-Level Production Technology**

### *5.1.1. Cotton*

Our analysis in section 3 indicates that the financial payoff is significantly higher (for both smallholders and JVCs) from the use of fertilizer, herbicides, and insecticides on cotton than from insecticide use alone. The addition of improved cotton varieties with higher yields and GORs would likely increase profits further. More study is required, but we offer a few hypotheses about why so few companies have begun using high-input packages for cotton.

First, using these inputs would necessitate up-front investments by the JVCs in adaptive research, training and supervision for contract farmers. These investments were relatively more attractive in the early 1990s when world cotton prices were high (peaking at \$2000/ton in 1993/94) than now, when prices have declined to \$1300/ton (1998/99) (Iowa State University 1999). Second, the administrative pricing system for cotton introduces an additional element of risk for the cotton companies, who cannot be certain how much of any additional input investment they will be able to recoup in a given year (see 5.2.1. for further analysis). Third, most insecticide used on smallholder cotton (and most fertilizer and a large part of pesticides) comes through the Japanese KRII program. The program has positive and negative points (discussed in section 5.2.2.), but a decided drawback is that the lengthy and non-transparent ordering and delivery process means that companies cannot be sure (a) when inputs will be delivered and (b) at what price they will be offered. Some JVCs (e.g., Lomaco), have largely given up on getting inputs through KRII because of these problems and are now ordering privately (C. Henriques, personal communication, June 1997). Fourth, the concession system as it is currently structured may not encourage sufficient competition among the cotton companies to provide better technology and services (see section 5.2.1.).

As the private input sector in Mozambique develops, input dealers may be willing to share the costs of adaptive research, extension and training with cotton companies if by so doing they increase the probability of increased pesticide sales in the future. Working with farmer associations can also reduce the cost of developing and extending more advanced cotton technology packages. Some cotton companies already train association members to carry out extension tasks within the association that were formerly done by company employees on an individual basis, and report

lower costs (through a resulting reduction in the need for field staff), higher yields and higher repayment rates among associations. Association members are also generally satisfied; working through the association instead of as individuals has resulted in more timely and transparent input delivery and distribution.

### 5.1.2. *Maize*

Our analysis indicates that a substantial amount of improved maize technology has been developed or is available in Mozambique but remains underutilized. A number of improved varieties with reported on-station yields of up to 9.5 tons/ha have been developed by INIA and SEMOC, and many high-yielding imported varieties have also been approved for distribution in Mozambique (Appendix 2). A very detailed set of soil-and crop-specific fertilizer recommendations is available from INIA's Soil and Water Department (Geurts 1997). Seed treatment chemicals and storage insecticides such as Actellic are well-known worldwide and proven to reduce pest damage to seed and stored grains. Pesticides for control of insects are such as stemborer and termites are known and available -- often in Maputo and some provincial capitals-- but rarely in rural areas.

These technologies are "on the shelf" but are not being effectively utilized. The high-input maize programs we examined used blanket technology recommendations -- the same types and levels of seed and fertilizer -- across agroecological regions that have distinct soil and altitude characteristics. Maize varieties distributed through the high-input programs are not matched to the agroecological zones for which they are best suited. For example, in 1996/97, Manica SR (a mid-to high altitude OPV) was distributed country-wide through the DNER/SG program. The following year, SEMOC 1 (a low to medium altitude OPV with a yield ceiling of 7.0 tons/ha compared to Manica's 8.5 tons/ha) was distributed to Nampula Province participants in both low and mid-altitude areas. Similarly, a standard dose of fertilizer was utilized in the DNER/SG (200 kg of 12-24-12 and urea) and Lomaco programs (150 kg/ha of 12-24-12) -- regardless of soil type.

In order to increase the farm-level profitability of high-input maize at the farm level and reduce the risk of financial losses, our analysis suggests that it will be important to (a) match varieties to the correct agro-ecological zones, and, where appropriate, encourage top farmers to experiment with higher-yielding hybrids as well as OPVs; (b) assess the impact of reducing fertilizer recommendations on yields, profitability, and risk; (c) determine the effectiveness of alternative methods for increasing soil fertility, e.g., green manuring, cover cropping with legumes -- alone and in combination with chemical fertilizers; (d) increase farmer awareness of agronomic recommendations on planting density, time of planting, and timing and intensity of weeding; and (e) improve pest control in fields and storage units. How can INIA and DNER, which have the responsibility for research and extension for smallholder maize, meet these needs given their limited resources?

We first consider how the private cotton companies approach similar research and extension tasks. The progressive JVCs have an intense financial interest in the yield and profitability of cotton technology packages, keeping careful cost-and-return records and funding a team of agronomists, farm managers, and extensionists to develop technology innovations, make sure that inputs arrive on

time and farmers carry out technical recommendations. In the smallholder maize sector, this feedback loop between farmers, agronomists, and input suppliers is largely missing, but is necessary to refine maize technology recommendations and make improved inputs more accessible and their use more profitable for farmers. JVCs have reduced the costs of disseminating technology by working in contiguous blocks of land and with farmer associations.

