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What Makes Agricultural Intensification Profitable for Mozambican Smallholders?

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AN APPRAISAL OF THE INPUTS SUBSECTOR AND THE 1996/97 DNER/SG2000 PROGRAM

by

Julie A. Howard*, José Jaime Jeje, David Tschirley***, Paul Strasberg*, Eric W. Crawford**** , and Michael T. Weber******

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EXECUTIVE SUMMARY

BACKGROUND

Mozambique, at peace since 1992 after three decades of civil strife, must increase agricultural production in order to reduce poverty and help feed its rapidly growing population. Intensification (increasing yields on land already under cultivation through the use of inputs such as chemical fertilizer, improved varieties of seed, and pesticides) is an important part of this strategy. The country's prime agricultural lands are already densely populated, and the presence of tsetse fly in the productive northern areas makes area expansion through the use of animal traction difficult.

Current yields of major food and export crops in Mozambique are low in comparison with other African countries[1], and the use of improved inputs is extremely limited. Mozambique uses 1.2 kg of NPK per hectare of arable land, compared to 13.9 kg/ha in Southern Africa, 20.1 kg/ha in SSA, and 87.1 kg/ha in the world (Bay and de Sousa 1990). Although many smallholders received improved varieties of seed through emergency programs during the late 1980s and early 1990s, the programs have now ended and farmers are replanting instead of purchasing new seed.

OBJECTIVES AND METHODS

This report summarizes an appraisal of input utilization and marketing in Mozambique, focusing on the following research questions: (1) What are current smallholder yields for major commodities, and what is the potential for increasing yields through the use of improved technologies? (2) To what extent are improved technologies already being used by smallholders, and is the use of improved technologies profitable? (3) How are improved seeds, fertilizer and pesticides currently produced and distributed? and (4) What are the key constraints and opportunities for increasing the use of improved technologies by smallholders?

A two-part approach was used to gather data. First, key informants and reports (from government agencies, NGOs, donors and international organizations) were consulted to obtain information on yields, levels of technology adoption, and production and distribution channels for seed, fertilizer and pesticides. Second, an in-depth analysis of one of the country's leading efforts to promote intensification was carried out. A survey of 223 smallholders participating in the *Direcção Nacional de Extensão Rural*/Sasakawa-Global 2000 program (DNER/SG2000) was undertaken to evaluate the financial and economic profitability of the improved maize technology package as applied by farmers in Manica and Nampula Provinces during 1996/97.

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[1]For example, smallholder maize yields range from 0.3-1.3 tons/ha: the average in Zimbabwe is 1.4 tons/ha and for Sub-Saharan Africa (SSA) is 1.2 tons/ha.

KEY FINDINGS ABOUT THE INPUTS SUBSECTOR

Use of Improved Inputs by Smallholders is Limited to Cotton and Tobacco Contract Growing Schemes and Greenbelt Vegetable Production. During the early 1980s Mozambique used 40,000-80,000 tons of fertilizer and 2-3 million liters/kilograms of pesticide per year, reflecting large investments in the state farm sector made by the Mozambican government and donors. Agrochemical use fell dramatically through the mid-1980s due to the war and collapse of the state farm sector. Current fertilizer and pesticide consumption is less than 10,000 tons and 400,000 lt/kg respectively.

Most agrochemicals currently imported are channeled by the three large joint venture companies (JVCs) and other smaller cotton and tobacco companies to their smallholder outgrowers. State sugar and citrus enterprises and large private producers of maize, rice, processing tomatoes, and other vegetables, tea and tobacco consume smaller amounts. Only an estimated 7% of smallholders use purchased inputs.

Large commercial farmers producing maize and vegetables and some smallholder producers of vegetables purchase improved varieties of seed annually through formal channels such as the Mozambican seed company SEMOC. Substantial quantities of improved seed for staple food crops were provided to Mozambican smallholders through emergency distribution programs during the late 1980s and early 1990s. These distributions met over half of the estimated annual seed demand for principal food crops. Most of these programs have now ended and up to 80% of the seed used by smallholders is saved from year to year (Dominguez and Chidiamassamba 1997).

Substantial Yield Gains are Possible Through the Use of Improved Inputs, but Fine-Tuning Recommendations to Agroecological Conditions is Very Important. A summary of available evidence indicates that the use of improved seed and fertilizer technologies could increase the yields of major crops by 67-576%. Current average and potential yields (in parentheses) are: maize 0.4-1.3 tons/ha (5-6.5); sorghum 0.3-0.6 tons/ha (0.8-2); rice 0.5-1.8 tons/ha (2.5-6); beans 0.3-0.6 tons/ha (0.5-2.5); cassava 4-5 tons/ha (5-10); and cotton 0.3-0.6 tons/ha (1.2) (MAP 1997a; World Bank 1996).

The response to fertilizer and improved varieties varies widely depending on the agroecological zone and soil type. This implies that recommendations should be fine-tuned to the soil type and zone if farmers are to maximize financial benefits. For the soil types found in the DNER/SG study areas, N and P recommendations for maize ranged from 30-100 kg/ha and 0 to 60 kg/ha, respectively (Geurts 1997). The actual amounts of N and P applied on DNER/SG plots were 58 and 24 kg/ha in all cases, usually a much lower rate than recommended. An additional 12 kg/ha of potassium was applied on the DNER/SG plots, although this was not recommended for any of the crop/soil/agroecological zone combinations.

Outside of Contract Growing Schemes, Smallholder Access to Improved Inputs Is Extremely Limited. Through the 1980s the parastatal Interquimica imported all agrochemicals and Boror Commercial, another parastatal, distributed them through a network of retail outlets. Both firms have subsequently been privatized and companies are now free to import agrochemicals. The closure of Boror Commercial retail outlets and the scarcity of private retail outlets for agrochemicals outside of Maputo have severely restricted small and medium-scale farmers' access to inputs. Large agricultural enterprises which are the major users of fertilizer and pesticides now obtain inputs in one of several ways: by ordering through private companies representing multinational firms such as BASF or Ciba-Geigy, ordering inputs directly, or obtaining inputs through donor aid programs (Pantazis 1997).

The KRII Aid Program Has Been Ineffective in Assuring a Reliable Supply of High Quality Inputs to Smallholder and Larger Growers. The KRII program has been operating since 1986 and supplies an estimated one-third of national pesticide demand and virtually all fertilizer used in Mozambique. These in-kind grants are worth approximately $9 million per year. KRII is intended to support smallholder food production, but in practice most of the inputs are routed to large companies for use (often by smallholder contract growers) on cash crops such as cotton and tobacco.[2] Recipients of KRII agrochemicals are supposed to pay a countervalue of 2/3 FOB for pesticides and 2/3-100% CIF for fertilizers and equipment into an agricultural development fund, but in practice a large part of the countervalue goes uncollected (World Bank 1996).

Companies can access KRII agrochemicals in two different ways. First, they can directly request specific products and quantities through the KRII program. Doing so is cheaper than ordering through agrochemical representatives or directly from the international market, but companies may be responsible for paying the countervalue, there is considerable uncertainty about when the inputs will arrive (it may take up to 18 months between order and delivery) and companies may also have to pay large storage fees if the inputs sit at the docks for a long period. In practice, a large part of KRII program imports go unclaimed and are auctioned off after one or two years. This provides a second, even cheaper way to get agrochemicals, if users can find what they need.

Creating a Demand for Purchased Seed Among Smallholders Has Been Difficult After Many Years of Free Seed Distribution. Development of the seed subsector since the 1970s has concentrated on the establishment of a formal seed industry similar to those in more developed countries. Formal seed production (non-cotton) by SEMOC (a former parastatal now being privatized) increased rapidly from 2000 tons in 1988 and peaked at almost 9000 tons in 1994, but the rapid expansion was due almost entirely to the demand for seeds by government and NGOs for distribution through emergency programs.[3] In the early 1990s, SEMOC's seed sales for emergency programs represented over 90% of its total business (Strachan 1994).

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[2] Research suggests that cotton production, especially when intensified, has positive spillover effects on food crop production among participating farmers. See Strasberg (1997) for more details.

[3] During this period an estimated 1.2 million families received seeds and tools programs annually (World Bank 1996).

When the emergency programs began to wind down in the mid-1990s, demand for formal sector seed fell sharply. National production fell to just over 5000 tons in 1995, far below the installed processing capacity of 18,000 tons/year. Because the distribution of emergency seeds was carried out through the Provincial Directorates of Agriculture or directly by NGOs, the commercial infrastructure for the distribution of seeds was almost non-existent by the mid-1990s.

KEY FINDINGS FROM THE DNER/SG PROGRAM

DNER/SG Maize Yields in 1996/97 Far Exceeded the Provincial Means for Smallholders Using No Purchased Inputs, But Were Lower Than Average Yields Reported on DNER/SG Plots in 1995/96. DNER/SG yields in 1996/97 were highly variable, ranging from .5 - 4.9 tons/ha. The mean yield for the sample was 2.3 tons/ha, compared to provincial means of .4 - 1.3 tons/ha and DNER/SG yields in the previous season of 4.6 tons/ha. Regression analysis indicates that plant density, number of days of labor input and weather conditions were all significant determinants of maize yield. Many farmers also reported abnormally late and intensive rains during 1996/97 that flooded fields, delaying operations and causing ears to rot in the field. In Regions 4 (East/Central Manica Province) and 7 (Ribaue District, Nampula Province) the late delivery of DNER/SG inputs further delayed planting. The mean plant density in the sample (35,659) was much lower than the density recommended by DNER (50,000 plants/ha).

Financial Analysis: Due to the High Cost of Inputs and Low Prices for Maize, Many DNER/SG Farmers Lost Money from the Investment in Maize Technology. Farmer decisions about whether to adopt a technology package will depend not only on the yield increases achieved but on the profitability of the package. Financial analysis shows the profitability of the DNER/SG package to farmers in 1996/97 using output and input prices actually faced by the farmer during that season. Net income per hectare was calculated for farmers selling maize in June, December, and midway between July and December.

During 1996/97, Storing Maize for Several Months Instead of Selling Immediately After Harvest Dramatically Increased Farmer Gains, Although This May Not Be True Every Year. When farmers sold in June, only 36% made a profit. At the December price, 80% profited; of those selling midway between July and December, 62% profited. The proportion of gainers and losers varied considerably by region and period. All of the Region 7 (Ribaue District, Nampula Province) farmers selling in June lost money; 25% turned a profit if they waited until December to sell. In Region 4 (East/Central Manica Province), 27% of farmers made a profit at June prices, while 89% took a profit at December prices.

Net income per hectare per day of family/mutual labor can be compared to the prevailing wage rate in the study areas to assess the relative attractiveness of the technology under varying yield and price levels. Estimated wage rates varied from 6000 meticais/day in Region 10 (Malema District, Nampula Province) to 20,000 mt/day in Region 4 (East/Central Manica Province). When maize was sold at June prices, net income per labor day was lower than the prevailing wage rate in all regions except the top terciles of Region 8 (Monapo/Meconta Districts, Nampula Province) (17,100 meticais/day) and Region 10 (Malema District, Nampula Province) (19,200 meticais/day).

At average July-December prices, returns per family/mutual labor day remained lower than the prevailing wage rate everywhere except the top terciles of Region 4 (East/Central Manica) (25,000 meticais/day), Region 8 (Monapo/Meconta, Nampula Province), and the top two terciles in Region 10-Manica (Western Manica Province) (12,000 - 22,000 meticais/day) and Region 10-Nampula (Malema District) (7000 - 24,000 meticais/day).

When farmers sell in December, returns per labor day are still negative for the bottom two terciles of Region 7 (Ribaue District, Nampula Province) (-9600-to -7200 meticais/day) and the lowest terciles in Region 4 (East/Central Manica) and Region 8 (Monapo/Meconta, Nampula Province), but exceed the wage rate elsewhere. These returns/day range from 20,000 meticais/day in Region 7 (Ribaue, Nampula Province) to 46,000 and 49,000 meticais/day for the top yield terciles in Region 10-Manica and Region 10-Nampula, respectively.

Economic Analysis: Farmers in Nampula Province May Be Better Off If They Can Export Maize to Malawi, Tanzania, Kenya or Elsewhere. An estimate of the value of maize production to the Mozambican economy was obtained by valuing maize, fertilizer, and seed at world market parity prices, and economic profitability was estimated for the contrasting scenarios of maize deficit and maize surplus in the Southern Africa region.

Maize Deficit in Southern Africa. When Southern Africa has a maize deficit, Mozambican farmers compete with U.S. or other world maize producers to supply the large Maputo consumer market and other consumers in the region. Three cases were considered: (a) high transport costs; (b) low transport costs; and (c) low transport costs, and Nampula Province farmers export maize to Malawi rather than Maputo.

Even under the assumption of high transport costs, conditions are relatively favorable for DNER/SG participants in Manica Province (Regions 4, 10-Manica), where intensified maize production is profitable for two-thirds of farmers. For farmers in Nampula (Regions 7, 8, 10-Nampula) who are far from the Maputo market, intensified maize is barely profitable for the top tercile in Region 10 and unprofitable for all the rest. With lower transport costs, profits increase for Manica Province farmers, but the package is still unprofitable for the lower tercile of farmers. Reduced transport costs do not help farmers in Region 7 (Ribaue, Nampula Province), where intensified maize is still unprofitable for all terciles, but seed and fertilizer use becomes profitable for the top two terciles in the rest of Nampula Province (Regions 8-Malema, 10-Nampula). Nampula Province farmers are best off when they can export maize to Malawi rather than transporting it the much greater distance to Maputo.

Maize Surplus in Southern Africa. When Southern Africa has a maize surplus, Mozambican producers compete with South Africa to supply Maputo. As a result, farm-level prices are much lower across the board than in the maize deficit scenario. Nampula Province farmers (Regions 7, 8 10-Nampula) are affected much more severely than their counterparts in Manica Province (Regions 4, 10-Manica). In surplus years, Manica Province prices fall by one third from deficit price levels, but in Nampula Province prices fall by an estimated 50-85%. When Southern Africa has a maize surplus, farmers in northern Mozambique may be better off exporting their maize to countries in other regions of Africa. Weather patterns in Tanzania and Kenya are different from Southern Africa's and may provide a market for surplus Mozambican maize (Koester 1986). Maize production in neighboring Malawi has been declining for some years, and this country may be a market for Mozambican maize even when the region as a whole is in surplus. If export to international markets is possible, the analysis indicates that maize intensification will be profitable for the top two yield terciles in Regions 8 (Monapo/Meconta) and 10 (Nampula), although it will still be unprofitable for farmers in Region 7 (Ribaue). Export to Malawi would likely be more profitable than to the international market.

Credit Repayment: DNER/SG is Setting a Dangerous Precedent by Not Enforcing Repayment of Input Loans Made to Farmers During 1996/97. DNER/SG has not started to collect loan repayments for the 1996/97 season, and farmers may not be expected to pay back these loans at all. As of December 1997, less than 20% of farmers had made any payments on loans from the previous season. Thus, farmers may now regard the DNER/SG program as a grant rather than a loan program, a potentially dangerous precedent that can undermine the development of private sector input supply channels in these areas.

CONCLUSIONS AND POLICY IMPLICATIONS

Our analysis of the DNER/SG program suggests that there is substantial scope for increasing farmer yields and agricultural production in Mozambique through the use of inputs such as improved seed varieties, fertilizer and pesticides. Sustained adoption of these inputs by farmers will depend on the successful implementation of policies and programs that increase the profitability of input use by (1) improving smallholder awareness of the benefits and correct use of inputs; (2) reducing the cost of inputs and ensuring their timely availability; and (3) reducing the cost of marketing commodity outputs and developing new markets for smallholder commodities.

Improving Smallholder Awareness of the Benefits and Correct Use of Inputs. Most sample farmers were convinced that the use of Manica seed and chemical fertilizer improved maize yields. The successful DNER/SG experience in Mozambique (and the DNER/SG experience in other countries) suggests that it would be useful to replicate this model elsewhere in the country with maize and other crops.

Since SG resources are limited, other NGOs, JVCs or private sector firms (including agrochemical and seed firms) could provide support to expanded DNER efforts in this area. Several modifications in the way the program is implemented would increase its effectiveness. First, the process of identifying candidate crops and areas for intensification should include a feasibility study to determine (a) the potential yield gains from use of improved technology, and (b) estimates of the farm-level profitability of the input package.

Second, the database of information from INIA and NGO trials on yield response to fertilizer and improved seed varieties should be more effectively utilized: fine-tuning seed and fertilizer recommendations to match the diversity of agroclimatic conditions found in the country can increase yields and reduce costs of improved technology. The addition of complementary technologies, e.g., storage pesticides and herbicides, may increase the farm-level profitability of the package. Storage pesticide would be especially important, allowing farmers to take advantage of potential seasonal price rises without the risk of losing a large proportion of their stored grain to insect pests. Herbicide would help address the weeding labor constraint, which becomes even more binding when fertilizer is used. Third, greater attention should be given to training extension agents and making sure they are providing adequate technical advice to farmers on appropriate planting, fertilization and weeding methods/timing.

Investments to Reduce Costs and Ensure Timely Availability of Inputs. In Mozambique the cost of inputs is very high compared to output prices currently faced by farmers. Using June prices, the ratio of the cost of the total input package to the price of one kilogram of maize ranges from 1,504 in Region 8 (Monapo/Meconta, Nampula Province) to 2,074 in Regions 4 and 10 in Manica Province. This means that farmers must produce between 1,504 and 2,074 kilograms of maize to pay for the package of inputs used on one hectare. Using prices from our economic analysis, we calculated ratios in Nampula that ranged from 717[4] to 3,165[5]. In Manica, the economic ratios ranged from a low of 700 to a high of only 873. These economic ratios are similar to the financial ratios faced by Ethiopian farmers in 1996/97, who only needed to produce 748 kilograms of maize to pay for a similar package of inputs (using comparable prices immediately after harvest). Not coincidentally, the SG package was highly profitable for nearly all Ethiopian SG participants.

This analysis suggests that if the export market is developed, especially to Malawi, Nampula farmers can expect to face ratios of around 1,000 or lower. This means that they will begin to make money with yields of 1 ton per hectare. With yields of 3 tons and more attainable on smallholder fields with this technology, the potential profits to farmers become extremely attractive.

Per-ton seed prices are comparable or lower than those in neighboring countries, but seed is expensive for Mozambican farmers relative to the output prices they receive. The average ratio of OPV seed to grain price is 4.5 in Sub-Saharan Africa and 5.4 in Southern Africa, compared to 7.1 in Mozambique (CIMMYT 1994). Late delivery of inputs was a problem for many of the DNER/SG participants and is also a concern of smallholder contract farmers working with JVCs and other large cotton firms. Major factors affecting input costs and delivery are the poor state of

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[4] Using the maize price when exporting to Malawi and assuming low transport costs.

[5] Using the lowest maize price -- selling in Maputo in a surplus year -- and the highest input cost.

transportation infrastructure[6], the lack of wholesale and retail outlets for inputs in the rural areas, and weak demand for fertilizer and seed by smallholders. Input dealers cannot deal in large enough quantities to realize significant economies of scale.

A four-part approach is recommended to reduce the cost of getting inputs to smallholders: (1) improving the transportation infrastructure; (2) reorienting the KRII program to give greater flexibility and control to private participants; (3) broadening the role of farmer associations in input distribution and encouraging private agribusiness to expand the wholesale and retail network for inputs; and (4) promoting the diversification of the seed subsector, especially more informal seed replication and distribution.

Improving Transport Infrastructure: The Mozambican government and donors are well aware of the need to improve transport infrastructure: the Roads and Coastal Shipping Project II (ROCs II) represents an important step in improving conditions. Roughly half of Mozambique's estimated 43,000 kms of paved, earth/gravel, and feeder roads are scheduled for rehabilitation by the year 2000. Additional investments will be required to upgrade the remaining portions of the network and maintain improved road surfaces.

Reorienting the Japanese KRII Program: The KRII program provides an important source of credit, but the current system of centralized ordering and distribution of KRII inputs is retarding the development of the private input procurement and distribution system in Mozambique. We propose that the centralized ordering and distribution system for KRII inputs be abandoned and that the KRII program become mainly a financing mechanism to enable private firms and farmer associations to order the quantities and types of agrochemicals they need, and pay back the amount over time. Using the KRII funds as a source of credit, but leaving the process of aggregating orders, tendering for bids, and arranging for importation in the hands of the Mozambican private sector would reduce costs through economies of scale and the long time lag between order and receipt of KRII goods. If it is not possible to reconfigure KRII in this way, the program should be eliminated.

Broadening the Role of Farmer Associations in Input Distribution and Facilitating the Development of Private Input Marketing Channels. **Strengthen farmer associations**. Building smallholder demand for improved inputs while simultaneously creating a network of wholesale and retail input suppliers will be a long-term process. Government and donor funds could be used to strengthen the capacity of smallholder associations to reduce the cost of input procurement and delivery by aggregating input orders, guaranteeing payment, and repackaging bulk orders for delivery to individual customers. One innovative experiment with farmer associations has had good results and should be studied more closely to determine how the model could be expanded to other areas in a cost-effective way. In 1996/97 the Cooperative League of the USA (CLUSA) began working with groups of farmers producing cotton for 3 JVCs operating in northern

[6] Transport and handling costs between the port and farmgate add 31-64% to the import parity price of fertilizer for farmers in Nampula and Manica Provinces.

Mozambique. The farmers had been unhappy with the late delivery and quality of inputs delivered by the company. Under new agreements negotiated by 18 associations supported by CLUSA, companies agreed to channel their input supply and extension services, which had traditionally been supplied to individuals, through associations instead. This strategy reduced the cost to JVCs of service provision and improved the timeliness of input delivery.

If supplier credit is made available through a redesigned KRII and other donor programs, Mozambican agrochemical firms might similarly work through farmer associations to aggregate orders and make inputs available locally on a cash basis. In the future, the DNER/SG program could work with CLUSA and farmer associations as well as individual stockists to organize input procurement, delivery and guarantee payment of credit.

Reduce barriers to market entry. Policy changes have made it easier to import and sell inputs, but several administrative barriers to market entry remain. Retail licenses must be approved by provincial governors and are difficult and time-consuming to obtain, for example. Lack of credit is widely perceived to be a major constraint to the development of input markets. However, the severity of the problem is not well understood, and the discouraging experience with scaled-up credit programs in many SSA countries calls for careful examination of alternative approaches to increasing credit availability.

Discontinue direct distribution of inputs by government and NGOs. The Mozambican government and NGOs can encourage the development of input markets by discontinuing the direct distribution of relief or otherwise subsidized fertilizer and seed for commodities that are available commercially, instead providing farmers with vouchers to purchase inputs from local sources.

Provide technical training for stockists. Another important constraint is the lack of trained personnel in rural areas who are capable of handling products safely, giving competent advice about their utilization, and bookkeeping. Innovative NGO programs such as Citizens Network are helping to train shopkeepers in Manica Province in collaboration with SG. In Zimbabwe, CARE's AGENT program also provides (in addition to technical training in input use, storage and bookkeeping) credit guarantees until the stockists graduate to regular supplier lines of credit after 6-8 months in the program.

