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Green Revolution Technology Takes Root in Africa

The Promise and Challenge of the Ministry of Agriculture/SG2000 Experiment with Improved Cereals Technology in Ethiopia

by

Julie A. Howard, Valerie Kelly, Julie Stepanek, Eric W. Crawford, Mulat Demeke, and Mywish Maredia

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May 1999

Statistical annex and copies of the questionnaire are available at
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EXECUTIVE SUMMARY

BACKGROUND AND OBJECTIVES

Ethiopia's food insecurity will increase unless it can dramatically boost agricultural productivity. In 1993, the Sasakawa/Global 2000 Program (SG) and the Ministry of Agriculture (MOA) began a joint program to demonstrate that substantial productivity increases could be achieved when farmers were given appropriate extension messages and agricultural inputs were delivered on time at reasonable prices. The program provided credit, inputs and extension assistance to participants willing to establish half-hectare demonstration plots on their own land. In 1995, the MOA/SG demonstration program reached more than 3,500 farmers. During the same year MOA launched the New Extension Program (NEP) based on SG principles but managed independently. By 1997, NEP was managing the bulk of the demonstration plots (about 650,000).

Although the MOA/SG program is widely considered to be a success, no formal analysis had been carried out to determine its profitability. In September 1997 MOA/SG agreed to collaborate with MSU to answer the following questions: (1) Is improved technology financially profitable for farmers? (2) Is it economically profitable from a national perspective? (3) What factors limit crop response to improved technologies? and (4) What challenges does the government face as it scales up the NEP program?

METHODS

The study examined the experiences of 1997 participants and graduates of the MOA/SG program in three zones of Oromiya Region: West Shoa (maize), Jimma (maize), and East Shoa (teff).[1] Agroecological conditions in all three zones are good. Our sample included 377 farmers. Data on yield, area and input use were collected between October and December 1997 for 226 program plots of current participants; 107 control plots where current participants used their usual or "traditional" practices; and 157 plots of program graduates using either improved or traditional practices.

YIELD RESULTS AND DETERMINANTS

Maize: There is strong evidence that practices used by MOA/SG participants and graduates resulted in much higher average yields (4.8 to 6.8 tons/ha) than those obtained on "traditional" plots (2.8 tons/ha in Jimma), and average national and regional yields (1.9-2.1 tons/ha).

[1]For maize, the recommended package (0.5 ha) was 50 kg DAP, 50 kg urea, and 12.5 kg hybrid maize seed. The teff package included 50 kg DAP, 50 kg urea, and 17.5 kg improved seed and herbicide.

Regrouping the survey plots to account for levels of inputs used,[2] we found strong evidence that improved seeds and fertilizer are associated with higher yields. Although farmers in West Shoa obtained average yields as high as 3.9 tons/ha using local seed without fertilizer, farmers using improved technologies produced an additional 2 tons/ha. Farmers using improved seed and fertilizer at less-than-recommended rates did as well as those using higher rates, signaling the possibility of increasing profits by slightly reducing fertilizer doses.

Despite evidence of superior average performance for the improved technologies, there was considerable yield variability across fields within a given technology type. Although insufficient variability and high multicollinearity across key variables made it impossible to isolate the yield impact of seeds, DAP, and urea, we were able to identify a number of environmental and management factors that affected yields. In Jimma, a farmer can increase yields by almost 1.5 tons/ha if he plants maize on red soils, and farmers plowing four or more times can increase yields by 550 kg/ha. Average Jimma losses for late planting were 260 kg/ha; for incorrect row distances they were 315 kg/ha. In West Shoa incorrect spacing reduced yields by 300 kg/ha.

Teff: Teff yields for the region average 1 ton/ha—about two-thirds of the 1.4-1.5 ton/ha average yield obtained by sample farmers. There was no statistically significant difference between yields on MOA/SG plots and other plot types. The same was true for teff straw. Two factors are responsible: (1) teff farmers have been using some type of improved seed and fertilizer for many years; and (2) MOA/SG participants were not required to use the program-recommended seed varieties. Consequently, there were no fixed differences in input use across plot types.

When we regrouped the plots by input level we found that the plots cultivated with the MOA/SG recommendations performed less well than those using retained seed and fertilizer at or below recommended rates. This suggests that the variety of seed distributed with the 1997 MOA/SG package was not as well adapted to the region as improved varieties distributed earlier.

FINANCIAL ANALYSIS

The use of improved technology was very profitable for both maize and teff farmers under a range of output price and yield scenarios. We calculated net income per ha and per labor day using 1998 prices for January, April-May, and August to assess potential gains from storage. We also calculated returns assuming hypothetical drops in January output prices of 25% and 50%. Finally, we calculated returns to maize for a case where storage losses were reduced by half using storage pesticides. Results from these six scenarios led to four key conclusions about maize and teff profitability.

Improved technology is profitable for both maize and teff, even if output prices decline by

[2] Some traditional plots used fertilizer and/or improved seed while a few graduates did not, hence regrouping the plots by levels of inputs used made it easier to examine the impact of the technology.

25% or 50%. Net income is high for improved teff and maize under almost every price scenario. Net income/ha ranged from 112-4406 birr/ha (6.70 birr=1USD) for farmers using improved technology. Returns to family and mutual labor ranged from 1.6 to 48.9 birr/day for improved technology users, far exceeding average daily wage rates (3-5 birr/day) in all cases except for teff farmers who used program seed with fertilizer when a 50% output price drop was assumed.

In Jimma maize farmers who used the complete package of improved seed, DAP and urea achieved double the net returns, and 40% higher returns per labor day, than farmers using the traditional practice of local seed plus DAP. Net returns for maize farmers in West Shoa using improved technology were 25 to 33% higher, and returns to labor were 50-60% higher, than farmers using only local seed and no fertilizer.

Farmers who adapted technology packages—using lower fertilizer recommendations and in the teff case a different seed type—achieved as high or higher profits than farmers who used the full technology recommendations. Our analysis suggests the existence of a "learning curve." After farmers' first exposure to a technology they subsequently learn more efficient ways to apply it. Graduate farmers tended to use less labor and fertilizer than current program participants.

Gains from storage are potentially great if storage insecticide is used and farmers are allowed to repay loans later in the marketing year. Teff grain prices rose by 23% and straw prices doubled between January and August. By storing and selling later, teff farmers could increase net income by at least 40%. Maize prices also rose significantly between January and August in West Shoa (29%) and Jimma (72%). Unlike teff, untreated maize deteriorates rapidly in storage. In Jimma, after accounting for storage losses, net income per hectare and per labor day rose by over 60% if farmers sold in August. In West Shoa the price rise was less dramatic, but farmers still gained 7-8% by selling later.

None of the sample farmers reported using storage insecticide, but EARO research indicates that use of insecticide can cut storage losses in half. Farmers using insecticide and selling in August instead of January would increase net income by 80% in Jimma and 20% in West Shoa. Current MOA lending policies make it difficult for farmers to store their crops for later sale as farmers are expected to pay back loans at harvest. Unless they have other sources of income to repay loans, most farmers would be obliged to sell when prices are lowest. Allowing farmers to pay back loans later if they are willing to pay higher accumulated interest charges could increase returns to improved technologies.

Improved seed and fertilizer represent 50-80% of total costs. Improved inputs are by far the biggest cost component in the budgets. This suggests that even small reductions in the farmgate cost of fertilizer and seed (e.g., by reducing transport and other marketing costs) could significantly increase farm profits.

ECONOMIC ANALYSIS

The economic analysis helps answer the following questions: (1) Which is cheaper for society overall—producing maize and teff domestically, using improved technologies, or importing foodgrains? (2) Will it be socially profitable for Ethiopia to export maize and teff produced with improved technology, i.e., will the economic returns from exports cover the economic costs? and (3) Do the benefits of government-supported programs to facilitate technology adoption outweigh their costs to society? Three key findings of the economic analysis are discussed below.

Assuming that intensified production of maize and teff fills a domestic need that otherwise would have to be filled by commercial imports, it is highly profitable from society's standpoint. If the alternative to intensified domestic production of maize and teff is importing grain for domestic consumption at commercial prices, there is a high payoff to intensive maize and teff production from society's perspective. Profits are high and stable even when world fertilizer prices are high.

Whether intensified maize produced for export is profitable at the societal level depends on the prevailing export price. Our analysis looks quite different if we assume that maize produced with purchased inputs will be exported rather than serving as an import substitute.

In 1997, Ethiopia exported maize to Kenya at a price of $194/ton CIF Mombasa (considered to be an unusually high price, influenced by a maize crop failure that year in Kenya). At this price level low-input and intensive maize production remains profitable for maize farmers in Jimma and West Shoa, although net gains are much lower compared to maize valued at import parity levels.

Future export prices are likely to be lower. The U.S. could supply maize CIF Mombasa at $161/ton or less; in West Shoa, break-even export prices range from $133/ton (local seed) to $151/ton (CIF Mombasa) for farmers using improved seed and fertilizer at or above recommended levels. Break-even export prices for Jimma are even higher, ranging from $153-$160/ton. This finding raises questions about whether Ethiopian maize will be able to compete with lower-cost producers in the regional market.

Role of Transport Costs: Subsector marketing and transport costs for maize and inputs will have to be reduced for Ethiopian maize to compete effectively on regional export markets. Transport costs between the port and farmgate add 22-57% to the CIF cost of DAP and urea in West Shoa, 27-68% in Jimma, and 22-58% in Debre Zeit.

Accounting for the cost of extension and credit reduces the economic profitability of teff significantly; the impact on maize depends on whether it is an import substitute or an export. In the economic analysis, net income represents the residual return to factors that facilitate crop production but are not explicitly costed out in the analysis. As a result of fertilizer market liberalization the **price** of fertilizer is no longer directly subsidized by the government. However, the government and donors are still facilitating farmer access to fertilizer in other ways, i.e., through the provision of intensive extension assistance and credit programs. These program costs are not recovered through the prices farmers currently pay for fertilizer.

If maize produced is considered to be an import substitute, the relative costs of extension and credit provision are low and have little impact on the net gains to society. When maize is an import substitute, accounting for program costs reduces net gains by only 11 to 15% in Jimma and West Shoa. If maize is exported, however, deducting program costs reduces net gains of exported maize by 39-60%.

As in the case of exported maize, accounting for the costs of extension and credit severely reduces net gains from intensive teff production—by 42-89%—depending on assumptions about fertilizer prices and levels of inputs used.

SUSTAINING THE MOMENTUM

Our results indicate that (1) the use of improved technology significantly increases yields and income for participant farmers; and (2) as long as increased production can be consumed locally, MOA/SG programs to promote these improved technologies are economically profitable. These results support the Government of Ethiopia's (GOE) current policy of encouraging sustained use of these new technologies by the early adopters and extending their use to a broader base of farmers.

Nevertheless, the recent transition from the relatively small-scale MOA/SG program to the much more ambitious goals of the NEP (almost 3,000,000 participants anticipated in 1998) reveals that there are numerous challenges to meet if this momentum is to be sustained. Some of the more important challenges are discussed below.

Expanding NEP Extension Coverage to A Wider Base of Farmers Without (1) Diluting the Quality of the Extension Message, and (2) Increasing Program Costs

Issues of Scale: Increases in the number of DAs (extension agents) have not kept pace with the rapid expansion in the numbers of NEP participants. Extension experts recommend a ratio of about one DA per 100 demonstration plots, but the ratio now ranges from one DA per 150 to as many as 500 demonstration plots in some areas.

Broadening the Scope of Coverage: The movement to less favorable agroecological zones and poorer farmers suggests that yield response will diminish and the production risks will increase as the program reaches out to a broader population of farmers. Agents will increasingly be working with farmers who need more supervision than the previous round of participants, but will have less time to devote to each one.

Cost Issues: To date, program expansion has been achieved largely through increases in the number of demonstration plots supervised by individual agents, but there are limits to how far this can go and legitimate concerns about the probable costs in terms of decreased quality of services. The NEP's failure to "wean" farmers from the program after two years is another factor pushing up costs as it limits the number of farmers trained and raises the costs per farmer.

Finding Low-cost, Financially Sound Ways of Administering Input Credit

Hidden but High Administrative Costs: The DAs, as well as other government personnel at the regional, zone, and wereda levels, are heavily involved in the administration of the extension credit. The current division of tasks appears to increase the public cost of the credit program because many of the tasks performed by government personnel are ones that would normally be performed by farmer organizations or banking sector personnel. Creative solutions are needed to alleviate these pressures.

Competition between Extension and Regular Credit: Another problem is the strong competition between the regular and the extension program for the limited, and sometimes declining, portfolio of available credit. In several zones and weredas the entire credit allotment was used for the NEP, leaving nothing for nonparticipants accustomed to getting credit through their cooperatives. The underlying reason appears to be the limited amount of credit allocated by the regional government, coupled with a desire to meet NEP targets. If this phenomenon continues, it may seriously compromise the ability of NEP participants to become true graduates capable of purchasing improved technologies on their own.

Reimbursement remains an important issue for the viability of the credit program. Although overall rates remain acceptable, they are lower than those obtained by SG2000 and will probably decline as the NEP moves to less favorable agroecological zones. Higher defaults will increase government costs and reduce the economic profitability of the program. In an effort to minimize their losses, regional goverments have frequently called on the local police to enforce repayment. This has resulted in some confiscation of farm assets to meet payments. While farmers must reimburse if the credit system is to remain viable, liquidation of assets must be the exception rather than the standard procedure. As the program moves to more risky farming situations, some type of renegotiated payment schedules should be considered to allow for truly poor harvests.

Developing a Transparent and Responsive Input Supply System That Can Function Independently of the NEP and Provide All Farmers Access to Low-cost, High-quality Agricultural Inputs

Fertilizer Distribution: Efforts to decentralize decision making to the regional level have made it difficult to fully liberalize fertilizer markets. In Amhara, Tigray, and southern regions the market is dominated by a single firm owned in whole or in part by the regional government. These firms are generally selected by the regional, zone, or wereda governments as the principal suppliers for fertilizer made available through both the NEP and the regular credit programs. Given the role that the government plays in allocating credit, it is easy for government agents to control which firm receives the supply orders for fertilizer purchased on credit.

In a fourth region (Oromiya), a government-owned firm exists but the regional government opted for a system of open bidding in 1998. The government firm competed with other distributors in a bidding process that awarded supply contracts for fertilizer purchased with NEP and regular credit to the lowest bidder, providing they could show proof of stocks required to fill the bid. Preliminary results of price analysis studies suggest that the Oromiya bidding system provides farmers with lower cost fertilizer (after controlling for transport and other cost factors) than the systems in the other three regions.

Another key issue is the lack of differentiation of participants across functional areas. Importers are performing the full range of import, wholesale and retail transactions, leaving very little of the market for the large number of independent wholesalers and retailers who have been trained by the NFIA in view of increasing competition in local markets. Further complicating the picture is the fact that many service cooperatives tend to overestimate their members' demand for credit purchases. This can result in substantial overstocks that the cooperatives try to liquidate through cash sales, providing further competition for the independent retailers.

Policy Uncertainty Is A Problem for Importers and Distributors: In 1998 fertilizer importers and distributors faced considerable policy uncertainty: stated fertilizer polices were often abandoned and markets were not as open as the fertilizer distributors originally perceived. The national government has stated its goal of developing a free market for fertilizer, but regional policies often carry different and changing messages. Policy uncertainties at both the national and regional levels raise the cost of investing in the fertilizer sector and may discourage new entrants.

Reducing Costs: Input costs (especially fertilizer, but also seed) are a large component of the financial budgets for farmers in the MOA/SG program. Reducing the cost of inputs will enhance the accessibility of the program to a broader population and make the technology more profitable for early adopters. Beyond increasing transparency and competition in the markets, there are a number of other potential areas for cost reduction: (1) better timing of imports (importing earlier to take advantage of seasonal drops in world prices and complete inland distribution before roads deteriorate because of the rains; (2) larger allotments of foreign exchange to get greater economies of size/scale in importing; (3) improved infrastructure (options mentioned were better roads and the building of an inland storage facility just inside the Ethiopian boarder to reduce excess port charges— these options would benefit other importers and exporters as well); (4) helping farmers' organizations to take on more of the responsibilities for credit administration and input delivery; and (5) better estimates of demand to avoid the expense of carry-over stocks.

Access to Improved Seed: Seed market development lags behind that of the fertilizer sector, despite the urgent need to increase the availability of maize hybrids being promoted by the NEP. Improved varieties of teff seed are available in local shops and markets, but hybrid maize seed is not. Furthermore, there is no credit available for hybrid seed purchased outside of the NEP. Apart from the National Seed Enterprise, a government parastatal that supplies the majority of hybrid maize seed, the multinational firm Pioneer Hi-bred is the only other major actor in the Ethiopian maize seed industry. Pioneer usually sells its hybrids to the National Seed Enterprise, but is now beginning to promote direct cash sales to farmers. Both the credit and supply constraints of hybrids have important implications for NEP graduates as without hybrid seed the responsiveness of fertilizer declines dramatically.

