Staff Paper

Can the Momentum be Sustained? An Economic Analysis of the Ministry of Agriculture/Sasakawa Global 2000's Experiment with Improved Cereals Technology in Ethiopia

by

Julie Howard, Mulat Demeke, Valerie Kelly, Mywish Maredia, and Julie Stepanek

Staff Paper 98-25 September 1998

Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

Can the Momentum be Sustained? An Economic Analysis of the Ministry of Agriculture/Sasakawa Global 2000's Experiment with Improved Cereals Technology in Ethiopia

49 pages

A Joint Research Activity of:

Ministry of Economic Development and Cooperation Grain Marketing Research Project/Michigan State University

Sasakawa Global 2000

Ministry of Agriculture Department of Extension and Cooperatives

Ethiopian Agricultural Research Organization

September 1998

Department of Agricultural Economics Staff Paper No. 98-25

Funding for this research was provided by the Food Security II Cooperative Agreement (AEP-5459-A-00-2041-00) between Michigan State University and the United States Agency for International Development, through USAID/Ethiopia and Africa Bureau's Office of Sustainable Development, Productive Sector Growth and Environment Division (AFR/SD/PSGE).

CONTRIBUTORS TO THE STUDY

The authors of this report are:

Julie Howard*, Mulat Demeke**, Valerie Kelly*, Mywish Maredia*, and Julie Stepanek*

* Department of Agricultural Economics, Michigan State University
** Department of Economics, University of Addis Ababa

Others contributing to the research are:

Survey Coordinator: Ali Said

Survey Supervisors: Demeke Abate, Mengistu Buta, Selamyihun Kidane

Interviewers:

Negusie Belete	Tsige Alemu	Yemiserach Gebeyehu
Jemal A/Faji	Tamrat Yigezu	Masresha Getachew
Afework Dubero	Kebede Negusie	Belayneh A/Mariam
Elfnesh Dubero	Aytenew Shibru	Biruk Seifu
Zewdu Damenu	Bullo Edossa	Dabeta Eticha
Birbo Bissa	Befekadu Tesfaye	Danil Tesfaye
Duresso Chimsa	Sebsibe Gemechu	Derbe Gudissa
Muluneh Kebede	Girma Mulugeta	Kumelcha Bulto
Aynalem Mekuria	Tesfaye Midikssa	Warkaye Bekele
Mame Kebede	Bekele Wakjira	
Raya Kebede	Nigatu Bekele	

Data Entry Clerks: Abebech Demissies, Senait Hundie

Data Cleaning Supervisors: Margaret Beaver, Tesfaye Zegeye, Mulat Demeke

Drivers: Asrat Gebre, Workeneh Molla

ACKNOWLEDGMENTS

The research team wishes to thank the participating farmers, the Ministry of Agriculture Department of Extension and Cooperatives staff in Addis Ababa, East Shoa, West Shoa, and Jimma, and the staff of SG2000 in Ethiopia for their generous assistance during the course of the survey. We are also grateful to Tesfaye Zegeye of the Ethiopian Agricultural Research Organization for assistance with data cleaning and analysis, and to tef, maize, and soils researchers from EARO who provided useful comments on the survey questionnaire and on preliminary versions of this report. GMRP staff members were also extremely helpful: thanks go to Alemu Asfaw for his assistance with price data, to Samson Dejene for assistance with data entry and analysis, to Tigist Tesfaye for secretarial support. The researchers with the GMRP and the MSU Food Security II Project who provided encouragement and willingly shared their ideas with us on numerous survey and analysis issues are too numerous to mention individually, but Aklu Girgre, Thom Jayne, and Mike Weber deserve special mention.

We would also like to thank Don Beaver for assistance in the design of plot measurement procedures and software; Rick Ward and Urs Schulthess for help in designing data collection procedures and interpreting results for the yield determinants parts of the research; and Scott Swinton and Eric Crawford for their assistance in designing the data analysis procedures and interpreting the results.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

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 research messages, adequate extension assistance, 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 intensive assistance from extension agents. Participants agreed to provide land for the demonstration plot and to pay 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 4 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

Specific research objectives include:

(1) Describe input use and yields for three distinct categories of plots:

- (a) those cultivated as program plots using recommended technical packages for maize or tef,
- (b) those cultivated by the same set of program participants using their 'traditional' methods for growing maize or tef, and
- (c) those cultivated by past graduates of the SG maize or SG tef program who are using the technology of their choice.

(2) Evaluate the profitability of the three different plot types, 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.

(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. Specific research objectives included:

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 tef in three zones located in the Oromiya Region: (1) West Shoa (maize); (2) Jimma (maize); and (3) East Shoa (tef) . Figure 1 shows the location of the survey sites. Maize and tef 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 woredas that were agroecologically homogenous and had a large number of current and graduate MOA/SG participants. All three zones are considered to have good to excellent agroecological conditions for tef and/or maize production. Woredas chosen for maize were Woliso and Wanchi (West Shoa Zone) and Dedo, Kersa, Seka Chekorsa (Jimma Zone). Ada Woreda in East Shoa Zone was selected for tef.