Diversification of the Seed Sector

Mozambican farmers in selected agroecological areas are becoming aware of the value of hybrid maize seed, and this market may expand over the coming years. For the foreseeable future, however, the bulk of demand will be for open-pollinated seed that can be replanted for several seasons, not renewed every year. This suggests that the development path for SEMOC will need to differ from counterpart formal seed organizations in neighboring countries that have relied heavily on centrally grown, centrally processed hybrid maize as a flagship product.

Because of its research and varietal testing capability for a wide range of crops and links with external public and private seed organizations SEMOC, (together with INIA, DNER and the public seed organizations) can play a unique role in the development of a multi-tiered seed sector in Mozambique that can better serve the needs of smallholders. Though some activities of the seed system can be supported by commercial firms, others will require support from the government and/or donors. Examples follow.

Decentralize seed production and marketing. First, SEMOC and other potential entrants to the seed market can reduce their costs by decentralizing seed production and marketing. This will require joint efforts by companies, public agencies and NGOs to (a) provide links to NARS, international research centers and other private sector firms to get information and seed of appropriate varieties; (b) train extension agents to choose appropriate varieties for different agroecological zones and types of clients; (c) train and supervise farmers in seed production, selection, storage and marketing; and (d) provide technical training to rural stockists.

Review seed system regulations and functions. Seed subsector regulations need to be rationalized to encourage the development of the informal seed sector. We recommend a two-tier seed multiplication and distribution system. At the first level, foundation seed would be multiplied to certified seed under the stringent and highly controlled conditions currently required by seed authorities and made available for direct sale. In the second stage, seed from the first level would be bulked by individual farmers and farmer groups in local villages under inspection by extension workers and marketed as standard seed.

Removing compulsory seed certification and restrictive trade licensing requirements will permit formal production of quality open-pollinated maize and other crops by smallholders and sale among neighboring farmers. In addition, seed companies will be able to involve smallholders in contract seed production more easily.

Reducing the Cost of Marketing Commodity Outputs and Developing New Markets for Smallholder Commodities. Increasing the demand for improved inputs by smallholders ultimately depends on expanding the post-harvest market for commodities produced by smallholders. It will be especially important to develop foreign markets for Mozambican commodities. Any strategy to develop regional export potential in food and other crops in northern Mozambique must be active on many fronts. Critical needs include continued improvement of port management and roads, especially secondary and tertiary routes; simplification of licensing and other bureaucratic procedures related to trade; improved access to credit for agricultural trade; and continued development of farmer associations. In addition, the government can facilitate regional trade in three ways.

Making a Clear Policy Statement that the Government will not Prohibit Maize Exports Even During Drought Years: If traders expect that government will close off profit opportunities during years of regional deficit, they will not invest in their capacity to efficiently and regularly assemble and export large quantities of grain. The result will be continued small-scale operations, high costs, low prices to farmers, and high prices for consumers.

Collaborating with the Private Sector to Create a Regional Trade Information Network: An effort is currently underway in MICTUR and should be strengthened. It will be especially important to coordinate this effort with the existing market information system (SIMA) in the Ministry of Agriculture and Fisheries. If successful, such a network could eventually provide the basis for an agricultural commodity exchange in the area.

Removing Bureaucratic Barriers to the Formalization of Farmer Associations so They Can Continue to Expand Their Marketing Activities: Strengthened farmer associations can play a key role in reducing the costs of marketing commodity outputs both domestically and internationally. During the 1995/96 season, CLUSA helped farmer associations working in JVC cotton areas to set up management systems that will enable them to weigh, record and deliver the cotton to the gins themselves for a higher price. Farmer groups are also beginning to coordinate exports. In 1995/96, 9 CLUSA-assisted associations involving about 3000 farmers in the Ribaue area coordinated to sell 1200 tons of maize to V&M, a South African company. The buyer paid the associations 1000 meticais/kg compared to the market price of 750 meticais/kg. Part of the proceeds were invested in the association's development fund. JVCs and other large commercial farms can also play a role in seeking out new markets and contracting smallholders for the production of these commodities. For example, several cotton firms interested in encouraging a cotton-maize or cotton-maize-legume rotation are actively exploring alternative markets for maize and legumes such as pigeon pea and groundnuts.

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DNER	Direcção Nacional de Extensão Rural
INIA	Instituto Nacional de Investigação Agronómica
JVC	Joint Venture Company
JICA	Japanese International Cooperation Agency
KRII	Japanese grant aid program
MAP	Ministério da Agricultura e Pescas
MSU	Michigan State University
NGO	Non-Governmental Organization
NPK	Nitrogen, phosphorus and potassium
OPV	Open-pollinated variety
PESU	Programa de Emergência de Sementes e Utensílios
SEMOC	Sementes de Moçambique Limitada
SG	Sasakawa-Global 2000 program
SIMA	Sistema de Informação de Mercados Agrícolas
WVI	World Vision International

1. INTRODUCTION

Mozambique, at peace since 1992 after three decades of civil strife, must increase agricultural production in order to reduce poverty and help feed its rapidly growing population and promote economic growth. Intensification (increasing yields on land already under cultivation through the use of inputs such as chemical fertilizer, improved varieties of seed, and pesticides) is an important part of this strategy. The country's prime agricultural lands are already densely populated, and the presence of tsetse fly in the productive northern areas makes area expansion through the use of animal traction difficult. Programs aimed at increasing agricultural production will revolve around smallholders, who make up 75% of Mozambique's population and farm 95% of the land.

Current yields of major food and export crops in Mozambique are low compared to other African countries. Smallholder maize yields range from 0.3-1.3 ton/ha, while the average in Zimbabwe is 1.4 tons/ha and in Sub-Saharan Africa (SSA) overall is 1.2 tons/ha. Yields in Mozambique for sorghum, rice, beans, and cotton are also on the very low end of regional and SSA averages. The use of improved inputs is extremely limited. During 1991-95, Mozambique used 1.84 kg of nitrogen, phosphorus, and potassium (NPK) per hectare of arable land annually, compared to 16.55 kg/ha in Southern Africa[7], 8.89 kg/ha in SSA overall, 54 kg/ha in Latin America, and 80.3 kg/ha in Southern Asia (Naseem and Kelly 1998). Although many smallholders received improved varieties of seed through emergency programs during the late 1980s and early 1990s, the programs have now ended and farmers are recycling instead of purchasing new seed (Domínguez and Chidiamassamba 1997).

1.1. Objectives and Methods

This report addresses the following research questions: (1) What are current smallholder yields for major food and cash crops, and what is the potential for increasing yields through the use of improved technologies? (2) To what extent are improved technologies already being used by smallholders, and is the use of improved technologies profitable? (3) How are improved seeds, fertilizer and pesticides currently produced and distributed? (4) What are the key constraints and opportunities for increasing the use of improved technologies by smallholders?

A two-part approach was used to gather data. First, key informants and reports from government agencies, NGOs, donors and international organizations were consulted to obtain information on yields, levels of technology adoption, and production and distribution channels for seed, fertilizer and pesticides. Second, an in-depth analysis of one of the country's leading efforts to promote intensification was carried out. A survey of 223 smallholders participating in the *Direcção Nacional de Extensão Rural*/Sasakawa-Global 2000 program (DNER/SG) was undertaken to evaluate the financial and economic profitability of the improved maize

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[7] Includes Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe.

technology package as applied by farmers in Manica and Nampula Provinces during the 1996/97 season.

1.2. Organization of the Report

The report begins with a brief overview of Mozambique's agricultural sector (Section 2). Section 3 reviews the status of input use in Mozambique and summarizes the evidence on the potential yield impacts of improved technologies. The structure and constraints affecting the seed, fertilizer and pesticide subsectors are analyzed in Section 4. Section 5 presents results from the analysis of the DNER/SG program in Manica and Nampula Provinces. The paper concludes with a synthesis of key findings from the study and a discussion of alternative policies and investments to increase the use of improved technology (Section 6).

2. AGRICULTURE IN MOZAMBIQUE: AN OVERVIEW

2.1. Agroecology and Farming Systems

Agriculture is the backbone of Mozambique's economy. The agricultural sector accounts for 40-50% of Gross Domestic Product (GDP), employs more than 80% of the labor force, and provides more than 80% of foreign exchange earnings. The *Instituto Nacional de Investigação Agronómica* (INIA) has divided the country into 10 agroecological regions (Figure 1). Regions 1,2, and 3 in southern Mozambique receive 400-800 mm of rainfall annually and are subject to prolonged periods of drought. Rainfall is higher (1000-1500 mm) and more dependable in regions north of the Save River (Regions 4-10). Soils are of average quality overall, with better soils found in the plateau and highland areas of northern and western Mozambique. Table 1 shows the distribution of cultivated area by crop and province. Maize, cassava, beans, cashew and sorghum are the most important crops in terms of area (DEA 1998).

The best areas for intensive and diversified agriculture are in northern Mozambique, in parts of Niassa, Nampula, Manica and Zambezia Provinces with good soils and adequate rainfall. Maize, cassava, beans, cashew, sorghum and cotton are the main crops in these areas. Parts of Zambezia, Sofala, Niassa, Nampula and Cabo Delgado Provinces are suited to intensive and semi-intensive agriculture and can support a wide range of rainfed crops. Most of southern Mozambique (Maputo, Gaza, Inhambane Provinces) is suited to extensive and semi-extensive agriculture (World Bank 1996).

2.2. Agricultural Sector Development

2.2.1. Colonial Period

During the colonial period Portuguese investments in Mozambique were aimed at increasing the supply of agricultural raw materials such as cashew, copra, cotton, and tea to Portugal. The agricultural sector had three components: large plantations, medium-sized settler farms, and small African family farms. Africans were forced to work on Portuguese plantations and farms initially as slaves and, after slavery was abolished in 1869, in order to pay taxes levied by public authorities. An estimated 100,000 adult rural males migrated to South Africa annually to work in the mines (World Bank 1996; Tesfai 1991).

Portuguese immigration to Mozambique was encouraged (the Portuguese population rose from 27,000 to 200,000 between 1940-74) and the economy grew dependent on a Portuguese labor force for all but the most basic tasks (World Bank 1996). Africans were not given access to basic education except through a few mission schools. The mass departure of Portuguese shortly before independence (1975) left a critical shortage of skilled labor and greatly disrupted the rural agricultural sector since the commercial network of Portuguese and Asian merchants had

Figure 1. Agroecological Regions

Table 1. Area Under Cultivation (ha) and Percentage of Cultivated Area Planted to Specific Crops, 1996

Province	Area cult. ('000 ha)	Cassava	Sorghum	Maize	Rice	Beans	Millet	Sweet potato	Sesame	Sunflower	Cotton	Cashew	Tobacco
		--percent of total cultivated area--											
Cabo Del.	451	18.3	17.4	33.7	7.6	6.5	0.1	0.1	0.2	0.3	2.4	13.5	0.0
Nampula	892	32.4	8.2	19.5	3.3	13.3	0.5	0.2	0.0	0.0	4.7	17.4	0.4
Niassa	260	4.2	17.4	48.6	2	16.3	0.5	2.2	0.3	0.1	1.3	5.4	1.7
Zambezia	799	25	6.0	24	16.7	20.2	.8	2.4	0.0	0.0	0.6	4.4	0.0
Tete	289	0.0	19.8	64.1	0.5	5.7	6.8	0.7	0.0	0.0	0.1	2.2	0.0
Manica	175	0.3	20.2	58.2	0.3	7.1	5.9	2.6	0.9	0.5	0.4	3.5	0.0
Sofala	356	3.9	25.4	42.3	8.0	7.3	5.6	2.2	0.6	0.1	1.1	3.6	0.0
Inhambane	879	15.7	8.5	35.2	1.4	18.6	0.2	0.2	0.5	0.0	0.0	19.5	0.1
Gaza	356	13.9	1.9	46.4	1.2	22.2	1.7	1.3	0.1	0.0	0.0	11.3	0.0
Maputo	237	13.1	0.1	51.5	0.4	16.9	0.0	6.3	0.0	0.0	0.0	11.6	0.0
TOTAL	4,696	17.5	10.9	35.7	5.3	14.6	1.5	1.3	0.2	0.1	1.4	11.3	0.2

Source: DEA 1998

provided consumer goods, agricultural inputs, and marketing services for commodity outputs. Between 1973-75 the marketed output of agricultural crops declined by 43% (World Bank 1996; Tesfai 1991).

2.2.2. Independence

Following independence in 1975 the new socialist government took over more than 2000 abandoned Portuguese properties and established large centralized state farms. Between 1978-82, 90% of government investment in agriculture was allocated to the new state farm sector, much of it used to purchase machinery (including 3000 tractors and 300 combines), fertilizers and pesticides. These expenditures were supported in part by a large agricultural development program funded by the Nordic countries, the Mozambique Nordic Agricultural Program (MONAP), which operated from 1977-90 (Tesfai 1991).

At the same time, parastatal monopolies were established to take over marketing and trade functions formerly managed by Portuguese and Asian traders. In 1981 the marketing of all crops, except for cashew and cotton, and the distribution of goods to rural areas was consolidated under Agricom, a state enterprise based in the Ministry of Internal Commerce. Private traders were still allowed to operate and were granted monopoly rights in geographically defined areas, but the government retained a monopoly at the wholesale level and regulated marketing margins (World Bank 1996).

2.2.3. War

Agricultural production partially recovered during the 1978-81 period, although it remained below colonial-era levels, but the intensification of the guerrilla war[8], poor development policies, and the severe drought of 1982-83 brought about the near collapse of the Mozambican economy. Between 1981 and 1986 GDP and food production fell by an estimated 30%, marketed production of maize and rice declined by half, and exports declined by 75%. The country grew dependent on food aid. The war also caused a huge displacement of the population toward the cities[9] and destroyed much of the economic infrastructure. The number of private traders fell from 6000 in 1975 to 2000 by 1990 (World Bank 1996).

2.2.4. Rehabilitation

Since 1987 Mozambique has made substantial progress in improving its macroeconomic policies -- liberalizing the exchange rate, reducing budget deficits and inflation -- and has gradually retreated from direct intervention in the economy. By 1994, 263 small- and medium-sized public

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[8]The war was waged by RENAMO first with Rhodesian and later South African support.

[9]By 1990, an estimated 1 million persons had been killed and 5 million were displaced.

enterprises had been restructured -- either privatized, converted to joint venture companies (JVCs), or leased. Most commodity prices (with the exception of cotton) are now market-determined.

The country is making a rapid recovery from decades of poor development policies and war: an estimated 4.7 million hectares were cultivated in 1996, a 60% increase over 1992 (DEA 1998; World Bank 1996). Cereals production tripled between 1991 and 1996, rising from .5 to 1.4 million tons (MAP 1997a). The area and production increase is due in large part to better rains following the devastating drought of 1991-92, the expansion of cultivated area by returning refugees and resident farmers, and the reappearance of markets in rural areas.

The bi-modal pattern of agricultural production established in the colonial era continues today. Most smallholders rely on hand hoes; these are supplemented with animal traction in southern Mozambique. Joint venture companies (JVCs) and private commercial farms use large machinery and inputs in combination with labor-intensive weeding and harvesting by farm workers (World Bank 1996).

3. INPUT USE AND YIELD RESPONSE FROM USE OF IMPROVED INPUTS

3.1. Fertilizer and Pesticide Use

Table 2 shows the quantities of fertilizer and pesticides consumed in Mozambique between 1980 and 1997[10]. During the early 1980s Mozambique used 40,000-80,000 metric tons of fertilizer and 2-3 million liters/kilograms of pesticide per year, reflecting large investments in the state farm sector made by the Mozambican government and donors. Agrochemical use fell dramatically through the mid-1980s due to the war and collapse of the state farm sector, and current fertilizer and pesticide consumption is less than 10,000 metric tons and 400,000 liters/kilograms respectively.

In Mozambique the emphasis in the past has been getting inputs to the large farm sector, not smallholders, and this remains true today. Most agrochemicals currently imported are channeled by the three large JVCs and other smaller cotton and tobacco companies to their outgrowers. State sugar and citrus enterprises and large private producers of maize, rice, vegetables, tea and tobacco consume smaller amounts. Only an estimated 7% of smallholders use purchased inputs (Strachan 1994). Most fertilizer is used in the central and northern areas of the country, although it is increasingly being used in southern Mozambique in peri-urban agriculture (fruits and vegetables) and in the irrigated areas (Bay and de Sousa 1990; Pantazis 1997).

3.2. Potential Yield Gains Through Fertilizer Use

3.2.1. Soil Fertility

The level of soil fertility determines how many years land can be cultivated and the quantities of nutrients needed to maintain yield levels. Fertility varies by soil type: the most fertile soils are the Fluvisols, found in valleys that flood regularly. Lixisols, Luvisols, Ferralsols and Acrisols maintain reasonable yields for 5-10 years, Arenolsols for only 1-3 years (Mazuze and Geurts 1997). Organic fertilizers such as animal manure and crop residues are important for small areas (such as intensive vegetable cultivation) and in areas where the use of chemical fertilizers is not financially viable, but are not adequate to replace nutrient losses at the national level. If all of the available manure in Mozambique were applied to the total cultivated area, each hectare would receive only 3.1 kg N, 0.1 kg P, and 2.6 kg K. The estimated nutrient deficit per hectare is 21 kg N, 6 kg P, and 15 kg K, however (Stoorvogel and Smaling 1990; cited in Geurts 1997).

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[10] Complete data are available only through the late 1980s, when importation and distribution were centrally controlled. Data for 1988/89 onwards represent only KRII program imports of fertilizer and pesticide, which are estimated to supply almost all of the fertilizer and one-third to one-half of pesticide demand.

Table 2. Fertilizer and Pesticide Utilization

Year	Pesticide consumption (kg/liters of product)	Fertilizer consumption (tons of product)	N (tons of nutrient)	P (tons of nutrient)	K (tons of nutrient)
1980/81	2,603,893	40,566	16,200	10,000	1,400
1981/82	2,705,298	84,094	20,100	15,000	6,300
1982/83	1,753,224	58,198	20,000	12,800	7,100
1983/84	1,103,048	22,471	7,500	4,300	2,900
1984/85	497,788	10,436	1,692	1,743	465
1985/86	528,406	10,295	1,686	1,471	646
1986/87	1,205,085	13,566	2,000	2,500	1,400
1987/88	451,132	9,610	3,000	2,500	1,000
1988/89	na	3,478	1,100	300	200
1989/90	na	6,500	1,700	300	400
1990/91	na	2,350	2,200	200	200
1991/92	518,440	9,950	2,100	1,700	1,300
1992/93	373,300	2,889	3,000	1,200	700
1993/94	264,975	13,177	2,000	200	1,000
1994/95	211,800	9,805	5,000	1,000	1,000
1995/96	390,500	9,800	5,000	1,000	3,000
1996/97	384,270	1,800	na	na	na

na: not available
Note: 1988/89-1996/97 data reflect only fertilizer and pesticides imported through the Japanese KRII program and do not include agrochemicals imported directly by private companies
Sources: Imports 1980/81-1990/91 MINAG-DEA 1994;1991/92-1996/97 JICA;N, P consumption–FAO 1998 and Guerts 1997

3.2.2. Fertilizer Response

Over 800 trials to measure soil fertility and response to nutrients were carried out between 1937 and 1991 by researchers from INIA, the Faculty of Agronomy of the Eduardo Mondlane University, and foreign scientists. INIA's Soil and Water Department recently compiled the results from these trials in a national database. This database was used to calculate fertilizer recommendations for the ten most important food crops and cotton, by soil type, water source, altitude, precipitation, and season. Key results are shown in Table 14, Appendix 1, including estimates of without-fertilizer yields, response to N and P, and a value/cost ratio (VCR)[11] for each recommendation, using fertilizer and market prices from 1992/93 (Geurts 1997).

In general, the results show a good response to N and P across a number of food crops and cotton (Table 14, Appendix 1). Average fertilizer response (% change in yield) was over 50% in cotton, potato, maize, soybean and wheat. Geurts also concludes that the use of fertilizer is profitable for many food crops and cotton, depending on agroecological conditions. All of the cotton VCRs were above 1, and most maize, groundnut, rice, potato, sorghum, soybean and wheat VCRs were well over 2. Areas of Nampula and Cabo Delgado Provinces and parts of Niassa, Tete and Manica Provinces have the most favorable conditions for intensive cotton cultivation. Nampula and Cabo Delgado Provinces and higher-elevation areas of Manica, Zambezia and Tete are best suited to maize production (Mazuze and Geurts 1997).

While the fertilizer response results are encouraging, the profitability estimates should be viewed with caution for two reasons. First, most of the data used in the analysis were from trials conducted under controlled on-station conditions. Actual farmer yields and responses would typically be lower. Second, the fertilizer and crop prices used in the VCR analysis were not adjusted for transportation costs. Because Mozambique's infrastructure is extremely poor, these costs are high and can significantly affect profitability, as the analysis of farm-level returns in the DNER/SG program demonstrates (Section 5).

An alternative measure of response (useful when prices are not known) is the ratio of output response to total kilograms of nutrient. An output/nutrient ratio of 10 is considered favorable for cereals (Yanggen et al. 1998). The output/nutrient ratios for rice, sorghum and maize in Mozambique exceed 10 under many conditions. Results for wheat are mixed. Sorghum and maize had the highest ratios, reaching 50 for maize in Luvisols, and over 20 for sorghum in Luvisols and for maize in Acrisols, Ferralsols and Lixisols (Table 14, Appendix 1).

The results show that fertilizer recommendations and response vary widely even for the same crop, depending on the agroecological zone and soil type. This implies that recommendations should be fine-tuned to the soil type and agroecological zone if farmers are to maximize financial benefits. For example, for the soil types found in the DNER/SG study areas in Manica and Nampula Provinces, N recommendations for maize ranged from 30-100 kg/ha and recommended P ranged from 0 to 60 kg/ha. The actual amounts of N and P applied on DNER/SG plots were 58 and 24 kg/ha in all cases, usually a much lower rate than recommended. An additional 12

[11] The value-cost ratio (VCR) is an indicator of financial viability that shows whether the value of the extra yield obtained through fertilizer use exceeds the cost of the fertilizer treatment. In the literature it is conventional to note that VCRs greater than or equal to 2 indicate that fertilizer application is profitable. This means that the increase in yield attributable to fertilizer must have a value of at least double the cost of the fertilizer used for farmers to consider it profitable.

kilograms per hectare of potassium was applied on the DNER/SG plots, although this was not recommended for any of the crop/soil/agroecological zone combinations.[12]

3.2.3. On-farm Fertilizer Trial Results

World Vision International (WVI) in collaboration with INIA carried out a set of researcher-controlled experiments in 1993/94, 1994/95, and 1995/96 to examine the effects of different combinations of N and P applied to the Manica maize variety. The experiments were conducted at locations in Zambezia, Tete, and Nampula Provinces. The trial results generally confirm the results of the Geurts study, although fertilizer response and yields were lower, and there was considerable variation in yields across locations and years.[13] Fertilizer rates ranged from 0 to 100 N 100 P. The most significant responses came from N and P applied together at the rate of 50N and 50P. Increasing the rate to 100P raised yields in some sites but not significantly. Average fertilizer response in the WVI/INIA trials was 42% in 1993/94 and 1994/95 and 54% in 1995/96, compared to over 100% for the trials reported in Geurts (1997) on similar soils. No significant impact was obtained from adding potassium (WVI undated).