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AFR/SD/PSGE	Africa Bureau's Office of Sustainable Development, Productive Sector Growth and Environment Division
AISE	Agricultural Input Supply Enterprise
CERES	Crop-Environment Resource Synthesis
CSA	Central Statistical Authority, Ethiopian Government
DA	Development Agent
DAP	Diammonium Phosphate
EAL	Ethiopia Amalgamated Ltd.
EARO	Ethiopian Agricultural Research Organization
EGTE	Ethiopian Grain Trading Enterprise
FA	Farmer Association
FDRE	Federal Democratic Republic of Ethiopia
GMRP	Grain Marketing Research Project
GPS	Global Positioning System
MOA	Ministry of Agriculture, Ethiopia
MOA/SG	Ministry of Agriculture/Sasakawa Global 2000 Demonstration Program
MSU	Michigan State University
NEP	New Extension Program, Government of Ethiopia
PLGY	POLYGON program
SG or SG2000	Sasakawa Global 2000
SC	Service Cooperative
TGE	Transitional Government of Ethiopia
USAID	United States Agency for International Development

1 quintal = 100 kg

1. INTRODUCTION

Ethiopia, one of the most densely populated countries in Africa, faces increasing food insecurity unless it can dramatically boost agricultural productivity per hectare. In 1993, the Sasakawa/Global 2000 Program (SG2000) began work in Ethiopia in partnership with the Ministry of Agriculture's Department of Extension and Cooperatives (MOA). The objective of their joint program was to demonstrate the productivity increases that could be achieved when farmers were provided with appropriate extension messages, adequate extension contact, and agricultural inputs such as improved seed, fertilizers and agrochemicals, delivered on time at reasonable prices (SG2000 1996).

The MOA/SG2000 program provided participating farmers with improved inputs on credit in amounts that were sufficient for one-half hectare demonstration plots. Farmers also received very close supervision from extension agents during critical periods in the cropping cycle. Participants agreed to provide land for the demonstration plot and to make a 25-50% down payment on the input package before planting, with the balance due after harvest. In 1995, the MOA/SG2000 demonstration program reached more than 3,500 farmers in four regions. During the same year the MOA launched the New Extension Program (NEP) funded and managed independently of the MOA/SG program, but based on SG2000 principles. By 1997, the NEP was managing the bulk of the demonstration plots (about 650,000) as the MOA/SG program reduced its direct participation in the demonstration program to about 2,000 plots.

Although the MOA/SG program is widely considered to be a success, no formal analysis has been carried out to determine the farm-level profitability of the program's improved technology packages. In September 1997 MOA/SG agreed to collaborate with the Grain Marketing Research Project (GMRP) and the Department of Agricultural Economics at Michigan State University (MSU) to analyze the financial returns to the recommended technology packages and determine the major factors affecting yield response.

1.1. Objectives

Our specific research objectives were to:

1. Describe the (a) characteristics of program participants versus nonparticipants; (b) input use patterns on program plots versus selected types of nonprogram plots; and (c) yield response by plot type and level of inputs used;

2. Evaluate the financial (i.e., private) and economic (i.e., social) profitability of selected plot types and input levels, with particular attention to the profitability of the recommended packages;

3. Analyze the relative contribution to yield of (a) different types of technologies, (b) environmental factors, and (c) management practices; and

4. Describe the key challenges faced by the government in its effort to expand the SG/NEP program, with particular attention to how the expansion is being affected by government efforts to decentralize decision making and liberalize and privatize input markets.

1.2. Methods

1.2.1. Sample Selection

The study examined the experiences of 1997 participants and graduates of the MOA/SG program for maize and teff in three zones located in the Oromiya Region: (1) West Shoa (maize); (2) Jimma (maize); and (3) East Shoa (teff). Figure 1 shows the location of the survey sites. Maize and teff were chosen because they have been the major foci for the MOA/SG program. Within each area, the study team (in consultation with MOA/SG staff) chose weredas that were agroecologically homogenous and had a large number of current and graduate MOA/SG participants (Table 1). All three zones are considered to have good to excellent agroecological conditions for teff and/or maize production (Table 2).

In the case of teff, the study included 1997 participants in the MOA's NEP program because the MOA/SG program focused on an experimental plant hormone to reduce lodging that had not yet been extensively tested. The NEP technology package is the same one used by MOA/SG in previous years: improved seeds, DAP and urea, and herbicides.

Within each zone, the team worked with local extension officials to construct a list of 1997 maize and teff program participants and graduates (i.e., farmers who had previously participated in the MOA/SG program, usually for two years). A total of 383 farmers were included in the sample.[3] In each of the three zones, 40-80 current participants and 40-60 graduates were chosen. In several cases all listed farmers were included in the sample. When it was necessary to make a selection among farmers this was done randomly.

In East Shoa (teff) and Jimma (maize), current program participants usually had one or more plots where they were using technology combinations different from the program plot. The survey collected information about yield, area and input use for these "non-program" plots, in addition to the program plots.

[3]Three households were subsequently dropped from the analysis because of missing yield data.

Figure 1. Location of Survey Sites

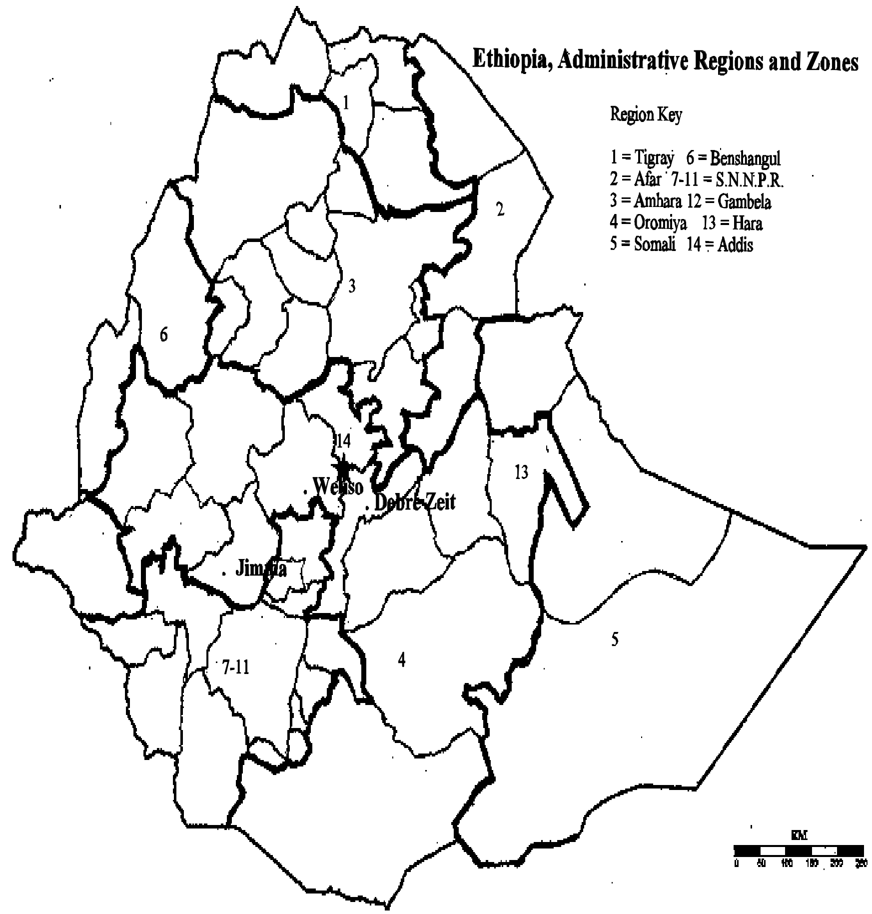

Table 1 summarizes the number of farmers in each category, and Table 2 describes key agroecological characteristics of each zone and the recommended technology package.

Table 1. Sample Composition

Characteristic→ Zone ↓	Study Crop	Sample Weredas	Total Number of Farmers	Current MOA/SG Participants	Traditional Plots of MOA/SG Participants	MOA/SG Program Graduates
East Shoa	Teff	Ada	120	60	60	60
West Shoa	Maize	Woliso, Wanchi	152	94	0	58
Jimma	Maize	Dedo, Kersa, Seka Chekorsa	111	72	47	39

Source: GMRP/MSU/SG2000/MOA 1997 Survey, Supervisor Field Reports.

Table 2. Agroecological Characteristics and Recommended Technology Packages

Characteristic→ Zone ↓	Study Crop	Altitude (meters above sea level)	Avg. Rainfall (mm)	Soils	Major Crops	Recommended Inputs Per Half Hectare Plot
East Shoa	Teff	1850	850	black, gray, red	teff, wheat, pulses	50 kg DAP,50 kg urea, 17.5 kg improved seed, herbicide
West Shoa	Maize	1600-2800	1420	red, gray	teff, barley, maize, sorghum, pulses	50 kg DAP, 50 kg urea, 12.5 kg BH660 hybrid maize seed, 80 cm between rows, 50 cm between plants
Jimma	Maize	1060-3000	1400-2000	red	teff, maize, wheat, sorghum, barley, pulses	Same as above

Source: GMRP/MSU/SG2000/MOA 1997 Survey, Supervisor Field Reports.

1.2.2. Questionnaire Design and Data Collection

Primary data collection was carried out in two rounds between October and December 1997. During these rounds the survey coordinator was assisted by three supervisors. Ten to fifteen enumerators were hired in each zone. Training and questionnaire pre-testing were carried out during the second and third weeks of October 1997. Primary data collection began the last week of October and continued through mid-December 1997.

Additional data on the fertilizer subsector were collected in August 1998 to better understand the characteristics of the rapidly evolving fertilizer subsector and estimate the costs of procuring and transporting fertilizer to survey areas. Data were collected through interviews with private sector importers, wholesalers, retailers, zonal and wereda-level agricultural officials, and a review of secondary documents.

Yield Estimation and Area Measurement: The objectives of the first round of data collection were to mark crop cut areas; harvest and weigh the grain from sample plots for yield estimation; complete a short questionnaire on soil characteristics and history of the field being sampled; measure field area; and geo-reference the field site using handheld global positioning system (GPS) equipment (details on methods used for yield and area measurements and a copy of the questionnaire used in the first round of the survey are available at http://aec.msu.edu/agecon/fs2/papers/index.htm#recentidwp).

Collection of Demographic and Input Use Data: The objectives of the second round of data collection were to gather demographic data on the household; general information for the whole farm on area/input use for major crops and changes in livestock holdings over the past five years; and specific information for the program, traditional, or graduate plot regarding (a) dates of major field activities; (b) household and non-household labor inputs and costs; (c) amounts used and costs of non-labor inputs (including animals, tractor, fertilizer, seed); (d) farmer perceptions of the importance of purchased inputs; (e) farmer assessment of risk factors affecting maize/teff yield during the past five years, including rainfall, hail/frost, wild animals, insects, plant diseases and weeds; (f) farmer opinion of extension services received; and (g) marketing/consumption of maize/teff over the last five years. (A copy of the questionnaire used for the second round of the survey is available at http://aec.msu.edu/agecon/fs2/papers/index.htm#recentidwp.)

Data Entry, Cleaning, and Analysis: All primary survey data were entered by clerks at Addis Ababa University during December 1997 and January 1998. Data cleaning and preliminary analysis were carried out at Michigan State University in February 1998 by GMRP, Ethiopian Agricultural Research Organization (EARO), and MSU researchers. Preliminary analyses (financial budgets and yield determinant models) were completed in September 1998 and reported in Howard et al. 1998. The current document is an expanded version of Howard et al. 1998. The main addition is an economic (i.e., social) analysis of program profitability using a variety of scenarios for import and export parity prices of cereals and fertilizer and a scenario that incorporates government costs for extension and credit support to the program.

1.3. Organization of the Paper

Presentation of findings begin in Section 2 with a brief comparison of participant and non-participant characteristics. Section 3 presents yields obtained by sample farmers and focuses on factors affecting yield variability across plots and farmers' choice of technology. Section 4 summarizes farm-level profitability across the different program types and input levels. Section 5 adopts a broader perspective, presenting results of an economic (i.e., social) analysis of the technologies that corrects for price distortions and government/donor costs of supporting SG/NEP activities. Section 6 looks further into the off-farm aspects of the SG/NEP programs, examining a number of difficult input and extension issues that must be dealt with as the SG/NEP program expands.

2. CHARACTERISTICS OF PROGRAM PARTICIPANTS COMPARED TO TYPICAL AGRICULTURAL HOUSEHOLDS

There is a tendency for extension programs to introduce new technologies to farmers with better resources and skills first, expanding the program to others once the yield response and profitability of the technologies have been demonstrated. To assess the extent to which this is the case with the MOA/SG program in Ethiopia we have compared selected characteristics of program participants covered by our 1997 survey with those of typical agricultural households located in the same vicinity and covered by the CSA Agricultural Sample Surveys conducted in 1995/96.

The picture emerging from these comparisons is that the households in the survey of program participants are better off than the average farm household (Table 3).[4] Participant households have 25 to 58% more people (i.e., more available labor); they cultivate 50 to 100% more land; and there is 10 to 72% more land per capita. Participant households appear to be wealthier (more livestock and traction animals), and are much more likely to have a literate household head than the typical households described by the CSA data.

As expected, the proportion of the general farm population using improved seed and fertilizer is quite low. The CSA Agricultural Sample Survey shows that less than 1% of farmers in the general area of our 1997 survey used improved seed for any crop during 1995/96. Among CSA farmers in the general area of West Shoa, only 4% used fertilizer on maize; the proportion increased to 27 for CSA farmers in the Jimma area. There is a longer history of fertilizer use on teff, however, and 82% of CSA teff farmers in the area around East Shoa reported using fertilizer in 1995/96.

Also as expected, the highest fertilizer application rates are associated with the program plots of current SG participants who used slightly greater than recommended doses. These doses exceeded those used by graduate farmers and the general farm population represented in the CSA survey (Table 4).[5] What is of more interest, however, is to compare fertilizer doses on non-program plots of current participants to regional and national averages, as this gives a hint as to whether current participants were already ahead of their fertilizer-using neighbors before joining the program. The non-program teff plots cultivated by participants averaged 147 kg of fertilizer per hectare—substantially higher than the 110 kg average in the Oromiya Region and 99 kg

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[4]As the CSA survey collected relatively few observations in any given wereda, the averages for the CSA comparisons are based on households in the weredas covered by our 1997 survey plus weredas that were located close to those in the survey (see full list in notes to Table 3).

[5]All three participant survey zones are located in the Oromiya Region; this is the most disaggregated level of fertilizer use data we were able to get from CSA for 1996/97.

average nationally.[6] The same pattern is apparent for maize, though the differences are not as pronounced. Non-program plots cultivated by participants averaged 92 kg/ha, while fields fertilized by farmers in the general CSA sample received 86 kg/ha in the Oromiya Region and 76 kg/ha nationally. Because the non-program plots of current participants represent the farming practices used before using the MOA/SG technologies, these results suggest that participant farmers were already using higher than average fertilizer doses before joining the MOA/SG program.

We conclude from the above discussion that participants in the MOA/SG program have better resource endowments than the general farm population and a tendency to use higher levels of improved seed and fertilizer— even without program participation— than their neighbors. These findings have implications for the expansion of the SG/NEP technologies to farmers who are more resource constrained and less accustomed to using improved inputs than the current participants (see Section 6 for further discussion).

Table 3. Characteristics of Participant Households and Average (CSA) Farm Households

	East Shoa (teff)[1]		West Shoa (maize)[2]		Jimma (maize)[3]		Ethi-opia
	Partici-pants	CSA Farmers	Partici-pants	CSA Farmers	Partici-pants	CSA Farmers	
Mean area cultivated (ha/household)	3.0	2.0	2.6	1.5	2.1	1.0	1.0
Mean household size (persons/household)	7.1	5.7	8.7	5.5	7.4	5.0	5.2
Mean hectares cultivated per capita[4]	0.62	0.36	0.34	0.31	0.31	0.21	0.21
Percent of literate household heads	95	22	85	36	95	19	22
Mean livestock units per household[5]	5.1	4.7	5.4	4.0	4.7	3.1	3.5
Mean number of draft animals per household	2.7	1.9	2.3	1.7	2.3	1.5	1.1

Sources: GMRP/MSU/SG2000/MSU 1997 data; MSU analysis of CSA agricultural data base for meher crops, 1995/96.

[1]205 households from the CSA survey were used in the East Shoa analysis which covered Boset, Lome, Ada, Dugda, Arsi Negele, Shashemene, Seraro, and Akaki weredas.

[2]221 households from the CSA survey were used for the West Shoa analysis which covered Woliso, Becho, Ambo Zuria, Dano, Wonchi, and Dendi weredas.

[3]478 households from the CSA survey were used in the Jimma analysis which covered Limu Seka, Limu Kosa, Sokoru, Tiro Afeta, Kersa Mana, Goma, Gera, Seka Cherkorsa, Dedo, and Omanada weredas.

[4] Calculated at the household level first, then averaged across households to give each household equal weight in the calculation; note that the same result will not be obtained when dividing sample mean area by sample mean population.

[5] Calculated using following weights: cattle=1, sheep/goats =.5, horses/mules = .7.

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[6]Note that the CSA data are application rates for fertilized fields only; fields receiving no fertilizer are not included in the analysis.

Table 4. Fertilizer Use of Participants and Average (CSA) Farm Households

	Type of Participant Plot		CSA Farmers
	Program	Non-program	Fertilized Fields Only
	(average kilograms of fertilizer product per hectare)		
Teff			
East Shoa (SG/NEP only)	202	147	155
Oromiya Region (CSA only)			110
National (CSA only)			99
Maize			
West Shoa (SG/NEP only)	216	—	84
Jimma (SG/NEP only)	205	92	192
Oromiya Region (CSA only)			86
National (CSA only)			76

Source: GMRP/MSU/SG2000/MOA 1997 Survey; CSA Statistical Bulletin 171, 1996/97.