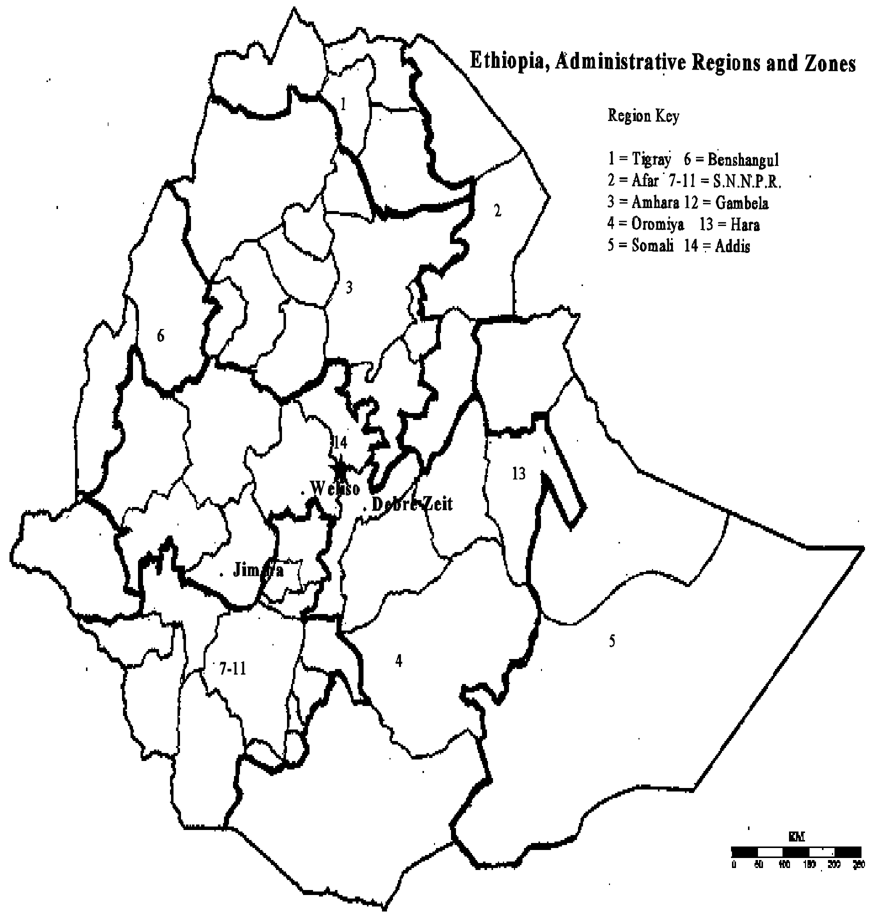
In the case of tef, the study included 1997 participants in the Ministry of Agriculture's NEP program because the MOA/SG program focused on an experimental plant hormone to reduce lodging that had not yet been extensively tested. The NEP technology package is the same one used by MOA/SG in previous years: 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 tef 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.[1] 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 (tef) and Jimma (maize), current program participants usually had one or more plots where they were using "traditional" technology or technology combinations different from the

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

Figure 3. Location of Survey Sites



program plot. The survey collected information about yield, area and input use for these plots, in addition to the program plots.

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 woredas	Total number of farmers	Current MOA/SG participants	Traditional plots of MOA/SG participants	MOA/SG program graduates
East Shoa	Tef	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	Tef	1850	850	black, gray, red	tef, wheat, pulses	50 kg DAP,50 kg urea, 17.5 kg improved seed, herbicide
West Shoa	Maize	1600-2800	1420	red, gray	tef, 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	tef, maize, wheat, sorghum, barley, pulses	Ditto

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.[2] Ten to fifteen enumerators were hired in each zone.[3] 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 informal interviews with private sector importers, wholesalers and retailers, and zonal and woreda-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, 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.

Collection of demographic and input use data: The objective of the second round of data collection was 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 other inputs (including animals, tractor, fertilizer, seed); (d) farmer perceptions of the importance of purchased inputs; (e) farmer assessment of risk factors affecting maize/tef 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/tef over the last five years. Round two questionnaires can be found in Appendix 1.

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. Data analysis was completed in September 1998.

---

[2] The two coordinators were a professor of economics at Addis Ababa University and a senior staff economist at GMRP. The three supervisors held bachelor or graduate degrees in agricultural economics or agronomy.

[3] All enumerators had secondary school certificates.

2. CHARACTERISTICS OF PROGRAM PARTICIPANTS COMPARED TO THOSE OF 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 (Table 3).[4] The picture emerging from these comparisons is that the households in our survey of program participants cultivate more land (both absolutely and per capita), have larger household sizes (i.e., more available labor), appear to be wealthier (more livestock and traction animals), and have better educated household heads than the typical households described by the CSA data.

The CSA Agricultural Sample Survey shows that less than one percent 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 percent increased to 27 for CSA farmers in the Jimma area. There is a longer history of fertilizer use on tef, however, and 82% of CSA tef farmers in the area around East Shoa reported using fertilizer in 1995/96.