3.3. Use of Improved Seed Varieties

Use of improved varieties of seed differs by farmer category and crop type. Commercial farmers producing maize and vegetables and some smallholder vegetable producers purchase improved varieties annually through formal channels such as Sementes de Moçambique Limitada (SEMOC), the Zimbabwe Seed Co-op, and South African seed companies (Dominguez and Chidiamassamba 1997). Substantial quantities of improved seed for staple food crops such as maize, beans, and cowpea were provided to Mozambican smallholders through an emergency distribution program, *Programa de Emergência de Sementes e Utensílios* (PESU) during the late 1980s and early 1990s (Table 3). These distributions met more than half of the estimated annual seed demand of 18,600 tons for principal food crops in a normal year (Bay and de Sousa 1990). PESU has now ended and up to 80% of the seed used by smallholders is saved from year to year (Dominguez and

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[12] In Mozambique there have been relatively few trials measuring the effect of potassium fertilizer, but in the examples that do exist only rarely was there a statistically significant response. In general a level of potassium greater than .2 mg/100 grams soil is considered to be adequate (Sanchez 1978; cited in Geurts 1997). Soil tests indicate that the level of potassium in Mozambique soil types ranges from .26 (Arenosols) to .98 mg (Acrisols) per 100 grams of soil, well above the required minimum.

[13] In 1993/94, yields of WVI/INIA trials ranged from 3.37 mt/ha (0N 0P) to 4.36 mt/ha (100N 100P) at Morrua, Zambezia Province; .88 mt/ha (0N 0P) to 1.49 mt/ha (100N 100P) at Furandungo (Tete), 1.47 mt/ha (0N 0P) to 2.05 mt/ha (100N 100P) at Nampula and 1.5 mt/ha (0N 0P) to 1.95 mt/ha (100N 100P) at Namapa (Nampula). Soils in these areas are predominantly Lixisols and Luvisols. Maize yields with and without fertilizer reported in Geurts 1997 for Lixisols were 1.3 mt/ha (0N 0P) to 1.8 mt/ha (80N 40P), 1.4 mt/ha (0N 0P) - 3.1 mt/ha (80N 60P), 1.5 mt/ha (0N 0P) - 2.5 mt/ha (50N 20P), 1.8 mt/ha (0N 0P) - 3.6 mt/ha (30N 50P), and 2.2 mt/ha (0N 0P) to 4.2 mt/ha (90N 30P). Results for Luvisols were 1.5 mt/ha (0N 0P) - 4.0 mt/ha (50N) and 5.7 mt/ha (80N 40P) - 6.4 mt/ha (80N 40P).

Chidiamassamba 1997). A large part of the saved seed is descended from improved varieties,[14] but improved seed tends to deteriorate over time if it is not replaced, outcrossing (depending on the reproduction type) with varieties in neighboring fields and/or becoming more vulnerable to disease.

Table 3. PESU Distributions of Seed, All Crops, 1987-92

Year	Seed (MT)
1987	10,278
1988	7,458
1989	9,427
1990	9,942
1991	10,023
1992	18,644

Source: Strachan 1994

The cotton companies are required to provide smallholders with cotton seed free of charge as part of their land concession agreement with the government. Seeds are separated from the cotton fiber during the ginning process, then treated, stored and distributed to farmers before the planting season. Most of these cotton varieties have been circulating in Mozambique for a long time, and research activities are underway to identify new varieties with higher ginning outturn ratios and insect resistance. Improved varieties of cashew have been multiplied and distributed to smallholders in northern Mozambique over the past several years as part of donor-funded programs to rehabilitate the subsector.

3.4. Potential Yield Gains Through the Use of Improved Seed Varieties

Seed variety research and development is carried out principally by INIA, the Faculty of Agronomy of Eduardo Mondlane University, and SEMOC. Several NGOs, including WVI and Food for the Hungry International (FHI), have also conducted variety trials and distributed improved seed as part of post-war rehabilitation efforts. Table 4 summarizes the available evidence on average and potential yields of major crops under research station conditions using improved seed varieties, fertilizer and improved husbandry practices. These results suggest that the use of improved technologies could increase the yields of major crops by 67 - 576%. Yields are typically much lower when improved technology is managed by farmers, however. For

[14] Surveys undertaken by World Vision International in Zambezia Province indicate that the most popular crop varieties included finger millet (100% of recipients saved seed for resowing), sweet potato (81.1%), rice (69.2%), mung bean (66.7%), maize (66.4%), sunflower (61.5%), and cowpea (58.6%). Most distributed varieties combined high yield with earliness and an acceptable taste. Less popular were distributed varieties of sorghum (32.3% of farmers saved seed), millet (48.4%) and groundnut (28.6%) (World Vision International 1996).

example, although the yield potential of improved varieties of maize with fertilizer can exceed 6 tons on research stations, on-farm trials using the same technology achieved yields between 1.5 - 4 mt/ha (WVI undated). A number of Mozambican and imported varieties of maize, cowpea, rice, soybean, bean, groundnut, sorghum, sunflower and wheat have been evaluated by INIA and the National Seed Service and are included in the official list of varieties approved for sale.[15]

Table 4. Average and Potential Yields of Major Crops

Crop	Average yield (mt/ha)	Potential yield (mt/ha)	% change in yield
Maize	0.4 - 1.3	5 - 6.5	576
Sorghum	.3 - .6	.8 - 2	211
Rice	0.5 -1.8	2.5 - 6	270
Beans	0.3 - 0.6	0.5 - 2.5	233
Cassava	4 - 5	5 - 10	67
Cotton	0.3 - 0.6	1.2	167
Cashew	0.1 - 0.2	6	390

Sources: MAP 1997b; World Bank 1996; personal communication, March 1996, Dr. M.V.R. Prasad (African Development Bank Cashew Rehabilitation Project)

3.4.1. Improved Maize Varieties

Improved seed can take two forms, open-pollinated varieties (OPVs) and hybrids. OPVs generate less quickly than hybrids, which must be replaced annually to maintain high yield levels. In most cases hybrids outyield OPVs and tend to be more responsive to fertilizer, but seed production is costly and technically demanding. Large seed companies tend to promote the use of hybrid seed because it must be purchased annually, but it may be too expensive for small farmers to use for less commercialized crops (Rusike, Howard, and Maredia 1997).

Elsewhere in Southern Africa major yield gains have been achieved through the introduction of hybrid maize seed to smallholders. In Zimbabwe and Zambia the introduction of SR-52 and newer hybrids increased yields by 45-164% over local varieties during the 1980s (Rohrbach 1988; Howard 1994). The emphasis on hybrids in these countries was justified in part by the existence of (1) a large group of commercial maize seed growers who could carry out the technically demanding tasks associated with hybrid maize seed production; and (2) a state-subsidized

[15] The national list of approved maize varieties is presented in Table 15, Appendix 1.

marketing and credit system for input distribution that made hybrid maize seeds and fertilizer available to smallholders at the local level.

In Mozambique the focus has instead been the development and dissemination of improved open-pollinated varieties of maize that in general have a lower yield potential but can be replanted for several seasons with little deterioration of varietal characteristics. There are fewer improved maize varieties suited to Mozambican conditions compared to other countries in Southern Africa. This is partly due to the relative youth of the breeding program in Mozambique, but also because much of the past breeding work in the region focused on the development of improved varieties and hybrids for cooler mid-altitude conditions (encompassing the predominant maize-growing areas of South Africa, Zimbabwe, Zambia and Malawi). The high-yielding hybrids developed for Zimbabwe and Zambia perform best at altitudes ranging from 900-1300 meters above sea level, for example. Some agroecological regions in Mozambique lie above 800 meters, e.g., parts of Zone 4 (Manica Province) and Zone 10 (Manica and Nampula Provinces), and farmers there are beginning to plant Zimbabwean and Malawian hybrids, but the majority of Mozambique's maize-growing area lies in the hotter lower altitudes.

Matuba and Manica SR (streak-resistant) are the principal maize varieties recommended by INIA Both varieties were improved by and are produced and sold through SEMOC. Both are open-pollinated: Matuba has a relatively short growing season (100-120 days); Manica's is longer (130-150 days), and both are rated favorably by farmers in terms of taste and milling characteristics. These varieties do well in central and southern Mozambique, but are less well suited to northern Mozambique, which normally has a longer growing season. Obregon (150 days) is recommended for higher altitude areas in northern Mozambique but has not been widely adopted. SEMOC 1 (115-130 days) and Umbeluzi (120-140 days) are additional Mozambican varieties that were distributed as part of PESU relief packages. The DNER/SG program distributed Manica during the 1995/96 and 1996/97 seasons, but used SEMOC 1 in 1997/98 instead, in part a shortened maize growing season was expected as a result of the El Niño phenomenon. More recently SEMOC has released 6 hybrids of varying season lengths for commercial farmers. R201, a Zimbabwean hybrid, has also performed very well in on-farm trials of seed and fertilizer conducted by WVI in Zambezia, Tete and Nampula Provinces, outyielding Manica and Matuba in all locations (WVI undated; SEMOC 1993a, 1994a; República de Moçambique 1995).

4. ORGANIZATION OF THE INPUTS SUBSECTOR AND CONSTRAINTS TO INCREASED INPUT USE

The evidence summarized in the preceding section suggests that there is considerable potential for improving the yields of major crops through the use of inputs such as improved seed and fertilizer. However, the level of input use remains extremely low, especially among smallholders. To what extent does the cost and scarcity of inputs at the local level deter their use by smallholders? In this section we describe how seed, fertilizer and pesticides are produced and distributed in Mozambique and explore key constraints and opportunities for increasing the use of these improved technologies by smallholders.

4.1. Manufacturing, Importation and Distribution of Fertilizer and Pesticide

4.1.1. Fertilizer and Pesticide Manufacture

A fertilizer manufacturing plant (*Empresa Quimica Geral*) was established in Matola in 1966 and produced simple superphosphate, ammonium sulfate and other fertilizers from imported raw materials between 1968-85. Aging equipment and dwindling demand halted fertilizer manufacture in the mid 1980s, but the factory continues to custom-blend 500-600 tons of simple fertilizers annually. The factory's total capacity is 155,000 tons/year, but average production from 1968 to 1983 was less than a third of that[16] (Quimica Geral 1996). Mozambique has deposits of raw materials (an estimated 114 billion cubic meters of natural gas at Pande and phosphate rock with 12% phosphate content at Monapo) that provide a potential source of raw materials for fertilizer manufacture. The economics of developing these resources will need to be analyzed in the light of limited domestic demand in the near future, existing excess fertilizer manufacturing capacity in the region, and the cost of rehabilitating the fertilizer plant, estimated at $10-15 million (Bay and de Sousa 1990; Rusike 1997).

Three private companies, EMOP, Shell, and BASF, each own pesticide formulation facilities in Mozambique. Their combined total capacity is 7700 tons, but national pesticide consumption averaged less than 1000 tons annually in the last decade. Almost all of this is met with finished products imported directly by large companies and through donor aid programs such as KRII.

[16] The factory consists of a plant for sulfuric acid with a capacity of 60,000 tons/year, an ammonium sulfate plant with a capacity of 60,000 tons/year, a superphosphate plant with a capacity of 15,000 tons/year, and a granulated fertilizer plant with a capacity of 20,000 tons/year.

4.1.2. Fertilizer and Pesticide Import and Distribution

Through the 1980s state agencies and commercial firms placed fertilizer and pesticide import orders with one of five international firms represented in Maputo. The parastatal Interquimica then imported all agrochemicals and Boror Commercial, another parastatal, distributed them through a network of retail outlets. Both of these firms have subsequently been privatized and companies are now free to import agrochemicals. The closure of Boror Commercial retail outlets and the scarcity of private retail outlets for agrochemicals outside of Maputo have severely restricted small and medium-scale farmers' access to fertilizer and pesticides. Farmers must now travel to Maputo or the largest regional centers to buy directly from Interquimica or representatives of multinational firms, or procure inputs informally from South Africa and Zimbabwe (Strachan 1994; Bay and de Sousa 1990; Pantazis 1997).

Following input market liberalization, large agricultural enterprises can obtain agrochemicals in several ways. First, they can order through agrochemical companies representing multinational firms (e.g., Agroquímicos, Tecap, Zeneca). These companies currently supply pesticides worth an estimated $3-5 million per year, meeting approximately one-third of total demand. Second, JVCs and other large commercial enterprises can order pesticides directly, accounting for another third of total pesticides used. Third, the Japanese KRII aid program supplies the rest of national pesticide demand and virtually all of the fertilizer used in Mozambique.

4.1.3. The KRII Program

Over the years a number of donors and international organizations, including the European Union, African Development Bank, USAID and ODA have provided inputs for agriculture. The largest such program currently functioning is the Japanese KRII program.[17] Since the program began operating in Mozambique in 1986 it has provided in-kind grants of pesticides, fertilizers and agricultural machinery worth approximately $9 million annually, supplying about half of the total agrochemical needs of the country (Strachan 1994). In most countries where KRII operates the agrochemicals are intended to support food production, and these were the terms under which KRII was approved for Mozambique. By 1989, however, part of the pesticide allotment was being used for cotton production (Strachan 1994; Pantazis 1997).

The KRII program functions as follows: the Mozambican government prepares a list of requested fertilizers, pesticides and equipment (JICA places few restrictions on agrochemicals and equipment that may be ordered through the program). After the Japanese government approves the request, Interquimica prepares an international tender and arranges importation of the products through Japanese trading companies. Pesticides are allocated to specific recipients at the time the order is placed, but Interquimica resells the fertilizer. Part of the equipment imported

[17] The KRII program has operated in 39 Sub-Saharan African countries. Through 1995 total disbursements were approximately $1.5 billion (Inaba 1997).

through the program is designated for government use and the remainder is resold (Strachan 1994; Pantazis 1997).

Recipients of KRII agrochemicals are supposed to pay a countervalue of two-thirds FOB for pesticides and 2/3-100% CIF for fertilizers and equipment into an agricultural development fund. The countervalue is payable up to two years after the goods are received at an interest rate that has been well below the commercial rate in most years. A large part of the countervalue goes uncollected, however. For example, in 1991 the Mozambican government decided that the countervalue would not be collected for pesticides used in smallholder cotton production. This represented an estimated 43% of the total KRII program in 1993 and 30% in 1992. Other recipients of KRII inputs have also been exempted or allowed to pay the countervalue over a long period of time. While the KRII subsidy is intended for smallholders, there is no public reporting of these subsidies and no assurance that the cotton companies or other traders are transmitting the subsidies to their smallholder growers. Instead the subsidy permits cotton companies to set a lower producer price for cotton, thus increasing their profits (Strachan 1994; Fok 1995; Pantazis 1997).

Companies can access KRII agrochemicals in a 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. For example, there is considerable uncertainty about when the agrochemicals will 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 the KRII program imports go unclaimed and are auctioned off by the Mozambican government after one or two years. This provides a second, even cheaper way to get agrochemicals, if users can find what they need.

As a long-term strategy, depending on the KRII program (or any aid program) is risky since the program is renewed on a year-to-year-basis by the Japanese government. Even more important, while the KRII program provides needed supplier credit, the current system of centralized ordering and distribution of KRII inputs is retarding the development of the private input procurement and distribution system in Mozambique.

4.2. Organization of the Seed Subsector

4.2.1. Formal Seed Production

Since the 1970s, efforts to develop the Mozambican seed subsector have focused on the establishment of a formal seed industry similar to those in Western countries. In the late 1970s the Mozambican government initiated the National Seed Program with assistance from FAO and the Scandinavian donors (through MONAP)[18] to support the development of basic seed by INIA and seed multiplication at regional centers in Chokwe, Chimoio and Nampula. Although the project was fully functional by 1980, it was unable to supply all of the country's seed requirements. Between 1982 and 1986 the marketing agency AGRICOM recirculated 2000-5000 metric tons of grain per year as seed to smallholders and private farmers as the war disrupted traditional seed preservation systems (Tesfai 1991; Strachan 1994).

In 1980 the government created a parastatal seed company to coordinate seed production in the country, the *Empresa Nacional de Sementes* (ENS), and in 1982 established a national seed service (SNS) within INIA (with bilateral assistance from Denmark) with responsibility for seed testing and quality control. In 1989 ENS was transformed into a semi-commercial seed company, *Sementes de Moçambique Limitada* (SEMOC).[19] The Swedish International Development Authority (ASDI) provided extensive foreign assistance, including the payment of expatriate salaries for technicians and researchers. The new company produced seed for rice, maize, groundnut, bean, cowpea, soybean, sorghum, sunflower and some vegetables, while cotton seed production remained the responsibility of the state. Production took place initially on centralized seed farms and, beginning in the early 1990s, with contracted seed producers. Processing plants with standardized equipment are located in Maputo, Lionde, Chimoio and Namialo.

SEMOC initially planned to concentrate on multiplication and distribution of varieties developed by INIA, but because INIA had a limited capacity for generating new varieties, SEMOC began varietal testing and other research activities on its own. In the short-run the company was to focus on variety screening of indigenous and introduced material, control of pre-basic and basic seed and utilization of open-pollinated varieties (OPV) instead of hybrids, given the low management level on seed farms and the limited capacity of Mozambican farmers to purchase hybrids each year (Tesfai 1991; Svalöf 1988, 1990; Strachan 1994).

Formal seed production (excluding cotton) increased rapidly from 2000 tons in 1988 and peaked at almost 9000 tons in 1994. Maize seed made up 70% of total seed production and 64% of total sales (SEMOC 1996). The rapid expansion was due almost entirely to the demand for seeds from PESU for distribution through emergency programs. At its height, an estimated 1.2 million families received seeds and tools through the emergency programs (World Bank 1996). In the early 1990s, SEMOC's seed sales for emergency programs represented over 90% of its total business (Strachan 1994). SEMOC marketed the remainder of the seed commercially through various wholesalers such as Boror Commercial, which retailed the seed through their own networks. SEMOC also retailed and sold seed directly to agricultural projects as well as small amounts to customers through its shop in Maputo. Since domestic production was insufficient to meet all emergency needs, SEMOC also became the leading seed importer as well as producer.

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[18] The Nordic countries spent over $21 million to develop the seed industry between 1977 and 1990 (Tesfai 1991).

[19] MAP holds 80% of shares, Svalöf AB (Sweden's largest seed company) 10% and Swedfund 10%.

By the mid 1990s, domestically produced seed constituted 60% of SEMOC's total sales with the remainder imported (SEMOC 1993b, 1994b; Svalöf 1989).

When the emergency programs began to wind down in the mid-1990s, demand for formal sector seed fell sharply. SEMOC sales fell from 14,000 tons in 1993 and 1994 to 9000 tons in 1995. SEMOC's seed production fell to 5335 tons in 1995, far below the installed processing capacity of 18,000 tons/year (SEMOC 1995; MAP 1997b). Because the distribution of emergency seeds was carried out through the Provincial Directorates of Agriculture or directly by NGOs, the commercial infrastructure for the distribution of seeds was almost non-existent in the mid-1990s. Creating a demand for purchased seed among smallholders has been difficult after many years of free seed distribution. To make seeds more accessible to smallholders, SEMOC began packaging seed in 2 kilogram packages beginning in 1988. SEMOC recently expanded its distribution network, opening dedicated stores in several centers (including Beira, Chokwe, Chimoio and Nampula) in addition to organizing a network of agents in most districts (F. Chilenge, personal communication, June 1997).

Per-ton seed prices in Mozambique are comparable or lower than those in neighboring countries, but seed is expensive for Mozambican farmers relative to the output prices they receive. The average ratio of OPV seed to grain price is 4.5 in Sub-Saharan Africa and 5.4 in Southern Africa, compared to 7.1 in Mozambique (CIMMYT 1994).

4.2.2. Informal Channels of Seed Production

Recent seed policies have given more attention to meeting smallholder needs and improving traditional methods of seed selection and conservation. The Agricultural Policy and Implementation Strategy approved in 1995 has four objectives related to seeds, including the expansion of propagation centers for improved roots and tubers, promotion of local seed production by farmers, and dissemination of techniques for the storage and conservation of seeds (Pereira 1997).

Seed production activities by smallholders were severely disrupted by the war. Some observers feared a general loss of genetic variability and deterioration of the capacity to preserve seed of traditional varieties, but a recent study suggests that indigenous knowledge of seed selection and conservation remains intact despite the upheavals of the past few years (MAP 1997b; Domínguez and Chidiamassamba 1997).

Seed conservation methods vary from region to region. Storage chemicals are generally not used. Farmers store seed in containers close to the house, and depending on the area may treat the seed with smoke, ashes or tobacco leaves tied to the mouth of containers, which are then sealed with dried leaves and mud. Laboratory analyses show that the germination rate for seed products stored using traditional methods is very high, especially for maize. Drought and insect attacks are the principal factors affecting informal seed production and storage. In recent years the traditional practice of giving and receiving seeds free of charge has begun to change. It is becoming more common for farmers to exchange seeds for other varieties or crops, or for other products, manual labor or cash (Domínguez and Chidiamassamba 1997).

4.3. Improving Incentives for the Private Sector to Serve Small Farmers

4.3.1. Fertilizer and Pesticides

Agrochemical companies encounter several problems in extending services to smallholders, including (1) the extremely poor state of transport infrastructure, which reduces the profitability of input use; (2) difficulty in obtaining credit at the wholesale and retail levels to procure fertilizers and pesticides, and the lack of farm-level credit programs to help cash-constrained smallholders purchase inputs over time; (3) smallholders' lack of knowledge about improved inputs; (4) the need to train retailers in product application, handling and bookkeeping practices; and (5) regulations that do not have a clear function and increase the cost of doing business.

Reducing Transport Costs: The farm-level cost of inputs is high in Mozambique: the analysis in Section 5 indicates that transport and handling costs between the port and farmgate add 31-64% to the import parity price of fertilizer. A key factor is the poor condition of Mozambique's transportation infrastructure. Only 30% of roads are in good condition, and 15% are not navigable on a regular basis. A major initiative by the Mozambican government and donors, the Roads and Coastal Shipping Project II (ROCs II), represents an important step in improving conditions: roughly half of Mozambique's estimated 43,000 kms of paved, earth/gravel, and feeder roads are scheduled for rehabilitation by the year 2000 (World Bank 1996). Additional investments will be required to assure that upgraded roads are maintained and the remaining portions of the network are improved.

Modifications to the KRII Program: The KRII program represents one approach used by the government and donors to reduce the high cost of inputs at the farm level. KRII has made an important contribution by relieving the credit constraint for agrochemical and other private companies that import fertilizer and pesticides. However, significant changes in its operation are needed if KRII is to contribute to building a sustainable input supply system throughout the country.