3. YIELD RESULTS AND FACTORS AFFECTING CROP YIELDS AND TECHNOLOGY CHOICE

We now turn to the presentation and analysis of yield results from our sample farmers. In the next section (3.1) we begin by examining the yield results obtained in the three plot types by zone and crop: program participants' plots using the recommended technology package, traditional plots grown by program participants, and plots managed by graduates using the technology of their choice. In Sections 3.2 and 3.3 we turn to an examination of the key factors affecting maize and teff yields and quantify the relative yield impact of these factors.

3.1. Yield Results by Plot Type

Average maize and teff yields across all survey plots far exceeded national and regional averages. Yields for plots where farmers used high-input technologies were much greater than yields for plots using low-input technologies. Greater heterogeneity than anticipated within given plot types (due to variation in types and levels of inputs) produced mixed yield performance across the three plot types. Table 5 summarizes these results, presenting yields by crop, study zone, and plot type. The budgets also break each plot-type group into terciles (by crop yield) in order to examine the variation within each plot type.

3.1.1. Maize

Jimma: Average maize yields on program and graduate plots in Jimma were 5.5 and 6.8 tons/ha, respectively. These yields were more than double the 1996/97 national and Oromiya Region averages (1.9 and 2.1 tons/ha, respectively). Program graduates in Jimma achieved yields that were 1.3 tons/ha higher than program participants although they used essentially the same technology (improved seed and approximately the same amount or less of DAP and urea). This suggests the existence of a "learning curve" with farmers becoming more proficient in the application of improved technology and management techniques over time.

Traditional plots in Jimma were generally cultivated with local seed and DAP. The mean yield for these plots was 2.8 tons/ha. The large yield differences (more than 2 tons) between the traditional plots and those cultivated with the improved technologies used on the program and graduate plots clearly demonstrate the role improved inputs play in augmenting maize yields.

West Shoa: Program participants in this zone obtained slightly higher average yields than participants in Jimma—5.6 tons/ha. The graduates did not do as well as those in Jimma, however. West Shoa graduates were split into two groups: more than half reverted to traditional methods (local seed without fertilizer) while the rest continued to use improved seed and recommended levels of fertilizer. Those using low-input techniques achieved average yields of

Table 5. Yield Results by Zone, Plot Type, and Yield Tercile

Commodity/ Zone	Item	(a) MOA/SG/NEP Program Plot 1	(a) 2	(a) 3	(a) Mean/ Total	(b) Traditional Plot 1	(b) 2	(b) 3	(b) Mean/ Total	(c) Graduate Plot 1	(c) 2	(c) 3	(c) Mean/ Total
MAIZE/	**YIELD** (ton/ha)	3.9	5.5	7.2	5.6*	na	na	na	na	2.9	4.6	6.9	4.8*
WEST SHOA	n used in calculations	30	31	31	92	na	na	na	na	19	19	19	57
MAIZE/	**YIELD** (ton/ha)	4.1	5.4	6.9	5.5**	1.6	2.7	4.1	2.8**	5.1	6.9	8.4	6.8**
JIMMA	n used in calculations	22	24	23	69	15	16	16	47	13	13	13	39
EAST	**GRAIN YIELD** (ton/ha)	0.9	1.3	2	1.4	0.8	1.4	1.9	1.4	1.0	1.4	2.0	1.5
SHOA/Teff	**STRAW YIELD** (ton/ha)	2.2	2.1	2.3	2.2	2.2	1.9	2.0	2.0	2.4	2.0	1.8	2.1
	n used in calculations	20	20	20	60	20	20	20	60	21	18	21	60

Yield Tercile

Source: Field data from 1997 GMRP/MSU/AAU/SG2000/MOA Survey.
na = not applicable
* yield differences between MOA/SG and graduate plots were significant at the 95% level.
** yield differences between MOA/SG and traditional plots belonging to the same household were significant at the 95% level; yield differences between MOA/SG and traditional plots, and MOA/SG and graduate plots, were also significant at the 95% level.

3.8 tons—far exceeding national and regional averages but still significantly lower than the 5.8 ton/ha yields obtained by those using the improved technologies.

3.1.2. Teff

Average grain yields for teff were similar on all plots (program, graduate, and traditional)— about 1.4-1.5 tons/ha or 50-55% higher than national and regional average yields of 0.9 ton/ha and 1 ton/ha, respectively (FDRE 1997). The lack of a significant difference across plot types is due in large part to the use of both improved seed and fertilizers on both traditional and graduate plots. Further complicating the comparison is the flexibility of the 1997 teff program— participants were allowed to partially adopt the recommended package by using different levels of fertilizer (often less than recommended rates of urea) or substituting a different variety of seed.[7] Although farmers often referred to these seeds as “local” varieties, according to Ethiopian Agricultural Research Organization (EARO) researchers, in the East Shoa region these are more likely to be saved seed from improved varieties that were previously distributed (e.g., DZ-Cross-37 or DZ-01-196) than traditional teff varieties.

Production of teff straw, which is becoming an important commercial crop, ranged from 2 to 2.2 tons/ha across survey plots. We are not aware of any national or regional statistics on teff straw yields that can be used for comparative purposes.

In summary, unlike the maize areas, most of the teff farmers surveyed had previously adopted the key components of the improved technology package for use on all teff plots. The use of improved technology allowed farmers to achieve yields that were substantially higher than national and regional averages.

3.1.3. Moving From Analysis by Plot Type to Analysis by Technology Type

In the preceding paragraphs the yield results were examined for the three plot types by zone and crop. For maize, the average yields obtained on program and graduate plots were significantly higher than those obtained on traditional plots. However, there was a wide variation in the crop yields within a given plot type, implying that the type and level of inputs used on these plots, especially on the traditional and graduate plots, were not always homogeneous for a particular crop and zone. For example, some maize graduates in West Shoa reverted to traditional production methods (local seed and no fertilizer) while others opted to continue using inputs

[7] This type of substitution was not permitted by the MOA/SG program but was introduced as responsibility for demonstration plots shifted from MOA/SG to NEP.

similar to the recommended package; among the traditional teff plots, some farmers used improved seed, DAP and urea while others used only improved seed and DAP.

The objective of the analysis in Sections 3.2 and 3.3 is to identify the key factors affecting maize and teff yields and to quantify the relative yield impact of these factors. To accomplish this the plots were grouped by types and levels of seed and fertilizer used rather than by the original sampling criteria (type of farmer and plot). This permits better control for the various technologies when examining the influence of other factors. The other factors examined fell into two broad categories: (1) exogenous factors that farmers respond to but cannot completely control such as rainfall, soil types, disease and pest attacks, and (2) endogenous factors linked to management practices such as timing of critical operations, amount of labor used, and number of plowings.

We proceed by (1) describing the principal technologies used and their yields, (2) presenting econometric results that identify and quantify key yield determinants, (3) discussing descriptive statistics for factors that are correlated with the use of improved technologies and, therefore, thought to encourage their adoption, and (4) describing graduate farmers' decisions about continued use of the high-input technologies. Section 3.2 discusses these topics for maize and Section 3.3 does so for teff.

3.2. Factors Affecting Maize Yields

3.2.1. Types of Maize Technologies and Their Yields

We grouped maize plots into the four technology types described in Table 6. We consider technology types 1 and 2 as 'low-input' technologies and types 3 and 4 as 'high-input' technologies. The only difference between the two high-input technologies is the level of fertilizer applied. In both high-input groups the amount of DAP and urea applied are equal within a given plot but not across plots. For plots in technology type 3 application rates range from 50 to 98 kg of each product per hectare; for plots in technology type 4 the rates range from the recommended level of 100 kg per hectare to 208 kg. The median for type 4 plots is 113 kg/ha, hence at least 50% of the farmers in this group are applying fertilizer at approximately the recommended level.

Table 6. Types of Maize Technology Represented in the Sample

Type of Maize Technology	Number of Plots Using a Given Technology	Average Yields (kg/ha)	Average Fertilizer Applied (kg/ha)	
			DAP	UREA
(1) Local seed, no fertilizer	37	3639	0	0
(2) Local seed plus DAP	44	2918	103	0
(3) Improved seed plus DAP and urea at < recommended dose	103	5910	86	86
(4) Improved seed plus DAP and urea at >= recommended dose	118	5786	119	119

Source: Calculated from GMRP/MSU/SG2000/MOA survey data.

A comparison of yields for each technology group shows statistically significant differences among all the groups but technology types 3 and 4. The lack of significant difference between these two high-input groups is not unexpected as the difference in fertilizer application rates is not very large. Surprisingly, however, the lowest technology level (local seed, no fertilizer) performed better than the next higher technology (local seed plus DAP). This result in the overall data is entirely attributable to 33 plots in the West Shoa zone cultivated by graduate farmers, as illustrated by the zone-disaggregated data presented in Table 7.

Although there is substantial variability in the yields obtained by this group of farmers (1.9 to 6.8 tons/ha), the overall average was about 3.9 tons/ha—more than double the yields for the comparable technology in Jimma (1.8 tons, but only 4 observations) and statistically higher than the yields for the next higher technology in both Jimma (2.9 tons based on 43 observations) and West Shoa (3.5 tons, but only 1 observation). Numerous checks were conducted on the data to verify that these results are not due to measurement errors. Numerous cross-checks were also conducted using both quantitative and qualitative variables in a search for clues as to why this low-input technology performed so well in West Shoa during 1997.

No evidence was found of measurement error in the yield estimates, or clear explanation for the good performance of this group of graduates. The leading hypotheses are: (1) the local variety performs better under poor rainfall conditions (31 of the 34 farmers indicated that the total quantity and/or the distribution of rainfall was poor in their village during the 1997 season), and (2) there may have been some residual fertilizer effect from the previous year because most (25 of 34) of these farmers applied recommended levels of DAP and urea on the same plots in 1995/96. Other possible mitigating factors might be differences in land quality. Farmers in this group were more likely than those in other groups to report level fields (vs. gullied or sloped fields) and more likely to report high fertility soils.

Table 7. Disaggregation of Maize Technology Types by Zone

Technology Type	Jimma				West Shoa			
	Number of Plots[a]	Average Yield kg/ha	Average kg/ha		Number of Plots[b]	Average Yield kg/ha	Average kg/ha	
			DAP	UREA			DAP	UREA
(1) Local seed with no fertilizer	4	1835	0	0	33	3858	0	0
(2) Local seed plus DAP	43	2905	100	0	1	3480	208	0
(3) Improved seed plus DAP and urea at < recommended dose	58	6007	87	87	45	5784	86	86
(4) Improved seed plus DAP and urea at >= recommended dose	50	5922	116	116	68	5685	121	121

Source: Calculated from GMRP/MSU/SG2000/MOA survey data.
[a] For Jimma, all the plots for technologies 1 and 2 were traditional plots; among the 58 type 3 plots, 24 were graduates and 34 SG participants; among the 50 type 4 plots 15 were graduates and 35 SG participants.
[b] For West Shoa, the type 1 and type 2 plots were all graduate plots; among the 45 type 3 plots were 11 graduates and 34 SG participants; among the 68 type 4 plots there were 10 graduates and 58 SG participants. Two farmers in West Shoa using intermediate technologies (local seed plus DAP and urea and improved seed with no fertilizer) were excluded from the analysis.

3.2.2. Econometric Analysis of Maize Yield Determinants

The objective was to identify and evaluate the relative importance of different factors affecting maize yields. It was planned to develop a model with a disaggregated set of input, crop management, and environmental variables that combined observations from all the available technology types. Unfortunately, the variability in the data did not allow this. The main problem was very high correlation, among the input variables in particular, but also among some of the other variables. For example, local seed was used exclusively with the two low-input technologies while improved seed is used exclusively with both DAP and urea. This made it impossible to separate the seed effect from the fertilizer effect. The application of DAP and urea in equal quantities for all the high-input plots further increased problems of multicollinearity, making it impossible to evaluate the relative contributions of urea and DAP. Similar problems were encountered with some of the environmental and management variables as some tended to be highly correlated with each other and frequently correlated with the dummy variable used to differentiate the two maize production zones.

The data did, however, permit us to model the yield impact of the different technology types, and some environmental factors and key management practices. Table 8 summarizes the results by zone.

Contribution of Technology Factors on Maize Yields: Both in West Shoa and Jimma the high-input technologies explain a large amount of the yield variation observed across plots. In Jimma the technology types 3 and 4 (improved seed with both DAP and urea) yielded almost 3.5 tons/ha more than the technology type 1 using local seed without fertilizer. In West Shoa, the high-input technologies (type 3 and 4) also performed better than the low-input ones, but the difference was substantially less than in Jimma—about 1.8 tons versus 3.5 tons increase when moving from low- to high-input technologies. This is due primarily to the very high yields obtained by the graduate farmers who opted to use local seed without fertilizer (see discussion in Section 3.1.1 above).

Contribution of Environmental Factors on Maize Yields: An important environmental factor contributing to the maize yield variability in Jimma was soil type—red soil produced almost 1.5 tons more output than gray or black soils in this zone. Fortunately 95% of farmers planted maize on red soils. Several soil variables were also significant in explaining the yield variability in West Shoa. Farmers in West Shoa who declared that their soils were poor (only 20% of the West Shoa sample) obtained yields about 700 kg lower than farmers having declared soil of medium or high fertility. Red soil was associated with yield increases of about 400 tons per hectare. But unlike Jimma, red soils did not significantly impact the yield variability. About 87% of West Shoa farmers planted maize on red soils.

Contribution of Management Practices on Maize Yields: Certain management practices also affect yields. In Jimma, yields declined by about 200 kg for each week a farmer deviated from the optimal planting week. The average deviation was 1.3 weeks, suggesting an average loss due to late planting of 260 kg/ha. Each centimeter of deviation from recommended row distances resulted is a yield loss of about 35 kg/ha. In Jimma, the average deviation was 9 centimeters, resulting in an average yield loss due to poor row spacing of 315 kg/ha. The last management variable in the Jimma model that appears to be related to yields (.07 level of significance) is the number of plowings. Farmers in the Jimma zone who plowed their fields more than four times before planting got about 550 kg more per hectare than those who plowed fewer times—84% plowed at least four times so this fairly substantial yield loss affected only 16% of farmers.

Table 8. Regression Analysis of Factors Affecting Maize Yields in Jimma and West Shoa

	Jimma (Adj R^2 0.55)				West Shoa (Adj R^2 0.30)			
Variables	Coef.	SE Coef.	T	Sig T	Coef.	SE Coef.	T	Sig T
Constant	1021	895	1.14	0.26	3723	588	6.33	.00
Tech2 dummy: Local seed plus DAP	855	725	1.18	0.24	Only one case of this technology in the zone; omitted from model.			
Tech3 dummy: Improved seed, lower than recommended fertilizer use	3459	727	4.76	0.00	1843	350	5.27	.00
Tech4 dummy: Improved seed, recommended or higher fertilizer use	3532	731	4.83	0.00	1803	317	5.68	.00
Diffrowdistance: Absolute deviation in cm. from ideal distance	-35	14	-2.57	0.01	-29	17	-1.64	.10
Diffplantdistance Absolute deviation (cm) from ideal plant distances	Not a significant variable in this zone.				-17	9	-1.79	.08
Diffplantdate: Absolute deviation (weeks) from ideal planting date	-194	90	-2.15	0.03	Not a significant variable in this zone.			
Diffweeddate Absolute deviation (weeks) from ideal weeding date	Not a significant variable in this zone.				-124	79	-1.58	.12
Plowing dummy 1 represents >4 plowings	563	309	1.82	0.07	Not a significant variable in this zone.			
Red soil dummy 1=redsoil	1448	533	2.71	0.01	432	372	1.16	.24
Soil fertility assessment dummy 1= medium to high fertility	Not a significant variable in this zone.				744	314	2.37	.02

Source: Estimated from GMRP/MSU/SG2000/MOA survey data.

In West Shoa, the failure to follow recommendations concerning planting distances (both between plants and between rows) reduced yields by about 15-30 kg per centimeter (Table 8). The average deviation from the recommendation was 18 centimeters for plant spacing and 10 centimeters for row spacing, resulting in an average loss of 280 kg/ha for planting distance errors and 300 kg/ha for row spacing errors. Failure to weed at the optimal number of weeks following planting reduced yields by about 125 kg per week. The average deviation from recommended weeding time was 1.6 weeks, resulting in an average loss of 200 kg/ha.

3.2.3. Descriptive Analysis of Factors Related to Maize Technology Choice

These regression results present a rough picture of the factors that appear to have had the most important influence on maize yields during the 1997 production season, but it is important to note the models still explain only a portion of the variability in the yield data—55% for Jimma and 30% for West Shoa.

Data was collected on a much wider range of variables representing both agroecological variables and management practices. Attempts to incorporate a wider range of these variables in the models were thwarted by a substantial amount of correlation among the variables and a fairly high degree of compliance with recommended practices. This meant that there was not much variation in the data for some variables of interest.

The set of variables concerning labor inputs is a case in point. These variables were not significant in the multivariate yield models estimated, but there appeared to be some important differences in labor use when households are classified by technology type. Table 9 summarizes the results of bivariate analyses conducted to test differences in labor use by type of technology. Farmers in the low-input technology groups used significantly less labor per hectare than those in high-input groups. Interestingly, the major differences seemed to come from the access of the high-input farmers to mutual and hired labor, as there is no statistically significant difference in the amount of family labor used per hectare. This suggests that use of high-input technologies requires not only more resources for the purchase of inputs but also more resources to attract non-family labor.