Given the high fertilizer application rates associated with program recommendations, one would expect participants to apply fertilizer at a higher rate than other farmers, even when averaging over all their fields for a particular crop. This is supported by comparisons of average fertilizer used per hectare by our 1997 survey participants and farmers in the Oromiya Region covered by the 1996/97 CSA survey (Table 4).[5] Program participants applied an average of 155 and 204 kg of fertilizer per hectare of maize in West Shoa and Jimma, compared to 86 kg/ha for CSA farmers using fertilizer on maize in the Oromiya Region. There was also a large difference between program participants in our survey and CSA farmers using fertilizer on tef in the Oromiya Region: 184 kg/ha versus 110 kg/ha. Both the participant and the CSA 'user' application rates far exceed the average quantities of fertilizer applied to the total maize and tef area (fertilized and unfertilized) in Oromiya: 24 kg for maize and 73 kg for tef (Table 4).

These findings have implications for the expansion of the NEP to farmers who are more resource constrained and less accustomed to using improved inputs (see Section 5 for further discussion).

[4] As the CSA Survey collected relatively few observations in any given woreda, the averages for the CSA comparisons are based on households in the woredas covered by our 1997 survey plus woredas 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.

Table 3. Selected Characteristics of Participant Households Versus the Broader Population of Agricultural Households

	East Shoa (tef)[1]		West Shoa (maize)[2]		Jimma (maize)[3]		Ethiopia
	Program participants	CSA sample farmers	Program participants	CSA sample farmers	Program participants	CSA sample farmers	
Mean area cultivated (ha/household)	3.0	2.0	2.6	1.5	2.1	1.0	1.0
Mean population (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; our 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 woredas.

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

[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 woredas.

[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.

Table 4. 1997 Fertilizer Use of Participants Versus the Broader Agricultural Population

		Program participants	CSA Sample Farmers	
			Fertilized fields	All fields
		(kilograms of fertilizer product per hectare)		
E. Shoa, fertilizer use on tef		184		
W. Shoa, fertilizer use on maize		204		
Jimma, fertilizer use on maize		155		
Oromiya Region average	maize		86	24
	tef		110	74
National average	maize		76	26
	tef		99	54

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

3. YIELD RESULTS AND FINANCIAL ANALYSIS

Average maize and tef 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. Profitability was high, however, across the full range of plot types, with program and graduate plots for maize out-performing traditional plots, but no significant differences among the three types of tef plots.

Table 5 (see page 15) summarizes these results, presenting yields and financial enterprise budgets 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. We discuss details of the yield results in Section 3.1. and of the financial analysis for the various plot-types and terciles in Section 3.2.

3.1. Yield Results

The discussion here focuses on a presentation of the yield results for survey plots, how survey yields compare to national and regional averages, and the extent to which yields differ across plot-types. A detailed analysis of factors responsible for yield differences across technologies, zones, and plot-types is postponed until Section 4.

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 amounts 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 demonstrates the role improved inputs play in augmenting maize yields.

West Shoa. Program participants in this zone obtained the same average yields as participants in Jimma – 5.5 tons/ha. The graduates did not do as well, however, as those in Jimma. 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 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.[6]

3.1.2. Tef

Average grain yields for tef were similar on all plots (program, graduate, and traditional) -- about 1.5 tons/ha or 50 % greater 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 allowed to participants in the 1997 tef program -- they 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 tef varieties.

Production of tef 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 tef straw yields that can be used for comparative purposes.

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

3.2. Financial Analysis

3.2.1. Data and Methods Used

Data. All plot-level data came from our survey. Wholesale prices from main market towns in each zone (E. Shoa, West Shoa, Jimma) were obtained from the Ethiopian Grain Trading Enterprise (EGTE) and adjusted to farmgate prices using price data from our survey. The cost of fertilizer,

---

[6] More details on the different types of technologies used by West Shoa graduates and the yield impacts is presented in Section 4.

[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.

seed, and pesticides was fixed for program participants. For other groups, farmer-reported costs were used. Maize participants paid no interest on seed, fertilizer and pesticide inputs while tef participants and graduate and traditional farmers who received either maize or tef inputs through the NEP program paid 10% interest annually.[8] Information reported by farmers was used to value or calculate depreciation for inputs such as animal traction, tools, sacks, and family and hired labor.

Methods. Two measures of outcome are used in the financial analysis to evaluate profitability: net returns per hectare and net income per labor day.[9] The latter measure is compared to wage rates (opportunity costs of labor) in the study areas to assess the relative attractiveness of the technology under varying yield and price levels.

Net income per hectare and per labor day are calculated for six different output price and yield scenarios identified as cases (a) through (f). Income is calculated for output prices prevailing in: (a) January 1998, (b) April-May 1998; and (c) August 1998 to assess potential gains from storage. In each case, interest payments are adjusted to reflect the length of the loan period and gross revenue is adjusted to reflect the opportunity costs associated with selling at different times of the year. During 1998, actual maize and tef prices rose throughout the season. Net income per hectare and per labor day are also calculated for hypothetical drops in output prices of (d) 25% and (e) 50% from their January 1998 values. In each of scenarios (a) through (e), maize is assumed to lose 2% of grain weight per month through storage losses, but no storage loss is assumed for tef. Scenario (f) calculates returns to maize if storage losses are reduced by half through the use of storage chemicals.

Key results from the financial budgets are presented in Table 5 at the end of this section (page 15). The complete budgets are included as Appendix 1. A review of these budgets leads to the three key conclusions about maize and tef profitability that are presented in Sections 3.2.2. through 3.2.4.