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 through the KRII program. The process through which KRII goods are distributed after arrival and rules about the payment of countervalue and other charges are equally unclear. This has led to speculation about graft associated with the program. 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.

To address the transparency problem, we propose three modifications in the way that the KRII program is organized in Mozambique. 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, KRII funds should be used as a source of credit, but the bidding and 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 KRII goods.

Third, upon arrival at port, 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, JICA and private sector 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 DNER/SG demonstration plots and technical 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.

Expanding the Network of Rural Input Dealers: Another important constraint is the lack of trained personnel in rural areas who are can handle products safely, give competent advice about agrochemical use, and maintain bookkeeping records. One innovative NGO program in Zimbabwe has been training rural stockists for the past several years. CARE’s AGENT program works with smallholders to identify trusted village-level stockists, provides them with technical training and guarantees short-term credit. CARE then aggregates orders from field agents and tenders them for bid. Orders are filled and delivered by local suppliers. The stockists sell the inputs to smallholders on a cash basis only. After 6-8 months, stockists graduate from CARE-guaranteed credit to regular supplier lines of credit (M. Mispelaar, personal communication, March 1997). DNER/SG in Manica Province recently began cooperating with the NGO Citizen’s Network to train rural storekeepers in input handling and distribution. It will be important to examine the lessons from the AGENT program and consider incorporating some of the best elements from AGENT into the DNER/SG/Citizen’s Network effort.

Eliminating Administrative Barriers: Over the past several years the Mozambican government has made many changes to facilitate the importation and sale of inputs. The import duty on fertilizer has been lowered from 20% to 2.5%, the tax rate on profits has been reduced, and the circulation tax (a cascading consumption tax) is scheduled to be replaced by VAT in 1998 (Pantazis 1997). Several administrative barriers to market entry remain, however. Retail licenses must be approved by provincial governors and are difficult and time-consuming to obtain. Applicants must pay a fee of US$40 and submit a long list of documents, including a police security check and sometimes a bank account statement showing a specified balance (World Bank 1996; Pantazis 1997). While independent importers are now free to bring in inputs from competing international companies, government regulations currently require independent importers to issue an international tender when the imports exceed a certain amount. The tendering process increases the cost of doing business, and since importers have a business incentive to procure from the least expensive sources, the purpose of the regulation is not clear (Pantazis 1997).

Credit: Lack of credit is widely perceived to be a major constraint to the development of input markets at the wholesale, retail and farm levels. However, the severity of the problem at different levels is not well understood. The discouraging experience with scaled-up credit programs in many Sub-Saharan countries should lead to more study of the problem and careful examination of alternative approaches to increasing credit availability. Several initiatives have recently been proposed in Mozambique. For example, a proposed finance ministry program (FARE) would provide credit guarantees to support the development of small business in agriculture and other sectors. The maximum loan under this initiative is 100 million meticais, payable in 5 years, with an interest rate pegged at 50% of the central bank's discount rate (Pantazis 1997).

4.3.2. Seeds

Thanks to relief programs during the late 1980s and 1990s, many smallholders received improved varieties of seed and continued to plant them in subsequent seasons (WVI 1996). However, serious problems have emerged following the phase-out of relief and rehabilitation schemes. First, SEMOC grew heavily dependent on the relief schemes as a means to distribute its products to rural areas. Now that the schemes have ended, SEMOC faces the expense of building a network of retail distributors in the rural areas from the ground up. Second, farmers grew used to the distribution of free seed and are now reluctant to buy SEMOC seeds because they perceive the prices to be very high. As a result, farmers are planting either deteriorating improved varieties or returning to established but lower yielding local varieties instead of purchasing seed through the formal sector.

Though improved varieties of seed are available through INIA and SEMOC, in Mozambique and other countries in Southern Africa adoption by smallholders has been linked to subsidized or free distribution of seed (Rusike, Howard, and Maredia 1997). In other countries, too, support to the seed system has up to now focused on development of the large centralized seed organizations. Only recently, as economic reforms eliminate subsidies that sustained production and distribution of seeds by large parastatals, have countries and donors become aware of the importance of developing other parts of the seed system (e.g., farm-level seed production and production by small businesses) in order to increase the flow of higher-yielding new varieties to smallholders.

It is useful to compare what is happening in Mozambique's seed sector with recent seed sector developments in Mozambique's western neighbors, Zambia and Zimbabwe. In those countries a tri-level seed system is emerging, roughly based on the biological and technical production features of a crop (e.g., reproductive characteristics, sowing rate, multiplication rates, rate of varietal deterioration) that affect seed profitability. At the first level, the large centralized private seed companies (including international firms such as Pioneer and Pannar) and former parastatals[20] are specializing in seed sectors with high profit margins and high and regular annual seed sales such as hybrid maize, sunflower, and hybrid sorghum. These companies have the financial and technical resources to carry out their own private research and extension programs. The research and varieties developed are targeted to high potential areas and to crops such as maize that have high multiplication rates. These seed commodities are less costly to manage because fewer multiplications are required and there are smaller quantities to process, store, transport and distribute at each stage (Rusike, Howard, and Maredia 1997).

At the second tier, emerging domestic seed companies and commercially-oriented NGOs are beginning to test varieties, train local seed producers, and develop niche markets for open-pollinated varieties of maize, sorghum, and groundnut seed, where financial returns to research and development have been too low to attract the large seed firms. In the third tier are NGOs and farmer organizations that undertake village-level varietal screening, seed production and germplasm conservation on subsistence crops. Bulky seed crops such as groundnuts and legumes are more amenable to production by localized seed companies, NGOs and farmer associations in tiers 2 and 3 that can minimize transport costs at each stage (Rusike, Howard, and Maredia 1997).

Unlike Zimbabwe and Zambia, SEMOC faces a disadvantage in not having a large group of commercial farmers in the country who are already using hybrid maize seed. In other countries in the region, hybrid maize has served as the flagship seed commodity. Hybrid maize represented 70-90% of the total volume of sales and 60% of revenue for Zamseed in the late 1980s (Howard 1994). To ensure Zamseed's viability, Zamseed and its technical advisers at Svalöf pushed for the development of hybrids, for which new seed would be purchased each year, rather than open-pollinated varieties whose seed could be saved and replanted as has been the emphasis at SEMOC (Howard 1994).

The bulk of SEMOC's seed sales and seed demand in the country are for maize, rice, and legumes such as cowpea and bean. SEMOC has developed some maize hybrids and can continue to develop this market, especially among large commercial farms who grow maize in rotation with cotton and small and medium farmers in mid-altitude regions who are already familiar with

[20] ZAMSEED in Zambia is now being privatized, but began as a parastatal similar to SEMOC with technical assistance from Svalöf financed by Swedish aid.

Zimbabwean and Malawian maize hybrids. It can also play a role in sourcing varieties and seeds for specialty crops that commercial farms are interested in, e.g., vegetables, special varieties of groundnuts, pigeon peas.

In the near future, however, the bulk of the seed market will be for seeds that can be replanted for several seasons and need to be renewed only periodically, not every year. This suggests that the development path for SEMOC will differ from its counterpart large seed organizations in other countries. Because of its research and varietal testing capability for a wide range of crops and links with external public and private seed organizations, SEMOC (together with INIA, DNER and the public seed organizations) can play a unique and important role in the development of a multi-tiered seed sector in Mozambique that can better serve the needs of smallholders. While some of these activities can be supported through commercial activities, others will require additional support from the government and/or donors.

What kind of support is needed to develop a broader-based seed sector and increase demand for higher-yielding varieties of seed? First, smallholder adoption of improved seed is constrained by the lack of information about the benefits of using improved technology. Underlying effective dissemination of information is the continuing need to maintain core research and extension services for commodities and marginal areas that are unlikely to be serviced by the for-profit private sector in the near future, including open pollinated maize, bean, sorghum and groundnut. These services can be provided directly by the public sector or contracted by the government to the private sector. SEMOC and INIA have information about the adaptability of varieties to different agroecological zones in the country and could work with agrochemical companies, DNER and NGOs to set up demonstrations with farmers similar to the DNER/SG program that show the benefits of using technology packages including improved seed, fertilizer and pesticides.

Second, 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) provide links to NARS and international research centers to get information and seed of appropriate varieties; (2) train and supervise farmers in seed production, selection, storage and marketing; (3) provide basic training on seeds and bookkeeping to rural shopkeepers; and (4) screen rural shopkeepers for creditworthiness, provide working capital for input stocks and aggregate orders to be filled from other input supply companies. As part of (2), finance could be made available to enable commodity traders to set up seed outgrower schemes under which traders would supply improved seed, other inputs, extension advice and supervision to farmer associations. Farmers could repay the inputs with a specified amount of seed grain at harvest time and retain the option of selling the crop to the trader or on the open market.

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

Fourth, increasing the demand for improved varieties by smallholders ultimately depends on expanding the post-harvest market for commodities traditionally produced by smallholders such as sorghum, groundnuts and pearl millet. For example, small-scale millers in Zimbabwe are experimenting with the production of ready-processed sorghum and millet weaning foods. Millers, stockfeed and beer industries might be given incentives such as preferential financing to access grains from the smallholder sector and develop domestic and international markets for new products.

Fifth, public sector seed regulations and functions need to be rationalized. We recommend that the Mozambican government facilitate the development of a two-tier multiplication and distribution system. At the first level, foundation seed would be multiplied to certified seed under the stringent and highly controlled conditions currently required by seed authorities and made available for direct sale. At the second level, seed from the first level would be bulked by individual farmers and farmer groups in local villages under inspection by extension workers and marketed as standard seed. Removing compulsory seed certification and restrictive trade licensing requirements will permit formal production of quality open pollinated maize, bean, sorghum, and groundnut seed by smallholders and sale among neighboring farmers. In addition, seed companies will be able to involve smallholders in contract seed production more easily.

5. OPPORTUNITIES AND CONSTRAINTS TO IMPROVED TECHNOLOGY USE AT THE FARM LEVEL: DNER/SG CASE STUDY

5.1. The DNER/SG Program in Mozambique

The DNER/SG pilot project represents one of several efforts by the *Direcção Nacional de Extensão Rural* to encourage intensification in Mozambique's most productive regions.[21] The program began operating during the 1995/96 cropping season with selected farmers[22] in high-potential areas of Manica and Nampula Provinces (Figure 2). DNER/SG operates in four different agroecological regions (Regions 4, 7, 8, and 10 -- see Figure 1), which are described in Table 5. Farmers participating in the DNER/SG program received a package of maize inputs on credit for use on a half hectare of their land. The 1996/97 package (the season in which the assessment was carried out) consisted of 15 kg of Manica SR improved open-pollinated maize, 50 kg each of 12-24-12 NPK and urea fertilizers, and actellic, a post-harvest storage insecticide. The composite fertilizer was applied at planting and urea was top dressed at two leaves of age. Improved practices included planting in rows and increased planting density (50,000 plants/ha).

DNER/SG organized a network of shopkeepers and a credit system to channel inputs to participating farmers. Farmers received credit in-kind (fertilizer and seeds) at a flat interest rate of 25%. Credit was available to rural shopkeepers only through the DNER/SG program. DNER/SG procured and delivered inputs to these shopkeepers, who were responsible for delivering inputs to farmers under a contract agreement that established a credit repayment schedule.

5.2. Objectives and Methods

Our overall objective was to evaluate the financial and economic profitability of the DNER/SG technology package in Nampula and Manica Provinces during the 1996/97 cropping cycle. Specific objectives included describing how the input package was used and what results were obtained, developing enterprise budgets to show returns per hectare and returns to family and non-family labor by yield tercile; and quantitative analysis of the effect of selected agronomic practices on farmer yield.

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[21] Other efforts include DNER's basic approach of extending improved seed and practices (without fertilizer) to participating farmers and the EC-funded Special Program to intensify production in selected areas of Manica and Nampula provinces.

[22] To ensure the best possible demonstration of the technology, DNER/SG chose farmers who had already worked for several years with extension agents. Extension agents also visited farmers during the season to supervise land preparation, planting, fertilizer applications, weeding and pest control.

Figure 2. Survey Sites

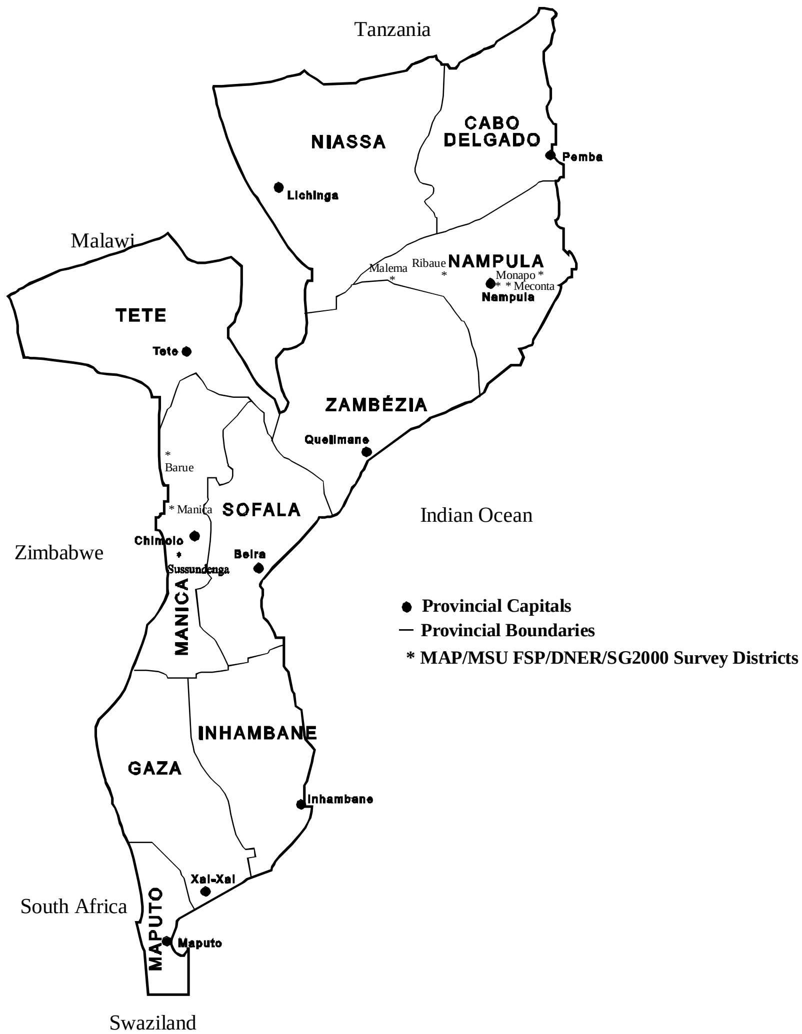

Table 5. Characteristics of Agroecological Regions Included in the 1996/97 DNER/SG Survey

	Region 4	Region 7	Region 8	Region 10
Location	Central and eastern parts of Sussundenga, Manica and Barue Districts, Manica Province	Ribaué District, Nampula Province	Monapo and Meconta Districts, Nampula Province	Western Manica Province; Malema District, Nampula Province
Altitude	200-1,000 meters	200-1,000 meters	coastal	> 1,000 meters
Avg. rainfall	1,000-1,200 mm	1,000-1,400 mm	800-1,200 mm	> 1,200 mm
Avg. temperature during cropping season	17.5-22.5°C	20-25°C	>25°C	15-22.5°C
Soils	Light, some areas of heavy soil	Sandy to heavier clay	Sandy, heavier soils in low-lying areas	Heavy
Dominant crops	Maize, sorghum, cassava,cowpea, cotton	Maize, sorghum, cassava, cowpea, groundnut, cotton	Cassava, maize	Maize

Source: MAP 1996

Sampling: We collected data for the study in a single visit during May-June 1997 (at or immediately following harvest). All participating DNER/SG farmers in Manica (115 farmers) and Nampula (108 farmers) were interviewed using a structured questionnaire, for a grand total of 223 interviews. The questionnaire is included as Appendix 2.

Questionnaire: The questionnaire included sections on the demography of the participating household; characteristics of the DNER/SG maize field and maize production harvested by the time of the interview; timing of each operation conducted on the field; amount and type of labor used in each activity; amount, cost and sources of inputs used on the field; questions asking the farmer to compare various characteristics of the improved seed with traditional varieties; and plans for future use of inputs and participation in the DNER/SG program.

Yield Estimates: We collected two types of yield estimates, farmer recall and crop cuts. We asked farmers to estimate total maize production from their DNER/SG. For the crop cuts, we trained enumerators to randomly select two 7 x 7 meter square areas in each field using a standard FAO technique. From these cuts, the enumerators counted the plants and ears, weighed the shelled grain, and measured the moisture content of the grain. We calculated the yield based on this 98 square meter sample plot, converting the production to a dry-grain equivalent per hectare.

In this case we considered the crop cut yield to be a better predictor of yield than the farmer estimate, for two reasons[23]. First, farmers may have had difficulty estimating production before harvest was complete (in many cases farmers were interviewed prior to the completion of harvest). Second, since farmers associated the enumerators/extension agents with DNER/SG, there may have been an incentive to underreport yields if farmers thought it might lead to partial forgiveness of the input loan.

In practice it was not possible to obtain crop cut data on all fields. After cleaning, 147 data points (with crop cut yields) were included in the crop budget and regression analyses, out of a total of 223 farmers interviewed.

5.3. Characteristics of Survey Participants

Table 6 presents some general characteristics of DNER/SG farmers participating in the case study. Most farmers were newcomers to the DNER/SG program: only 5% had participated in the DNER/SG program during the previous season (1995/96), all of these in Regions 4 and 8. Household heads in the sample had 3.8 years of formal education on average.[24] The mean family size was 6.9 members, but differed significantly across regions. Regions 7 and 8 had smaller households (5.4 and 5.6 members, respectively); households in Regions 4 and 10 were larger (7.6 and 8 members).[25]

Except in Region 10, few of the sample households had recent experience with fertilizer. Only 6.5% of sample farmers (11% in Region 10) had used fertilizer the previous season on the plot where DNER/SG inputs were used in 96/97. Comparatively more farmers have used improved varieties of seed, probably because the PESU program distributed improved seed to farmers during the late 1980s and early 1990s as part of rehabilitation efforts. One-quarter of farmers in the sample reported planting new or recycled improved seed varieties in 1996/97; almost half of farmers in Region 10 (nearly all from districts of Manica Province that border Zimbabwe) had used improved varieties.

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[23] The correlation between farmer-reported yield and crop cut yields was surprisingly low. Even after the data were cleaned and villages where enumerator error was suspected were removed, the correlation factor was only .578. Farmer estimates were much lower than crop cut yields, even after adjusting for the possibility that crop cut yields sometimes overestimate yields by as much as 20% (although this is less likely with such a large sample plot size, and crop cut results in Mozambique do not appear excessive compared to other estimates of farmer yields using improved maize technology).

[24] This suggests that DNER/SG program participants are better educated than average farmers: the World Bank estimates that only 33% of adults in rural and urban areas are literate (1996).

[25] These estimates are comparable to findings of the TIA 1996/97 survey carried out by the Ministry of Agriculture, which estimated average family size as 4.7 and 6.4 persons in Nampula (R7, R8, part of R10) and Manica Provinces (R4, part of R10), respectively.

Table 6. Characteristics of DNER/SG Case Study Participants by Region

	R4 (East/Central Manica Province)	R7 (Ribaue, Nampula Province)	R8 (Monapo/ Meconta, Nampula Province)	R10 (Western Manica Prov. and Malema, Nampula Prov.)	
	Total	Total	Total	Total	Grand Total
Participated in DNER/SG program 95/96 (%)	10.0	0.0	10.0	0.0	4.5
(n)	60.0	45.0	40.0	78.0	223.0
Years of education (household head, mean)	3.8	3.4	4.1	3.8	3.8
Family size (mean)	7.6	5.4	5.6	8.0	6.9
Used chemical fertilizer in 95/96 on site of current DNER/SG plot	5.1	0.0	7.7	10.8	6.5
(n)	51.0	45.0	39.0	74.0	217.0
Planted new or recycled improved maize seed variety 96/97	15.0	0.0	0.0	46.3	25.0
(n)	60.0	32.0	14.0	82.0	188.0

Source: DNER/ SG Survey

5.4. Yields: Descriptive and Econometric Results

5.4.1. Yield by Agroecological Zones

Maize yields on DNER/SG fields for 1996/97 are reported in Table 7 by yield tercile and overall mean, together with means for Nampula and Manica Provinces for several years. Mean yields on the DNER/SG fields were variable (.5 - 4.9 tons/ha, sample mean 2.3 tons/ha) but they were much higher than mean yields for Nampula and Manica Provinces (.4-1.3 tons/ha) under low input conditions in various years. The DNER/SG 1996/97 yields were slightly higher than those obtained under high-input regimes in neighboring Cabo Delgado Province in 1994/95 (2.0 tons/ha), but lower than yields reported by DNER/SG in 1995/96 of 4.6 tons/ha (DNER 1996).

Table 7. **Maize Yields on DNER/SG Fields and Comparisons**

	Zones	Tercile Yields (tons/ha) 1	2	3	Average
DNER/SG 1996/97	East/Central Manica Prov.(R4)	.9	2.1	3.4	2.2
	Ribaue, Nampula Prov. (R7)	.5	.7	1.4	.8
	Monapo/ Meconta, Nampula Prov.(R8)	1.2	2.5	3.8	2.5
	Western Manica Prov. (R10)	1.2	2.6	3.8	2.5
	Malema, Nampula Prov. (R10)	1.3	2.9	4.9	3.0
	Total				2.3
DNER/SG 1995/96, Manica and Nampula Provinces					4.6
Mean Nampula Province		NA	NA	NA	1996/97:1.0 1995/96: .9 1994/95: .8
Mean Manica Province		NA	NA	NA	1996/97:1.3 1995/96:1.2 1994/95: .6
High-input, Cabo Delgado Prov. (1994/95)		.9	1.9	3.2	2.0
Mean Monapo/ Meconta District (1994/95)		.2	.3-.4	.6-.9	.4

Sources: (1) DNER/SG fields from survey data and DNER 1996; (2) means for Nampula and Manica provinces from Early Warning Unit, Ministry of Agriculture and Fisheries; (3) Cabo Delgado (Montepuez District) and Monapo/Meconta results for 1994/95 from Strasberg (1997)
Cabo Delgado "high-input" results are from the Lomaco PUPI scheme

5.4.2. Yield Determinants Results

To analyze the factors associated with the observed variability in maize yields on DNER/SG plots, we estimated a Cobb-Douglass production function using field-level data. The model was of the following form:

ln (YIELD) = F (ln (LABOR DAYS), WEEK, ln (PLANT DENSITY), REGION, WEATHER)[26]

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

Table 8 reports means and standard deviation of all variables used in the model and Table 9 reports model results.