Similarly, INIA and DNER, whose extension agents are already working with small groups of farmers in the training-and-visit program, could expand this approach and work more closely with both farmer associations and input suppliers to (a) carry out on-farm trials and demonstrations to refine variety, fertilizer and pest control recommendations for local areas and address specific problems identified by local farmers; (b) use local meetings of farmer associations and trained volunteer assistants to inform farmers about key research and extension messages in a cost-effective way, and (c) use local and regional association meetings to get feedback on research and extension priorities, and get political and possibly financial support for the work.

## **5.2. Improvements in Input and Output Markets**

The fundamental export/cash crop versus food/cash crop distinction between cotton and maize drives most of the differences evident in the input and output markets serving the two subsectors. In general, the provision of in-kind credit is much less risky for cotton than maize. The JVC concession system of local monopsony rights makes it easier for credit to be deducted by the company from the farmer's sales receipts at the end of the season. Because of this "closed circuit" characteristic, input (including credit) and output marketing services are already fairly well developed for the cotton sector. The key challenges are how to improve the quality of marketing services and make them more efficient. Because maize can be sold anywhere, it is a riskier proposition: private investors who supply credit could be left empty-handed, and as yet there is no functional legal system that would provide a low-cost means of pursuing claims. The challenges are deeper here -- establishing input services (including credit) where none currently exist, and encouraging the growth of fledgling output markets. In the final part of this paper we review some of the key policy and organizational issues and options for reducing input and output market costs in Mozambique.

### *5.2.1. Revision of the Cotton Sector Legal Framework and Pricing Policy*

Concession rights and the role of associations. As discussed before, Mozambique's cotton development strategy since 1990 has been based on a system of monopsony buying rights granted to JVCs and other private companies. All suitable areas for cotton have now been allocated, and there is little possibility for new firms to acquire concession rights unless the existing concession holders break up. The main justifications given for the concession system were (a) to attract private investment and reverse the downward trend in cotton production; and (b) a high degree of vertical integration would be more efficient than many different players carrying out specialized functions in the commodity chain.

In fact, the performance of JVCs and other firms holding concession rights has been extremely

uneven. Some companies have invested considerable resources in adaptive research, farmer training programs and field demonstrations, while other companies give little priority to these services. In some areas, there have been reports of concessions failing to buy all the cotton grown in their area. In general, average cotton yields remain low and many farmers still have problems obtaining inputs and extension support.

The cotton law was changed in 1998 to allow associations controlling more than 20 hectares of cotton to sell to buyers other than the JVC holding the area concession. This change was intended to encourage the formation of associations and improve the quality and efficiency of extension, input and output marketing services by promoting competition among the service providers. This experiment is very new and deserves closer study, but some preliminary observations can be made. First, JVCs that are actively working with associations report higher yields and rates of credit recovery, and lower input and output marketing costs for associations compared to dispersed family-sector farmers. Associations perform (at lower cost) many of the responsibilities formerly carried out by salaried JVC personnel, including extension, inventory management, and crop collection and weighing. In return associations are usually given a “bonus” payment by the JVC, typically 5-12% over the official minimum price, depending on the volume of cotton produced.

Some preliminary evidence suggests that the change in concession law is already having positive effects, but there may also be some negative impacts in the future. On one hand, the policy change has already encouraged new finance and marketing companies to enter the cotton sector, which may result in improved service and returns at the farm level. On the other hand, some of the larger cotton companies contend that they have made large investments in infrastructure improvement (e.g., roads, gins, extension) from which the new market entrants are benefitting (and are able to offer farmers higher prices as a result) but to which they have not directly contributed. The concessionaires may be less willing in the future to make the additional investments in infrastructure, research and extension that will be required to increase the use of improved technology if they are not able to recoup their investments, i.e., if their purchasing volume contracts due to what they perceive as a “free-rider” problem.

Pricing policy. Minimum producer prices for Grades A and B seed cotton are usually announced at the beginning of the marketing season by the National Commission for Prices and Wages. These prices are based on the National Cotton Institute’s recommendations, determined in consultation with the Ministry of Agriculture and Fisheries and the Mozambique Cotton Association.

The current price-setting mechanism is a matter of concern for both farmers and companies. First, yearly changes in official prices have often not reflected changes in world market conditions. Some companies have proposed eliminating administrative price-setting altogether and instead tying producer prices to a fixed percentage of the world market price. Second, in the past producer prices have usually been announced at the beginning of the marketing season. By waiting policymakers have hoped to reflect world market conditions, but farmers complain that they need price information eight months earlier, at planting time. This season, the National Cotton Institute announced indicative prices prior to the planting season, but more effort needs to be given to disseminating the information to farmers. Third, minimum prices announced by the government

should be adjusted for transport costs in different regions. Pan-territorial prices provide little incentive to serve dispersed farmers. Fourth, the seed cotton grading system needs to be adjusted to better reflect international standards, and with a greater price spread between grades to enhance farmer incentives to improve raw cotton quality.