3.2.2. Improved Technology is Profitable for both Maize and Tef, Even if Output Prices Decline by 25% or 50%

For both tef and maize, net income per hectare and per labor day are high (though variable between terciles) for farmers using improved technology under all price scenarios. Net income and returns per labor day increase with yield, but variable costs are covered and returns to family

---

[8] As a non-profit organization SG2000 is not allowed to earn income, hence they do not charge interest to farmers who participate in the MOA/SG demonstration program.

[9] All financial analysis results are reported in Ethiopian birr (EBr). The exchange rate during the 1997 crop and marketing year was US$1.00=EBr6.70

and mutual labor far exceed average daily labor rates (3-6 birr per day) for every program and graduate tercile.

In Jimma, net returns from program plots were double those from traditional plots, although for the traditional plots returns were also positive and returns per labor day exceeded the average wage rate. Returns per labor day were 1/3 higher on program plots compared to traditional plots, 15 birr/day versus 11 birr/day at January output prices. Jimma graduates received the highest net returns per hectare and per labor day in the zone. Graduates had significantly higher yields than program participants, while costs remained about the same. In West Shoa, net maize income per hectare was similar for program participants and graduates (less than half continued to use improved inputs), but net income per labor day was 3-4 birr/day higher for program participants.

As discussed above, differences between program types in East Shoa are blurred because tef farmers used improved varieties and fertilizer on all tef plots (program, traditional, graduate). While yield differences between program types were not significant, net income per hectare was significantly higher for traditional and graduate plots than for program plots. Net returns per labor day were highest for traditional plots because fewer family/mutual labor days were used. In general, returns per labor day for tef in East Shoa (14-57 birr/day) were far higher than returns per labor day in maize production (9-23 birr/day in West Shoa and 6-22 birr/day in Jimma).

If output prices drop by 25% from January 1998 price levels, net income per hectare and per labor day drop substantially, but in all zones net income/ha is positive and returns per labor day exceed average wage rates (Table 5). Even if output prices decline by 50%, net income per hectare and per labor day remain positive for all terciles and zones except the first tercile of program participants in Jimma. Returns per labor day remain at or above the average wage rates for the second and third yield terciles in all groups.

3.2.3. Gains from Storage and Use of Storage Insecticide

There were significant gains from storing tef 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 40% by selling in August instead of January.

Maize prices also rose significantly between January and August 1998 in West Shoa (29%) and Jimma Zones (72%). Unlike tef, 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 44-46% between January and August. In West Shoa the price rise was less dramatic, and farmers **lost** 4-5% of net income if they stored and sold maize in August instead of January.

None of our survey farmers reported using storage insecticide following the 1997 production year. If Jimma and West Shoa farmers used insecticide and storage losses were reduced by half[10], net income per hectare and per labor day would increase by an estimated 10-17%[11] for all groups in West Shoa, and from 9-13% in Jimma, after the costs of storage insecticide are taken into account.

3.2.4. Improved Seed and Fertilizer Costs Represent 50-80% of Total Costs

Improved seed and fertilizer are by far the biggest cost component in the financial enterprise budgets. In East Shoa the costs of improved seed and fertilizer represent 52-56% of total costs (exclusive of family labor). They are 56-66% and 60-80% of total costs in West Shoa and Jimma, respectively. This analysis 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.

---

[10]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).

[11]Assumes farmers sell in August 1998.

Table 5. Summary of Key Yield and Profitability Results by Zone, Plot Type, and Yield Tercile

		(a) MOA/SG/NEP Program Plot				(b) Traditional Plot Yield Tercile				(c) Graduate Plot			
Commodity/ Zone	Budget Item	1	2	3	Mean/ Total	1	2	3	Mean/ Total	1	2	3	Mean/ Total
MAIZE/	**YIELD** (ton/ha)	3.9	5.5	7.2	5.5*	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
	TOTAL FAMILY/MUTUAL LABOR DAYS 2/												
	(adult equiv. days/ha)	164	143	167	159	na	na	na	na	177	240	200	206
	FINANCIAL ANALYSIS												
	a. Net Income												
	Jan 98 Price	1531	2657	3850	2695					1616	2690	3695	2672
	April-May 98 Price	1289	2315	3399	2349					1432	2402	3252	2368
	August 98 Price	1446	2537	3691	2573					1550	2585	3517	2556
	Aug 98 w/ storage insect.	1658	2838	4087	2877					1711	2836	3893	2819
	Jan 98 Price - 25%	888	1747	2651	1774					1129	1931	2552	1876
	Jan 98 Price - 50%	244	836	1452	854					643	1172	1409	1080
	b. Net Income per Family and Mutual Labor Day												
	Jan 98 Price	9	19	23	17					9	11	19	13
	April-May 98 Price	8	16	20	15					8	10	16	12
	August 98 Price	9	18	22	16					9	11	18	12
	Aug 98 w/ storage insect. Jan	10	20	25	18					10	12	20	14
	Jan 98 Price - 25%	5	12	16	11					6	8	13	9
	Jan 98 Price - 50%	2	6	9	5					4	5	7	5