[26] Respondents provided unstructured responses to the question, "What weather, programmatic or pest factors positively or negatively affected your production this year on your DNER/SG maize plot?" During the modeling phase of this research, we began by including each of these factors -- weather, program or pests -- as independent dichotomous variables. We used a stepwise procedure to eliminate each variable if it was not statistically significant. WEATHER remained in the model as the only one of these three variables that was (nearly) statistically significant. It should be noted that the results change very little when WEATHER is excluded.

Table 8. Mean and Standard Deviation of Variables in Maize Yield Model

Variable	Mean	Std. Dev.
YIELD	2,307	1,311
LABOR DAYS	106	63
WEEK	7.7	2.7
PLANT DENSITY	35,659	8,805
REGION 4	31 percent = 1	
REGION 7	11 percent = 1	
REGION 8	17 percent = 1	

Source: DNER/SG Survey

Table 9. Results of Maize Yield Determinants Model

Variable	Coefficient	S.E.	P-value
ln (LABOR DAYS)	0.194	0.093	0.04
WEEK	-0.002	0.028	0.41
ln (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(YIELD)
N=143
Adjusted R-sq = 0.262
F-stat = 5.4, Significance = 0.00
Source: DNER/SG Survey

5.4.3. Interpretation of Econometric Results

Key findings from the econometric model include:

Planting density had a positive and significant effect on yield. This suggests that yields could be increased, *ceteris paribus,* by increasing planting density from the observed mean of 35,659 plants/ha. As mentioned earlier in this chapter, the recommended density is 50,000 plants/ha.

Previous on-farm productivity research in the same region of Mozambique showed that labor availability at peak weeding periods was a key determinant of productivity (Strasberg 1997). The positive and significant coefficient found on the LABOR variable suggests that **labor availability -- possibly at such peak times as weeding -- represents a production constraint for some households.** It may be important to consider practical ways for participating households to ease this constraint. Possible alternatives include increasing the use of family or hired labor or adopting herbicide.[27] The results also show the marginal productivity of a labor day (at mean labor application rates) are equal to 6.3 kgs (Region 8), 4.4 kgs (Region 10), 3.8 kgs (Region 4) and 1.8 kgs (Region 7) of maize.

5.4.4. Other Factors Affecting Production in 1996/97

Actual production in the DNER/SG plots was much lower than results reported for the DNER/SG program in 1995/96, which ranged from an average of 3.6 tons/ha in Sussundenga (Manica Province) to 5.7 tons/ha in Meconta-Ratane (Nampula Province) (DNER 1996). Comments by sample farmers provide additional insights about natural factors affecting production on DNER/SG plots during the 1996/97 season (Table 10). 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.

Successful program implementation, including timely delivery of inputs and extension assistance, is also critical to achieving targeted yield levels among participating farmers. During the survey participants were asked open-ended questions about possible problems related to program implementation. Table 11 presents the responses to these questions by district. It is worth noting, given the young nature of the program, that 74% of households overall cited no particular implementation problem. Of the remaining 26% of participants, the most significant complaint about 1996/97 program implementation was that seed and fertilizer arrived late, forcing farmers to plant later than they would have liked. This problem appears to have been particularly concentrated in Ribaue District in Nampula, and Barue and Sussendenga Districts of Manica where more than 35% of households noted late input delivery as a concern.

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[27] The use of herbicide on fertilized maize was found to be an important feature of the Montepuez high-input maize scheme. For further details, see Strasberg (1997).

Among the two other types of implementation problems cited by participants, poor seed quality and lack of and/or improper extension advice were the most frequent problems. Poor seed quality was an important issue for 16% of Sussendenga participants. Fourteen percent of Monapo/Meconta participants felt that they received inadequate extension service; this problem was mentioned by fewer farmers elsewhere.

Table 10. Proportion of Participating Households Reporting Natural Factors Affecting Crop Yield

	Natural Factors		
Province/ District	Abnormal Rainfall / Weather	Pests	Soil Quality / Soil Erosion
Manica Province	— percentage of households reporting a problem this year —		
Manica	44	7	0
Barue	48	24	0
Sussundenga	60	14	5
Nampula Province			
Monapo/Meconta	40	11	0
Ribaue	36	2	0
Malema	65	74	0
Total	47	17	1

5.5. Financial and Economic Analysis of the DNER/SG Technology Package

Table 12 presents key results from the financial and economic analysis by region. The complete financial and economic budgets can be found in Appendix 3, Tables 16 through 18. The financial attractiveness of a given production technology depends on the physical response of the crop to the technology, the cost of obtaining that physical response, and on the prices received when the crop is sold or the opportunity cost of home consumption. The crop's physical response and the cost of obtaining it are (in turn) partly a function of the way in which a farmer applies the technology, i.e., the timing and intensity of field activities. In practice, any technology is affected by variation in all of these dimensions. Farmer understanding of, commitment to, and ability to apply a technology can vary a great deal. Problems with input availability may alter the

Table 11. Proportion of Participating Households Reporting Program-Related Factors Affecting Crop Yield

Province/ District	No Problem Reported	Program Factors: Late Input Arrival	Poor Seed Quality	Lack of / or Improper Extension Advice
		— percent of households reporting —		
Manica Province				
Manica	95	0	2	5
Barue	65	35	0	0
Sussundenga	58	40	16	0
Nampula Province				
Monapo/Meconta	74	17	0	14
Ribaue	64	36	0	2
Malema	78	13	0	9
Total	74	22	4	5

timing of certain activities or even the ability to carry them out. Agroecological conditions, and prices that farmers receive can vary significantly over time and space. In assessing the financial attractiveness of a technology, then, the analyst must reflect the key dimensions of variation that will affect outcome.

With this in mind, enterprise budgets were constructed based on yield terciles and for varying price levels (Table 12). Two measures of outcome are reported for each yield tercile and price level: net returns in meticais[28] per hectare and net returns per day of family and mutual labor applied to the crop. This latter measure can be compared to opportunity costs of labor in the study areas to assess the relative attractiveness of the technology under varying yield and price levels. All field level data came from the DNER/SG survey described in this paper. Prices came from the *Sistema de Informação de Mercados Agrícolas* (SIMA) of MAP's Directorate of Economics. Because farmgate prices were not available, average prices paid to producers in the main district markets were used.

[28] 11,500 meticais=$1.

Table 12. Summary of Results -- Financial and Economic Analyses of 1996-97 DNER/SG Maize Technology Package, by Region and Yield Tercile

	Study Zone														
	Region 4 (East/Central Manica Province)			Region 7 (Ribaue, Nampula Province)			Region 8 (Monapo/Meconta, Nampula Prov.)			Region 10 (Western Manica Province)			Region 10 (Malema, Nampula Province)		
	Maize Yield Tercile														
Budget Item	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
YIELD (mt/ha) [a]	0.9	2.1	3.4	0.5	0.7	1.4	1.2	2.5	3.8	1.2	2.6	3.8	1.3	2.9	4.9
TOTAL FAMILY/MUTUAL LABOR DAYS															
(adult equiv. days/ha)	77	124	102	80	73	105	81	47	73	97	109	132	67	110	88
N used in calculations	14	15	15	5	6	5	8	8	8	12	13	13	7	7	7
FINANCIAL ANALYSIS															
a. Net Income [b] ('0000 meticais/ha)															
June 97 Price	(137.7)	(34.5)	37.5	(90.7)	(77.9)	(44.1)	(44.8)	31.7	124.6	(118.7)	(39.0)	42.2	(40.3)	54.8	169.4
Dec 97 Price	(22.6)	272.9	545.5	(77.1)	(52.9)	21.0	(24.1)	86.7	215.8	51.0	341.1	609.3	16.5	204.8	430.7
Jul-Dec 97 Price	(90.4)	98.1	259.1	(94.6)	(79.7)	(38.7)	(50.8)	28.4	124.2	(47.3)	125.8	289.9	(36.4)	75.4	210.1
b. Net Income per Family and Mutual Labor Day ('0000 meticais/ha) [c]															
June 97 Price	(1.8)	(0.3)	0.4	(1.1)	(1.1)	(0.4)	(0.6)	0.7	1.7	(1.2)	(0.4)	0.3	(0.6)	0.5	1.9
Dec 97 Price	(0.3)	2.2	5.4	(1.0)	(0.7)	0.2	(0.3)	1.9	3.0	0.5	3.1	4.6	0.3	1.9	4.9
Jul-Dec 97 Price	(1.2)	0.8	2.5	(1.2)	(1.1)	(0.4)	(0.6)	0.6	1.7	(0.5)	1.2	2.2	(0.5)	0.7	2.4
Median wage rate per 8 hour day ('0000 meticais)	2.0	2.0	2.0	1.0	1.0	1.0	1.6	1.6	1.6	1.2	1.2	1.2	0.6	0.6	0.6
ECONOMIC ANALYSIS															
a. Maize Deficit in Southern Africa															
NET INCOME ('0000 meticais/ha)															
HTC [d]	(121.5)	12.0	186.8	(157.8)	(146.7)	(148.1)	(158.8)	(91.5)	(57.7)	(64.6)	92.7	236.1	(106.2)	(67.6)	0.4
LTC [e]	(95.5)	68.6	275.3	(115.2)	(91.4)	(48.3)	(68.6)	77.2	193.6	(29.9)	160.8	333.9	(15.7)	126.8	318.6
Export to Malawi	(not a viable option at this time)			(87.1)	(51.2)	34.2	4.7	225.1	419.8	(not a viable option at this time)			58.0	299.1	608.3
b. Maize Surplus in Southern Africa															
NET INCOME ('0000 meticais/ha)															
HTC	(161.9)	(87.2)	26.1	(180.3)	(178.8)	(214.0)	(217.3)	(209.5)	(238.2)	(121.7)	(28.8)	57.4	(165.1)	(205.1)	(230.8)
LTC	(135.9)	(30.7)	114.6	(137.7)	(123.5)	(114.2)	(127.1)	(40.8)	13.1	(87.0)	39.3	155.2	(74.5)	(10.7)	87.4
Export to Int'l Mkt	(not a viable option at this time)			(128.7)	(110.7)	(87.9)	(103.8)	62.8	85.1	(not a viable option at this time)			(51.0)	44.2	179. 65

Source: Field data from DNER/SG Survey

Notes to Table 12
[a] Estimated from crop cuts. Assumes storage losses of 1% per month
[b] Gross revenue - (cash costs + interest + purchased labor)
[c] Net income/adult equivalent family + mutual labor days
[d] Long distance road haulage cost is estimated at USD 0.05/ton/km (Coulter 1995)
[e] Long distance road haulage cost is estimated at USD 0.03/ton/km (Coulter 1995)

Interest rates, and the cost of fertilizer and seed, were fixed for DNER/SG participants (though package costs were higher in Manica Province than Nampula- see Table 12). Other inputs such as animal traction, tractor services, and family and hired labor varied and were valued at the actual cost incurred by the farmers. We used three levels of output prices in the budget: average June 1997 (immediately after harvest), average December 1997, and average July-December 1997.

5.5.1. Financial Budget Results by Agroecological Zone, Yield Tercile and Price Level

Gains from Storage: We calculated income and cost streams for three different scenarios, when the farmer sells maize (a) in June, immediately following harvest; (b) in December, 6 months after harvest; and (c) midway between July and December. December and mean July-December yields were adjusted for storage losses estimated at 1% per month. Estimates of gross revenue (GR) were obtained by multiplying yield by price. The December and July-December average GR estimates were adjusted to account for the compounded earnings foregone by storing maize rather than selling it in June.

Because of a sharp rise in maize prices between June and December, farmers in some regions more than doubled gross revenues by storing maize for later sale instead of selling immediately after harvest. Gains were highest in Manica Province survey areas closest to Maputo, the main consumption center (Region 4 and part of Region 10), with 105% and 165% gains in GR between June and December, respectively. Gross revenues in Regions 7 and 8 climbed by 84% and 69% in the same period. Though farmers can normally expect the maize price to increase in this period, prices may not rise so steeply every year. For example, in Manica Province the retail price of maize rose by 310%, 200%, and 214% between June and December in 1994, 1995 and 1997, respectively, but in 1993 and 1996 the price rises were only 25% and 16% (SIMA 1998).

High Cost of Fertilizer and Seed: Production costs included in the enterprise budget were the costs of the fertilizer and seed package, animal traction, tractor services, interest on the input package, and purchased labor. All of the costs were relatively minor except for the fertilizer and seed package. With interest, fertilizer and seed costs made up 83-94% of total cash expenditures related to production. Region 7 and 8 farmers were able to negotiate a lower price for the fertilizer and seed package with DNER/SG than farmers in other regions. Under competitive conditions, however, input costs in Regions 7 and 8 are likely to be higher than in Regions 4 and 10, which are closer to the main ports of Maputo and Beira and consequently have lower transportation costs.

The cost of the fertilizer and seed package (including interest) was also high in relation to the cost paid by Ethiopian SG participants who used a similar package of inputs on maize during the 1997 season (25 kg hybrid seed, 100 kg DAP, 100 kg urea per hectare). Like Mozambique, Ethiopia has poor infrastructure and imported fertilizer must be transported over long distances to reach participating farmers. The dollar equivalent of the Ethiopian fertilizer and seed package was $94 per hectare, compared to $104 per hectare for Mozambican farmers in Nampula Province (Regions 7,8, part of Region 10) and $135 per hectare in Manica Province (Region 4, part of Region 10).

Variability of Net Income: We calculated the net income per hectare by subtracting cash costs, interest, and wage labor payments from gross revenue realized when farmers sell (alternatively) in June, December, and midway between July and December. Storing maize for several months instead of selling immediately after harvest dramatically affected farmer gains. Table 13 shows the proportion of farmers in the sample and within each region who profited or lost when they sold maize in different periods. When farmers sold in June, only 36% of sample farmers made a profit; the remainder lost money. At the December price, by contrast, 80% of farmers in the sample profited and 20% lost money. Of farmers who sold midway between July and December, 62% gained and 38% lost. The proportion of gainers and losers varied considerably by region and period. All of the Region 7 farmers who sold in June lost money; 25% turned a profit if they waited until December to sell. In Region 4, 27% of farmers made a profit at June prices, and 89% took a profit at December prices.

Table 13. Break-Even Analysis

Break-Even Analysis [a]	Region 4	Region 7	Region 8	Region 10	Total
June price					
Net income/ha >0 (%)	27	0	58	44	36
Net income/ha <0 (%)	73	100	42	56	64
December price					
Net income/ha >0 (%)	89	25	79	88	80
Net income/ha <0 (%)	11	75	21	12	20
July-December avg. price					
Net income/ha >0 (%)	64	6	63	75	62
Net income/ha <0 (%)	36	94	38	25	39

[a] assumes storage losses of 1% per month
Source: Field data from DNER/SG survey; prices from SIMA Market Information System

Net income per labor day was calculated by dividing net income per hectare by the total number of days worked by family members and friends and relatives who assisted with farm activities in exchange for similar help on their own plots (Table 12). These results can be compared to the prevailing wage rate[29] in the study areas to assess the relative attractiveness of the technology under various yield and price levels. Estimated wage rates vary from 6000 meticais/day in Malema District, Nampula Province to 20,000 meticais per day in East/Central Manica Province.

When maize was sold at June prices, net income per labor day was lower than the prevailing wage rate in all regions, ranging from an average loss of 8400 mt per day in Region 7 (Nampula Province) to a gain of 5500 mt per day in Region 8 (Nampula Province). If farmers sold midway between July and December, net income per labor day was higher but still below the estimated wage rate in all regions. Net income per day varied from a loss of 8400 mt per day in Region 7 (Nampula) to an 11,300 mt gain in Region 10 (Nampula and Manica Provinces). At December prices, farmers still realized average losses of 4400 mt/day in Region 7. Returns were slightly lower than the estimated wage rate in Region 8 (13,900 mt), but exceeded the wage rate elsewhere: 26,700 mt in Region 4 and 29,700 mt in Region 10.

5.5.2. Economic Budget Results by Region and Yield Tercile

The financial analysis in the preceding section showed the profitability of the DNER/SG package to farmers in 1996/97. Economic analysis shows the costs and returns to society as a whole, using international maize, fertilizer, and seed prices. This type of analysis is important because the elimination of domestic price controls on most commodities and the increasingly free flow of goods across international borders mean that in the future Mozambican farmers will compete with other producers in Southern Africa and the world to supply both domestic and international consumers. The economic analysis will help answer these questions: (a) How profitable is intensified maize production in different regions when farmers face international instead of domestic prices? (b) How will profitability be affected in years when Southern Africa has a maize surplus compared to deficit years? (c) How will profitability be affected when farmers face full international market prices for fertilizer and seed (as well as other inputs) instead of prices that are subsidized or taxed by projects or the government?[30]

We estimated farm-level prices and profitability for two scenarios, the contrasting conditions of maize deficit and surplus in the Southern Africa region. Details of the calculations of import and export parity prices for maize, import parity prices for fertilizer, and economic prices for improved seed can be found in Appendix 4. In essence, the farm-level price calculations estimate the maximum price which, if paid to farmers in the different regions, would be comparable to the full cost of maize imported from either the United States (in the case of a Southern Africa maize deficit) or from South Africa (if there is a regional maize surplus).

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[29] The estimated wage rate is based on DNER/SG Survey data.

[30] This analysis draws heavily on a 1995 study of economic efficiency and market pricing in Mozambique (Coulter 1995). For the DNER/SG case study, a few prices have been updated but most of the assumptions of transportation, handling and marketing costs used by Coulter have been retained. For details of the analysis see Appendix 4.

Deficit Year: When Southern Africa has a maize deficit, Mozambican farmers compete with U.S. or other world maize producers to supply the large Maputo consumer market and other consumers in the region. The main results of the analysis for the maize deficit scenario are summarized in Table 12. Three cases were considered: (a) high transport costs; (b) low transport costs; and (c) low transport costs, with Nampula Province farmers (Regions 7, 8, and part of Region 10) exporting maize to Malawi rather than Maputo.[31]

High Transport Costs: Under the assumption of high transport costs, conditions are relatively favorable for farmers in Region 4 and Manica Province portions of Region 10 (intensified maize production is profitable for two-thirds of farmers in each area), but much less so for Nampula Province farmers far from the Maputo markets (Regions 7,8, part of Region 10). In the Nampula Province areas, intensified maize was barely profitable for the top tercile of farmers in Region 10 and unprofitable for all the rest.

Low Transport Costs: With lower transport costs, profits increased for Manica Province farmers (Region 4, part of Region 10) using improved seed and fertilizer, but the package was still unprofitable for the lower tercile of farmers in each area. Reduced transport costs did not help farmers in Region 7 (intensified maize was still unprofitable for all terciles), but seed and fertilizer use became profitable for the top two terciles of Regions 8 and 10 (Nampula Province).

Northern Farmers Export to Malawi: Farmers in Region 7, 8 and Nampula Province portions of Region 10 were best off if they could export maize to Malawi rather than transporting maize the much greater distance to Maputo markets. In this case, intensified maize production was profitable for all of the farmers in Regions 8 and 10 (Nampula) and the top tercile of farmers in Region 7.

Surplus Year: When the Southern Africa region has a maize surplus, Mozambican producers compete with South African maize producers in the Maputo market. As a result, farm-level prices are much lower across the board than in the maize deficit scenario. In 1996/97, Nampula Province (Regions 7, 8, 10) farmers were affected much more severely than their counterparts in Manica Province (Regions 4, 10). In the surplus scenario, Manica Province prices fell by one-third from deficit price levels, but in Nampula Province prices fell by an estimated 50-85%. Key results for the surplus maize case are presented in Table 12.

High Transport Costs: Assuming that transportation costs are high, maize intensification was profitable only for the top tercile of farmers in Regions 4 and 10 in Manica Province, and unprofitable for all farmers in Regions 7, 8 and areas of Region 10 within Nampula Province.

Low Transport Costs: With lower transport costs, use of the improved maize package was profitable in the top yield tercile of Region 4 and the top two terciles of Region 10 in Manica

[31] Long distance road haulage costs using backhaul are estimated at USD .03/ton/km (low) and USD .05/ton/km (high) (Coulter 1995).

Province, unprofitable in all of Region 7 and all but the top yield terciles in Regions 8 and 10 (Nampula Province).

Northern Farmers Export to the International Market: If there were a maize surplus in Southern Africa, farmers in northern Mozambique might be better off exporting their maize to countries in other regions of Africa through the port of Nacala. Weather patterns in Tanzania and Kenya are different from Southern Africa's and may provide a market for surplus Mozambican maize. For example, Koester showed that production in northern Mozambique is negatively correlated with that in southern Tanzania (1986, cited in Coulter 1995). Maize production in neighboring Malawi has been declining for some years, and this country may also be a market for Mozambican maize even when the region as a whole is in surplus. If export to international markets were possible, the analysis indicates that maize intensification would be profitable for the top two yield terciles in Regions 8 (Monapo/Meconta) and 10 (Nampula), although it would still be unprofitable for farmers in Region 7 (Ribaue). Export to Malawi would likely be more profitable than to the international market.

5.5.3. Farmer Opinions About DNER/SG and Improved Technology

Comments About DNER/SG: Most farmers attributed the mixed results of the demonstration trials to poor weather and maintained an overwhelmingly positive attitude toward the DNER/SG program and improved seed and fertilizer technology. Over 90% of sample farmers said they wanted to participate in the DNER/SG program again during the 1997/98 season (Appendix 5, Table 19). The highest proportion of farmers wishing to enroll again in 1997/98 (98%) came from Region 7, which had the poorest results with the DNER/SG technology during 1996/97. Some of the farmers' enthusiasm may be explained by the fact that DNER/SG has not started to collect loan repayments for the 1996/97 season, and it is not clear that farmers will be expected to pay back these loans at all. As of December 1997, less than 20% of farmers had made any payments on their loan from the previous season. Thus, farmers may now regard the DNER/SG program as a grant rather than a loan program, a potentially dangerous precedent that can undermine the development of private sector input supply channels in these areas.

Comments About Improved Seed and Fertilizer Technology: Most sample farmers were convinced that the use of Manica seed and chemical fertilizer improved maize yields (62% and 73% for seed and fertilizer, respectively) and wanted to continue using the technology in the future. More than 80% said that even if credit were not available, they would buy improved seed and fertilizer with their own cash resources. Most farmers thought seed was more essential than fertilizer: asked to rank purchased inputs in order of importance, two-thirds thought improved seed was most important and one-third ranked chemical fertilizer first (Appendix 5, Tables 20 and 21).

In other parts of Southern Africa adoption of improved varieties has been affected by smallholder perceptions that improved maize is inferior to local varieties with regard to color, taste, and storage and milling properties (Howard 1994; Smale and Heisey 1997). There may be fewer problems with Manica seed because it was derived from a local Mozambican population and has probably retained many of the qualities that farmers value in "local" seed varieties. Table 21 (Appendix 5) presents farmer responses to questions about how the characteristics of Manica seed compare to local varieties. Half of the farmers said that they preferred Manica's color and taste to those of local varieties. The other results were ambiguous because the questions were difficult (particularly on storage and milling) for farmers who had no previous experience with Manica seed. Twenty-three percent said that Manica stored better than other varieties, 35% said it was worse, while 40% could not yet comment. Thirty-one percent said they preferred Manica's milling characteristics to local, fifteen percent said they preferred the local varieties, and half could not distinguish between them yet.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Our analysis of the DNER/SG program suggests that there is substantial scope for increasing farmer yields and agricultural production in Mozambique through the use of inputs such as improved seed varieties, fertilizer and pesticides. Sustained adoption of these inputs by farmers will depend on the successful implementation of policies and programs that increase the profitability of input use by (1) improving smallholder awareness of the benefits and correct use of inputs; (2) reducing the cost of inputs and ensuring their timely availability; and (3) reducing the cost of marketing commodity outputs and developing new markets for smallholder commodities.