### *5.2.2. Reform of the KRII Program*

Over the years a number of donors and international organizations have provided inputs for agriculture. The largest such program currently functioning is the Japanese KRII program. Companies can access KRII agrochemicals in two different ways. First, they can directly request specific products and quantities through the KRII program. If they do so they are responsible for paying the countervalue (unless the product is destined for smallholder cotton production or is otherwise exempt from payment). Obtaining agrochemicals through KRII is cheaper than ordering through agrochemical representatives or directly from the international market, but there are drawbacks. There is considerable uncertainty about when the agrochemicals may arrive (it may take up to 18 months between order and delivery). Companies may also have to pay large storage fees if the agrochemicals sit at the docks for a long period. In practice, a large part of KRII program imports go unclaimed and are auctioned off by the Mozambican government after one or two years to recoup the storage costs. This provides a second, even cheaper way to get agrochemicals if users can find what they need.

While the KRII program provides an important source of supplier credit, the current system of centralized ordering and distribution of KRII inputs is retarding the development of the private input system in Mozambique. One fundamental problem is the lack of transparency in the way that KRII goods are ordered, distributed and paid for. Currently a three-person team of government officials is responsible for drawing up the list of goods to be submitted to the Japanese government. Decisions about quantities and types of products to be ordered do not appear to be based on technical recommendations or realistic estimates of effective demand for inputs. As a result, there is a mismatch between the country's needs and what gets ordered. The process through which the KRII goods are distributed after arrival and rules about countervalue payment are equally unclear. The uncertainty surrounding the timing and prices (frequently well below import parity prices) at which large quantities of KRII fertilizer and agrochemicals will be released on the market makes local agrochemical dealers reluctant to import and maintain private stocks, and discourages new market entrants.

To address the transparency problem, we propose three modifications. First, the committee responsible for ordering KRII inputs should be broadened to include technical experts from the government and private sector, representatives of agrochemical companies, and other major users of agrochemicals in the for- and non-profit private sector. This committee would be charged with drawing up a list of goods to be ordered through KRII that reflects the types and quantities of inputs that are technically correct and for which there is likely to be an effective demand (Pantazis 1997).

Second, all KRII products should be put up for auction, with the proceeds deposited in an agricultural development fund to be jointly administered by a panel of government, private sector

and donor representatives. The panel could openly solicit proposals from the public and private sectors for activities aimed at increasing smallholder demand for purchased inputs or expanding the number of shops selling inputs in rural areas. Potentially important activities include the expansion of demonstration plots, availability of credit, and assistance to farmer organizations to enable them to estimate input demand, aggregate input orders and

contract directly with agrochemical firms to reduce transport costs and ensure timely delivery.

Third, the importation process should be left as much as possible in the hands of the Mozambican private sector. This would provide important experience in aggregating orders to realize economies of scale and decrease costs, and might reduce the long time lag between order and receipt of products.

### *5.2.3. The Seed Sector*

Thanks to relief programs during the 1980s and 1990s, many smallholders received improved varieties of seed and continued to plant them in subsequent seasons. Serious problems are emerging now that the programs have phased out, however. SEMOC, currently the only commercial seed company operating in Mozambique, grew heavily dependent on the demand from relief schemes and relied on those schemes to distribute seed instead of building its own retail capacity in rural areas. Second, farmers grew used to the distribution of free seed and are now reluctant to buy what they perceive as very expensive seed from SEMOC. As a result, farmers are planting either genetically-deteriorating improved varieties or returning to established but lower-yielding local varieties.

What kind of support is needed to develop a broader-based seed sector and increase demand for improved seed? First, the process for registration and release of new varieties should be quickly finalized and made operational in a way that facilitates the entry of new commercial seed companies and ensures rapid access by Mozambican farmers to improved varieties already available in the region and/or from international research centers.

Second, smallholder adoption is constrained by the lack of information about the benefits of improved variety use. SEMOC and INIA have information about the adaptability of varieties to different regions in the country and could work with associations, DNER and NGOs to set up local demonstration plots. Associations are already gaining practical business experience in joint marketing of commodity outputs: in the near future, it is conceivable that umbrella organizations of farmer associations could aggregate associations' orders for specific seed varieties (and fertilizer and pesticides) and procure them directly from SEMOC and input firms, well in advance of the season, with payment guaranteed by the association.