Commodity/ Zone	Budget Item	(a) MOA/SG/NEP Program Plot 1	2	3	Mean/ Total	(b) Traditional Plot Yield Tercile 1	2	3	Mean/ Total	(c) Graduate Plot 1	2	3	Mean/ Total
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	69
	TOTAL FAMILY/MUTUAL LABOR DAYS												
	(adult equiv. days/ha)	101	115	106	107	77	86	70	78	98	110	108	106
	FINANCIAL ANALYSIS												
	a. Net Income												
	Jan 98 Price	1385	1963	2757	2044	459	933	1667	1030	1740	2627	3257	2543
	April-May 98 Price	1495	2108	2941	2191	500	1002	1777	1104	1862	2798	3476	2711
	August 98 Price	2087	2892	3936	2939	726	1385	2370	1508	2579	3778	4668	3674
	Aug 98 w/ storage insect. Jan	2321	3203	4329	3298	815	1537	2605	1668	2868	4171	5145	4060
	Jan 98 Price - 25%	847	1250	1853	1323	252	584	1128	662	1076	1724	2170	1656
	Jan 98 Price - 50%	309	538	949	602	46	235	589	293	412	821	1075	768
	b. Net Income per Family and Mutual Labor Day					nh							
	Jan 98 Price	11	14	20	15	6	9	18	11	14	18	22	18
	April-May 98 Price	12	15	21	16	6	10	20	12	15	19	23	19
	August 98 Price	17	20	28	22	9	14	26	16	21	26	31	26
	Aug 98 w/ storage insect. Jan	19	23	31	24	10	16	29	18	23	29	34	29
	Jan 98 Price - 25%	7	9	13	10	3	6	12	7	9	12	15	12
	Jan 98 Price - 50%	3	4	7	5	1	2	7	3	3	6	7	6

Commodity/ Zone	Budget Item	(a) MOA/SG/NEP Program Plot 1	2	3	Mean/ Total	(b) Traditional Plot 1	2	3	Mean/ Total	(c) Graduate Plot 1	2	3	Mean/ Total
						Yield Tercile							
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/TEF	**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
	TOTAL FAMILY/MUTUAL LABOR DAYS												
	(adult equiv. days/ha)	69	65	56	63	52	65	55	57	92	73	67	78
	FINANCIAL ANALYSIS												
	a. Net Income												
	Jan 98 Price	991	1718	2994	1904	1209	1945	3116	2091	1229	2097	3247	2194
	April-May 98 Price	1006	1891	3224	2087	1357	2115	3332	2269	1395	2276	3461	2381
	August 98 Price	1314	2553	4166	2787	1837	2785	4232	2952	1955	2958	4384	3105
	Jan 98 Price - 25%	476	991	1930	1135	721	1200	2094	1339	649	1348	2185	1395
	Jan 98 Price - 50%	-40	264	866	366	233	454	1072	587	70	598	1122	596
	b. Net Income per Family												
	Jan 98 Price	14	26	54	30	23	30	57	37	13	29	49	28
	April-May 98 Price	15	29	58	33	26	33	61	40	15	31	52	31
	August 98 Price	19	39	74	44	35	43	77	52	21	41	65	40
	Jan 98 Price - 25%	7	15	35	18	14	19	38	24	7	19	33	18
	Jan 98 Price - 50%	-1	4	16	6	5	7	20	10	1	8	17	8

Source: Field data from 1997 GMRP/MSU/AAU/SG2000/MOA Survey. See Tables 19-21 in Appendix 1 for detailed budgets and notes.
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.

4. FACTORS AFFECTING CROP YIELDS AND TECHNOLOGY CHOICE

In Section 3 we examined the financial profitability of 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. The financial profitability was found to be highly correlated with the grain yield, which in turn was influenced by the seed and fertilizer inputs used by the farmers.

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

The objective of the analysis in this section is to identify the key factors affecting yields and to quantify the relative yield impact of these factors. To accomplish this we grouped the plots by types and levels of seed and fertilizer used rather than by the original sampling criteria (type of farmer and plot). This permits us to better control for the various technologies when examining the influence of other factors. The other factors examined fall 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 4.1 discusses these topics for maize and Section 4.2 does so for tef.

4.1. Factors Affecting Maize Yields

4.1.1. 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

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.

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.

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. We were surprised, however, to find that 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). We have conducted numerous checks on the data to verify that these results are not due to measurement errors. We have also conducted numerous cross-checks 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.

We found no evidence that there was measurement error in the yield estimates, but have not yet found any clear explanation for the good performance of this group of graduates. The leading

Table 7. Disaggregation of Maize Technology Types by Zone

Technology type	Jimma: Number of plots[a]	Jimma: Average yield kg/ha	Jimma: Average kg/ha DAP	Jimma: Average kg/ha UREA	West Shoa: Number of plots[b]	West Shoa: Average yield kg/ha	West Shoa: Average kg/ha DAP	West Shoa: Average kg/ha 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 analyses.

hypotheses are: (1) the local variety performs better under poor rainfall conditions (31of 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.