6.1. Improving Smallholder Awareness of the Benefits and Correct Use of Inputs

Most sample farmers were convinced that the use of Manica seed and chemical fertilizer improved maize yields. The successful DNER/SG experience in Mozambique (and the DNER/SG experience in other countries) suggests that it would be useful to replicate this model elsewhere in the country with maize and other crops.

Since SG resources are limited, other NGOs, JVCs or private sector firms (including agrochemical and seed firms) could provide support to expanded DNER efforts in this area. Several modifications in the way the program is implemented would increase its effectiveness. First, the process of identifying candidate crops and areas for intensification should include a feasibility study to determine (a) the potential yield gains from use of improved technology, and (b) estimates of the farm-level profitability of the input package.

Second, the database of information from INIA and NGO trials on yield response to fertilizer and improved seed varieties should be more effectively utilized: fine-tuning seed and fertilizer recommendations to match the diversity of agroclimatic conditions found in the country can increase yields and reduce costs of improved technology. The addition of complementary technologies, e.g., storage pesticides and herbicides, may increase the farm-level profitability of the package. Storage pesticide would be especially important, allowing farmers to take advantage of potential seasonal price rises without the risk of losing a large proportion of their stored grain to insect pests. Herbicide would help address the weeding labor constraint, which becomes even more binding when fertilizer is used. Third, greater attention should be given to training extension agents and ensuring that they are providing adequate technical support on appropriate planting and fertilizer methods and weeding times.

6.2. Investments to Reduce Costs and Ensure Timely Availability of Inputs

In Mozambique the cost of inputs is very high compared to the output prices currently faced by farmers. Using June prices, the ratio of the cost of the total input package to the price of one kilogram of maize ranges from 1,504 in Region 8 (Monapo/Meconta, Nampula Province) to 2,074 in Regions 4 and 10 in Manica Province. This means that farmers must produce between 1,504 and 2,074 kilograms of maize to pay for the package of inputs used on one hectare. Using prices from our economic analysis, we calculated ratios in Nampula that range from 717[32] to 3,165[33]. In Manica, the economic ratios ranged from a low of 700 to a high of only 873. These economic ratios are similar to the financial ratios faced by Ethiopian farmers in 1996/97, who only needed to produce 748 kilograms of maize to pay for a similar package of inputs (using comparable prices immediately after harvest). Not coincidentally, the SG package was highly profitable for nearly all Ethiopian SG participants.

This analysis suggests that if the export market is developed, especially to Malawi, Nampula farmers can expect to face ratios of around 1,000 or lower. This means that they will begin to make money with yields of 1 ton per hectare. With yields of 3 tons and more attainable on smallholder fields with this technology, the potential profits to farmers become extremely attractive.

Per-ton seed prices are comparable or lower than those in neighboring countries, but seed is expensive for Mozambican farmers relative to the output prices they receive. The average ratio of OPV seed to grain price is 4.5 in Sub-Saharan Africa and 5.4 in Southern Africa, compared to 7.1 in Mozambique (CIMMYT 1994). Late delivery of inputs was a problem for many of this year's DNER/SG participants and is also a concern of smallholder contract farmers working with JVCs and other large cotton firms. Major factors affecting input costs and delivery are the poor state of transportation infrastructure[34], the lack of wholesale and retail outlets for inputs in the rural areas, and weak demand for fertilizer and seed by smallholders. Input dealers cannot deal in large enough quantities to realize significant economies of scale.

A four-part approach is recommended to reduce the cost of getting inputs to smallholders: (1) improving the transportation infrastructure; (2) reorienting the KRII program to give greater flexibility and control to private participants; (3) broadening the role of farmer associations in input distribution and encouraging private agribusiness to expand the wholesale and retail network for inputs; and (4) promoting the diversification of the seed subsector, especially more informal seed replication and distribution.

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[32] Using the maize price when exporting to Malawi and assuming low transport costs.

[33] Using the lowest maize price -- selling in Maputo in a surplus year -- and the highest input cost.

[34] Transport and handling costs between the port and farmgate add 31-64% to the import parity price of fertilizer for farmers in Nampula and Manica Provinces.

6.2.1. Improving Transport Infrastructure

The Mozambican government and donors are well aware of the need to improve transport infrastructure: the Roads and Coastal Shipping Project II (ROCs II) represents an important step in improving conditions. Roughly half of Mozambique's estimated 43,000 kilometers of paved, earth/gravel, and feeder roads are scheduled for rehabilitation by the year 2000. Additional investments will be required to upgrade the remaining portions of the network and maintain improved road surfaces.

6.2.2. Reorienting the Japanese KRII Program

The KRII program provides an important source of credit, but the current system of centralized ordering and distribution of KRII inputs is retarding the development of the private input procurement and distribution system in Mozambique. We propose that the centralized ordering and distribution system for KRII inputs be abandoned and that the KRII program become mainly a financing mechanism to enable private firms and farmer associations to order the quantities and types of agrochemicals they need, and pay back the amount over time. Using the KRII funds as a source of credit, but leaving the process of aggregating orders, tendering for bids, and arranging for importation in the hands of the Mozambican private sector, would reduce costs through economies of scale and the long time lag between order and receipt of KRII goods. If it is not possible to reconfigure KRII in this way, the program should be eliminated.

6.2.3. Broadening the Role of Farmer Associations in Input Distribution and Facilitating the Development of Private Input Marketing Channels

Strengthen Farmer Associations: Building smallholder demand for improved inputs while simultaneously creating a network of wholesale and retail input suppliers will be a long-term process. Government and donor funds could be used to strengthen the capacity of smallholder associations to help reduce the cost of input procurement and delivery by aggregating input orders, guaranteeing payment, and repackaging bulk orders for delivery to individual customers. One innovative experiment with farmer associations has had good results and should be studied more closely to determine how the model could be expanded to other areas in a cost-effective way. In 1996/97 the Cooperative League of the USA (CLUSA) began working with groups of farmers producing cotton for 3 JVCs operating in northern Mozambique. The farmers had been unhappy with the late delivery and quality of inputs delivered by the company. Under new agreements negotiated by 18 associations supported by CLUSA, companies agreed to channel their input supply and extension services, which had traditionally been supplied to individuals, through associations instead. This strategy reduced the cost to JVCs of service provision and improved the timeliness of input delivery.

If supplier credit is made available through a redesigned KRII and other donor programs, Mozambican agrochemical firms might similarly work through farmer associations to aggregate orders and make inputs available locally on a cash basis. In the future, the DNER/SG program could work with CLUSA and farmer associations as well as individual stockists to organize input procurement, delivery and guarantee payment of credit.

Reduce Barriers to Market Entry: Policy changes have made it easier to import and sell inputs, but several administrative barriers to market entry remain. Retail licenses must be approved by provincial governors and are difficult and time-consuming to obtain, for example. Lack of credit is widely perceived to be a major constraint to the development of input markets. However, the severity of the problem is not well understood, and the discouraging experience with scaled-up credit programs in many SSA countries calls for careful examination of alternative approaches to increasing credit availability.

Discontinue Direct Distribution of Inputs by Government and NGOs: The Mozambican government and NGOs can encourage the development of input markets by discontinuing the direct distribution of relief or otherwise subsidized fertilizer and seed for commodities that are available commercially, instead providing farmers with vouchers to purchase inputs from local sources.

Provide Technical Training for Stockists: Another important constraint is the lack of trained personnel in rural areas who are capable of handling products safely, giving competent advice about their utilization, and bookkeeping. Innovative NGO programs such as Citizens Network are helping to train shopkeepers in Manica Province in collaboration with SG. In Zimbabwe, CARE's AGENT program also provides (in addition to technical training in input use, storage and bookkeeping) credit guarantees until the stockists graduate to regular supplier lines of credit after 6-8 months in the program.

Diversification of the Seed Sector: Mozambican farmers in selected agroecological areas are becoming aware of the value of hybrid maize seed, and this market may expand over the coming years. For the foreseeable future, however, the bulk of demand will be for open-pollinated seed that can be replanted for several seasons, not renewed every year. This suggests that the development path for SEMOC will need to differ from counterpart formal seed organizations in neighboring countries that have relied heavily on centrally grown, centrally processed hybrid maize as a flagship product.

Because of its research and varietal testing capability for a wide range of crops and links with external public and private seed organizations SEMOC, (together with INIA, DNER and the public seed organizations) can play a unique role in the development of a multi-tiered seed sector in Mozambique that can better serve the needs of smallholders. Though some activities of the seed system can be supported by commercial firms, others will require support from the government and/or donors. Examples follow.

Decentralize Seed Production and Marketing: First, SEMOC and other potential entrants to the seed market can reduce their costs by decentralizing seed production and marketing. This will require joint efforts by companies, public agencies and NGOs to (a) provide links to NARS, international research centers and the other private sector to get information and seed of appropriate varieties; (b) train extension agents to choose appropriate varieties for different agroecological zones and types of clients; (c) train and supervise farmers in seed production, selection, storage and marketing; and (d) provide technical training to rural stockists.

Review Seed System Regulations and Functions: Seed sub-sector regulations need to be rationalized to encourage the development of the informal seed sector. We recommend a two-tier seed multiplication and distribution system. At the first level, foundation seed would be multiplied to certified seed under the stringent and highly controlled conditions currently required by seed authorities and made available for direct sale. In the second stage, seed from the first level would be bulked by individual farmers and farmer groups in local villages under inspection by extension workers and marketed as standard seed.

Removing compulsory seed certification and restrictive trade licensing requirements will permit formal production of quality open-pollinated maize and other crops by smallholders and sale among neighboring farmers. In addition, seed companies will be able to involve smallholders in contract seed production more easily.

6.3. Reducing the Cost of Marketing Commodity Outputs and Developing New Markets for Smallholder Commodities

Increasing the demand for improved inputs by smallholders ultimately depends on expanding the post-harvest market for commodities produced by smallholders. It will be especially important to develop foreign markets for Mozambican commodities. Any strategy to develop regional export potential in food and other crops in northern Mozambique must be active on many fronts. Other needs include continued improvement of port management and roads, especially secondary and tertiary routes; simplification of licensing and other bureaucratic procedures related to trade; improved access to credit for agricultural trade; and continued development of farmer associations. In addition, the government can facilitate regional trade in three ways.

6.3.1. Making a Clear Policy Statement that the Government will not Prohibit Maize Exports even During Drought Years

If traders expect that government will close off profit opportunities during years of regional deficit, they will not invest in their capacity to efficiently and regularly assemble and export large quantities of grain. The result will be continued small-scale operations, high costs, low prices to farmers, and high prices for consumers.

6.3.2. Collaborating with the Private Sector to Create a Regional Trade Information Network

An effort is currently underway in MICTUR and should be strengthened. It will be especially important to coordinate this effort with the existing market information system (SIMA) in the Ministry of Agriculture and Fisheries. If successful, such a network could eventually provide the basis for an agricultural commodity exchange in the area.

6.3.3. Removing Bureaucratic Barriers to the Formalization of Farmer Associations so They Can Continue to Expand Their Marketing Activities

Strengthened farmer associations can play a key role in reducing the costs of marketing commodity outputs both domestically and internationally. During the 1995/96 season, CLUSA helped farmer associations working in JVC cotton areas to set up management systems that will enable them to weigh, record and deliver the cotton to the gins themselves for a higher price. Farmer groups are also beginning to coordinate exports. In 1995/96, 9 CLUSA-assisted associations involving about 3000 farmers in the Ribaue area coordinated to sell 1200 tons of maize to V&M, a South African company The buyer paid the associations 1000 meticais/kg compared to the market price of 750 meticais/kg. Part of the proceeds were invested in the association's development fund. JVCs and other large commercial farms can also play a role in seeking out new markets and contracting smallholders for the production of these commodities. For example, several cotton firms interested in encouraging a cotton-maize or cotton-maize-legume rotation are actively exploring alternative markets for maize and legumes such as pigeon pea and groundnuts.

APPENDIX 1

FERTILIZER RESPONSE AND NATIONAL MAIZE VARIETY LIST

Table 14. Response to Nitrogen and Phosphorus and Profitability of Fertilizer Use on Food Crops and Cotton in Mozambique

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Cotton	Arenosols rainfed	0-200 masl 800-1200 mm Nov.-April	seed	155	20	30	400	650	250	63	1.2	
Cotton	Lixisols rainfed	0-200 masl 800-1200 mm Nov.-April	seed	166	60	60	750	1400	650	87	1.7	
Cotton	Nitisols rainfed	200-600 masl 800-1200 mm Nov.-April	seed	167	50	60	1100	1700	600	55	1.7	
Cotton	Fluvisols rainfed	0-200 masl 600-800 mm Nov.-April	seed	149	40	20	1250	1800	550	44	2.5	
Cotton	Luvisols rainfed	0-200 masl 800-1200 mm Nov.-April	seed		50	60	1300	1700	400	31	1.1	
Cotton	Lixisols rainfed	200-600 masl 800-1200 mm Nov.-April	seed	154	60	60	1400	2400	1000	71	2.6	
Cotton	Luvisols rainfed	600-1000 masl 800-1200 mm Nov.-April	seed		50	60	1450	3250	1800	124	5.0	
Cotton	Luvisols rainfed	200-600 masl 800-1200 mm Nov.-April	seed	149	50	60	1500	2250	750	50	1.7	
Groundnut	Arenosols rainfed	0-200 masl 800-1200 mm Nov.-April	grain	126	25	75	200	400	200	100	2.5	

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Groundnut	Arenosols rainfed	0-200 masl 600-800 mm Nov.-April	grain	132	0	40	200	450	250	125	6.7	
Groundnut	Arenosols irrigated	0-200 masl 600-800 mm Nov.-April	grain		25	40	375	400	25	7	1.3	
Groundnut	Lixisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	120	25	60	500	650	150	30	2.2	
Groundnut	Lixisols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	126	25	60	750	800	50	7	0.6	
Groundnut	Luvisols rainfed	0-200 masl 800-1200 mm Nov.-April	grain	124	25	65	825	1300	475	58	6.1	
Groundnut	Fluvisols rainfed	0-200 masl 600-800 mm Nov.-April	grain	113	25	0	1225	1450	225	18	10.5	
Groundnut	Fluvisols irrigated	0-200 masl 600-800 mm Nov.-April	grain		25	40	1550	1800	250	16	4.0	
Rice, lowland	Fluvisols irrigated	0-200 masl 800-1200 mm Nov.-April	with husk, short, direct seeding	100-130	60	0	1500	2250	750	50	3.5	12.5
Rice, lowland	Fluvisols irrigated	0-200 masl 600-800 mm Nov.-April	with husk, tall, direct seeding	> 160	50	0	1750	2500	750	43	4.2	15

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Rice, lowland	Fluvisols irrigated	0-200 masl 800-1200 mm Nov.-April	with husk, tall, direct seeding	> 160	50	0	2000	2125	125	6	0.8	2.5
Rice, lowland	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	with husk, short, direct seeding	100-130	90	0	2500	4250	1750	70	6.2	19.4
Rice, lowland	Fluvisols irrigated	0-200 masl 600-800 mm Nov.-April	with husk, short, direct seeding	130-160	90	30	3600	4750	1150	32	2.5	9.6
Rice, lowland	Fluvisols rainfed	0-200 masl > 1200 mm Nov.-April	with husk, short, transplt	130-160	70	60	4000	5100	1100	28	2.4	8.5
Rice, lowland	Fluvisols rainfed	0-200 masl 600-800 mm Nov.-April	with husk, short, direct seeding	100-130	100	40	4100	6250	2150	52	4.3	15.4
Rice, lowland	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	with husk, short, direct seeding	130-160	100	0	4250	5250	1000	24	3.4	10
Potato, common	Fluvisols irrigated	0-200 masl 0-600 mm April-Sept.	fresh tubers	136	60	80	11,000	18,000	7000	64	30.1	

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Potato, common	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	fresh tubers	115	80	30	14,000	23,000	9000	64	49.8	
Potato, common	Ferralsols irrigated	600-1000 masl 800-1200 mm April-Sept.	fresh tubers	109	100	60	19,000	30,000	11,000	58	42.4	
Bean, common	Ferralsols rainfed	>1000 masl 800-1200 mm Feb.-June	grain		60	45	275	450	175	64	1.1	
Bean, common	Ferralsols rainfed	600-1000 masl 800-1200 mm Feb.-June	grain		40	40	425	460	35	8	0.3	
Bean, common	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	grain		30	0	450	760	310	69	7.8	
Sunflower	Luvisols rainfed	200-600 masl 800-1200 mm Feb.-June	grain	126	40	40	650	750	100	15	0.3	
Sunflower	Ferralsols rainfed	>1000 masl 800-1200 mm Feb.-June	grain		75	60	650	1125	475	73	0.8	
Sunflower	Lixisols rainfed	600-1000 masl 800-1200 mm Feb.-June	grain		80	60	700	1625	925	132	1.5	
Sunflower	Fluvisols irrigated	0-200 masl 600-800 mm Feb.-June	grain	124	40	0	1250	1500	250	20	1.4	

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Sunflower	Nitisols rainfed	200-600 masl 800-1200 mm Feb.-June	grain		30	30	2125	2750	625	29	1.9	
Sunflower	Nitisols rainfed	600-1000 masl 800-1200 mm Feb.-June	grain		30	30	2500	2725	225	9	0.7	
Cassava	Arenosols rainfed	0-200 masl 800-1200 mm year round	fresh tubers	496	0	0	16,500	17,500	1000	6		
Cassava	Lixisols rainfed	0-200 masl 800-1200 mm year round	fresh tubers	453	0	0	33,500	34,500	1000	3		
Sorghum	Luvisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	87	70	30	1000	3400	2400	240	4.0	24
Maize	Arenosols rainfed	0-200 masl 600-800 mm Nov.-April	grain		0	40	200	600	400	200	1.9	10
Maize	Arenosols rainfed	0-200 masl 800-1200 mm Nov.-April	grain	112	60	40	300	700	400	133	1.0	4
Maize	Arenosols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	146	20	40	600	900	300	50	0.8	5
Maize	Lixisols rainfed	0-200 masl 800-1200 mm Nov.-April	grain	125	80	40	1300	1800	500	38	1.1	4.2

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Maize	Lixisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	126	80	60	1400	3100	1700	121	2.3	12.1
Maize	Ferralsols rainfed mixed with beans	> 1000 masl 800-1200 mm Nov.-April	grain	189	50	20	1500	2500	1000	67	2.9	14.3
Maize	Luvisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	125	50	0	1500	4000	2500	167	12.3	50
Maize	Lixisols rainfed	>1000 masl 800-1200 mm Nov.-April	grain	170	30	50	1800	3600	1800	100	5.3	22.5
Maize	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	grain	148	60	0	1800	2750	950	53	3.8	15.8
Maize	Nitisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	132	80	60	2100	3900	1800	86	3.4	12.9
Maize	Lixisols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	151	90	30	2200	4200	2000	91	4.2	16.7
Maize	Fluvisols irrigated	0-200 masl 600-800 mm Nov.-April	grain	149	90	0	2500	3900	1400	56	4.1	15.6
Maize	Acrisols rainfed	600-1000 masl >1200 mm Nov.-April	grain	160	100	60	2700	6000	3300	122	5.3	20.6

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Maize	Ferralsols rainfed sole-cropped	> 1000 masl 800-1200 mm Nov.-April	grain	189	100	40	2700	5800	3100	115	4.8	22.1
Maize	Acrisols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	142	100	60	2800	4400	1600	57	2.6	10
Maize	Acrisols rainfed	600-1000 masl 600-800 mm Nov.-April	grain		100	30	2900	4500	1600	55	3.1	12.3
Maize	Fluvisols irrigated	0-200 masl 0-600 mm Nov.-April	grain	138	80	0	3400	4200	800	24	2.7	10
Maize	Ferralsols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	144	80	40	4000	4800	800	20	2.2	6.7
Maize	Ferralsols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	136	70	0	4100	6300	2200	54	8.3	31.4
Maize	Luvisols irrigated	0-200 masl 600-800 mm Nov.-April	grain	145	80	40	5700	6400	700	12	1.3	5.8
Soybeans	Luvisols irrigated	200-600 masl 800-1200 mm Nov.-April	grain	151	20	40	500	1250	750	150	11.3	
Soybeans	Ferralsols rainfed	600-1000 masl 800-1200 mm Nov.-April	grain	93	20	40	600	1000	400	67	6.0	

Crop	Soil-water source	Altitude-precip.-season	Char.	Cycle (days)	N (kg/ha)	P (kg/ha)	Crop yield w/o fertilizer kg/ha	Crop yield w/fertilizer kg/ha	Response	% change in yield	VCR	Output/ nutrient ratio
Soybeans	Ferralsols rainfed	>1000 masl 800-1200 mm Nov.-April	grain	167	20	40	750	1625	875	117`	11.3	
Soybeans	Nitisols rainfed	200-600 masl 800-1200 mm Nov.-April	grain	104	20	40	1250	1500	250	20	5.6	
Soybeans	Fluvisols irrigated	0-200 masl 600-800 mm Nov.-April	grain	144	0	0	1700	2300	600	35		
Wheat	Ferralsols rainfed	> 1000 masl 800-1200 mm April-Sept.	grain	136	30	30	375	800	425	113	2.0	7.1
Wheat	Ferralsols irrigated	> 1000 masl 800-1200 mm April-Sept.	grain	143	50	50	625	1250	625	100	2.0	6.3
Wheat	Luvisols irrigated	600-1000 masl 800-1200 mm April-Sept.	grain		40	0	700	1750	1000	143	7.5	25
Wheat	Fluvisols irrigated	0-200 masl 600-800 mm April-Sept.	grain	123	60	0	1150	2300	1150	100	5.4	19.2
Wheat	Fluvisols irrigated	0-200 masl 800-1200 mm April-Sept.	grain		30	0	1375	2000	625	45	6.1	20.8
Wheat	Ferralsols irrigated	600-1000 masl 800-1200 mm April-Sept.	grain	123	30	30	1625	2100	475	29	2.0	7.9

Source: Adapted from Geurts 1997

Table 15. National Variety List for Maize

Variety	Source	Cycle (days)
Manica	INIA	130-150
Matuba	INIA	100-120
MMV-400	Imported	105-125
MMV-600	Imported	135-155
Kalahari	Imported	130
SR-52 (hybrid)	Imported	155-160
R-201 (hybrid)	Imported	138
PNR-473 (hybrid)	Imported	130
Obregon	INIA	150
Obregon flint	INIA	150
Umbeluzi	INIA	120-140
Silver Mine	INIA	140-155
Semoc 1	SEMOC	115-130
UCA	Imported	135-145
Ferke 7822	INIA	134-145
Obregon 7643	INIA	130-150
R-200 (hybrid)	Imported	120-135
SC 501 (hybrid)	Imported	120-135
PAN 6671	Imported	125-140
PAN 437 (hybrid)	Imported	125-140
SM 401 (hybrid)	SEMOC	115-130
SM 402 (hybrid)	SEMOC	125-140
SM 404 (hybrid)	SEMOC	120-135
SM 504 (hybrid)	SEMOC	130-150
SM 612 (hybrid)	SEMOC	135-160
SM 652 (hybrid)	SEMOC	135-160
Manica SR	SEMOC	125-145

Source: República de Moçambique 1995

APPENDIX 2

1996/97 DNER/SG SURVEY QUESTIONNAIRE

MINISTERIO DE AGRICULTURA E PESCAS
and
Michigan State University/USAID
Survey of Input Utilization in the Smallholder Sector
SG 2000
May 1997

MAP/MSU Food Security Project in Mozambique
National Directorates of Agricultural Economics/Rural Extension
Provincial Directorates of Agriculture for Manica and Nampula

NOTE

You have the right to decline to participate in this interview; your participation is entirely voluntary. If you decide to participate, all of the information collected will be held in complete confidence -- under no circumstances will your name be associated with any specific response.