Table 9. Labor Use in Maize Production by Technology Group

Type of Labor	Low-input Technology (Types 1 and 2)	High-input Technology (Types 3 and 4)	Mean Difference between Low-input and High-input Technology (Level of Significance)
Total labor days/hectare (8 hrs/day)	87	122	.00
Total weeding days/hectare	28	46	.00
Number of plowings	4.8	5.2	.00
Days of mutual labor/hectare	14	41	.00
Days of hired labor/hectare	9	14	.04
Days of family labor/hectare	65	66	.78

Source: Calculated from GMRP/MSU/SG2000/MOA survey data.

3.2.4. Graduate Farmers' Decisions Concerning Choice of Maize Technology

Graduate farmers in Jimma appear to be convinced that the recommended maize technologies and production practices are worthwhile as 100% of the graduates surveyed in the zone are continuing to use the new technologies (under the NEP program). This is not the case in West Shoa, where 60% of the graduate farmers in this zone discontinued the use of improved technologies in 1997. Table 10 summarizes the behavior of graduates in both zones with respect to a number of key recommendations.

It is noteworthy that the 60% of West Shoa farmers who abandoned the technology abandoned it in its entirety, dropping both the improved seed and all fertilizers. The reasons for discontinuing the technology package in West Shoa throw some light on the agronomics and the economics of maize production in the zone (see Table 11). The predominant reason for discontinuing both the seed and fertilizer technology was the unsatisfactory yield response in the previous year—a year of relatively good rains but more hail damage than usual. Many farmers simply did not see enough difference in yield to justify the added risk and expense of improved seed (hybrids) and fertilizer. Some noted that they had suffered major crop losses due to hail and animal damage the previous year but were still obliged to repay the credit. Two such farmers mentioned having sold their oxen to take care of the debt. Another farmer claimed he was forced to sell his maize early at very low prices in order to reimburse the credit—something he did not want to be forced into doing again.

Table 10. Graduate Farmers' Response to Recommended Maize Practices

	West Shoa	Jimma
Number of Graduates➜	58	39
Technology Component	(percent continuing a given technology)	
Improved seed	36	100
Recommended seeding rate	38	100
Planting in rows	38	100
Recommended rate of DAP	38	100
Recommended rate of urea	36	100
Recommended row spacing	36	100
Recommended spacing between plants	38	100

Source: Calculated from GMRP/MSU/SG2000/MOA survey data.

Another frequently used explanation for abandoning the technology in West Shoa was the delayed start of the rains in 1997, which substantially increased the risk of not covering input costs. Farmers never specifically said that they believed local varieties performed better in years of poor rainfall; most alluded to the desire to reduce the risk of not being able to reimburse credit and the fact that the late planting could be done more quickly by broadcasting local varieties than by planting improved varieties in rows. In general, farmers' responses suggest that risk aversion is compelling them to dis-adopt improved seed and fertilizer technologies. Another frequently mentioned constraint was the high cost of the inputs, particularly fertilizer, and an inability to mobilize enough cash for the down payment. A less common explanation (two cases) was a land constraint—i.e., the farmer could not find another farmer willing to combine land resources to meet the minimum plot size of 0.5 hectares.[8] In sum, given the relatively poor rains in the 1997 season, many farmers felt more secure using traditional maize technologies which are much less expensive and, therefore, less risky.

[8] Note that the minimum size plot is only a requirement for participation in the demonstration plot program but the only way MOA/SG 2000 graduates could get access to maize improved seed was to participate in the NEP program —hence the mention of a land constraint.

Table 11. Reasons Given by Maize Graduates in West Shoa for Not Continuing A Given Technology Component

Technology Component	Common Reasons for Discontinuing A Given Technology Component	% of Graduates Not Using the Recommended Practice for A Given Reason
Improved seeds	Unsatisfactory yield from previous year	54
	Returned improved seed to distributor due to delayed rains	24
	Inability to pay for the whole package	14
Seeding rate	Broadcast seeding is easier and requires less labor	72
Row planting	Demands fertilizer which is unaffordable	39
	Requires more labor and time	28
	Believes that broadcast is better	11
DAP rate	Applying fertilizer has not increased yield	38
	High cost of fertilizer	28
	Shortage of rain	17
Urea rate	High cost of fertilizer	27
	Applying fertilizer has not increased yield	24
	Shortage of rain	16
Row spacing	No reasons given, but local seed is often broadcasted and considered a more rapid method of planting in years when the rains are late	
Plant spacing	As above	

Source: Calculated from GRMP/MSU/SG2000/MOA survey data.

However, the follow-up report of the field supervisors in the West Shoa zone gives an impression that a majority of graduates who had returned to traditional practices in 1997 for a variety of reasons had re-adopted the technology package in the following year. Perhaps the strong evidence of good yields enjoyed by other graduates who had continued the technology package in 1997 made many graduates realize the benefits of hybrid maize seeds and fertilizer even in poor rain conditions.

3.3. Factors Affecting Teff Yields

3.3.1. Teff Technology Types and Their Yields

Compared to maize, the use of improved teff technology was much more widespread across the program, traditional and graduate plots surveyed in the East Shoa region. All 180 farmers surveyed (60 from each plot type) reported using improved seeds and only 6 said they used no fertilizer at all. Despite this uniformity in the use of improved seeds and fertilizer across all plot types, teff yields varied greatly, ranging from about half a ton to 3.3 tons per hectare.

The variation in the yield levels compelled us to look further into "the recommended teff technology package" and the alterations in the package made by the farmers on their traditional and graduate plots. As noted earlier, the teff technology package recommended by the extension service consisted of 35 kg/ha improved seeds (Qoladma or Magna), 100 kg/ha each of DAP and urea, and herbicides. However, the only mandatory requirement under the NEP program was the purchase of equal (unspecified) quantities of DAP and urea. Unlike the maize program participants, teff program farmers in East Shoa were allowed to use their own improved seeds saved from previous harvests (in place of the distributed seeds, Qoladma and Magna) and any quantity of herbicides. As indicated in Table 12 almost 50% of the current participants used their own improved seeds retained from previous harvests. Also, unlike the maize technology package, the seed component of the teff technology package was not exclusively for the current participants. Qoladma and Magna were also available for use on graduate and participants' traditional plots. Thus, nine current participants and three graduate farmers reported using the improved seeds Qoladma or Magna on their traditional and graduate plots.

Because of the flexibility in the seed input, the teff technology used by the current participants differed from the traditional and graduate plots only in the rate and ratio of DAP and urea application and the seeding rate (Table 12). Farmers altered the recommended fertilizer application rate by either lowering both the DAP and urea application rate, only the urea application rate, or not applying urea at all. The seeding rate on traditional and graduate plots was significantly higher than the seeding rate on participant plots. This is explained entirely by the higher seeding rate used with farmer-saved seed (Table 13), which was used by a majority of farmers on the graduate and traditional plots.

The seeding rate of farmer-saved seed was significantly higher than the seeding rates of Qoladma and Magna, which is closer to the recommended seeding rate of 35 kg/ha. Yields from farmer-saved seed were also significantly higher than the improved varieties Qoladma and Magna distributed by the NEP program (Table 13).

Table 12. Teff Seed and Fertilizer Use in East Shoa by Different Plot Types

Technology Package	Participant Plot	Traditional Plot	Graduate Plots	All
Seed		Number of Farmers Using		
Qoladma	24	4	2	30
Magna	7	5	1	13
"Local"	29	51	57	137
		Mean Application Rate (kg/ha)		
Seed	47 (a,b)	57 (b,c)	69 (a,c)	58
DAP	104	89	95	96
Urea	104	58	59	72
Herbicide	0.45	0.27	0.36	0.36

Source: Calculated from GRMP/MSU/SG2000/MOA survey data.
a Differences in the seed application rate were significantly different at the 99% level.
b Differences in the seed application rate were significantly different at the 90% level.
c Differences in the seed application rate were significantly different at the 95% level.

Table 13. Seeding Rate and Grain Yields by Teff Seed Varieties Used in East Shoa

Seed Variety	Seeding Rate (kg/ha)[a]	Grain Yields (kg/ha)[a]
Qoladma (N=30)	39 (a)	1096 (a)
Magna (N=13)	41 (b)	1110 (a)
Farmer saved (N=137)	63 (a,b)	1498 (a)
All	58	1403

Source: Calculated from GRMP/MSU/SG2000/MOA survey data.
[a]Differences were statistically significantly at the 99% level.
[b]Differences were statistically significant at the 95% level.

The teff plots are grouped into 5 technology types (described in Table 14) based on the various combinations of improved seed type and fertilizer application rates found in the sample. Technology type 1 corresponds to the full technology package recommended by the extension service (100 kg DAP, 100 kg urea, Qoladma/Magna seed). Technology type 2 users apply near-recommended quantities of fertilizer but use saved (improved) seed. Plots classified as technology types 1 or 2 were generally those of current program participants. Those in technology types 3 and 4 were traditional and graduate plots. In technology types 3 and 4, DAP is applied at close to the recommended rate, but only 50% of the recommended rate of urea is used. Technology type 5 is characterized by the use of improved seeds (mostly farmer-retained) and no fertilizer. There was no significant variation in the herbicide application rate within a given technology type. A majority of the farmers used some herbicide in all the technology groups, as indicated in Table 14. In technology type 1 (full NEP package), herbicide was used by all 35 farmers.

A comparison of teff grain yields shows statistically significant differences between technology types that use different seed varieties, but not between technology types with different urea rates. Thus, yields for technology type 1 (Qoladma/Magna seed with recommended quantities of DAP and urea) are significantly lower than technology type 2 (farmer-retained improved seed with near-recommended DAP and urea). Similarly, yields for technology type 3 (Qoladma/Magna with recommenced quantity of DAP, 50% urea) are statistically lower than yields for technology type 4 (farmer-retained improved seed, recommended DAP, 50% urea). However, yield differences between technology types 1 and 3 (Qoladma/Magna, recommended DAP, different urea rates) and types 2 and 4 (farmer-retained improved seed, recommended DAP, different urea rates) are not significant. Technology type 5 grain yields were not statistically different from yields of other technology types.

3.3.2.   Econometric Analysis of Teff Yield Determinants

Several models were developed to disaggregate the impacts of technology, environment, and crop management variables on teff grain yields based on the 160 observations across all technology types described in Table 14. Results from two of these models are summarized in Tables 15 and 16.

Contribution of Technology Factors to Teff Yields: The results from Model 1 indicate that farmers who used saved seed (improved) (Groups 2 and 4) obtained yields that were about 300 kg/ha higher than yields when farmers used the seed distributed by NEP, Qoladma/Magna (Group 1). Reducing urea rates by half had no significant impact on teff yield—indicated by the coefficients (and their lower significance level) of variables Technology 3 and Technology 5. Herbicide application had a negative but statistically insignificant impact on yield variability.

Table 14. Teff Technology Types Represented in the Sample

Type of Teff Technology	Number of Plots Using a Given Technology	Average Yields kg/ha	Average kg/ha of Fertilizer		% of Farmers in a Given Technology Group Applying Herbicides
			DAP	Urea	
(1) Improved seed (Qoladama or Magna) plus recommended quantities of DAP and urea	35	1082	105	105	100
(2) Farmer-retained improved seed plus near-recommended quantities of DAP and urea	63	1523	96	96	73
(3) Improved seed (Qoladma or Magna) plus near-recommended quantities of DAP, 50% of recommended urea	8	1181	95	47	88
(4) Farmer-retained improved seed plus near-recommended DAP, 50% of recommended urea	69	1482	98	45	73
(5) Any improved seed and no fertilizer	5	1385	0	0	60

Source: Calculated from GMRP/MSU/SG2000/MOA Survey data.

Results from Model 2 (Table 16) also confirm the association between use of farmer-retained improved seed and higher yields. *Ceteris paribus*, yields on plots where farmer retained seed was used were about 300 kg/ha higher than plots where farmers used Qoladma or Magna seed. Fortunately three-quarters of farmers in the sample used their own saved seeds.

Including kilograms per hectare of DAP and urea as variables in Model 2 did not change the results very much: neither fertilizer nor herbicide use were significant factors explaining yield variation.

Table 15. Regression Analysis of Factors Affecting Teff Yields in East Shoa (Model 1)

Variables	Coef.	SE Coef.	T	Sig T
Constant	1234	95	12.95	0.00
Tech2 dummy: Farmer-retained improved seed, near-recommended quantities of DAP and urea	323	94	3.42	0.00
Tech3 dummy: Improved seed (Qoladma or Magna), near recommended DAP, 50% urea	59	169	0.35	0.73
Tech4 dummy: Farmer-retained improved seed, near-recommended DAP, 50% urea	295	93	3.08	0.00
Tech5 dummy: Any improved seed and no fertilizer	118	207	0.57	0.57
Herbicide (kg/ha)	-43	103	-0.41	0.68
Plowing dummy:1 = more than 4 plowings	-135	75	-1.81	0.07
Rain distribution dummy (farmer assessment): 1 = good/excellent distribution	344	92	3.74	0.00
Gray soil dummy:1= gray color soil	-227	72	-3.14	0.00

Source: Calculated from GMRP/MSU/SG2000/MOA Survey data.
Note: Adjusted R^2 = 0.24

Table 16. Regression Analysis of Factors Affecting Teff Yields in East Shoa (Model 2)

Variables	Coef.	SE Coef.	T	Sig T
Constant	1227	105	11.7	0.00
Seed type dummy:1 = farmer retained improved seed	295	82	3.6	0.00
DAP (kg/ha)	-0.17	0.8	-0.2	0.84
Urea (kg/ha)	0.33	0.9	0.4	0.71
Herbicide (kg/ha)	-43	107	-0.4	0.68
Plowing dummy:1 = more than 4 plowings	-137	75	-1.8	0.07
Rain distribution dummy (farmer assessment): 1 = good/excellent distribution	346	92	3.7	0.00
Gray soil dummy:1= gray color soil	-216	72	-2.9	0.00

Source: Calculated from GMRP/MSU/SG2000/MOA Survey data.
Note: Adjusted R^2 = 0.24.

Contribution of Environmental Factors on Teff Yields: A number of variables summarizing information on environmental factors were used in the teff regression models. These variables included soil type (distinguished by color, local names and clay/sand content), farmer assessment of soil fertility, and farmer assessment of various biotic and abiotic stresses (e.g., rain shortage, rain distribution, weed damage, diseases, insects). Only two of these environmental variables proved to be significant: farmer assessment of rain distribution and soil color.

Yields on plots where farmers classified the distribution of rainfall as good or excellent were 350 kg/ha higher than plots where farmers said rain distribution was poor. Teff planted on gray soils yielded 200 kg/ha less on average compared to teff planted on black or red soils. These results were consistent across both models.

Contribution of Management Practices on Teff Yields: Number of plowings was the only management variable that appeared to have a significant impact on teff yield. However, unlike maize, the number of plowings had a negative effect on yields. On average, farmers who plowed more than four times got about 137 kg/ha less than those who plowed less. Fortunately, only 41 farmers in the sample plowed more than four times. These results are also consistent across Models 1 and 2 (Tables 15 and 16).

The regression results presented in Tables 15 and 16 give a rough picture of factors that appear to have had the most important influence on teff yields in the 1997 growing season in East Shoa. However, it is important to note that these models explain only a portion (24%) of the variability in the yield data.

3.3.3. Graduate Farmers' Decisions Concerning Choice of Teff Technology

Table 17 disaggregates the various components of the teff technology package and reports the number of graduates continuing each given practice. The reasons given by graduates for not continuing a recommended practice are listed in Table 18.

Table 17. Graduate Farmers' Response to Recommended Teff Practices, East Shoa

Number of Graduates	60
Technology Component	**Percentage of Graduates in the Zone Continuing a Given Technology**
Improved seed	40
Recommended seeding rate	45
Recommended rate of DAP	65
Recommended rate of Urea	25

Source: Calculated from GMRP/MSU/SG2000/MOA Survey data.

Table 18. Most Common Reasons Given by Graduates in East Shoa for Not Continuing A Given Teff Technology Component

Technology Component	Common Reasons for Discontinuing a Given Technology Component	% of Farmers Not Using the Recommended Practice for a Given Reason
Improved seeds	Couldn't get improved seed	61
	Seed isn't supplied/local seed is better	39
Seeding rate	Seed damage necessitated second planting	55
	To control weeding	30
DAP rate	High cost of fertilizer	52
	Land is fertile	19
Urea rate	Urea causes plant lodging	51
	High cost of fertilizer	25

Source: Calculated from GMRP/MSU/SG2000/MOA Survey data.

Farmers in East Shoa appear to have little confidence in the seed type and seeding rate recommended by the NEP. Only 40% of the graduates surveyed continued to use Qoladma or Magna seed—a rational decision, as shown above, since those who used retained seed obtained significantly higher yields than Qoladma/Magna users (Table 17). The main reason given for switching from the recommended seed variety back to retained seed was the unavailability of improved seeds (Table 18).[9] Graduates also nearly doubled the recommended seeding rate from 35 to 69 kg/ha (Table 17). Farmers said the seed they received was often damaged and it was necessary to increase the seeding rate in order to avoid having to plant a second time. The other main reason given for a higher seeding rate was to increase the plant density in order to control weed growth.