4.1.2. Econometric Analysis of Maize Yield Determinants

As our objective is to identify and evaluate the relative importance of different factors affecting maize yields we 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 permit us to do 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 is used exclusively with the two low-input technologies while improved seed is used exclusively with both DAP and urea. This makes 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 increases 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 do, 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 4.1.1 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 in 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 Jimma zone who plowed their fields more than 4 times before

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 diviation (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 assessmect 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.

planting got about 550 kg more per hectare than those who plowed fewer times -- 84% plowed at least 4 times so this fairly substantial yield loss affected only 16% of farmers.

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.

4.1.3. 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 the models still explain only a portion of the variability in the yield data -- 55% for Jimma and 30% for West Shoa.

We collected data on a much wider range of variables representing both agroecological variables and management practices, but attempts to incorporate a wider range of these variables in our models were thwarted by a substantial amount of correlation among the variables and a fairly high degree of compliance with recommended practices, which 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 we estimated, but there do appear 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 seem 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.

4.1.4. 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.

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.

Although the analysis of financial profitability in Section 3 shows that these high-input technologies are also profitable for farmers in West Shoa under a wide range of yield and price assumptions, 60% of the graduate farmers in this zone did not use the 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.

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.

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 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
	Believe 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	Ditto	

Source: Calculated from GRMP/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 (2 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.[12] In sum, given the relatively poor rains in 1997 season, many farmers felt more secure using traditional maize technologies which are much less expensive and, therefore, less risky.

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 financial returns to the high-input technology 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.

4.2. Factors Affecting Tef Yields

4.2.1. Types of Tef Technologies and Their Yields

Unlike maize, the composition of tef technology was less distinct across the program, traditional and graduate plots surveyed in the East Shoa region. All the 180 farmers surveyed (60 from each plot type) reported using improved seeds and only 6 reported no fertilizer application at all. Despite this uniformity in the use of improved seeds and fertilizer, tef yields across all the plot types ranged 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 tef technology package” and the alterations in the package made by the farmers on their traditional and graduate plots. As noted earlier, the tef technology package recommended and distributed to farmers for the extension plot consisted of 35 kg/ha improved seeds (Qoladma or Magna), 100 kg/ha each DAP and urea, and herbicides. However, the only mandatory purchase required for farmers to participate in the NEP program was the equal quantities of DAP and urea. Unlike the maize technology package, the participants in the tef extension program 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 Table12 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 tef technology package was not exclusively for the current participants. Improved seeds, Qoladma and Magna, were also available for use by graduates and participants’ traditional plots. Thus, nine current participants

---

[12] 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.

and three graduate farmers reported using the improved seeds Qoladma or Magna on their traditional and graduate plots.

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

Technology package	Participants 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 denotes that the independent t-test of the seed application rate was significantly different at 99% level.
b denotes that the independent t-test of the seed application rate was significantly different at 90% level.
c denotes that the independent t-test of the seed application rate was significantly different at 95% level.

Because of the flexibility in the seed input, the tef 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 participants plots. This is explained entirely by the higher seeding rate of 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 nad Magna, which is closer to the recommended seeding rate of 35 kg/ha. Also, the farmer-saved seeds yielded significantly higher than the improved seeds Qoladma and Magna distributed by the NEP program (Table 13).

Table 13. Seeding Rate and Grain Yields by Tef 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 (c)
Farmer saved (N=137)	63 (a,b)	1498 (a,c)
All	58	1403

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

[a] Letters a and c denote that the independent t-test on differences in the seed application rate was statistically significantly at the 99% level. Letter b denotes that the t-test was statistically significant at 95% level.

Based on the various combinations of the improved seed type and the fertilizer application rates, the tef plots are grouped into 5 technology types described in Table 14. The technology types 1 and 2 correspond to the tef technology recommended by the NEP; with technology type 1, actually distributed as a package by NEP. In technology types 1 and 2, the DAP and urea fertilizer was applied in equal quantities on a given plot with a mean application rate of 105 kg/ha and 96 kg/ha, respectively, which is close to the recommended rate of 100 kg/ha. The technology types 3 and 4 reflect the alterations in the seed and fertilizer components of the technology encountered on the traditional and graduate plots. In technology types 3 and 4, the mean DAP application rate is close to the recommended rate. However, the mean applicaiton rate of urea is almost half the recommended rate and the rate observed in technology groups 1 and 2. Technology type 5 consists 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 (extension program package), herbicide was used by all the 35 farmers in the group.

A comparison of tef grain yields for each technology group shows statistically significant differences among technology types with different seed types, but not among technology types with different rate and ratio of fertilizer application. Thus, yields of technology type 1 (Qoladma/Magna seed with receommended rate and ratio of DAP and urea) are statistically lower than that of technology type 2 (farmer retained improved seed with receommended rate and ratio of DAP and urea). Similarly, the yields of technology type 3 are statistically lower than yields of technology type 4. However, yields of technology type 1 and 3 (using the Qoladma/Magna seed with a different rate and ratio of fertilizer) and types 2 and 4 (using the farmer retained improved seed with a different rate and ratio of fertilizer) are not statistically different. The grain yields of technology type 5 (mostly farmer retained seed with no fertilizer) were not found to be statistically different than yields of other technology types.