Province ______________________________ **PROV**

District ______________________________ **DIST**

Village ______________________________ **ALD**

Household ______________________________ **AF**

Name of Producer ______________________________

Name of Trader ______________________________ **NOMCO**

Name of Extension Agent ______________________________ **NOMEXT**

Questionnnaire type (1 = SG2000 participant, SG2000 plot, 2 = SG2000 participant, traditional plot, 3 = non-participant) __________ **QTYPE**

Did you participate in the SG2000 program this year? Yes = 1 No = 0 _____ **P9697**

Did you participate in SG2000 during the 95/96 season? Yes = 1 No = 0 _____ **P9596**

Table I. Demographic Data about the Household

Name	No.	Relationship to household head 1 household head 2 spouse 3 son/daughter 4 father/ mother 5 other family member 6 other (specify)	Age	Sex 1 m 2 f	Age categorized - computed variable 1 = < 7 2 = (>=7,<=8) 3 = (>=9,<=12) 4 = (>=13,<=15) 5 = (>=16,<=54) 6=>=55	Conversion Unit (from conlab.sav)
NOME	MEM	I1	I2	I3	AGECODE	CONUNIT

AF1 _________ Household head's level of education

0 Illiterate
1,2,...12 Last year of school completed
99 Did not attend school, but knows how to read and write

Prov ____ Distrito ____ Ald ____ AF ____

II. FIELD MAP

EXTENSION AGENT: Using a compass and tape, measure all sides and angles of the SG2000 (or traditional) maize field, distinguishing between parts of the field where conventional tillage and no-till techniques were used (if applicable). Sketch the field below, noting side and angle measurements.

==

Prov ____ Distrito ____ Ald ____ AF ____

Table II. DESCRIPTION OF THE SG2000 (OR TRADITIONAL) MAIZE FIELD

Field Type	Area in hectares	Other crops in this field (intercropped))			Soil type		Was this field fertilized during the 95/96 season? (Or the 94/95 season?)			Have you harvested from this field during the current season? 0 no 1 yes	Household head's estimate of total production from this field for 96/97 season		
		2 beans 3 cassava 4 rice 6 groundnut 8 sorghum			1 Heavy 2 Normal 3 Sandy	1 Red 2 Dark 3 White	Type	Quant.	Unit 3 Kg 50 50 kg sack 90 90 kg sack 99 Other (specify)		Qt.	Unit 3 Kg 20 kg can 50 kg sack 90 kg sack 99 Other (specify)	Form 1 Grain 2 Ears 3 Green
MACH	**II1**	**II2**	**II3**	**II3a**	**II4**	**II5**	**II6**	**II7**	**II8**	**II9**	**II10**	**II11**	**II12**
"Conventional Tillage" (1)													
"Zero tillage" (2)													
"Traditional system" (3)													

Prov ____ Distrito ____ Ald ____ AF ____

WORKSHEET: MAIZE FIELD ACTIVITIES (not entered as data)

Activity	When was it carried out?	
	Month (1,2,...,12 or indicate that not done)	Week (1,2,3,4)
Animal Traction		
1 1st Plowing		
2 2nd Plowing		
3 3rd Plowing		
4 Opening furrows		
5 Hilling up		
Tractor		
6 1st Plowing		
7 2nd Plowing		
8 3rd Plowing		
9 Opening furrows		
10 Hilling up		
Other Activities Done by Hand		
11 Clearing		
12 Land Preparation		
13 Planting		
14 Planting and Application of Basal Fertilizer AT THE SAME TIME		
15 Application of Basal Fertilizer		
16 1st Application of Herbicide		
17 1st Weeding		
18 Thinning		
19 Thinning + Application of Top Dressing AT THE SAME TIME		
20 Application of Top Dressing and Hilling Up AT THE SAME TIME		
21 2nd Application of Herbicide		
22 2nd Weeding		
23 Application of Insecticide		
24 First Harvest		
25 First Transport (to House)		
26 Second Harvest		
27 Second Transport (to House)		
28 Third Harvest		
29 Third Transport (to House)		
Other (specify)		
Other (specify)		

Comments:

Table III. INPUTS UTILIZED IN THE SG2000 (OR TRADITIONAL) MAIZE FIELD

Input	Utilized?	When was it applied?		How did you get it? 1 Trader 2 Neighbor 3 Saved 4 SEMOC 5 Other (specify)	How much was applied?		How much did it cost?					Did you pay immediately after receiving the input or did you receive credit? 1 immediate payment 2 Credit 3 Other (specify)	If you received credit, what was the interest rate?
	0 no (skip to the next input) 1 yes	Month (1,2,...12)	Week (1,2,3,4)		Qt	Unit 3 Kg 4 Liter 50 50 kg sack 90 90 kg sack 99 Other (specify)	Qt	Unit 1 unit price 2 total value	Type of in kind payment	Number of units (in kind payment)	unit value		
INSUMO	**III1**	**MES**	**SEMANA**	**III2**	**III3**	**III4**	**III5**	**III6**	**III6a**	**III6b**	**III6c**	**III7**	**III8**
1 Seed Variety _________________ _________________													
Animal Traction													
2 First Plowing													
3 Second Plowing													
4 Opening Furrows													
5 Hilling Up													
Tractor													
6 First Plowing													
7 Second Plowing													
8 Opening Furrows													
9 Hilling Up													
Other Inputs													
10 Basal Fertilizer (Compound) Type______________													
12 Top Dressing (Simple) Type_______________													

Input	Utilized?	When was it applied?		How did you get it? 1 Trader 2 Neighbor 3 Saved 4 SEMOC 5 Other (specify)	How much was applied?		How much did it cost?					Did you pay immediately after receiving the input or did you receive credit? 1 immediate payment 2 Credit 3 Other (specify)	If you received credit, what was the interest rate?
	0 no (skip to the next input) 1 yes	Month (1,2,...12)	Week (1,2,3,4)		Qt	Unit 3 Kg 4 Liter 50 50 kg sack 90 90 kg sack 99 Other (specify)	Qt	Unit 1 unit price 2 total value	Type of in kind payment	Number of units (in kind payment)	unit value		
INSUMO	**III1**	**MES**	**SEMANA**	**III2**	**III3**	**III4**	**III5**	**III6**	**III6a**	**III6b**	**III6c**	**III7**	**III8**
13 Herbicide 1 Type and forumulation________ ____________________													
14 Herbicide 2 Type and formulation_________ ____________________													
15 Insecticide Type and formulation_________ ____________________													
16 Other													

Prov _____ Dist _____ Ald _____ AF _____

Table IV. LABOR UTILIZED IN THE MAIZE FIELD

Activity	When was the activity carried out in the maize field? (If not carried out, skip to the next activity)		How many persons in the family worked in this activity?	Family labor			Non-family labor										
	Mo. 1,2., 12	Week 1,2,3,4		How many days were spent on this activity?			Was non-family labor employed in this activity? 0 no (skip to next activity) 1 yes	Type of non-family labor	Total number non-family workers for activity	No.of (individual) worker	No. of days	Hours per day	Total cash pay-ment	Comment	If in-kind payment was made		
				Name	Days	Hours per day									Quant.	Unit	Type of in-kind paymnt
ACT	**IV1**	**IV2**	**IV3**	**IV4**	**IV5**	**IV6**	**IV7**	**IV16**	**IV8**	**IV9**	**IV10**	**IV11**	**IV12**	**IV12a**	**IV13**	**IV14**	**IV15**
										1							
										2							
										3							
										4							

V. COMMENTS ABOUT THE NEW TECHNOLOGY

Table V. IMPACT OF INPUTS ON YIELD

Input	Impact on YIELD 1 Improved yield 2 Did not have an effect on yield 3 Reduced yield 4 Doesn't know	Comments
INSUMO	V1	V2
Manica Seed		
Basal Fertilizer		
Top Dressing Fertilizer		
Herbicide		
Storage Insecticide		

AF2 ---------- **What are the STORAGE CHARACTERISTICS of Manica variety maize compared to traditional varieties?**

1 Manica variety stores better
2 No difference between Manica and traditional varieties
3 Manica variety doesn't store as well as traditional varieties
4 Doesn't know

AF3 ________ **If Manica stores more poorly, why?**

0 Doesn't know
1 Insects
2 Fungus
3 Other (specify)

Prov _____ Dist _____ Ald _____ AF _____

AF4 _______ **What are the MILLING (POUNDING) CHARACTERÍSTICS of Manica variety maize compared to traditional varieties?**

1 Manica variety pounds better
2 No difference between Manica and traditional varieties
3 Manica variety pounds more poorly than traditional varieties
4 Doesn't know

AF5 _______ **How does the color of Manica compare to traditional varieties?**

1 Prefers Manica
2 Doesn't see any difference
3 Prefers the traditional varieties
4 Doesn't know

AF6 _______ **How does the taste of Manica compare to traditional varieties?**
1 Prefers Manica
2 No difference
3 Prefers the traditional varieties
4 Doesn't know

AF7 _______ **Did you cultivate a traditional variety(ies) of maize this year?**

0 No (skip to question AF9)
1 Yes AF7a Name______________________________
AF7b Name______________________________
AF7c Name______________________________

AF8 ______ **What is the principal destination for the TRADITIONAL varieties of maize you produce?**

1 Market
2 Home consumption
3 Both

AF9 ______ **What is the principal destination for the MANICA variety maize you produce?**

1 Market
2 Home consumption
3 Both

AF10 ______ **How does the PRICE that traders pay for Manica compare to the price paid for traditional varieties?**

1 Pay more for Manica
2 Pay the same
3 Pay less for Manica
4 Doesn't know

AF11 ______ **Did you use a storage insecticide or fungicide during the past year?**

0 **No**
1 **Yes** **Name and formulation**

AF12 _______ **Are you planning to use a storage insecticide or fungicide this year?**

0 **No**
1 **Yes** **Name and formulation**

Prov _____ Dist _____ Ald _____ AF _____

VI. FUTURE USE OF IMPROVED TECHNOLOGY

AF13 _______ **If the SG2000 program continues next year, would you like to participate or do you prefer to leave the program? (SG2000 participants only)**

1 Would like to participate (skip to Table VI)
2 Prefers to leave

AF14 **If you prefer to leave, why? (SG2000 participants only)**

____

Table VI. Future input use

Input	If you had to pay for this input immediately (instead of receiving credit), would you purchase it? 0 Would not buy 1 Would buy	Rank each input in order of its importance (1=most important, 4=least important)	Comments
INSUMO	VI1	VI2	VI3
Manica Seed			
Basal Fertilizer			
Top Dressing Fertilizer			
Herbicide			
Storage Insecticide			

AF15 **Do you have additional comments about the SG2000 program or the technologies used in the program? (SG2000 participants only)**

VII. Crop Cut Data for Yield Estimation

Província ______________________________________

District ______________________________________

Village__--

Name of Farmer________________________________

Extension Agent---

Plot Number PLOT	Area of parcel AREAPARC	Number of plants PLANTAS	Number of ears ESPIGAS	Weight of grain (gross) PESOGRAO	% of moisture HUMIDAD	Tillage Type (added during data entry) TILLAGE	Farmer estimate of production Not entered

Comments:

____

Prov _____ Dist _____ Ald _____ AF _____

____
____

The following questions are for NON-PARTICIPANTS in SG2000 ONLY, qtype=3)

AF2a ______ **Have you heard of the SG2000 program? (NON-PARTICIPANT in SG2000, qtype = 3)**

0 No
1 Yes

AF3a ______ **Would you like to participate in the program next season? (NON-PARTICIPANT in SG2000, qtype = 3)**

0 No
1 Yes

AF4a **Why or why not? (NON-PARTICIPANT in SG2000, qtype = 3)**

____
___

APPENDIX 3

FINANCIAL AND ECONOMIC BUDGETS

Table 16. Summary of Farm Level Enterprise Budget, High-Input Technology Package, 1996-97, by Region and Yield Tercile

	Study Zone																
	Region 4				**Region 7**				**Region 8**				**Region 10**				
	Maize Yield Tercile																
Budget Item	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	Grand Total
YIELD (quintals/ha)																	
June 97[a]	8.58	21.08	34.12	21.55	4.77	6.81	13.98	8.42	12.43	25.06	38.34	25.28	12.83	26.63	43.26	27.57	23.29
Dec 97[b]	8.08	19.85	32.12	20.29	4.49	6.41	13.16	7.93	11.70	23.59	36.10	23.80	12.08	25.07	40.73	25.96	21.93
Jul-Dec 97 Mean[c]	8.28	20.35	32.95	20.81	4.61	6.58	13.50	8.13	12.00	24.20	37.02	24.41	12.39	25.71	41.77	26.62	22.49
LOCAL MARKET PRICE (mt/quintal)[c]																	
June 97	6.53	6.53	6.53	6.53	6.66	6.66	6.66	6.66	6.94	6.94	6.94	6.94	6.58	6.58	6.58	6.58	6.63
Dec 97	24.19	24.19	24.19	24.19	13.94	13.94	13.94	13.94	11.23	11.23	11.23	11.23	20.45	20.45	20.45	20.45	19.38
Jul-Dec 97 Mean	14.26	14.26	14.26	14.26	8.38	8.38	8.38	8.38	7.87	7.87	7.87	7.87	12.11	12.11	12.11	12.11	11.67
GROSS REVENUE ('0000 mt/ha)[d]																	
June 97 Price	56.03	137.65	222.80	140.72	31.77	45.35	93.11	56.08	86.26	173.92	266.08	175.44	84.42	175.22	284.65	181.41	154.46
Dec 97 Price[e]	188.03	461.96	747.73	472.26	58.42	83.40	171.22	103.12	120.06	242.06	370.33	244.18	235.90	489.64	795.42	506.93	410.07
Jul-Dec 97 Price[f]	114.55	281.52	455.67	287.80	36.58	52.22	107.20	64.56	88.97	179.37	274.42	180.94	144.71	300.36	487.93	310.96	252.59
CASH COSTS ('0000 mt/ha)																	
Fertilizer & seed[g]	135.40	135.40	135.40	135.40	104.40	104.40	104.40	104.40	104.40	104.40	104.40	104.40	124.85	124.85	124.85	124.85	122.16
Animal traction[h]	27.40	6.34	15.37	16.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.08	17.97	14.57	15.56	11.53
Tractor	0.00	1.33	0.00	0.45	0.00	0.00	0.00	0.00	0.00	3.33	3.75	2.36	4.25	5.00	5.79	5.00	2.66
INTEREST																	
June 97[i]	19.75	19.75	19.75	19.75	15.23	15.23	15.23	15.23	15.23	15.23	15.23	15.23	18.09	18.09	18.09	18.09	17.81
Dec 97[j]	36.67	36.67	36.67	36.67	28.28	28.28	28.28	28.28	28.28	28.28	28.28	28.28	33.60	33.60		33.60	33.08
Jul-Dec Mean[k]	31.03	31.03	31.03	31.03	23.93	23.93	23.93	23.93	23.93	23.93	23.93	23.93	28.84	23.93	23.93	23.93	28.70
LABOR																	
Purchased labor ('0000 mt/ha)[l]	11.15	93.55	14.79	11.78	2.80	3.61	17.56	7.71	11.45	19.31	18.13	16.29	17.89	16.74	25.32	19.90	15.54
Family labor (ae days/ha)[m]	75	101	95	91	80	73	96	82	71	38	52	54	76	105	104	95	86
Mutual labor (ae days/ha)[m]	2	23	7	11	0	0	9	3	10	9	21	13	14	8	7	9	10
NET INCOME ('0000 mt/ha)[n]																	
June 97 Price	(137.67)	(34.52)	37.50	(42.78)	(90.66)	(77.88)	(44.08)	(71.27)	(44.81)	31.65	124.58	37.16	(93.97)	(6.66)	96.80	(1.21)	(15.25)
Dec 97 Price	(22.59)	272.86	545.50	271.84	(77.06)	(52.89)	20.98	(37.27)	(24.06)	86.74	215.78	92.85	41.99	292.24	592.05	308.79	225.09

	Study Zone																
	Region 4				Region 7				Region 8				Region 10				
	Maize Yield Tercile																
Budget Item	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	Grand Total
Jul-Dec 97 Price	(90.42)	98.06	259.08	93.02	(94.55)	(79.72)	(38.69)	(71.48)	(50.81)	28.40	124.22	33.96	(44.04)	108.12	289.72	117.98	75.51
NET INCOME/FAMLY AND MUTUAL LABOR DAY ('0000 mt/ha)[o]																	
June 97 Price	(1.79)	(0.28)	0.37	(0.42)	(1.13)	(1.07)	(0.42)	(0.84)	(0.55)	0.67	1.71	0.55	(1.04)	(0.06)	0.87	(0.01)	(-.13)
Dec 97 Price	(0.29)	2.20	5.35	2.67	(0.96)	(0.72)	0.20	(0.44)	(0.30)	1.85	2.96	1.39	0.47	2.59	5.33	2.97	2.25
Jul-Dec 97 Price	(1.17)	0.79	2.54	0.91	(1.18)	(1.09)	(0.37)	(0.84)	(0.63)	0.60	1.70	0.51	(0.49)	0.96	2.61	1.13	0.74
Median wage rate ('0000 mt per 8 hour day)[p]	2.00	2.00	2.00	2.00	1.04	1.04	1.04	1.04	1.60	1.60	1.60	1.60	1.20(.6)	1.20(.6)	1.20 (.6)	1.20 (.6)	1.20(.6)
n	14	15	15	44	5	6	5	16	8	8	8	24	21	21	21	63	147

Source: Field data from DNER/SG Survey; Prices from MAP/MSU FSP Market Information System

[a] Estimated from crop cuts

[b] 2/Assumed 1% grain weight loss from pests each month (personal communication, Rudy van Gent, Zambian Ministry of Agriculture, Food and Fisheries Research Branch Food Conservation and Storage Unit

[c] Prices are from MAP/MSU/FSP Market Information System. Region 4 prices are from Manica; Region 7 from Ribaue; Region 8 from Monapo. Region 10 price is a weighted average of Manica and Malema prices.

[d] Yield * price.

[e] Adjusted to account for revenue lost by holding maize rather than selling it in June. The foregone compounded earnings from investment of June 97 gross revenue at 25% annual rate of interest, for a 6-month period, are subtracted from the December 97 gross revenue.

[f] Adjusted to account for revenue lost by holding maize rather than selling it in June. The foregone compounded earnings from investment of June 97 gross revenue at 25% annual rate of interest, for a 3- month period, are subtracted from the mean July-December 97 gross revenue.

[g] Includes 30 kg of improved seed, 100 kg 12-24-12, and 100 kg urea, all provided as part of the DNER/SG2000 package.

[h] Calculated as follows: actual rental amount for farmers who paid cash for animal traction services; for farmers who owned oxen, depreciated value for oxen and tools estimated as 1/3 of actual rental rate and multiplied by number of 8-hour days of oxen use.

[i] Assumes farmer receives inputs in November and repays loan in June, accumulating 7 months of interest.

[j] Assumes farmer receives inputs in November and repays loan in December of the following year, accumulating 13 months of interest.

[k] Assumes farmer receives inputs in November and repays loan the following October, accumulating 11 months of interest.

[l] Actual wages reported by farmers.

[m] adult equivalent days/hectare.

[n] Gross revenue-(cash costs+interest+purchased labor)

[o] Net income/adult equivalent family + mutual labor days

[p] Based on wages paid in each region. For Region 10, rates in parentheses are for parts of Region 10 in Nampula Province; others are for Manica Province.