Third, SEMOC and other potential entrants to the seed market can reduce their costs by decentralizing seed production and marketing as much as possible. This will require joint efforts by companies, public agencies and NGOs to (1) access information and seed of appropriate varieties; (2) train and supervise farmer associations in seed production, storage, and marketing; and (3)

facilitate the development of rural seed retail outlets.

Third, governments and NGOs can encourage the development of seed markets by discontinuing the direct and free distribution of relief seed for commodities that are available commercially and instead provide farmers with vouchers to purchase seed locally.

#### *5.2.4. Improving Transport Infrastructure*

Transport and handling costs between the port and farmgate add an estimated 31-64% to the import parity price of fertilizer for farmers and 36-74% to the price of exported maize. The Mozambican government and donors are already taking some important steps to improve transport infrastructure. Under the Roads and Coastal Shipping Project II, roughly half of Mozambique's estimated 43,000 kilometers of paved, earth/gravel and feeder roads will be rehabilitate by 2000. Additional investments will be required to maintain the improved surfaces and upgrade the remaining portions of the network, especially local farm-to-market roads, bridges, the coastal shipping system and railways.

#### *5.2.5. Regional Maize Market Liberalization*

Regional trade liberalization also has a potentially important contribution to make to the profitability of maize production as well as to food security in the region. Mozambique has proven historical experience in this regard. In 1853, the Portuguese authorities reduced tariffs on agricultural exports and opened up trade to foreign companies. In the next two decades, exports of groundnuts increased sixfold while exports of sesame rose tenfold (Hewitt, 1995). Consequently, Mozambique was well placed to serve the growing market for food products in South Africa that accompanied of the development of mining concessions in the latter part of the nineteenth century. Such positive effects have also been documented in recent history. Santos and Tschirley (1999) report a significant increase in producer prices for maize in northern Mozambique following the opening of trade in maize with Malawi in 1997.

In response to the positive effects of regional trade, Mozambique entered the current round of SADC Trade Protocol negotiations on agricultural products with a proposal for immediate tariff reduction for maize. Unfortunately, the other five countries participating in the negotiations have all declared maize to be a "sensitive" product, implying that liberalization of trade in maize will require separate country-by-country negotiations. While it may be some time before regional trade in maize is fully liberalized, actions recommended by Santos and Tschirley to capture at least some of the potential benefits of regional trade are the improvement of regional market outlook information and policy monitoring, and the simplification of export procedures.

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## APPENDIX 1: COTTON YIELD MODEL

### Cotton -Yield Equation Results

Equation 1:  $\ln(\text{YIELD}) = f(\text{HIGH\_INB}, \text{HIGH\_IND}, \ln(\text{INSECT}), \ln(\text{TOTWAE}), \ln(\text{SEEDWEEK}), \text{INSPESTS}, \text{VIL1..n}, \ln(\text{KGSTOR95}))$

Equation 2: same as Equation 1, but excludes  $\ln(\text{KGSTOR95})$   
where:

YIELD=	kgs seed cotton production per hectare
HIGH_INB=	1 if high-input cotton block 0 otherwise
HIGH_IND=	1 if high-input dispersed field 0 otherwise
INSECT=	number of insecticide applications
TOTWAE=	total adult-equivalent weeding days, family and non-family included
SEEWEEK=	seeding week, 1=earliest weeding week (2 <sup>nd</sup> week, November), 2=3 <sup>rd</sup> week, November...
INSPESTS=	1 if excessive insect infestation reported on field during growing season 0 otherwise
KGSTOR95=	cereal reserves, January 1995 (kgs)
VIL1..n=	village level dichotomous variables

The predictive power of the two equations was relatively high: equation 1 explained 67.6 % of the variation and equation 2 explained 67.9%.

Variable	Equation 1			Equation 2		
	Coef-ficient	S.E.	P-value	Coef-ficient	S.E.	P-value
HIGH_INB	0.94	0.25	0.00	0.94	0.25	0.00
HIGH_IND	0.73	0.26	0.00	0.67	0.26	0.01
ln(INSECT)	0.82	0.06	0.00	0.81	0.07	0.00
ln(TOTWAE)	0.22	0.12	0.06	0.23	0.12	0.05
ln(SEEDWEEK)	-0.86	0.21	0.00	-0.85	0.21	0.00
INSPESTS	-0.45	0.22	0.04	-0.43	0.22	0.05
ln(KGSTOR95)	---	---	---	0.06	0.04	0.08
VILMTZ1	-0.25	0.27	0.36	-0.38	0.28	0.18
VILMTZ2	-0.15	0.32	0.64	-0.24	0.32	0.46
VILMTZ3	-0.56	0.28	0.05	-0.62	0.28	0.03
VILMTZ4	-1.60	0.29	0.00	-1.72	0.30	0.00
VILMTZ5	-0.38	0.36	0.29	-0.45	0.36	0.21
VILMTZ6	-0.71	0.41	0.08	-0.83	0.42	0.05
VILMON2	-0.31	0.36	0.39	-0.27	0.36	0.44
VILMON3	-0.03	0.48	0.95	0.05	0.48	0.91
VILMON4	0.31	0.28	0.28	0.28	0.28	0.32
VILMON5	-0.08	0.32	0.81	-0.13	0.32	0.69
VILMON6	-0.41	0.28	0.15	-0.33	0.28	0.24
VILMON7	0.10	0.30	0.75	0.16	0.30	0.59
VILMON8	-0.73	0.35	0.04	-0.63	0.35	0.07
VILMON9	-0.38	0.36	0.30	-0.28	0.36	0.44
Constant	6.00	0.57	0.00	5.79	0.58	0.00