Almost two-thirds of the graduates continued to use DAP at the recommended rates, but only one-quarter continued to use high levels of urea—again, as shown above, this appears to be a very rational decision. Decreasing urea rates by 50% had no significant impact on yields in Models 1 or 2. Farmers cited the high cost of fertilizer as the most important reason for discontinuing DAP and urea in general. The main reason given for reducing the urea rate was the problem of lodging associated with urea application.

[9] This reason reported by graduates does not seem quite convincing given the fact that Qoladma and Magna seeds were available and used by some graduates and on traditional plots.

4. FINANCIAL ANALYSIS

Section 3 presents yield results and analyzed the key factors contributing to yield differences across plots where farmers used different levels of inputs. These results demonstrate that the use of improved seed and fertilizer technology significantly increased maize and teff yields in the surveyed zones. Farmers using improved technology also incur additional costs to obtain these yield increases, however. These include the cost of the inputs themselves, interest charges if the inputs are obtained on credit, and the cost of additional labor that may be required for fertilizer application, weeding, and harvest. This section analyzes whether it is financially profitable for farmers to use improved technology for maize and teff, i.e., do the gains from sale of these commodities compensate farmers for the costs of production?

4.1. Data and Methods Used

The study used two measures, net income per hectare and net income per labor day, to evaluate financial profitability under different price and technology scenarios. Summaries of key results from the maize and teff financial budgets are presented in Tables 19 and 20. Financial results are reported by program type and input use level. All financial analysis results are reported in Ethiopian birr (birr).[10]

Using plot-level data from the survey and additional secondary data, net income was calculated as: (a) gross revenue was calculated by multiplying the crop yield per hectare by the farmgate price[11]; and (b) costs of production reported by survey farmers or program administrators were then subtracted from the gross revenue to obtain net income per hectare. These costs included the cost of inputs such as seed, DAP, urea, herbicide, insecticide, and fungicide; interest costs on input loans if applicable[12]; cash or the cash value of in-kind payments to non-family laborers working on the plot; the depreciated value of animals and tools used for animal traction, including animal feed and health maintenance costs; and the depreciated value of hand tools used in crop production and the cost of sacks used to transport the commodity to market.

[10]The average exchange rate during the 1997 crop and marketing year was US $1.00=6.70 birr.

[11]Wholesale prices from main market towns in each zone (East Shoa, West Shoa, Jimma) were obtained from the Ethiopian Grain Trading Enterprise (EGTE) and adjusted to farmgate prices using data from our survey.

[12]Current MOA/SG maize program participants paid no interest on seed, fertilizer, and pesticide inputs while current teff NEP program participants and maize/teff graduate and traditional farmers who received inputs through the NEP program paid 10% interest annually. Under Ethiopian law a non-profit organization is not allowed to earn income, hence SG2000 does not charge interest to farmers who participate in the MOA/SG demonstration program.

In financial analysis no monetary value is imputed to family labor, but net income per day of family labor is calculated by dividing the net income per hectare by the number of (family) adult equivalent days used during crop production and harvest. Net income per day of family labor can be compared to area wage rates (which approximate the opportunity cost of labor) to assess the relative attractiveness of the technology at different yield and price levels.

We calculated net income under several different price scenarios, assuming that farmers harvesting in November 1997 sold their crop in (a) January 1998, (b) April-May 1998, and (c) August 1998, to assess potential gains from storage. In each case crop yields were adjusted to reflect storage losses[13] and interest charges according to the length of the loan period. Gross revenue was also adjusted to reflect the opportunity costs associated with selling at different times of the year. During 1998, actual maize and teff prices rose throughout the season. Net income per hectare was also calculated for hypothetical drops in output prices of (d) 25%, and (e) 50% from their January 1998 values. An additional scenario (f) was calculated for maize in which it was assumed that farmers selling in August 1998 were able to cut their storage losses in half through the purchase and use of storage insecticide.

A review of the budgets presented in Tables 19 and 20 led to three key conclusions about maize and teff profitability. These are presented in Sections 4.2 through 4.4 below.

4.2. The Use of Improved Technology for Maize and Teff Is Extremely Profitable, Even if Output Prices Decline by 25% or 50%

For both teff and maize, net income per hectare and per labor day are high (though variable between yield terciles) for farmers using improved technology. Both measures of return were extremely robust under all price scenarios. Net income and returns per labor day increase with yield, but variable costs are covered and returns to family and mutual labor exceed average daily labor rates (3-6 birr per day) under all price scenarios, for almost every program and input level category.

The sole exception was the case of teff farmers using program-supplied seed with recommended quantities of DAP and urea. With a hypothetical drop in output price of 50% below January 1998 levels, net returns remained positive but net income/day dipped to 1.6 birr/day, below average wage rates. In all other cases returns were positive and net income/day exceeded wage rates by a large margin.

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[13]Teff is highly resistant to pests and it was assumed that no storage losses occurred (Seyfu 1993). Maize storage losses were assumed to be 2% per month, the average of various estimates from Abraham et al. 1993.

4.2.1. Jimma—Maize

Results by Program Type: In Jimma, net returns per hectare and per labor day from program plots were double those from traditional plots. Gains from graduate plots were even higher since graduates had significantly higher yields than program participants while costs were the same or lower. Even for the traditional plots net income was positive and returns per labor day exceeded the average wage rate.

At January output prices, net income per hectare ranged from 1029 birr/ha for traditional plots to 2042 birr/ha for MOA/SG plots and 2543 birr/ha for graduate plots. Returns per labor day were one-third higher on program plots (15 birr/day) compared to traditional plots (11 birr/day) at January output prices. Graduate plot returns per day (18 birr/day in January) were 60% higher than traditional plots on average. In the most pessimistic case, assuming a price drop of 50% from January levels, net income per hectare falls to 293 birr/ha for traditional plots, to 601 birr/ha for MOA/SG program plots, and to 768 birr/ha for graduate farmers. Net returns per labor day decline to 3.2 birr/day (traditional), 4.4 birr/day (MOA/SG), and 5.5 birr/day (graduate).

Results by Input Level: Net returns per hectare for farmers who used the complete package of inputs (improved seed plus DAP and urea >= or < the recommended rate) were roughly double the returns received by farmers who used only local seed with DAP in every price scenario. At January prices, net returns per hectare ranged from 1054 birr/ha (local seed + DAP) to 2107 birr/ha (improved seed, DAP, urea >= recommended rate) to 2261 birr/ha (improved seed, DAP, urea <= recommended rate). Farmers in all groups still recover all variable costs and make a profit even if price levels drop 50% below the January levels. Net returns for the case of a 50% price drop range from 510 birr/ha (local seed + DAP) to 997 birr/ha (improved seed + DAP +urea >= recommended rates) to 1135 birr/ha (improved seed + DAP + urea < recommended rate).

Returns per labor day were highest for farmers who used improved seed plus DAP and urea below the recommended rate. Most farmers in this group were program graduates and used labor more efficiently than new program participants. Returns per labor day for this group were 71-80% higher than the group using local seed plus DAP, and 50% higher than returns for the group using inputs at or slightly above the recommended rate. Farmers using improved seed and fertilizer at >= the recommended rate had returns 13-16% higher than the local seed plus DAP group. For all groups, returns per day from maize production far exceeded the prevailing daily wage rate. Returns to maize production ranged from 11.3 (DAP plus urea) to 19.7 (improved seed plus DAP, urea < recommended rates) for January 1998 sales, compared to prevailing wage rates of 3-6 birr/day. If price levels drop by 50%, returns per day drop but are still above the wage rate: they are 5.5 birr/day (local seed + DAP), 6.2 birr/day (improved seed, fertilizer >= recommended rate), and 9.9 birr/day (improved seed, fertilizer < recommended rate).

4.2.2. West Shoa—Maize

Results by Program Type: Returns in West Shoa were also high and robust in response to price changes, but results did not vary significantly between the two program groups. At January 1998 prices, MOA/SG participants achieved returns of 2781 birr/ha and graduates got 2702 birr/ha. A price drop of 50% reduces gains to 940 birr/ha for MOA/SG participants and 1110 birr/ha for program graduates.

Unlike Jimma, program graduates in West Shoa appeared to use labor less efficiently than current program participants, but this is probably due to the fact that less than half continued to use improved inputs after leaving the MOA/SG program, as discussed in Section 3. Although net returns per hectare were similar between the two groups, returns per labor day were up to one-third higher for current program participants. In January 1998 net returns per day were 17.6 birr/ha for MOA/SG plots compared to 13.1 birr/day for graduates, declining to 5.9 and 5.4 birr/ha respectively when output prices drop by 50%.

Results by Input Level: Under all price scenarios, net returns per hectare and per labor day were highest for the group using improved seed and fertilizer at less than the recommended rate (mostly program graduates). If maize is sold at January 1998 prices, net returns per hectare ranged from 2316 birr/ha (local seed only), to 2759 birr/ha (improved seed plus fertilizer >= recommended rate) to 3102 birr/ha (improved seed plus fertilizer < recommended rate). The package of improved inputs outperformed local seed with no fertilizer in all but the worst price scenario (-50% from January 1998 levels). In that case, gains from improved seed plus fertilizer >= recommended rates were 874 birr/ha compared to 1037 birr/ha (local seed, no fertilizer) and 1185 (improved seed, fertilizer < recommended rates).

Returns per labor day were highest for farmers using improved seed and fertilizer below the recommended rates. Returns per day for this group were 23-47% higher than for the group using inputs at >= recommended rates, and 50-74% higher than returns/day for farmers using only local seed. At January 1998 price levels returns per day ranged from 11.4 birr/day (local seed only) to 16.0 birr/day (improved seed + fertilizer >= recommended rates) and 19.6 birr/day for the groups using improved seed plus fertilizer at less than the recommended rates.

4.2.3. East Shoa—Teff

Results by Program Type: As discussed in Section 3, differences between program types in East Shoa are blurred because teff farmers used improved varieties and fertilizer on all teff plots (program, traditional, graduate). Yield differences between program types were not significant, but net income per hectare was significantly higher for traditional and graduate plots than for program plots. At January 1998 price levels, net returns ranged from 1904 birr/ha (MOA/SG) to 2091 birr/ha (traditional) and 2193 birr/ha (graduate). Net returns remained positive even assuming a drop of 50% in January 1998 prices, with net returns declining to 366 birr/ha (MOA/SG), 587 birr/ha (traditional), and 595 birr/ha (graduate).

Labor requirements for teff are much lower than for maize. Thus while net returns per hectare are comparable or slightly lower than returns received by maize farmers in West Shoa and Jimma, net returns per labor day were much higher because teff required only half as much (or less) family labor. Net returns/labor day at January prices were 29.7 birr (MOA/SG), 36 birr (traditional), and 28.5 birr (graduate). If the teff price declines by 50% these returns drop to 5.7 birr (MOA/SG), 10.1 birr (traditional), and 7.7 birr (graduate)—still above average area daily wage rates of 3-6 birr/day.

Results by Input Level: These results are much more revealing. Because of an apparent problem with the improved varieties of teff distributed through the MOA/SG program during the 1997 season, farmers using program seed with recommended quantities of fertilizer had significantly lower yields than farmers using saved (improved) seed and fertilizer. Users of program-distributed seed obtained net returns that were only two-thirds as high as returns in the other two categories. At January 1998 prices, net returns ranged from 1331 birr/ha (program seed, recommended quantities of fertilizer) to 2192 (saved seed, recommended quantities of fertilizer) to 2306 (saved seed, recommended quantities of DAP, 50% of the recommended quantity of urea). Farmers who used only half the recommended quantity of urea achieved almost the same yields as farmers using more urea, but had higher net returns since their costs were lower. This suggests that there is a need to review and possibly revise the fertilizer recommendation for teff in this area to help farmers maximize income gains from the use of improved technology.

Net returns per labor day were also highest for farmers using saved (improved seed) with recommended quantities of DAP and 50% of the recommended quantity of urea. Returns at January 1998 prices ranged from 19.6 birr/day (program seed, recommended quantities of fertilizer) to 32.7 birr/day (saved seed, recommended quantities of DAP, urea) and 34.9 birr/day (saved seed, near recommended DAP, 50% urea). In the worst-case scenario, in which January 1998 prices drop by 50%, net returns per labor day drop to 1.6 birr/day for the program seed group, below average wage rates for the area, but remain above the wage rate for the other two groups: 7.8 birr/day (saved seed, recommended quantities of fertilizer) and 10.3 birr/day (saved seed, recommended DAP, 50% urea).

4.3. Gains from Storage and Use of Storage Insecticide

4.3.1. Teff

There were significant gains from storing teff for later sale in the 1998 season. Farmgate grain prices rose by 23% and straw prices doubled between January and August 1998. Farmers can increase net income by more than 33-44% by selling in August instead of January. It should be noted that current MOA/NEP contracts require farmers to pay back their input loans soon after harvest, however. Since liquidity is a constraint for most farmers, unless the contracting arrangements can be changed to permit farmers to repay the loans at a later time (with additional interest charges) they may be unable to benefit from these income gains through storage.

4.3.2. Maize

Maize prices also rose markedly between January and August 1998 in West Shoa (29%) and Jimma Zones (72%). Unlike teff, untreated maize deteriorates rapidly in storage. In Jimma, the price rise over time was steep. Even accounting for storage losses, net income per hectare and per labor day rose by over 60% between January and August. In West Shoa the price rise was less dramatic, and net income increased by just 7-8% if farmers stored and sold maize in August instead of January.

None of the survey farmers reported using storage insecticide following the 1997 production year, but our results indicate that income gains from pesticide use (through reducing the amount of maize lost to storage pests) would be substantial in both Jimma and West Shoa. If Jimma and West Shoa farmers used insecticide and storage losses were reduced by half[14], net income per hectare would increase by 19-23% if farmers sold in August 1998 rather than January, even after the costs of storage insecticide are deducted. Net income for Jimma farmers (selling in August rather than January) would increase by 80-85%.

4.4. Improved Seed and Fertilizer Costs Represent 50-75% of Total Costs

Improved seed and fertilizer are by far the biggest cost component in the financial enterprise budgets. In East Shoa (teff) the costs of improved seed and fertilizer represent more than half of total costs (exclusive of family labor). Purchased seed and fertilizer make up two-thirds to three-quarters of total production costs for maize in West Shoa and Jimma. This suggests that even small reductions in the farmgate cost of fertilizer and seed (e.g., by reducing transport and other marketing costs) could significantly increase farm profits.

[14] This is a conservative estimate. Recent research suggests that the application of storage insecticide can reduce storage losses to 2-13% of grain weight over a 5-9 month period (Abraham et al. 1993).

Table 19. Summary of Maize Results: Financial Analyses by Zone, Program Type and Input Level

	JIMMA						WEST SHOA					
	Program Type			Input Level			Program Type			Input Level		
Zone/Budget Item	MOA/ SG	Tradi- tional	Graduate	Local Seed + DAP	Imp. Seed + DAP+ Urea < Rec. Rate	Imp. Seed + DAP+ Urea >= Rec. Rate	MOA/ SG	Tradi- tional	Graduate	Local Seed, No Fertilizer	Imp. Seed + DAP+ Urea < Rec. Rate	Imp. Seed + DAP+ Urea >= Rec. Rate
YIELD (t/ha) 1/	5.6	2.8	6.8	2.9	6.0	5.9	5.6	n/a	4.8	3.9	5.8	5.7
TOTAL FAMILY/MUTUAL LABOR DAYS												
(adult equiv. days/ha)	135	92	140	93	115	162	159		206	204	158	172
N used in calculations	69	47	39	43	58	50	92		57	33	45	68
FINANCIAL ANALYSIS												
a. Net Income (Birr/ha) 2/												
Jan 98 Price	2042.1	1029.1	2543.2	1053.7	2260.8	2106.7	2781.0		2702.4	2316.1	3102.3	2758.9
April-May 98 Price	2300.8	1160.3	2848.3	1201.0	2564.7	2404.7	2577.7		2521.0	2184.1	2902.9	2562.4
August 98 Price	3257.4	1648.0	4012.6	1715.1	3626.3	3450.5	3010.9		2890.1	2477.2	3340.7	2991.9
Aug 98 w/storage insecticide	3577.2	1811.0	4405.7	1937.2	4082.6	3901.3	3322.0		3159.2	2759.2	3761.4	3405.5
Jan 98 Price - 25%	1321.3	660.8	1655.8	990.9	2130.9	1978.7	1860.3		1906.2	1676.5	2143.4	1816.5
Jan 98 Price - 50%	600.5	292.5	768.4	509.5	1135.2	997.2	939.6		1110.0	1037.0	1184.6	874.1
b. Net Income per Family and Mutual Labor Day (Birr/ha) 3/												
Jan 98 Price	15.1	11.2	18.2	11.3	19.7	13.0	17.6		13.1	11.4	19.6	16.0
April-May 98 Price	17.0	12.6	20.3	12.9	22.3	14.8	16.3		12.2	10.7	18.4	14.9
August 98 Price	24.1	17.9	28.7	18.4	31.5	21.3	19.1		14.0	12.1	21.1	17.4
Aug 98 w/storage insecticide	26.5	19.7	31.5	20.8	35.5	24.1	21.0		15.3	13.5	23.8	19.8
Jan 98 Price - 25%	9.8	7.2	11.8	10.7	18.5	12.2	11.8		9.3	8.2	13.6	10.6
Jan 98 Price - 50%	4.4	3.2	5.5	5.5	9.9	6.2	5.9		5.4	5.1	7.5	5.1