Table 17. Summary of Economic Budget, High-Input Technology Package, 1996-97, by Region and Yield Tercile Assuming Maize Deficit in Southern Africa

	--Study Zone--																			
	Region 4				Region 7				Region 8				Region 10 Manica Prov.				Region 10 Nampula Prov.			
	--Maize Yield Tercile--																			
Budget Item	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total
YIELD[a] (qt/ha)	8.28	20.35	32.95	20.81	4.61	6.58	13.50	8.13	12.00	24.20	37.02	24.41	11.71	24.91	36.65	24.76	12.06	28.19	47.41	29.22
PRICE[b,c] (mt/qt)																				
Hi trans. costs (HTC)[d]	13.17	13.17	13.17	13.17	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20	13.17	13.17	13.17	13.17	4.20	4.20	4.20	4.20
Lo trans. costs (LTC)[e]	15.70	15.70	15.70	15.70	10.64	10.64	10.64	10.64	10.64	10.64	10.64	10.64	15.70	15.70	15.70	15.70	10.64	10.64	10.64	10.64
Export to Malawi, LTC[f]	15.70	15.70	15.70	15.70	16.75	16.75	16.75	16.75	16.75	16.75	16.75	16.75	15.70	15.70	15.70	15.70	1,675.00	1,675.00	1,675.00	1,675.00
GROSS REVENUE [g] (‘0000 mt/ha)																				
HTC	109.06	268.04	433.99	274.09	19.37	27.64	56.72	34.16	50.42	101.67	155.53	102.55	154.24	328.10	482.73	326.12	50.67	118.43	199.18	122.76
LTC	130.01	319.52	517.36	326.74	49.06	70.02	143.66	86.51	127.70	257.51	393.94	259.75	183.87	391.12	575.45	388.76	128.33	299.98	504.50	310.94
Export to Malawi	130.01	319.52	517.36	326.74	77.23	110.23	226.15	136.19	201.00	405.40	620.16	408.92	183.86	391.12	575.45	388.76	202.03	472.24	794.21	489.49
CASH COSTS (‘0000 mt/ha)																				
Fert. & seed HTC [h]	115.00	115.00	115.00	115.00	132.94	132.94	132.94	132.94	132.94	132.94	132.94	132.94	115.00	115.00	115.00	115.00	132.94	132.94	132.94	132.94
Fert. & seed LTC [h]	109.94	109.94	109.94	109.94	120.06	120.06	120.06	120.06	120.06	120.06	120.06	120.06	109.94	109.94	109.94	109.94	120.06	120.06	120.06	120.06

-------------------------Study Zone-------------------------

---------------------------------------Maize Yield Tercile---------------------------------------

Budget Item	Region 4 1	Region 4 2	Region 4 3	Region 4 Total	Region 7 1	Region 7 2	Region 7 3	Region 7 Total	Region 8 1	Region 8 2	Region 8 3	Region 8 Total	Region 10 Manica Prov. 1	Region 10 Manica Prov. 2	Region 10 Manica Prov. 3	Region 10 Manica Prov. Total	Region 10 Nampula Prov. 1	Region 10 Nampula Prov. 2	Region 10 Nampula Prov. 3	Region 10 Nampula Prov. Total
Animal traction [i]	27.40	6.34	15.38	16.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.95	25.47	30.42	24.16	0.00	0.00	0.00	0.00
Tractor[j]	0.00	1.33	0.00	0.45	0.00	0.00	0.00	0.00	0.00	3.33	3.75	2.36	7.08	7.69	7.69	7.50	0.00	0.00	1.43	0.48
LABOR																				
Purchased labor (‘0000 mt/ha)[k]	11.15	9.36	14.79	11.78	2.80	3.61	17.56	7.72	11.45	19.31	18.13	16.29	22.57	21.81	14.30	19.48	3.86	20.09	37.99	20.65
Median wage rate (‘0000 mt per 8 hour day)[l]	2.00	2.00	2.00	2.00	1.04	1.04	1.04	1.04	1.60	1.60	1.60	1.60	1.20	1.20	1.20	1.20	0.60	0.60	0.60	6.00
Value of family and mutual labor (‘0000 mt/ha)[m]	77.00	124.00	102.00	102.00	41.41	37.78	54.34	44.00	64.80	37.60	58.40	53.60	58.20	65.40	79.20	67.80	20.10	33.00	26.40	26.70
NET INCOME (‘0000 mt/ha[n]																				
HTC	(121.50)	12.00	186.83	28.74	(157.78)	(146.70)	(148.13)	(150.50)	(158.78)	(91.51)	(57.69)	(102.65)	(64.58)	92.73	236.11	92.19	(106.23)	(67.60)	0.42	(58.01)
LTC	(95.49)	68.55	275.26	86.45	(115.21)	(91.44)	(48.31)	(85.26)	(68.62)	77.21	193.60	67.43	(29.89)	160.81	333.90	159.88	(15.69)	126.82	318.62	143.05
Export to Malawi	(95.49)	68.55	275.26	86.45	(87.05)	(51.23)	34.18	(35.58)	4.71	225.09	419.82	216.60	(29.89)	160.81	333.90	159.89	58.01	299.08	608.33	321.61
n	14.00	15.00	15.00	44.00	5.00	6.00	5.00	16.00	8.00	8.00	8.00	24.00	12.00	13.00	13.00	38.00	7.00	7.00	7.00	21.00

Source: Field data from DNER/SG Survey

[a] Estimated from crop cuts. Assumes storage losses of 1% per month and that maize is stored on average 2.5 months.

[B] Import parity price. Assumes that in deficit years Mozambican maize competes with maize imported from the U.S. For calculation of import parity price under different assumptions see Appendix 2.

[c] Throughout the economic analysis it is assumed that no adjustment for overvaluation of the exchange rate is required (J. Coates, World Bank, personal communication 4/2/98).

[d] Calculation of import parity price assuming high transport costs, adapted from Coulter 1995 (Appendix 2).

[e] Calculation of import parity price assuming low transport costs, adapted from Coulter 1995 (Appendix 2).

[f] Assumes Nampula Province farmers export to Malawi in times of regional deficit (export parity price) and that transport costs are low. Manica Province farmers face import parity prices. (Appendix 2)

[g] Yield * price.

[h] Includes 30 kg of improved seed, 100 kg 12-24-12, and 100 kg urea, all provided as part of the DNER/SG package.
[i] Calculated as follows: actual rental amount for farmers who paid cash for animal traction services; for farmers who owned oxen, depreciated value for oxen and tools estimated as 1/3 of actual rental rate and multiplied by number of 8-hour days of oxen use. Assumes that the animal rental rate accurately reflects the economic value of these services.
[J] Actual rental amounts paid by farmers. Assumes that the tractor rental rate accurately reflects the economic value of these services.
[K] Actual wages reported by farmers.
[l] Based on wages paid in each zone.
[m] Family and mutual labor was valued at .5 of the median wage rate for each zone.
[n] Gross revenue - (cash costs + purchased labor + value of family and mutual labor).

Table 18. Summary of Economic Budget, High-Input Technology Package, 1996-97, by Region and Yield Tercile Assuming Maize Surplus in Southern Africa

-------------------------Study Zone-------------------------

---------------------------------------Maize Yield Tercile---------------------------------------

Budget Item	Region 4				Region 7				Region 8				Region 10 Manica Prov.				Region 10 Nampula Prov.			
	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total
YIELD (qt/ha)[a]	8.28	20.35	32.95	20.81	4.61	6.58	13.50	8.13	12.00	24.20	37.02	24.41	11.71	24.91	36.65	24.76	12.06	28.19	47.41	29.22
PRICE (mt/qt)[b,c]																				
Hi trans.costs (HTC)[d]	8.29	8.29	8.29	8.29	(0.68)	(0.68)	(0.68)	(0.68)	(0.68)	(0.68)	(0.68)	(0.68)	8.29	8.29	8.29	8.29	(0.68)	(0.68)	(0.68)	(0.68)
Lo trans.costs (LTC)[e]	10.82	10.82	10.82	10.82	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	10.82	10.82	10.82	10.82	5.76	5.76	5.76	5.76
Export to int'l market LTC[f]	10.82	10.82	10.82	10.82	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	10.82	10.82	10.82	10.82	7.71	7.71	7.71	7.71
GROSS REVENUE ('0000 mt/ha)[g]																				
HTC	68.68	168.79	273.30	172.60	(3.12)	(4.45)	(9.12)	(5.49)	(8.11)	(16.35)	(25.02)	(16.49)	97.13	206.61	303.98	205.37	(8.15)	(19.05)	(32.04)	(19.75)
LTC	89.62	220.27	356.66	225.25	26.58	37.93	77.82	46.86	69.17	139.50	213.39	140.71	126.75	269.63	396.71	268.01	69.52	162.49	273.28	168.43
Export to int'l mkt	89.62	220.27	356.66	225.25	35.54	50.73	104.09	62.68	92.52	186.58	285.42	188.20	126.75	269.63	396.71	268.01	92.98	217.34	365.53	225.29
CASH COSTS ('0000 mt/ha)																				
Fert. & seed HTC[h]	115.00	115.00	115.00	115.00	132.94	132.94	132.94	132.94	132.94	132.94	132.94	132.94	115.00	115.00	115.00	115.00	132.94	132.94	132.94	132.94
Fert. & seed LTC[h]	109.94	109.94	109.94	109.94	120.06	120.06	120.06	120.06	120.06	120.06	120.06	120.06	109.94	109.94	109.94	109.94	120.06	120.06	120.06	120.06
Animal traction[i]	27.40	6.34	15.37	16.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.95	25.47	30.42	24.16	0.00	0.00	0.00	0.00
Tractor[j]	0.00	1.33	0.00	0.45	0.00	0.00	0.00	0.00	0.00	3.33	3.75	2.37	7.08	7.69	7.69	7.50	0.00	0.00	1.43	0.48
LABOR																				
Purchased labor ('0000 mt/ha)[k]	11.15	9.36	14.79	11.78	2.80	3.61	17.56	7.72	11.45	19.31	18.13	16.29	22.57	21.81	14.30	19.48	3.86	20.09	37.99	20.65
Median wage rate ('0000 mt per 8 hour day)[l]	2.00	2.00	2.00	2.00	1.04	1.04	1.04	1.04	1.60	1.60	1.60	1.60	1.20	1.20	1.20	1.20	0.60	0.60	0.60	6.00
Value of family and mutual labor ('0000 mt/ha)[m]	77.00	124.00	102.00	102.00	41.41	37.78	54.34	44.00	64.80	37.60	58.40	53.60	58.20	65.40	79.20	67.80	20.10	33.00	26.40	26.70

	Study Zone: Region 4				Study Zone: Region 7				Study Zone: Region 8				Region 10 Manica Prov.				Region 10 Nampula Prov.			
Maize Yield Tercile																				
Budget Item	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total	1	2	3	Total
Net income ('0000 mt/ha)[n]																				
HTC	(161.88)	(87.24)	26.13	(72.75)	(180.27)	(178.79)	(213.97)	(190.15)	(217.30)	(209.54)	(238.24)	(221.69)	(121.69)	(28.76)	57.37	(28.57)	(165.05)	(205.08)	(230.80)	(200.51)
LTC	(135.87)	(30.70)	114.56	(15.04)	(137.70)	(123.53)	(114.15)	(124.91)	(127.14)	(40.81)	13.05	(51.61)	(87.00)	39.32	155.16	39.13	(74.50)	(10.66)	87.40	0.54
Export to int'l mkt	(135.87)	(30.70)	114.56	(15.04)	(128.73)	(110.73)	(87.89)	(109.10)	(103.79)	62.76	85.08	(41.19)	(87.00)	39.32	155.16	39.13	(51.04)	44.19	179. 65	57.40
n	14	15	15	44	5	6	5	16	8	8	8	24	12	13	13	38	7	7	7	21

Source: Field data from DNER/SG Survey

[a] Estimated from crop cuts. Assumes storage losses of 1% per month and that maize is stored on average 2.5 months.

[B] Import parity price. Assumes that in surplus years Mozambican maize competes with maize imported from South Africa. For calculation of import parity price under different assumptions see Appendix 2.

[c] Throughout the economic analysis it is assumed that no adjustment for overvaluation of the exchange rate is required (J. Coates, World Bank, personal communication 4/2/98).

[d] Calculation of import parity price assuming high transport costs, adapted from Coulter 1995 (Appendix 2).

[e] Calculation of import parity price assuming low transport costs, adapted from Coulter 1995 (Appendix 2).

[f] Assumes Nampula Province farmers export to the international market in times of regional surplus (export parity price) through the port at Nacala and that transport costs are low. Manica Province farmers face import parity prices. Import parity price used for Manica Province.(Appendix 2)

[g] Yield * price.

[h] Includes 30 kg of improved seed, 100 kg 12-24-12, and 100 kg urea, all provided as part of the DNER/SG package.

[i] Calculated as follows: actual rental amount for farmers who paid cash for animal traction services; for farmers who owned oxen, depreciated value for oxen and tools estimated as 1/3 of actual rental rate and multiplied by number of 8-hour days of oxen use. Assumes that the animal rental rate accurately reflects the economic value of these services.

[j] Actual rental amounts paid by farmers. Assumes that the tractor rental rate accurately reflects the economic value of these services.

[k] Actual wages reported by farmers.

[l] Based on wages paid in each zone.

[m] Family and mutual labor was valued at .5 of the median wage rate for each zone.

[n] Gross revenue - (cash costs + purchased labor + value of family and mutual labor).

APPENDIX 4

CALCULATION OF ECONOMIC PRICES FOR MAIZE, FERTILIZER, AND SEED

CALCULATION OF ECONOMIC PRICES FOR MAIZE, FERTILIZER, AND SEED

Assumptions [a]	
Long distance road haulage cost in US/ton/km, using backhaul	
Low estimate	0.03
High estimate	0.05
Distance by road from Nampula to Maputo (km)	2150
Distance by road from Chimoio to Maputo (km)	1100
Cost of shipping from Nampula to Maputo by land/sea	
assuming large operation (e.g., 1500 tons, $/ton)	63
Exchange rate 1997 Mt/$ [b]	11500
Cost of bags for informal traders -- $/ton of grain handled	8

PART 1. CALCULATION OF IMPORT AND EXPORT PARITY PRICES FOR MAIZE

1. Maputo and Nacala FOB,CIF prices

Calculation of Maputo import parity price of white maize, 1997 [a]

	Deficit Year	**Surplus Year**
Item	USD/ton	
Yellow maize, FOB Gulf [c]	117	
Premium for white maize	10	
Freight and insurance, Gulf to Maputo [d]	50.85	
Port charges and bagging	14	
Transport from port to warehouse	3	
Maputo import parity price, white maize	194.45	

2. Determination of Economic On-Farm Prices Based on Import Parity

(a) Calculation of wholesale price in Maputo at import parity (USD/metric ton) [a]

Farmer price of yellow maize, South Africa		71
Handling, storage, fumigation		17
Bagging		11
Cost FOR		99
Profit margin (7.5% of FOR)		7
Yellow maize, FOB Gulf	117	
Premium for white maize	10	10
Freight and insurance, Gulf to Maputo	51	29
CIF price	177	145
Port charges and bagging	14	
Transport from port to warehouse	3	3
Cost delivered to warehouse	194	148
Wholesale margin	19	15
Wholesale price	214	163

(b) Calculation of price to farmer in Western Nampula Province assuming low transport costs (trader shipping by sea)[a]

Wholesale price in Maputo	214	163
Overheads/profit margin of trader (20%)	36	28
Trader's direct cost delivered to Maputo	178	135
Transport from Malema to Maputo	67	67
Transport from field to railhead	10	10
Bags	8	8
Price paid to farmer	93	50
Price in mt per kilo@ Mt 11500	1064	576

(c) Calculation of price to farmer in Western Nampula Province assuming high transport costs assuming informal trader shipping to Maputo by truck [a]

Wholesale price in Maputo	214	163
Overheads/profit margin of trader (20%)	36	28
Transport from Nampula province	108	108
Transport to pick up point on main highway	25	25
Bags	8	8
Price paid to farmer	37	-6
Price in mt per kilo@ Mt 11500	420	-68

(d) Calculation of price to farmer in Manica province, assuming low transport costs (selling by roadside to informal trader shipping to Maputo by truck)[a]

Wholesale price in Maputo	214	163
Overheads/profit margin of trader (20%)	36	28
Transport from point of purchase to Maputo	33	33
Bags	8	8
Price paid to farmer	137	94
Price in mt per kilo@ Mt 11500	1570	1082

(e) Calculation of price to farmer in Manica province, assuming high transport costs (selling by roadside to informal trader shipping to Maputo by truck)[a]

Wholesale price in Maputo	214	163
Overheads/profit margin of trader (20%)	36	28
Transport from point of purchase to Maputo	55	55
Bags	8	8
Price paid to farmer	115	72
Price in mt per kilo@ Mt 11500	1317	829

3. Determination of Economic On-Farm Prices Based on Export Parity

(a) Maximum Price to Northern Farmers Supplying the Int'l Market [a]

Price FOB Nacala	127
Wholesaler/exporter's margine (20%)	21
Subtotal	106
Unloading and loading on ship	11

Rail from Malema to Nacala	7
Transport from primary buyer's store to railhead	6
Primary buyer's mark-up incl. bags	15
Price paid to farmer	67
Price in mt per kilo@ Mt 11500	771

(b) Maximum Price to Northern Farmers Based on Export to Malawi [a]

Price FOB Gulf	127
Ocean freight and insurance	51
Port unload to rail including bagging	14
Rail Nacala-border with Malawi	10
Total	202
Less: informal trader's margin (20%)	33
rail from Malema to border	5
transport from field to railhead	10
bags	8
Price paid to farmer	146
Price in mt per kilo@ Mt 11500	1675

PART 2. CALCULATION OF IMPORT PARITY PRICES FOR FERTILIZER

1. Maputo CIF price--fertilizer imported from South Africa

Item	12-24-12 USD/ton	Urea
Fertilizer, South Africa [e]	250	230
Freight and insurance, Sasolburg to Maputo (rail)[f]	48.5	47.5
Transport from port to warehouse [a]	3	3
Maputo import parity price, fertilizer	301.5	280.5

2. Determination of Economic On-Farm Prices Based on Import Parity (US$/ton)

(a) Calculation of wholesale price in Maputo at import parity

	12-24-12	Urea
Fertilizer, FOB, South Africa	250	230
Freight and insurance, Sasolburg to Maputo (rail)[b]	48.5	47.5
Transport from port to warehouse	3	3
Cost delivered to warehouse	302	281
Wholesale margin	8	7
Wholesale price	309	288

(b) Calculation of price to farmer in Western Nampula Province assuming low transport costs (trader shipping by sea) [a]

Wholesale price in Maputo	309	288
Overheads/profit margin of trader (20%)	53	49
Transport from Maputo to Malema	67	67
Transport from railhead to field	10	10
Price paid by farmer	439	413
Price in mt per kilo@ Mt 11500	5044	4754
Wholesale price in Maputo	309	288
Overheads/profit margin of trader (20%)	53	49
Transport to Nampula province	108	108
Transport from Nampula to farmgate	25	25
Price paid by farmer	495	469
Price in mt per kilo@ Mt 11500	5688	5398

(c) Calculation of price to farmer in Manica province, assuming low transport costs

Wholesale price in Maputo	309	288
Overheads/profit margin of trader (20%)	53	49
Transport from Maputo to point of sale	33	33
Price paid by farmer	395	369
Price in mt per kilo@ Mt 11500	4538	4248

(d) Calculation of price to farmer in Manica province, assuming high transport costs

Wholesale price in Maputo	309	288
Overheads/profit margin of trader (20%)	53	49
Transport from Maputo to point of sale	55	55
Price paid by farmer	417	391

Price in mt per kilo@ Mt 11500	4791	4501

Notes

[a] Except where noted, from Coulter 1995

[b] from OANDA currency converter, http://www.oanda.com/cgi_bin/ncc. It is assumed that no adjustment for overvaluation is required per personal communication, J. Coates, World Bank 4/2/98

[c] Average May 1997-January 1998 from FAO/GIEWS

[d] Freight charges Gulf-Maputo $45 (AMIC 1998). Insurance estimated at 5% FOB Gulf price

[e] Personal communication, J. Abel, Omnia, based on 12/96 price for urea and 4/98 price for 12-24-12. Urea price based on actual exports;

[f] 12-24-12 price is an estimate only. The product is not widely traded and 12-24-12 needs are currently supplied by KRII imports.

[g] Freight charges Sasolburg-Maputo USD 36. Insurance estimated at 5% FOB Sasolburg price.

PART 3. CALCULATION OF ECONOMIC PRICE FOR MANICA SEED

1. Calculation of Economic Seed Price for Nampula and Manica Provinces (meticais)[a]	MT/kg
Retail price of Manica SR seed/kg -- Nampula and Manica stores [b]	6006
cost of 30 kgs	180180
Transport to from district center to farmgate[c]	34700
Total cost seed	220886

APPENDIX 5

DESCRIPTIVE RESULTS FROM THE DNER/SG SURVEY

Table 19. Comments about the DNER/SG Program by Region

	Region 4 Total	Region 7 Total	Region 8 Total	Region 10 Total	Grand Total
Would like to continue in DNER/SG program 97/98 (%) (n in parentheses)	91 (57)	98 (45)	90 (39)	95 (74)	94 (215)
Specific comments (% of responses)[a]					
Deliver inputs earlier	36.9	66.7	24.1	15.4	30.4
Provide inputs for larger area or for other crops	21.7	22.2	24.1	25.0	23.4
Assist with marketing	17.4	5.6	20.7	25.0	19.3
Provide loans for animals, antrac equipment	15.2		10.3	15.4	12.4
Input cost too high	4.3		13.8	7.7	6.9
Facilitation of credit important	2.2		3.4	3.8	2.8
Spacing recommendations incorrect	2.2	5.6	3.4	1.9	2.8
Seed was poor quality				5.7	2.1
Total %	99.9	100.1	99.8	99.9	100.1
n [b]	46.0	18.0	29.0	52.0	145.0

Source: DNER/SG Survey

[a] Respondents gave up to 3 comments each. These were pooled, unweighted, for this analysis.

[B] All respondents were asked for general comments about the DNER/SG program or technology used in the program, but only cases for which a yield estimate by crop cut was available were analyzed in this table. An additional 27 cases gave non-useful responses, e.g., the program/technology was good, or they planned to continue in the program. These responses were excluded from the analysis.

Table 20. Farmer Opinions about Fertilizer, by Region

	Region 4 Total	Region 7 Total	Region 8 Total	Region 10 Total	Grand Total
IMPACT ON YIELD (%)					
Improved	67.8	53.3	75.0	87.8	72.9
No impact	5.1	28.9	10.0	5.4	11.0
Reduced	6.8	13.3	5.0	0.0	5.5
Doesn't know	20.3	4.4	10.0	6.8	10.6
n	59.0	45.0	40.0	74.0	218.0
Would purchase with own resources if credit unavailable (%)	75.5	86.4	67.5	93.0	82.2
n	53.0	44.0	40.0	71.0	208.0
% ranking chemical fertilizer first in order of importance among purchased inputs	29.4	28.9	47.5	31.5	33.5
n	51.0	45.0	40.0	73.0	209.0

Source: DNER/SG Survey

Table 21. Farmer Opinions about Manica Seed, by Region

	Region 4 Total	Region 7 Total	Region 8 Total	Region 10 Total	Grand Total
IMPACT ON YIELD (%)					
Improved	52.5	48.9	77.5	70.3	62.4
No impact	11.9	26.7	5.0	9.5	12.8
Reduced	6.8	20.0	10.0	8.1	10.6
Doesn't know	28.8	4.4	7.5	12.2	14.2
Would purchase with own resources if credit unavailable (%)	83.3	88.9	67.5	87.7	83.0
% ranking Manica first in order of importance among purchased inputs	75.9	73.3	44.7	71.2	68.1
STORAGE					
Better than local varieties	12.1	13.3	12.5	41.9	22.6
No difference	0.0	8.9	2.5	2.7	3.2
Worse than local varieties	24.1	53.3	60.0	17.6	34.6
Doesn't know	63.8	24.4	25.0	37.8	39.6
MILLING					
Prefer Manica to local varieties	20.3	20.0	43.6	38.4	30.6
No difference	3.4	2.2	7.7	2.7	3.7
Worse than local varieties	11.9	22.2	28.2	6.8	15.3
Doesn't know	64.4	55.6	20.5	52.1	50.5
COLOR					
Prefer Manica to local varieties	28.1	75.6	70.0	43.2	50.9
No difference	19.3	13.3	20.0	24.3	19.9
Prefer local varieties	8.8	8.9	0.0	1.4	4.6
Doesn't know	43.9	2.2	10.0	31.1	24.5
TASTE					
Prefer Manica to local varieties	20.3	57.8	70.0	47.3	46.3
No difference	15.3	8.9	15.0	12.2	12.8
Prefer local varieties	8.5	0.0	5.0	1.4	3.7
Doesn't know	55.9	33.3	10.0	39.2	37.2
n	57.0	45.0	39.0	73.0	214.0

Source: DNER/SG Survey

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