Dependent variable=ln(YIELD)

N=279

Adjusted R-square = 0.676

F-stat = 30, Significance = 0.00

Source: Strasberg 1997

Adjusted R-square = 0.679

F Sta=29, Significance = 0.00

## APPENDIX 2: CHARACTERISTICS OF MAIZE OPVS AND HYBRIDS

Name, source	Days to maturity	Potential yield <sup>1</sup> (tons/ha)	Target region	Characteristics
Manica SR SEMOC	Medium-late to late 125-145	8.5	Mid to high altitude, irrigation in lowlands	OPV, semident, strong resistance to MSV, leaf blights and rusts
Matuba INIA/SEMOC	Early to medium 110-125 days	6.0	Low to medium altitudes	OPV, semiflint, strong resistance to MSV, downy mildew, blights
SEMOC 1 SEMOC	Early to medium 115-130 days	7.0	Low to medium altitudes	OPV, flint, strong resistance to MSV, downy mildew, blights
Umbeluzi INIA	Medium late to late 120-140 days	7.5	Mid to high altitudes	OPV, flint, strong resistance to MSV, susceptible to downy mildew
Obregon 7643 INIA	Late 130-150 days	8.0	Mid to high altitudes	OPV, dent, resistant to leaf blight and rust, susceptible to MSV/DM
Obregon flint INIA	Late 130-150 days	7.5	Mid to high altitudes	OPV, flint, resistant to leaf blight and rust, susceptible to MSV/DM
MMV-400 Imported	Early 105-125 days	5.0	Low to mid altitudes	OPV, flint, susceptible to MSV, downy mildew and rusts
MMV-600 Imported	Late 135-155 days	7.5	Mid to high altitudes	OPV, semiflint to semident, good resistance to MSV and blights
Kalahari Imported	Late 130-150 days	7.0	Mid to high altitudes	OPV, dent, resistant to leaf blight, susceptible to MSV and mildew
SM 401 SEMOC	Early 115-130 days	7.0	Low to mid altitudes	Hybrid, semiflint, good resistance to MSV, rust, drought, lodging
SM 402 SEMOC	Medium 125-140 days	9.5	Mid to high altitudes	Hybrid, semiflint-semident, strong resistance to MSV, rust, blight, drought
SM 404 SEMOC	Early to medium 120-135 days	8.0	Low to high altitudes	Hybrid, semiflint-semident, strong resistance to MSV, rust, blight, drought
SM 504 SEMOC	Medium-medium late 125-145 days	8.5	Mid to high altitudes	Hybrid, semident, strong resistance to MSV, rust, blight, lodging
SM 512 SEMOC	Medium late to late 125-150 days	9.0	Mid to high altitudes	Hybrid, semident, strong resistance to MSV, rust, blight, lodging
SM 652 SEMOC	Late 130-155 days	9.5	Mid to high altitudes	Hybrid, dent, strong resistance to rust and blight, susceptible to MSV
R 201 Imported	Early to medium early 115-130 days	7.0	Low to mid altitudes	Hybrid, dent, strong resistance to drought, susceptible to MSV/DM
SC 501 Imported	Early to medium early 115-130 days	7.5	Low to mid altitudes	Hybrid, good resistance to drought, susceptible to MSV/DM

Name, source	Days to maturity	Potential yield <sup>1</sup> (tons/ha)	Target region	Characteristics
PAN 473 Imported	Medium 120-140 days	8.0	Low to high altitudes	Hybrid, medium tolerance to MSV, good adaptability
PAN 6671 Imported	Medium 120-140	8.0	Low to high altitudes	Hybrid, medium tolerance to MSV

Source: M. Denic, personal communication, June 1999.