Sources: Survey and secondary data.
1/Estimated from crop cuts. **Maize** assumes storage losses of 2%per month. Yield differences were significant at the 95% level between all groups within the program and input level categories EXCEPT improved seed, DAP, urea < recommended rate and improved seed, DAP, urea >= recommended rate in both Jimma and West Shoa.
Teff assumes no grain or straw lost during threshing and no storage loss. Yield differences between program groups were not significant. For input level groups, yield differences between program seed and saved seed categories were significant at the 95% level. Differences between the saved seed groups were not significant.
2/All prices are in Ethiopian birr. During the study period the average exchange rate was USD 1 = 6.7 birr. Net Income=Gross revenue - (cash costs + interest + purchased labor + animal traction costs + hand tool and sack cost). Prices used were as follows (birr/kg) (from EGTE and survey data):
Maize -Jimma: **Jan.** .54, **April-May** .65, **Aug.** .93; **Maize-West Shoa**: **Jan**. .69, **April-May** .72, **Aug**. .89
Teff -East Shoa: **Jan.** 2.04, **April-May** 2.11, **Aug.** 2.51
3/Net income/total family and mutual labor days

Table 20. Summary of Teff Results: Financial Analyses by Zone, Program Type and Input Level

Zone/Budget Item	MOA/SG	Traditional	Graduate	Prog. Seed, Recommended Quantities DAP, Urea	Saved (Imp.) Seed, Near Recommended DAP, Urea	Saved (Imp.) Seed, Near Recommended DAP, 50% Urea
EAST SHOA	Program Type			Input Level		
GRAIN YIELD (t/ha) 1/	1.4	1.4	1.5	1.1	1.5	1.5
STRAW YIELD (t/ha) 1/	2.2	2.0	2.1	2.1	2.1	2.1
TOTAL FAMILY/MUTUAL LABOR DAYS	64.0	58.0	77.0	68.0	67.0	66.0
N used in calculations	60.0	60.0	60.0	35.0	63.0	69.0
FINANCIAL ANALYSIS						
a. Net Income (Birr/ha) 2/						
Jan 98 Price	1903.6	2090.5	2193.4	1331.4	2192.1	2306.0
April-May 98 Price	2008.9	2192.6	2299.5	1431.6	2385.0	2494.0
August 98 Price	2602.7	2771.9	2912.5	1912.0	3139.7	3227.8
Jan 98 Price - 25%	1134.6	1338.6	1394.0	721.8	1356.4	1493.8
Jan 98 Price - 50%	365.6	586.8	594.5	112.1	520.7	681.6
b. Net Income per Family and Mutual Labor Day (Birr/ha) 3/						
Jan 98 Price	29.7	36.0	28.5	19.6	32.7	34.9
April-May 98 Price	31.4	37.8	29.9	21.1	35.6	37.8
August 98 Price	40.7	47.8	37.8	28.1	46.9	48.9
Jan 98 Price - 25%	17.7	23.1	18.1	10.6	20.2	22.6
Jan 98 Price - 50%	5.7	10.1	7.7	1.6	7.8	10.3

Sources: Survey and secondary data.
1/Estimated from crop cuts. **Maize** assumes storage losses of 2%per month. Yield differences were significant at the 95% level between all groups within the program and input level categories EXCEPT improved seed, DAP, urea < recommended rate and improved seed, DAP, urea >= recommended rate in both Jimma and West Shoa.
Teff assumes no grain or straw lost during threshing and no storage loss. Yield differences between program groups were not significant. For input level groups, yield differences between program seed and saved seed categories were significant at the 95% level. Differences between the saved seed groups were not significant.
2/All prices are in Ethiopian birr. During the study period the average exchange rate was USD 1 = 6.7 birr. Net Income=Gross revenue - (cash costs + interest + purchased labor + animal traction costs + hand tool and sack cost). Prices used were as follows (birr/kg) (from EGTE and survey data):
Maize -Jimma: **Jan.** .54, **April-May** .65, **Aug.** .93; **Maize-West Shoa**: **Jan**. .69, **April-May** .72, **Aug**. .89
Teff -East Shoa: **Jan.** 2.04, **April-May** 2.11, **Aug.** 2.51
3/Net income/total family and mutual labor days

5. ECONOMIC ANALYSIS

In the preceding section we considered whether or not it is financially profitable for **farmers** to use improved maize and teff technology, given the farmgate prices they pay for inputs, other production costs, and the farmgate prices received for maize and teff output. This section summarizes the results of the economic analysis, which considers profitability from the viewpoint of society instead of the individual farmer. Three questions are addressed:

- **(1) Which is cheaper for society overall—producing maize and teff domestically, using improved technologies, or importing foodgrains?**

- In the past Ethiopia has mainly been a cereal grains importer, but in two of the past five years it has exported grain to neighboring countries. If production gains continue, it may become common for Ethiopia to have grain surpluses that could be exported. **(2) Will it be socially profitable for Ethiopia to export maize and teff produced with improved technology, i.e., will the economic returns from exports cover the economic costs?**

- The Ethiopian government is currently subsidizing the costs of extension assistance and credit provision for program farmers, but the price farmers pay for improved seed and fertilizer does not include the full cost of these programs.
  (3) Do the benefits of government-supported programs to facilitate technology adoption outweigh their costs to society?

The following sections review the differences between financial and economic analysis and explain the procedures followed for calculating economic values in the Ethiopia case. The results are presented and discussed, and are summarized in Tables 22 through 24. A number of scenarios are considered: (1) net benefits when maize and teff produced through the intensive production program are valued as import substitutes, and world fertilizer prices are high; (2) net benefits when maize and teff are valued as import substitutes, and world fertilizer prices are low; (3) net benefits when maize production through the program is assumed to be exported at a relatively high price, and farmers face high world fertilizer prices; (4) break-even maize export prices when fertilizer prices are high; (5) net benefits when maize and teff are valued as either import substitutes or exports and costs of operating the extension and credit programs are added; and (6) net benefits when extension and credit program costs are reduced by half.

5.1. Differences Between Financial and Economic Analysis

The economic analysis considers the impact of technology program costs and benefits on society as a whole. In practice, this involves adjusting financial prices to economic prices in two steps.

First, taxes and subsidies, which were included in the financial analysis, are excluded in economic analysis because they represent transfers of funds within the economy from one group to another group, via the government, without affecting total national income.[15] For example, the Ethiopian government used to provide a direct subsidy on the price of fertilizer to farmers. The price subsidy has now been removed, but if it were still in place, this type of subsidy would be considered a direct income transfer (here, from the government or taxpayers to producers) rather than a real cost reduction, and would not be included in the economic analysis.

The additional costs incurred by the extension agency to provide intensive technical assistance to program participants and manage the MOA/SG credit program, or to provide other support services, should be treated as a cost to the society, even if farmers do not pay for them directly, since these expenditures reflect the use of real resources to support the technology program.

The second step in the economic analysis is to calculate the appropriate values for traded items (e.g., imported inputs, import substitutes, and exports). Traded items are expressed in terms of their world price equivalents. These are often termed “border prices,” since they are based on import or export prices, but they are often calculated at the farm level by adjusting for domestic transportation and marketing costs between the point of import or export and the production zone. In addition, the values of traded items are converted from foreign currency into domestic currency using the economic foreign exchange rate (in our Ethiopia study, the parallel market exchange rate) rather than the official exchange rate (in Ethiopia, the domestic auction rate). The resulting prices are referred to as import or export “parity” prices.

5.2. Method Used to Determine the Economic Values of Traded Items

Four steps were followed: (1) estimating the parallel exchange rate; (2) establishing what proportion of costs represent tradeable items; (3) converting that amount to local currency terms using the parallel exchange rate; and (4) estimating the import parity prices for maize, teff, and fertilizer and substituting the import parity prices for market prices in the economic analysis. Ethiopia has been a net cereal importer in most years, but exported maize to Kenya in two of the past five years. Therefore, an export parity price is also estimated for maize.

5.2.1. Parallel Exchange Rate

Parallel exchange rates are reported by the National Bank of Ethiopia. On average the birr was overvalued by 3-10% for the period of our analysis. In calculating the import parity price of teff

[15]The process of imposing taxes and subsidies distorts markets and therefore entails economic costs. Where it is possible to estimate the magnitude of these losses, they should be taken into account.

and maize, we used the average rate for October 1997-August 1998, the period when imported grains (substituting for domestic production in the crop year 1996/97) would be ordered and delivered to Ethiopia. Seed and fertilizer inputs for the 1996/97 crop season would have been ordered and imported earlier: the average parallel rate for November 1996-March 1997 was used for the input import parity calculations.

5.2.2. Import and Export Parity Prices

Import parity prices for grains (calculated at the farm-level) estimate the maximum price which, if paid to farmers in the different zones, would be comparable to the full cost of grain imported from the United States. Since teff is not widely traded on the world market, the import parity price for wheat, a substitute for teff in Ethiopia, is calculated instead. Because there is a significant price difference between teff and wheat in the domestic market, however, a price premium of 40% (reflecting the higher value consumers place on teff over wheat) was added to the wheat price based on price data from the FEWS-European Union Food Security Project.

Details of the calculation of the import parity prices for maize, teff, and fertilizer are available at http://aec.msu.edu/agecon/fs2/papers/index.htm#recentidwp. It is assumed that maize and wheat imported to Ethiopia would come from the U.S. and the FOB price at the point of export from the U.S. Gulf, for shipment to either Assab or the port of Djibouti, is used as the basis for the calculation.

It is also assumed that DAP fertilizer would be imported from the U.S., but urea would come from Middle Eastern sources. Because world fertilizer prices can vary substantially from year to year (especially nitrogen-based fertilizers), economic prices are calculated for two scenarios: "low" and "high" world fertilizer prices.[16] Transportation to the port and insurance costs are added to get the CIF price at the port of entry. Estimates of shipping, port, transportation and handling costs were provided by a private Ethiopian fertilizer importer (Kassahun 1998). The CIF price is adjusted by the cost of transport and marketing to the farmgate to get a farm-level economic import parity price for each commodity. Transport and marketing costs were estimated using data collected by our survey supervisors and secondary data. The financial transportation rates are adjusted to economic prices by assuming that 75% of the cost of rail and truck transport is composed of tradeable goods and valued at the parallel exchange rate.
Because maize seed is a tradeable item, the economic price of maize seed was based on the price charged by Pioneer Hi-Bred International Seed Company. Pioneer imports basic seed for hybrid maize from Zimbabwe and multiplies it in Ethiopia. The price for hybrid maize seed charged by

[16]The "low" DAP price was $200/ton (FOB U.S. port); the high DAP price was $240/ton. Low and high urea prices were $100/ton (FOB Mideast port) and $225/ton. The price range was based on an analysis of fertilizer originating from several U.S., European and Middle Eastern ports in 1997 and 1998 (Stepanek 1999).

Pioneer-Ethiopia seems to cover the full costs of seed production and marketing, unlike the price charged by the Ethiopian Seed Enterprise (ESE), which supplied the MOA/SG program. ESE's production costs are subsidized by the government of Ethiopia.

In calculating the export parity price for maize, we assume that the most likely market for future exports is Kenya. The export parity price shows, for a given CIF price offered in Mombasa, what price could be paid to Ethiopian farmers in different zones after shipping, road transport and marketing costs are subtracted.

5.2.3. Estimating Program Costs

The study assumes that program costs for the MOA/SG and NEP programs are similar (personal communication, Quinones, September 1998). Estimated costs of extension assistance and credit administration are based on the 1995 NEP program budget reproduced below in Table 21 (MOA, cited in Gordon, Habtemariam, and Kiflu 1995). The budget provides costs only for the NEP program, not total costs for the extension agency. For example, all staff salaries (NEP and non-NEP) and operating costs for non-NEP programs are excluded. The costs of credit administration are also included in the budget, since credit provided to participating farmers was administered by the extension service through the 1996/97 season. Extension will continue to manage the credit program for the next year or two, after which banks and cooperative societies are expected to take it over (Gordon, Habtemariam, and Kiflu 1995).

The study therefore assumes that the budget is a fair approximation of the incremental cost of the MOA/SG and NEP programs, i.e., that the items represent extra costs incurred by the new program, not basic costs of the day-to-day running of the extension agency that would have been supported by the government anyway.

Table 21. NEP Extension Intervention Budget for the 1995 Crop Season

Item	Value in Ethiopian Birr	Share
Input cost	11,370,123	24%
Mobility (Lorry, Vehicle, Motors, Bicycle)	18,364,242	39%
Training and field equipment	1,123,225	2%
Operating costs	9,916,323	22%
Tariffs and bank commission	6,269,626	13%
Total	47,043,840	100%

Source: MOA, reproduced in Gordon, Habtemariam, and Kiflu 1995.

The study calculated a per-demonstration plot/farm estimate of program costs as follows:

- There were 35,160 demonstration plots planned for 1995 (MOA, cited in Gordon, Habtemariam, and Kiflu 1995).

- The estimated total cost per demonstration plot: 47,043,840/35160 = 1338 birr per demonstration plot.

- We subtracted input, bank charges, and tariffs since these are already accounted for or should be excluded from the economic budget = 47,043,840 - 11,370,123 - 6,269,626 = 29,404,091 birr. 29,404,091/35160 = 836 birr per demonstration plot or farm.

- The budget is 39% transport-related, 2% training and field equipment. We assumed that 75% of these category totals were traded goods and valued them at the parallel exchange rate. Revised cost per farm = 843 birr.

5.3. Economic Analysis: Summary of Main Findings

Key results from the economic analysis are summarized in Tables 22 through 24. These tables summarize results by zone, program type and input level. More detailed economic budgets for maize, teff, fertilizer and seed, including notes on specific data sources can be found at http://aec.msu.edu/agecon/fs2/papers/index.htm#recentidwp. The key findings of the economic analysis are discussed below in Sections 5.3.1-5.3.3.

5.3.1. Economic Profitability of Intensive Maize and Teff Production

If domestically produced maize and teff will substitute for commercial imports, it is highly profitable from society's standpoint to produce these crops using intensive technology. The net economic benefits of domestic production of improved maize and teff are high and stable even when world fertilizer prices are high.

Maize Import Parity with High/Low Fertilizer Prices: Assuming that increased domestic production substitutes for imports, net gains to society from the use of improved inputs on maize in Jimma exceed gains from more traditional practices by 100-114% (Table 22, lines a-b). Net gains when farmers use local seed plus DAP were 3067-3102 birr/ha, depending on the assumption of low or high world fertilizer prices. Farmers using improved seed and recommended or higher-than-recommended fertilizer rates earned 6124-6289 birr/ha. Those using improved seed and fertilizer at less than the recommended rate (mainly program graduates) had the highest net gains, 6515-6638 birr/ha.

For West Shoa, the gains to society from the use of improved inputs instead of more traditional practices were less dramatic but still sizable. Again, the payoff was highest for experienced farmers who used less-than-recommended fertilizer rates. This group had net gains 43-46% higher (6731-6853 birr/ha) than farmers using only local seed with no fertilizer (4691 birr/ha). Net gains for program participants using fertilizer at recommended rates or higher were 32-36% (6198-6370 birr/ha) greater than the low-input group.

The net nominal protection coefficient (NPC) for maize, defined as the financial price divided by the economic price,[17] ranges from .34 to.35 in Jimma and from .45 to .49 in West Shoa. A NPC less than one indicates that the market price actually received by farmers for maize is less than its economic value and therefore acts as an implicit disincentive to farmers.

Teff Import Parity with High/Low Fertilizer Prices: As with maize, net gains to society from the production of teff with improved inputs are high and robust even when fertilizer prices are relatively high, if teff is valued as an import substitute (Table 23, lines a-b). This analysis also shows the impact of the apparent problem with teff seed distributed with the MOA/SG program in 1998. Farmers using improved seed provided by the program with recommended quantities of

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[17]Here we compare the January 1998 farmgate financial price (Table 19) with the economic import parity farmgate price assuming high fertilizer prices (Table 22).

DAP and urea had positive net gains, but at levels 75-102% (943-1084 birr/ha) lower than other technology packages. Farmers who used saved (also improved) seed, near recommended levels of DAP, and 50% of the recommended urea rate had the highest net gains (1908-1990 birr/ha), 5-9% higher than individuals using saved seed and recommended rates of DAP and urea (1757-1894 birr/ha).

Unlike the case of maize, the net NPC for teff[18] exceeds 1, ranging from 1.21-1.41. This suggests that teff's domestic price is quite high relative to its estimated value to society as an import substitute. The magnitude of net gains to society from investments in improved teff technology is also much lower (943-1990 birr/ha) than the societal payoff to investments in improved maize technology (5783-6853 birr/ha) if cereal production is valued as an import substitute.

5.3.2. Variable Profitability of Maize for Export

Whether intensified maize produced for export is profitable at the societal level depends on the prevailing export price. Our analysis looks quite different if we assume that maize produced with purchased inputs will be exported rather than serving as an import substitute. This idea is not far-fetched considering that maize production in Ethiopia has increased an average of 14% annually from 1993 to 1998 (although annual levels fluctuated considerably) (FAOSTAT 1999). Imports are declining and made up less than 2% of the total maize supply between 1993 and 1996 (FAOSTAT 1999). These data suggest that Ethiopia is at or nearing self-sufficiency levels in maize.