Table 14. Types of Tef Technology Represented in the Sample

Type of Tef Technology	Number of plots using a given technology	Average yields kg/ha	Average kg/ha of fertilizer DAP	Average kg/ha of fertilizer Urea	% of farmers in a given technology group applying herbicides
(1) Improved seed (Qoladama or Magna) plus equal quantity of DAP and Urea	35	1082	105	105	100
(2) Farmer retained improved seed plus equal quantity of DAP and Urea	63	1523	96	96	73
(3) Improved seed (Qoladma or Magna) plus DAP and Urea quantity based on farmers' discretion	8	1181	95	47	88
(4) Farmer retained improved seed plus DAP and Urea quantity based on farmers' discretion	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

4.2.2. Econometric Analysis of Tef Yield Determinants

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

Contribution of technology factors on tef yields. The regression results of Model 1, using the technology groups described in Table 14 to represent the different combinations of seed and fertilizer inputs, indicate that the technology group 2 and 4 using farmer retained seed yielded significantly higher (about 300 kg/ha) than the yields of technology group 1 (which is not included in the equation). The rate and ratio of DAP and urea application had no significant impact in explaining yield variation as indicated by the coefficients (and their lower significance level) of variables Tech 3 and Tech 5. The herbicide application had a negative but statistically insignificant impact on yield variability.

Table 15. Regression Analysis of Factors Affecting Tef 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 plus equal quantity of DAP and Urea	323	94	3.42	0.00
Tech3 dummy: Improved seed (Qoladma or Magna) plus DAP and Urea quantity based on farmers' discretion	59	169	0.35	0.73
Tech4 dummy: Farmer retained improved seed plus DAP and Urea quantity based on farmers' discretion	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 Tef 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 $R^2 = 0.2$.

The higher yielding ability of farmer retained improved seed is also confirmed by the regression results of Model 2 given in Table 16. *Ceteris Paribus*, the plots that used farmer retained improved seeds obtained about 300 kg/ha more yields than their counterparts using Qoladma or

Magna seed. The higher yield for seed retained by farmers was enjoyed by a majority of farmers in the sample, as 137 out of 180 farmers surveyed used their own seeds.

The inclusion of kg/ha DAP and urea variables in Model 2 did not change the results much. Both fertilizer (DAP and urea) and herbicide variables in Model 2 were not significant variables in explaining yield variations.

Contribution of environmental factors on tef yields. Various variables summarizing the information on environmental factors that could potentially impact grain yields were used in the regression models for tef. This included, soil types (distinguished by color, local names and clay/sand content) and farmer assessment of soil fertility, farmer assessment of various biotic and abiotic stresses (rain shortage, rain distribution, weed damage, diseases, insects, etc.). However, only two environmental variables turned out to be significant in explaining the yield variation. These were the farmer assessment of rain distribution and soil color.

Farmer's who assessed the distribution of rainfall to be good or excellent (only 28 farmers) experienced about 350 kg/ha more yield than the farmers who assessed the rain distribution to be poor. The soil color gray, which was reported by 51 farmers, had a negative impact on yields. Gray soil types reduced the yields by more than 200 kg/ha compared with red or black soils in the zone. These results are consistent across both the models (Table 15 and Table 16).

Contribution of management practices on tef yields. The only management variable that showed significant impact on tef yield was the number of plowings. However, unlike in maize, the number of plowings had a negative effect on farmers yields. On an average, farmers who plowed more than 4 times got about 137 kg/ha less than those who plowed less. Fortunately, only 41 farmers in the sample plowed more than 4 times. These results are also consistent across both the models (Table 15 and Table 16).

The regression results in Table 15 and Table 16 present a rough picture of factors that appear to have had the most important influence on tef 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.

4.2.3. Graduate Farmers' Decisions Concerning Choice of Tef Technology

Table 17 lists the various components of tef technology practices and the number of graduates continuing a given practice. The reasons for not continuing a recommended practice given by the graduates are listed in Table 18.

Table 17. Graduate Farmers' Response to Recommended Tef 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. The Most Common Reasons Given by Graduates in East Shoa for Not Continuing a Given Tef 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 enforced second planting	55
	To control weeding	30
DAP rate	High cost of fertilizer	52
	Land is more fertile	19
Urea rate	Urea lodges the plant	51
	High cost of fertilizer	25

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

The farmers in the East Shoa zone seem to be less convinced of the seed type and seeding rate recommended by the Extension program. As indicated in Table 17 only 40 percent of the graduates surveyed continued the use of recommended improved seed (Qoladma or Magna) and the seeding rate (35 kg/ha). In fact, the mean seeding rate in graduate plots was observed to be 69 kg/ha, almost double the recommended rate. The main reason for switching from the recommended seed variety to their own improved seed saved from the previous harvests given by the graduates was the unavailability of improved seeds (Table 18).[13] However, 40% of the graduates had made a rational choice of switching to the better yielding improved seeds of their own. The main reason why many graduates had to increase the seeding rate was the seed damage

[13] 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.

that forced them to plant the second time. The other important reason for higher seeding rate was to increase the plant density and control the growth of weeds.

In the case of fertilizer technology, more graduates seem to be convinced of the importance of DAP than of urea as almost two-thirds of the graduates continued the recommended rates of DAP compared to only a quarter of graduates continuing urea. Although, high cost of fertilizer was cited as an important reason for discontinuing DAP and urea, the main reason for lowering the urea rate was the problem of lodging associated with urea application.