<sup>1</sup> under research station conditions

### APPENDIX 3: MAIZE YIELD MODELS

#### Maize Yield Equation Results: Cotton-Maize Program 1994/95

Equation 1:  $\ln(\text{YIELD}) = f(\text{HIGH\_INB}, \text{HIGH\_COT}, \text{LANDQUAL}, \ln(\text{TOTWAE}), \text{RAINPROB}, \text{VIL1..n}, \ln(\text{KGSTOR95}))$

Equation 2: same as Equation 1, but excludes  $\ln(\text{KGSTOR95})$   
where:

YIELD=	kgs maize grain produced per hectare
HIGH_INB=	1 if high-input maize block 0 otherwise
HIGH_COT=	1 if high-input cotton participant 0 otherwise
LANDQUAL=	1 if soil quality is judged high for maize with no nutrient depletion 0 otherwise
TOTWAE=	total adult-equivalent weeding days, family and non-family included
RAINPROB=	1 if drought reported on field during growing season 0 otherwise
KGSTOR95=	cereal reserves, January 1995 (kgs)
VIL1..n=	village level dichotomous variables

The predictive power of the two equations was relatively high: equation 1 explained 46.8% of the variation and equation 2 explained 46.5%.

Variable	Equation 4-3			Equation 4-4		
	Coef-ficient	S.E.	P-value	Coef-ficient	S.E.	P-value
HIGH_INB	0.71	0.19	0.00	0.71	0.19	0.00
HIGH_LOW	0.30	0.18	0.09	0.31	0.18	0.09
LANDQUAL	0.19	0.10	0.05	0.19	0.10	0.05
ln(TOTWAE)	0.14	0.08	0.08	0.14	0.08	0.09
RAINPROB	-0.26	0.12	0.03	-0.26	0.12	0.03
ln(KGSTOR95)	---	---	---	-0.01	0.03	0.79
VILMTZ1	0.57	0.21	0.01	0.58	0.22	0.01
VILMTZ2	0.90	0.22	0.00	0.90	0.22	0.00
VILMTZ3	0.59	0.21	0.00	0.59	0.21	0.00
VILMTZ4	0.37	0.21	0.08	0.37	0.21	0.08
VILMTZ5	-0.12	0.28	0.66	-0.13	0.28	0.65
VILMTZ6	-0.33	0.32	0.30	-0.33	0.32	0.30
VILMON2	-0.21	0.32	0.51	-0.22	0.32	0.49
VILMON3	-0.36	0.35	0.29	-0.39	0.36	0.28
VILMON4	0.28	0.23	0.23	0.27	0.23	0.24
VILMON5	-0.33	0.26	0.21	-0.33	0.26	0.22
VILMON6	-0.32	0.21	0.14	-0.34	0.23	0.13
VILMON7	0.16	0.25	0.53	0.14	0.27	0.61
VILMON8	-0.25	0.25	0.33	-0.27	0.27	0.32
VILMON9	0.05	0.35	0.88	0.03	0.36	0.93
Constant	5.40	0.32	0.00	5.44	0.35	0.00

Dependent variable=ln(YIELD)

N=196

Adjusted R-square = 0.468

F-stat = 10, Significance = 0.00

Source: Strasberg 1997

Adjusted R-square = 0.465

F Stat - 9.5, Significance = 0.00

## Maize Yield Equation Results: DNER/SG Maize Program 1996/97

$\ln(\text{YIELD}) = F(\ln(\text{LABOR DAYS}), \text{WEEK}, \ln(\text{PLANT DENSITY}), \text{REGION}, \text{WEATHER})$   
 where:

- YIELD= maize grain yield per hectare  
 LABOR DAYS= total adult equivalent labor days, family and non-family, per hectare, excluding harvest labor  
 WEEK= planting week where WEEK = 1 if first week of November, 2 if second week of November...fourth week of January  
 PLANT DENSITY= number of maize plants per hectare estimated from crop cut area  
 REGION 4= 1 if farmer is in Region 4  
 0 otherwise  
 REGION 7= 1 if farmer is in Region 7  
 0 otherwise  
 REGION 8= 1 if farmer is in Region 8  
 0 otherwise  
 (REGION 10 represents omitted category)  
 WEATHER= 1 if farmer stated that abnormal rainfall patterns or high winds on his plot negatively affected yield

Variable	Coef-ficient	S.E.	P-value
$\ln(\text{LABOR DAYS})$	0.194	0.093	0.04
WEEK	-0.002	0.028	0.41
$\ln(\text{PLANT DENSITY})$	0.526	0.220	0.02
REGION 4	-0.237	0.129	0.07
REGION 7	-0.929	0.246	0.00
REGION 8	0.174	0.238	0.47
WEATHER	-0.171	0.121	0.16
Constant	1.590	2.238	0.48

Dependent variable= $\ln(\text{YIELD})$

N=143

Adjusted R-square = 0.262

F-stat = 5.4, Significance = 0.00

Source: Howard, Jeje et al. 1998

## Maize Yield Equation Results: DNER/SG, DNER Maize Program and Non-Program Participants 1997/98

$\ln(\text{YIELD}) = F(\text{REGION}, \text{WKPLANT}, \text{REDSOIL}, \text{OTHERDAM}, \text{EDUC}, \text{PLDENS}, \text{LABOR}, \text{RAIN}, \text{TECH})$

where:

YIELD=	maize grain yield per hectare
WKPLANT=	planting week where 1= 4 <sup>th</sup> week of October, 2=1st week of November
REDSOIL=	1 if farmer reported maize plot had red soil 0 otherwise
OTHERDAM=	1 if farmer reported damage to maize plot from termites, wind, excess rain, drought, rats 0 otherwise
EDUC=	School grade completed by head of household
PLDENS=	Number of maize plants per hectare estimated from crop cut area
RAINLO=	1 if farmer reported rainfall distribution was good, 0 otherwise
RAINHI=	1 if farmer reported poor rainfall distribution, 0 otherwise
TTOTLHNHV=	total labor days per hectare excluding harvest labor
TECH2=	1 if farmer participated in the DNER low-input maize program 0 otherwise
TECH3=	1 if farmer did not participate in any maize program 0 otherwise
REGION 8=	1 if farmer resides in Region 8 0 otherwise
REGION 10=	1 if farmer resides in Region 10 0 otherwise

<b>Variables</b>	<b>Coef.</b>	<b>SE Coef.</b>	<b>Stdized Coeff.</b>	<b>Sig. T</b>
Constant	6.409	.165	.410	.000
REGION 8	.423	.070	.410	.000
REGION 10	.225	.088	.156	.012
WKPLANT	1.564E-02	.011	.080	.169
REDSOIL	.131	.062	.125	.035
OTHERDAM	-.226	.064	-.207	.001
EDUC	-1.978E-02	.012	-.093	.106
PLDENS	2.380E-05	.000	.499	.000
RAINLO	6.935E-02	.110	.036	.531
RAINHI	.157	.068	.148	.023
TOTLHNHV	-1.579E-04	.000	-.035	.557
TECH2	.170	.086	.158	.049
TECH3	3.956E-02	.095	.035	.677

Adjusted R<sup>2</sup>=.44

## **APPENDIX 4: FINANCIAL BUDGETS**

**Table 11. Farm-Level Enterprise Budgets for Maize**

<u>Year</u>	<u>Region 7 -- Montepuez and Ribaue Districts</u>				<u>Region 8 -- Monapo and Meconta Districts</u>		<u>Region 10 -- Malema District</u>
<b>MAIZE-COTTON PROGRAMS 1994/95(hi input maize programs in bold)</b>							
	<b>Hi Maize/Hi Cotton Block</b>	Hi Cotton, Lo Maize- Dispersed	Lo Cotton, Lo Maize- Dispersed	No Cotton, Lo Maize	Lo Maize/Lo Cotton- Block	Lo Maize/Lo Cotton- Dispersed	No Cotton, Lo maize
Maize grain yield (tons/ha)	<b>2.0</b>	1.0	0.6	0.6	0.5	0.4	0.4
Harvest farmgate price (\$/kg)	<b>0.088</b>	0.084	0.084	0.084	0.074	0.074	0.074
Gross revenue (\$/ha)	<b>173.93</b>	82.39	53.31	50.99	38.39	28.82	26.95
Purchased inputs excluding labor (\$/ha)	<b>113.12</b>	3.50	3.09	3.25	3.53	4.24	4.22
Hired labor (\$/ha)	<b>6.67</b>	7.20	3.09	2.25	2.23	0.74	0.12
Weedings	<b>1.45</b>	1.81	1.89	1.96	2.00	2.17	2.00
Herbicide applications (\$/ha)	<b>1.00</b>	0	0	0	0.00	0.00	0.00
Fertilizer applications (\$/ha)	<b>1.00</b>	0	0	0	0.00	0.00	0.00
Tractor provided	<b>Yes</b>	No	No	No	No	No	No
Family labor (ae days/ha)	<b>31.93</b>	39.33	55.65	68.62	53.67	62.53	63.51
Net returns to land (\$/ha)	<b>54.14</b>	71.69	47.12	45.49	32.63	23.86	22.61
Net returns to family labor (\$/ae day)	<b>1.32</b>	1.98	0.83	0.69	0.59	0.35	0.36
<b>PRICE SENSITIVITY ANALYSIS</b>							
Hungry season farmgate price(\$/kg)	<b>0.22</b>	0.22	0.22	0.22	0.21	0.21	0.21
Net returns to land (\$/ha)	<b>379.33</b>	206.61	126.88	127.63	96.78	69.62	70.07
Net returns to family labor (\$/ae day)	<b>11.88</b>	5.25	2.28	1.86	1.80	1.11	1.10