Maize production will continue to rise as the NEP program expands. Average harvested maize area in the period 1996-1998 was 1,683,000 hectares, and average yield was 1.7 tons/ha. Assuming that the NEP program expands successfully in the future and farmers obtain 5 ton/ha yields (MOA/SG averages) on 25% of total maize area (and 1.7 tons/ha on the remaining area), maize production will increase to 4.2 million tons from current levels of 2.8 million tons (1996-1998). If farmers achieve slightly lower yields of 4 tons/ha on 50% of maize area, total maize production will rise to 4.8 million tons.

A similar projection can be made for teff. If teff yields increase to MOA/SG levels of 1.5 tons/ha on 25% of total teff area, and farmers get 0.9 ton/ha (the national average yield) on the remaining area, total teff production will rise from current levels of 2 million tons (1996/97) to 2.3 million tons. If farmers can get slightly lower yields of 1.4 tons/ha on 50% of total teff area, production will rise to 2.5 million tons.

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[18]Comparing (as above) January 1998 farmgate financial price (Table 19) with the economic import parity farmgate price assuming high fertilizer prices (Table 23).

High Export Price for Maize: If maize is produced primarily for export, the farmgate price is the CIF price at the border of the importing country minus the costs of transport, marketing and handling incurred in bringing the maize from the farmgate to the importing country's port. Under these conditions, whether intensive maize is profitable or not from society's point of view will depend on the export price. In 1997, Ethiopia exported maize to Kenya at a price of $194/ton CIF Mombasa (Jayne, personal communication). At this price level, Table 22 shows that low-input and intensive maize production remains profitable for maize farmers in Jimma and West Shoa, although net gains are much lower compared to when maize is valued at import parity levels.

Net gains (at the $194/ton price[19]) in Jimma range from 745 birr/ha for traditional farmers to 1972 birr/ha for program graduates. Net gains were 87-130% higher in groups using improved seed with fertilizer (1429-1752 birr/ha) compared to farmers using local seed plus DAP (764 birr/ha).

Because farmers in West Shoa obtained relatively high yields even without improved seed and fertilizer (3.9 tons/ha, compared to 5.7-5.8 tons/ha for improved seed and fertilizer users), the profit gain from using improved inputs on maize (at $194/ton CIF Mombasa) is less striking. Net gains from the use of local seed with no fertilizer (1635 birr/ha) are nearly the same as net gains for the group using improved seed and fertilizer at or exceeding the recommended rate (1695 birr/ha). Farmers who reduced the fertilizer rate fared better, with net gains of 2149 birr/ha.

Break-even Export Price: Considered to be an unusually high price, $194/ton CIF Mombasa is influenced by a maize crop failure that year in Kenya. Future export prices are likely to be lower. For example, the 1996-1998 average price FOB U.S. Gulf was $124/ton, and prices have trended lower in the last two years. Shipping and insurance costs to East Africa are about $37/ton, so the U.S. could supply maize CIF Mombasa at $161/ton or less.

Table 24 (line a) shows the export prices (CIF Mombasa) that maize farmers would need in order for the investment in technology to break even from society's standpoint (net gain=0). In West Shoa, break-even export prices range from $133/ton (CIF Mombasa) for farmers using local seed and no fertilizer to $151/ton for farmers using improved seed and fertilizer at or above recommended levels. Break-even export prices for Jimma are even higher: Jimma is farther away from the ports of Assab/Djibouti and transport costs are higher. Break-even prices range from $153/ton for farmers using improved seed and fertilizer at less than recommended rates to $160/ton for farmers using improved seed and fertilizer at higher raises. This finding raises questions about whether Ethiopian maize will be able to compete with lower-cost producers in the regional market.

Role of Transport Costs: Subsector marketing and transport costs for maize and inputs will have to be reduced for Ethiopian maize to compete effectively on regional export markets, and in order

[19]Assumes high world fertilizer prices.

to provide Ethiopian farmers with a farmgate price that makes it attractive to produce surplus maize. Transport costs between the port and farmgate add 22-57% to the CIF cost of DAP and urea in West Shoa, 27-68% in Jimma, and 22-58% in Debre Zeit.

5.3.3. Extension and Credit Costs Reduce Profitability

Accounting for the cost of extension and credit reduces the economic profitability of teff significantly; the impact on maize depends on whether it is an import substitute or an export. In the economic analysis, net income represents the residual return to factors that facilitate crop production but are not explicitly costed out in the analysis, such as (in this case) the costs of implementing extension and credit programs. As a result of fertilizer market liberalization the **price** of fertilizer is no longer directly subsidized by the government. This is confirmed by our finding that the import parity price of fertilizer at the farmgate level (accounting for transport costs) is close to the price farmers currently pay for DAP and urea through the SG and NEP programs.

However, the government and donors are still facilitating farmer access to fertilizer in other ways, i.e., through the provision of intensive extension assistance and credit programs. These program costs are not recovered through the prices farmers currently pay for fertilizer: an analysis of program costs in Section 5.2.3 suggests that the handling margin and interest on fertilizer sold through the SG and NEP programs is insufficient to cover the costs of credit provision. The study estimates the per farm cost of extension assistance and credit program administration to be 843 birr per program farmer. Accounting for these costs in the analysis reduces the economic profitability (i.e., the net gains to society) of improved technology use, but the magnitude of the impact differs by crop and whether the cereal produced is an import substitute or an export. Table 22 (lines c, d, f), Table 23 (lines b, c) and Table 24 (lines b, c) show the impact when program costs are deducted from net gains under different fertilizer price and technology assumptions.

Estimates of program costs are based on MOA budgets from 1995. Between 1995 and 1997 (the year of the survey), the number of farmers covered in the program expanded considerably. Since it is unlikely that the program budget also increased significantly, costs per farmer probably declined. Tables 22-24 show the impact of program costs on economic profitability if they are only one-half of our original estimate, 422 birr/farmer.

Maize: If maize produced is considered to be an import substitute, the relative costs of extension and credit provision are low and have little impact on the net gains to society. When maize is an import substitute, accounting for program costs reduces net gains by only 11 to 15% in Jimma and West Shoa. If program costs are reduced by 50%, net gains are reduced by only 5-8%.

The results are very different when the study assumes that intensive maize will be exported. Under the export scenario net gains are much lower because the farmgate price for exported maize is relatively low (even assuming that the CIF Mombasa price is $194/ton). Deducting program costs reduces net gains of exported maize by 39-60%. If program costs are halved, net gains are still reduced substantially, by 20-30% (Table 22).

Teff: As in exported maize, accounting for the costs of extension and credit severely reduces net gains from intensive teff production—by 42-89%—depending on assumptions about fertilizer prices and levels of inputs used. The impact is still substantial, a 21-45% reduction of net gains, if program costs are reduced by 50%.

The results presented in Section 4 confirm the importance of intensive extension assistance and on-time, reliable delivery of inputs in raising yields and motivating farmers' continued use of improved technology. Government and donor support of these special programs is particularly important at this time because there are few alternative channels for input supply and extension advice. However, in the past in Ethiopia and in other countries, promising increases in input utilization have ended abruptly with the withdrawal of special programs such as MOA/SG and NEP. Identifying strategies to reduce program costs while maintaining the high quality of extension and credit provision will be critically important if Ethiopia is to sustain this success story among better-off farmers in Ethiopia and expand program coverage to poorer farmers. The remainder of this paper discusses problems and key challenges for Ethiopia in reducing these program costs and expanding the cereals intensification program.

Table 22. Summary of Economic Analysis Results for Maize by Zone, Program Type and Input Level

	JIMMA						WEST SHOA				
	Program Type			Input Level			Program Type		Input Level		
Zone/Budget Item	MOA/ SG	Tradi- tional	Graduate	Local Seed + DAP	Imp.Seed + DAP+ Urea < Rec. Rate	Imp. seed + DAP+ Urea >= Rec. Rate	MOA/ SG	Graduate	Local Seed, No Fertilizer	Imp. Seed + DAP+ Urea <Rec. Rate	Imp.Seed + DAP+ Urea >= Rec. Rate
ECONOMIC ANALYSIS											
Net Income (Birr/ha)											
a. Import Parity Hi Fert Price 1/	5783	2966	7325	3067	6515	6124	6182	5571	4691	6731	6198
b. Import Parity Lo Fert Price 2/	5929	2998	7462	3102	6638	6289	6334	5628	4691	6853	6370
c. Import Parity Hi Fert Price incl. extension, credit costs 3/	4940	n/a	6482	n/a	5672	5281	5339	4728	n/a	5888	5355
d. Import Parity Lo Fert Price incl. extension, credit costs 3/	5086	n/a	6619	n/a	5795	5446	5491	4785	n/a	6010	5527
e. Import Parity Lo Fert, 50% ext., credit costs 4/	5361		6903		6093	5702	5760	5150		6310	5777
f. Import Parity Hi Fert, 50% ext., credit costs 4/	5507		7040		6217	5867	5913	5207		6432	5948
g. Export Parity Hi Grain and Hi Fert. Prices 5/	1435	745	1972	764	1752	1429	1763	1750	1635	2149	1695
h. Export Parity Hi Grain and Hi Fert. Prices incl. extension, credit costs	592	n/a	1129	n/a	909	586	920	907	n/a	1306	852

Sources: Survey and secondary data.
1/Assumes the following fertilizer prices: DAP (FOB U.S. Gulf) USD 240; urea (FOB Middle East port) USD 225.
2/Assumes the following fertilizer prices: DAP (FOB U.S. Gulf) USD 200, urea (FOB Middle East port) USD 100.
3/Net income at the import or export parity price, assuming high fertilizer prices and accounting for costs of extension and credit program administration estimated at 843 birr per hectare.
4/Assumes extension and credit program costs are 422 birr/ha.
5/Assumes the maize price CIF Mombasa is USD 194 (T. Jayne, personal communication).

Table 23. Summary of Economic Analysis Results for Teff by Zone, Program Type, and Input Level

	EAST SHOA					
	Program Type			Input Level		
Zone/Budget Item	MOA/SG	Traditional	Graduate	Prog. Seed, Recommended Quantities DAP, Urea	Saved (Imp.) Seed, Near Recommended DAP, Urea	Saved (Imp.) Seed, Near Recommended DAP, 50% Urea
ECONOMIC ANALYSIS						
Net Income (Birr/ha)						
a. Import Parity Hi Fert Price 1/	1498	1728	1750	943	1757	1908
b. Import Parity Lo Fert Price 2/	1640	1822	1846	1084	1894	1990
c. Import Parity Hi Fert incl. extension, credit costs 3/	655	n/a	907	100	914	1065
d. Import Parity Lo Fert incl. extension, credit costs 3/	797	n/a	1003	241	1051	1147
e. Import Parity Hi Fert incl. 50% extension, credit costs 4/	1077		1328	521	1335	1486
f. Import Parity Lo Fert incl. 50% extension, credit costs 4/	1218		1425	662	1472	1569

Sources: Survey and secondary data.
1/Assumes the following fertilizer prices: DAP (FOB U.S. Gulf) USD 240; urea (FOB Middle East port) USD 225.
2/Assumes the following fertilizer prices: DAP (FOB U.S. Gulf) USD 200, urea (FOB Middle East port) USD 100.
3/Net income at the import or export parity price, assuming high fertilizer prices and accounting for costs of extension and credit program administration estimated at 843 birr per hectare (farm). Extension and credit costs were calculated from Ministry of Agriculture Extension Department budgets reproduced in Gordon, Habtemariam, and Kiflu 1995.
4/Assumes extension and credit program costs are 422 birr/ha.

Table 24. Break-Even Export Prices for Maize

	JIMMA						WEST SHOA					
	Program Type			Input Level			Program Type			Input Level		
Item	MOA/ SG	Tradi- tional	Graduate	Local Seed + DAP	Imp. Seed + DAP+ Urea < Rec. Rate	Imp. Seed + DAP+ Urea >= Rec. Rate	MOA/ SG	Tradi- tional	Graduate	Local Seed, No Fertilizer	Imp. Seed + DAP+ Urea < Rec. Rate	Imp. Seed + DAP+ Urea >= Rec. Rate
a. Break-Even Export Parity Price CIF/Mombasa assuming high fertilizer price ($/ton)	157	157	153	157	153	160	147		140	133	140	151
b. Break-Even Export Price, Hi Fertilizer Price, including credit/extension costs ($/ton)	179		170		172	180	169		167		161	172
c. Break-Even Export Price, Hi Fertilizer Price, including 50% of credit/extension costs ($/ton)	168		162		162	169	159		154		151	161

6. SUSTAINING THE MOMENTUM

The results presented in Sections 3 and 4 indicate that the use of improved technology significantly increases yields and income for participant farmers. Results in Section 5 show that as long as increased production can be consumed locally, MOA/SG programs to promote these improved technologies are economically (i.e., socially) profitable after adjustments are made for price distortions and government funding of extension and credit services. These results support the GOE's current policy of encouraging sustained use of these new technologies by the early adopters and extending their use to a broader base of farmers.

Nevertheless, the recent transition from the relatively small scale MOA/SG program (<3,500 participants at its height in 1995) to the much more ambitious goals of the NEP (almost 3,000,000 participants anticipated in 1998) reveals that there are numerous challenges to meet if this momentum is to be sustained. Some of the more important challenges identified by field surveys conducted in August 1998 are:

- Expanding NEP *extension* coverage to a wider base of farmers without (1) diluting the quality of the extension message, and (2) increasing program costs.
- Finding low-cost, financially sound ways of administering input *credit*.
- Developing a transparent and responsive *input supply* system that can function independently of the NEP and provide all farmers access to low-cost, high-quality agricultural inputs.

6.1. Expanding the NEP Extension Coverage to a Broader Group of Farmers

The objectives of NEP are similar to those of MOA/SG: to introduce farmers to new technologies in a well-supervised environment so that after a year or two of participation in the program they (1) see the merits of the new technology, and (2) are able to "graduate" and continue using the new technology on their own without special assistance. The main difference between the two programs is the scale. Analyses in Section 2, however, showed that MOA/SG participants are wealthier than average farmers, with larger land holdings and better access to resources such as animal traction and labor. This means that in addition to increases in the scale of operations the NEP will need to extend the scope of coverage to poorer farmers in less favorable agroecological zones.

6.1.1. Issues of Scale

Increases in the number of DAs (extension agents) have not kept pace with the rapid expansion in the numbers of NEP participants. Extension experts in the Ministry of Agriculture recommend a ratio of about one DA per 100 demonstration plots. However, it is estimated that this ratio now ranges from one DA per 150 to as many as 500 demonstration plots in some areas. At this level, the DAs may not be able to provide sufficient technical assistance to each participating farmer. With the increased load comes additional responsibilities for credit administration (see Section 6.2) that also reduce the time agents can spend interacting with farmers on technical training.

6.1.2. Broadening the Scope of Coverage

The movement to less favorable agroecological zones and poorer farmers raises questions about what will happen to yield response for the recommended technologies. The most logical hypothesis is that the response will diminish and the production risks will increase as the program reaches out to a broader population of farmers. Agents will increasingly be working with farmers who need more supervision than the previous round of participants, but the agents will have less time to devote to each one. The extension service has already begun to address this problem by encouraging previous graduates and local school teachers to serve as volunteer assistants to the extension agents during peak periods (planting, in particular), but this is a situation that will need to be monitored closely as the program evolves.

There is not a sound basis for estimating the size of the yield gap or increased riskiness of the technology as the adoption frontier moves out, but some preliminary results based on a CERES modeling exercise suggest that the cumulative probability of yields less than 4 tons per hectare increases from .05 to .25 when moving from the high rainfall zone of Jimma (1570 mm/year) to a slightly lower rainfall zone such as Ambo (995 mm/year) (Schulthess and Ward 1999). In other words, program expansion implies not only a challenge for the extension agents who will progressively encounter farmers with less capacity to adopt the technologies but also for researchers who must work to adapt improved varieties and other technologies to more difficult production environments.

6.1.3. Cost Issues

Keeping the costs of the extension program under control is another real challenge. To date, program expansion has been achieved largely through increases in the number of demonstration plots supervised by individual agents, but there are limits to how far this can go and legitimate concerns about the probable costs in terms of decreased quality of services. The NEP’s failure to “wean” farmers from the program after two years is another factor pushing up costs as it limits the number of farmers trained and raises the costs per farmer. Weakness in both credit allocation (Section 6.2) and input market development (Section 6.3) are making it difficult for farmers to “graduate” from the program within the prescribed two-year period.

6.2. Improving the Credit System

6.2.1. Evolution of the "Regular" Credit System

In the early 1990s the agricultural input credit system in Ethiopia was in a state of disarray with credit recovery rates declining from 54% in 1990 to 37% in 1991 and only 15% in 1992. By 1994, a new system was in place. Two government banks, the DBE and the CBE, began to provide credit to farmers' organizations (i.e., not to individuals). The DBE and CBE have a total of only 185 branches throughout the country—about one branch for 44,000 households. The credit is guaranteed by regional governments, who play an important role in the administration of the credit system (estimating input demand and credit needs, certifying creditworthy farmers' organizations, etc.). In some regions (Amhara, Tigray, and Southern) the government actually gathers loan applications, processes them, and issues purchase orders to suppliers—leaving the banks with the relatively easy task of disbursing payments to designated suppliers. In other regions (primarily Oromiya) the banks deal directly with farmer organizations that the government has certified to be creditworthy. Since 1994 the credit system has shown some signs of improvement: loan disbursements increased from 187 million birr in 1994 to 471 million approved for disbursement in 1996 and repayment rates have been much better than in the early 1990s. At the same time, a number of problems exist that raise questions about the ability of the system to respond efficiently to farmers' growing demand for input credit.