<u>Year</u>	<u>Region 7 -- Montepuez and Ribaue Districts</u>			<u>Region 8 -- Monapo and Meconta Districts</u>			<u>Region 10 -- Malema District</u>		
<b>MAIZE PROGRAMS (hi input maize programs in bold)</b>									
<b>1996/97</b>	<b>Hi-Input Maize</b>	Lo-Input Maize	Non-Prog. Part.	<b>Hi-Input Maize</b>	Lo-Input Maize	Non-Prog. Part.	<b>Hi-Input Maize</b>	Lo-Input Maize	Non-Prog. Part.
Maize grain yield (tons/ha)	<b>0.8</b>			<b>2.4</b>			<b>2.9</b>		
Harvest farmgate price (June) (\$/kg)	<b>0.058</b>			<b>0.060</b>			<b>0.058</b>		
Gross revenue (\$/ha)	<b>48.76</b>			<b>152.56</b>			<b>175.24</b>		
Purchased inputs excluding labor (\$/ha)	<b>90.78</b>			<b>90.78</b>			<b>90.78</b>		
Interest	<b>13.24</b>			<b>13.24</b>			<b>13.24</b>		
Hired labor (\$/ha)	<b>6.71</b>			<b>14.17</b>			<b>17.95</b>		
Tractor costs	<b>0</b>			<b>2.05</b>			<b>0</b>		
Family labor (ae days/ha)	<b>85</b>			<b>67</b>			<b>89</b>		
Net returns to land (\$/ha)	<b>(61.97)</b>			<b>32.32</b>			<b>53.27</b>		
Net returns to family labor (\$/ae day)	<b>(0.73)</b>			<b>0.48</b>			<b>0.60</b>		
<b>PRICE SENSITIVITY ANALYSIS</b>									
<b>July-December</b> average farmgate price(\$/kg)	<b>0.073</b>			<b>0.068</b>			<b>0.073</b>		
Net returns to land (\$/ha)	<b>(62.15)</b>			<b>29.53</b>			<b>72.20</b>		
Net returns to family labor (\$/ae day)	<b>(0.73)</b>			<b>0.44</b>			<b>0.81</b>		
<b>December</b> average farmgate price (\$/kg)	<b>0.12</b>			<b>0.098</b>			<b>0.12</b>		
Net returns to land (\$/ha)	<b>(32.41)</b>			<b>80.74</b>			<b>188.95</b>		
Net returns to family labor (\$/ae day)	<b>(0.38)</b>			<b>1.21</b>			<b>2.12</b>		
1 USD = 11,500 meticaais									

Year	Region 7 -- Montepuez and Ribaue Districts			Region 8 -- Monapo and Meconta Districts			Region 10 -- Malema District		
	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.	Hi-Input Maize	Lo-Input Maize	Non-Prog. Part.
<b>1997/98</b>									
Maize grain yield (tons/ha)	<b>1.3</b>	1.3	1.1	<b>2.7</b>	2.0	1.7	<b>1.9</b>	2.0	1.2
Farmgate price (September) (\$/kg)	<b>0.088</b>	0.088	0.088	<b>0.088</b>	0.088	0.088	<b>0.088</b>	0.088	0.088
Gross revenue (\$/ha)	<b>115.16</b>	113.36	93.12	<b>231.61</b>	168.84	149.81	<b>160.61</b>	167.21	106.93
Purchased inputs excluding labor (\$/ha)	<b>96.50</b>	1.98	1.38	<b>96.50</b>	4.50	4.50	<b>96.50</b>	3.16	1.45
Interest	<b>14.48</b>	0	0	<b>14.48</b>	0	0	<b>14.48</b>	0	0
Tools and sacks	<b>2.64</b>	3.63	4.98	<b>4.64</b>	2.87	3.19	<b>4.00</b>	4.38	4.64
Hired labor (\$/ha)	<b>7.22</b>	1.68	0.85	<b>15.63</b>	23.07	22.60	<b>27.76</b>	43.06	0
Family labor (ae days/ha)	<b>61</b>	93	109	<b>75</b>	161	188	<b>47</b>	108	116
Net returns to land (\$/ha)	<b>(5.68)</b>	106.07	85.91	<b>100.37</b>	138.40	119.50	<b>17.88</b>	116.62	100.85
Net returns to family labor (\$/ae day)	<b>(0.09)</b>	1.14	0.79	<b>1.34</b>	0.86	0.64	<b>0.38</b>	1.08	0.87
<b>PRICE SENSITIVITY ANALYSIS</b>									
<b>November</b> average farmgate price(\$/kg)	<b>0.14</b>	0.14	0.14	<b>0.13</b>	0.13	0.13	<b>0.14</b>	0.14	0.14
Net returns to land (\$/ha)	<b>55.60</b>	167.58	136.44	<b>188.63</b>	203.62	177.37	<b>103.81</b>	207.34	158.86
Net returns to family labor (\$/ae day)	<b>0.91</b>	1.80	1.25	<b>2.52</b>	1.26	0.94	<b>2.21</b>	1.92	1.37
1 USD = 12,000 meticaís									