The most common critique of the existing system concerns the impact that it has had on the development of a private sector fertilizer marketing network. The administrative rules for allocation of credit have led to defacto input distribution monopolies in several regions because the regional governments tend to issue delivery orders to only one firm. These monopolies are in the hands of the major fertilizer importers/wholesalers—sometimes they are companies owned by the regional government (i.e., mini-parastatals). This system leaves little room for the development of a competitive retail sector (see Section 6.3). It is within this context of change in agricultural credit that the NEP introduced a second line of input credit tied to the extension program.

6.2.2. The Beginning of SG2000 and NEP Credit

Credit for the early MOA/SG participants did not pass through the official input credit program described above but was made available through a parallel system guaranteed by SG2000 and administered by the extension personnel assigned to the SG program. Early SG participants made a 50% down payment to obtain inputs with the balance due at harvest. No interest was paid because SG2000 believes that its nonprofit status prohibits this. Reimbursement rates were better than 95%. When the NEP began in 1995, credit was made available to participants by setting up a line of "extension" credit which runs parallel to the line of "regular" credit described above.

As in the regular credit program, extension credit is guaranteed by the regional governments and administered jointly by them and the two government banks (DBE and CBE).The rules for NEP credit are standard but differ from the earlier SG2000 rules: the down payment required is only 25%[20] and interest is charged at prevailing rates (15% until 1996 when, following a reduction in inflation, it was reduced to 10.5%). Unlike regular credit, which is issued only to organizations, extension credit is allocated to individuals who sign up for participation in the NEP demonstration plot program with their local extension agents (DAs).

Hidden But High Administrative Costs: The DAs, as well as other government personnel at the regional, zone, and wereda levels, are heavily involved in the administration of the extension credit—signing up individuals, determining their creditworthiness, collecting down payments, issuing delivery orders and/or organizing public bidding procedures, and collecting payments after harvest. Many of the DAs interviewed in August 1998 expressed concern about their heavy involvement in credit administration—not only because it kept them from their technical responsibilities (advising farmers on use of improved technologies), but also because their role as credit collection agents had a negative impact on their personal relationships with farmers. The current division of tasks among farmers, banks, and government appears to increase the public cost of the credit program because many of the tasks performed by government personnel are ones that would normally be performed by farmer organizations or banking sector personnel. Creative solutions are needed to alleviate these pressures and some are already being tested. For example, in one wereda, the DA has organized a group of farmers who are now assisting him with the collection of down payments and reimbursements.

Competition Between Extension and Regular Credit: Another problem that became evident in 1998 is the strong competition between the regular and the extension program for the limited, and sometimes declining, portfolio of available credit. The Oromiya region provides an illustration of increasing problems with credit availability. Although the aggregate amount of agricultural credit has increased fairly consistently from 1993/94 through 1997/98 , the allocation by zone has been irregular, leading to sharp reductions for some zones and important increases for others (Table 25). This pattern is inconsistent with the NEP program objectives of introducing farmers to new technologies that they can continue to use after program assistance stops, as few farmers appear to have the financial capacity to pay cash for the full technology package.

[20] When the NEP instituted a 25% down payment, SG2000 also reduced theirs to the same level, but they maintained their policy of no interest.

Table 25. Fertilizer Credit in the Three MOA/SG Study Zones, Oromiya Region
('000 Ethiopian Birr)

Zone	1993/94	1994/95	1995/96	1996/97	1997/98
Jimma	6,753.0	17,432.4	16,426.0	14,080.5	13,246.4
East Shoa	39,417.5	55,201.3	62,705.8	52,663.6	40,559.0
West Shoa	27,861.3	44,633.1	57,002.9	42,159.4	51,280.0
Oromiya Region Total*	138,295.2	190,479.2	211,135.6	210,758.6	225,971.6

Source: Oromiya Regional Government, Addis Ababa, Ethiopia, 1998.
* All zones, not just the three listed above.

Surveys in August 1998 revealed that the problem of competition between extension and regular credit was important. In several zones and weredas the entire credit allotment was used for the NEP, leaving nothing for nonparticipants accustomed to getting credit through their cooperatives. The underlying reason appears to be the limited amount of credit allocated by the regional government, coupled with a desire to meet NEP targets. For example, only one of the three weredas surveyed in the Jimma zone extended fertilizer credit to farmers outside of the NEP in 1998. This means that SG/NEP graduates in the other two weredas will have to participate in the program again to obtain fertilizer credit. It is reported that the DAs enroll graduate farmers readily because they are known to repay their loans. However, this practice reduces the chance that a farmer who has not participated in the program will be chosen and limits the amount of regular credit available for nonparticipants. If this phenomenon continues, it risks seriously compromising the ability of NEP participants to become true graduates capable of purchasing improved technologies on their own.

Reimbursement remains an important issue for the viability of the credit program. Although overall rates remain acceptable, they are lower than those obtained by SG2000 and will probably decline as the NEP moves to poorer farmers and less favorable agroecological zones. As regional governments are guaranteeing these loans, higher defaults will increase government costs and reduce the economic profitability of the program. In an effort to minimize their losses, regional governments have frequently called on the local police to enforce repayment. This has resulted in some confiscation or forced liquidation of farm assets (animals, equipment) to meet payments. While farmers must repay if the credit system is to remain viable, liquidation of assets must be the exception rather than the standard procedure for ensuring reimbursement. As the program moves to more risky farming situations, some type of renegotiated payment schedules should be considered to allow for truly poor harvests.

6.3. Developing a Transparent, Responsive, Low-cost Input Supply System

The government's stated goal for fertilizer sector development is to promote a streamlined, competitive and efficient fertilizer importation and marketing system to ensure the availability of fertilizer on a sustainable basis (National Fertilizer Policy 1993, cited in World Bank 1995). Unfortunately, the government's concurrent objective to decentralize many administrative processes has led to very uneven progress toward fertilizer subsector goals. Regional governments have become major actors in fertilizer markets, designing the rules and regulations that shape fertilizer distribution within their region and, in several cases, creating what amounts to regional parastatals with monopoly control of fertilizer marketing activities. Although substantial progress has been made in liberalizing fertilizer imports, much remains to be done to improve internal fertilizer distribution systems, reduce overall costs, and respond to farmers' overall needs for both fertilizer and improved seeds.

6.3.1. Encouraging Transparency and Competition in the Fertilizer Sector

Fertilizer Imports: The current process of importing fertilizer is largely a function of procedures established by the World Bank-funded Ethiopia National Fertilizer Sector Project. The project encouraged the establishment of the National Fertilizer Industry Agency (NFIA) which has the general task of assisting with and monitoring the liberalization of the fertilizer market. The NFIA helps organize a series of foreign exchange auctions devoted exclusively to fertilizer (all other foreign exchange in Ethiopia is made available through a general auction covering all other goods). Any licensed importer (currently five in number) can submit a bid. Most fertilizer auctions provide funds for imports of 25-30,000 tons (the maximum size of ship that can be handled at ports serving Ethiopia) but occasionally bids are for smaller quantities (e.g., 10,000 tons—a less economical size of shipment) .

Under the terms of the World Bank project agreement, foreign exchange is provided by the GOE and/or bilateral donors for the first 160,000 metric tons per year as well as for 33% of imports above this base amount. The International Development Association (IDA) of the World Bank provides the project with foreign exchange for 67% of the imports over the base tonnage (this import support represents about 92% of the $191.1 million three-year project portfolio).

Importers interviewed in August 1998 identified several characteristics of the bidding system that tended to increase landed costs of fertilizer, but most acknowledged that many of the shortcomings experienced the first year (particularly very long delays between bidding and receiving foreign exchange) have diminished in importance. Among the most frequent complaints are:

- Timing and infrequency of the auctions does not always permit importers to take advantage of seasonal dips in fertilizer prices (foreign exchange auctions for other products are held weekly);

- Conditionalities on bilateral funding often slow down the process and increase costs (e.g., restrictions on suppliers or shippers);

- The need to obtain letters of credit from banks for the full amount of the foreign exchange is often slow and the amount of collateral demanded (generally 100%) is considered excessive by some importers;

- The length of time that passes from the moment that the importer gets a cost estimate from his supplier and the time that he actually has the foreign exchange to finalize the transaction is so long (one to two months) that suppliers add substantial margins into their estimates to protect them against unexpected price fluctuations during the interval; and

- Some importers believe they could obtain foreign exchange and credit from their suppliers at better rates than what is available locally, but such transactions are currently illegal.

Despite these problems, fertilizer imports have followed a general upward trend since 1993, though with important inter-annual fluctuations due to large carry-over stocks in some years. Table 26 summarizes data on aggregate imports and shares of the market going to each importer. Though the playing field at the distribution level (see below) remains quite uneven, competition exists at the import level and there is evidence of new players entering the market (e.g., Fertline and Guna in 1998).

Table 26. Fertilizer Import Trends: 1993 to 1998

Year	AISE	EAL	Fertline	Ambassel	Guna	Total
			Metric Tons of Fertilizer Imported			
1993	not avail.	not avail.	not avail.	not avail.	not avail.	175,000
1994	not avail.	not avail.	not avail.	not avail.	not avail.	68,200
1995	232,219	55,400	0	0	0	287,619
1996	219,574	94,669	0	24,337	0	349,580
1997	160,000	0	0	0	0	160,000
1998	179,808	56,000	35,000	61,000	50,000	381,808

Source: Compiled from National Fertilizer Industry Agency, 1998.
Notes: AISE is a government parastatal that formerly had a national monopoly on input supply. It now competes with other importers but also maintains buffer stocks in case other suppliers fail to cover the market adequately. EAL and Fertline are long-established private sector firms that recently entered the fertilizer import market (in 1995 and 1998, respectively). Ambassel and Guna are regional parastatals based in Amhara and Tigray, respectively.

Fertilizer Distribution: As noted above, efforts to decentralize decision making to the regional level have made it difficult to fully liberalize fertilizer markets. In Amhara, Tigray, and Southern regions (three of the four principal fertilizer consuming regions) the market is dominated by a single firm owned in whole or in part by the regional government. These firms are generally selected by the regional, zone, or wereda governments as the principal suppliers for fertilizer made available through both the NEP and the regular credit programs. Given the role that the government plays in allocating credit (see Section 6.2 above), it is easy for government agents to control which firm receives the supply orders for fertilizer purchased on credit. The lack of competition and transparency goes even further, however, as surveys revealed several instances of private sector distributors having been denied the right to make cash sales from retail outlets in these regions. The truly private sector firms (EAL and Fertline) as well as the national parastatal (AISE) tend to become involved in these three regions only when the regional parastatal experiences a shortfall. At such times help is solicited, usually from AISE first and then from the others.

In the fourth region (Oromiya), a government-owned firm exists but the regional government opted for a system of open bidding in 1998. The government firm (Dinsho) competed with other distributors in a bidding process that awarded supply contracts for fertilizer purchased with NEP and regular credit to the lowest bidder, providing they could show proof of stocks required to fill the bid. It is interesting to note that it is in the Oromiya region where the government is also less directly involved in administration of input credit—the wereda agricultural office certifies the creditworthiness of farmers' associations, but representatives of these associations deal directly with the banks to work out the details of the loans and make the payments after harvest.

Preliminary results of price analysis studies suggest that the Oromiya bidding system provides farmers with lower cost fertilizer (after controlling for transport and other cost factors) than the systems in the other three regions (Stepanek forthcoming). Nevertheless, many problems that exist in the other regions also exist in Oromiya. One key issue is the lack of differentiation of participants across functional areas. Importers are performing the full range of supply functions, importing as well as covering most of the wholesale and retail transactions. This leaves very little of the market for the large number of independent wholesalers and retailers who have been trained by the NFIA with the objective of increasing competition in local markets. Further complicating the picture is the fact that many service cooperatives tend to overestimate their members' demand for credit purchases (i.e., they, in collaboration with wereda officials, overestimate the amount of credit that is eventually allocated). This can result in substantial overstocks that the cooperatives try to liquidate through cash sales, providing further competition for the independent retailers. It remains unclear if the vertical integration of these activities and the manner in which the cooperatives are assuming retail functions are in the interest of farmers (i.e., resulting in lower-cost fertilizer) or not. This is an issue that requires further research.[21]

Policy Uncertainty Is A Problem for Importers and Distributors: In 1998 fertilizer importers and distributors faced considerable policy uncertainty: stated fertilizer polices were often abandoned and markets were not as open as the fertilizer distributors originally perceived. Given the unpredictable policies across Ethiopia, fertilizer importers and distributors are unsure what fertilizer policy will be enacted in the coming season. The national government has stated its goal of developing a free market for fertilizer, but regional policies often carry different and changing messages. Private wholesalers have frequently been unable to obtain a market share because the regional government's policies favor certain importers and regional government companies. These policy conflicts may be due to the government's efforts to decentralize administrative responsibilities while simultaneously maintaining the right to set national goals. Policy uncertainties at both the national and regional levels raise the cost of investing in the fertilizer sector and may discourage new entrants.

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[21] For example, some cooperatives are adding margins to both their credit and cash sales that are greater than margins charged by other distributors.

6.3.2. Reducing Costs

Input costs (especially fertilizer, but also seed) are a large component of the financial budgets for farmers in the MOA/SG program (see Section 4). Reducing the cost of inputs will enhance the accessibility of the program to a broader population and make the technology more profitable for early adopters.

The preliminary results of the price analyses mentioned above suggest that fertilizer costs can be reduced by increasing transparency and competition in the markets. There are a number of other potential areas for cost reduction that were mentioned by the market participants interviewed. Among the most common suggestions were:

- Better timing of imports (importing earlier to take advantage of seasonal drops in world prices and completing inland distribution before roads deteriorate during the rainy season;

- Larger allotments of foreign exchange to obtain greater economies of size/scale in importing;

- Improved infrastructure (options mentioned were better roads and the building of an inland storage facility just inside the Ethiopian border to reduce excess port charges—these options would benefit other importers and exporters as well);

- Helping farmers' organizations to take on more of the responsibilities for credit administration and input delivery; and

- Better estimates of demand to avoid the expense of carry-over stocks.[22]

There is a need to look more closely at the relative costs and benefits of these as well as other options for reducing costs of fertilizer.

6.3.3. Meeting Needs of All Farmers

Fertilizer Credit: In 1998 the input supply system failed to meet the needs of farmers in several different ways. In many cases, the problems stemmed from the manner in which the credit system was managed. For example, many farmers not participating in the NEP program were unable to get credit through the regular credit program and were therefore forced to cut back on fertilizer use. The NEP appears to be absorbing more and more of the agricultural credit resources as it

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[22]Demand is generally estimated by extension agents in collaboration with farmers' organizations, with the latter tending to be overly optimistic about how much effective demand there really is.

expands, and the total amount of credit available for agriculture is not increasing proportionally. Although the NEP has expanded, it is reported that in two of the three MOA/SG survey zones total credit declined between 1997 and 1998. In Jimma the amount of fertilizer credit disbursed fell by 5.9% between 1997 and 1998. In East Shoa the amount of fertilizer credit disbursed fell by 23% between 1997 and 1998.[23] Where there were once multiple channels for credit accessible to farmers, now in some areas NEP is the only credit source.

In some cases, non-participants who had cash still had problems because regional governments were discouraging cash sales (a problem in Amhara, for example). This made it difficult (sometimes impossible) for farmers to "graduate" from the NEP program because the only way to get credit in many cases was to sign up again for a demonstration plot—this clearly limits the capacity of the NEP to reach new farmers with their extension message. The shortage of regular credit also made it difficult for farmers who had previously used fertilizer but never participated in the NEP to find credit to maintain their past levels of fertilizer use.

Improved credit targeting and simultaneous development of the fertilizer cash market would probably serve a broader group of farmers better than the current system. The better-off farmers often join the NEP credit program simply to obtain improved seed that is not otherwise available on the market (see below). Encouraging these farmers to purchase some fertilizer for cash or through the regular credit program would free up NEP credit and extension resources that could be targeted to poorer farmers.

Access to Improved Seed: Seed market development lags behind that of the fertilizer sector, despite the urgent need to increase the availability of maize hybrids being promoted by the NEP. Improved varieties of teff seed are available in local shops and markets, but hybrid maize seed is not. Furthermore, there is no credit available for hybrid seed purchased outside of the NEP. Apart from the National Seed Enterprise, a government parastatal that supplies the majority of hybrid maize seed, the multinational firm Pioneer Hi-Bred is the only other major actor in the Ethiopian maize seed industry. Pioneer usually sells its hybrids to the National Seed Enterprise, but is now beginning to promote direct cash sales to farmers.

Both the credit and supply constraints of hybrids have important implications for NEP graduates since without hybrid seed the responsiveness of fertilizer declines dramatically. Even graduate farmers who are able to get fertilizer through the regular credit program end up participating in the NEP again simply to have access to the hybrid maize seed.[24]

[23] Credit information for 1997 and 1998 from unpublished data provided by the Commercial Bank of Ethiopia.

[24] DAs anxious about filling their quotas for participants will often ignore the fact that an applicant has already been in the program for two years.

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