5. MOVING FROM DEMONSTRATION PLOTS TO SUSTAINABLE INCREASES IN AGRICULTURAL PRODUCTIVITY

The results presented in Sections 3 and 4 clearly indicate that the use of improved technology significantly increased yields and income for our survey farmers. 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. The NEP is now turning to the task of extending improved technologies beyond this select group to a much larger group of farmers in more marginal agroecological areas. In this section we consider how these changes in the program and the nature of NEP clientele are likely to affect NEP and partner institutions in the seed, fertilizer, and credit subsectors.

The task of extending these technologies to a much broader group of farmers throughout the country is not an easy one, but it is a task that the current Ethiopian government made one of its top priorities in 1995 when it began the transition from the MOA/SG program, which covered a maximum of 3,500 farmers annually, to the NEP program, which has a goal of almost 3 million demonstration plots for 1998. 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 with no special assistance. The main differences between the two programs are the scale and the fact that NEP aims to extend coverage of the program to poorer farmers in less favorable agroecological zones.

Plans to rapidly expand the number of demonstration plots raise serious challenges for the extension service as well as the banking and the input supply sectors. The extension agency will need to increase the efficiency with which it delivers services to farmers so that the costs of the program do not become prohibitive, yet it must be careful not to dilute the quality of the message or the supervision -- both of which appear to have been key ingredients in the success of the MOA/SG efforts. The banking sector (along with the government services that are now involved in processing and/or guaranteeing loans to farmers) will need to be sure that credit is available in a timely and low-cost manner for program participants, graduates, and key actors in the input distribution sector. Input suppliers will need to become more responsive to the needs of farmers graduating from the demonstration program by providing the desired quantity and quality of seeds, fertilizers, and pesticides at the right time for the lowest possible costs.

In the following pages of the report we describe the key characteristics of the extension, credit and input supply systems, focusing on important changes that have taken place during the 1998/99 cropping season and evaluating their likely impact on farmers' ability to continue using the improved technologies promoted by MOA/SG and NEP.

5.1. Challenges Facing the Extension Service

Increases in the number of DAs (extension agents) have not kept pace with the rapid expansion in the numbers of NEP participants (from thousands to millions in three years). 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 has expanded to one DA per 150 to 500 demonstration plots in some areas. At this level, the DAs may not be able to adequately provide sufficient technical assistance to each participating farmer. With the increased load come additional responsibilities for credit administration that also reduces the time agents can spend interacting with farmers on technical training.

As noted in Section 2, participants in the MOA/SG program and current participants in the NEP program who were covered by our survey manage farms that have a much better resource base than the average Ethiopian farm -- more land both absolutely and per capita, larger family sizes (i.e., more labor), better education, more livestock and more traction animals. This raises some questions about what will happen to yield response as the improved technologies are extended to less well endowed farmers. It also presents a real challenge for the extension agents expanding the demonstration plot program as they will progressively encounter farmers who have less capacity to adopt the technologies and use them effectively. 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.

Another challenge for the extension service is 'weaning' the farmers from the program. This is a particularly difficult problem for maize given that the improved maize seed is still not available on the open market. Included in our survey are farmers who spent two years with the MOA/SG program and are now in the first or second year of the NEP because they cannot obtain improved seed outside the program. Unless a supply of hybrid seed can be developed that is independent of the NEP, it is unlikely that farmers will really graduate from the program. If this happens, the government risks carrying the costs of a very expensive program as more and more new farmers are added but few of the earlier participants are able to continue using the technology on their own.

5.2. Evolution of the Agricultural Input Credit System

Fertilizer sales in Ethiopia are primarily credit sales due to the poor cash position of most farmers. Since 1991 input credit has been made available to farmers through farmer associations or service cooperatives. With the launching of the NEP in 1995, farmers could also obtain credit by participating in that program.

Although historically the bulk of agricultural input credit has been channeled through farmers' groups, in 1998 the availability of credit through this channel apparently declined in a number of zones and woredas. This left farmers with three options: to participate in the NEP, to purchase inputs for cash, or to revert to low-input production techniques. The decisions to limit credit to the NEP are being made locally (at the zone or woreda level) and the reasons appear to be diverse, including (1) a desire to meet NEP targets and (2) inadequate credit resources to cover both program and nonprogram farmers. This phenomenon could keep NEP graduates from continuing to use the improved technologies.

Another characteristic of the current credit program that needs to be evaluated is the amount of time government personnel (DAs and other extension staff in particular, but also other zonal and woreda administrators) are spending processing paperwork for both the NEP and the regular credit program. Many of the tasks performed by government personnel are ones that would normally be performed by farmer organizations or banking sector personnel. The current division of tasks not only increases the public cost of the credit program but also keeps key employees such as the DAs from devoting their full energies to advising and supervising farmers.

Another concern is the rate of reimbursement. The smaller MOA/SG program was characterized by very high rates of repayment (>95% in most years). As the NEP expands to a more diverse group of farmers the repayment rate may decline. Nevertheless, the sustainability of the program depends on the ability of both the NEP and the service cooperatives to ensure relatively high reimbursement rates.

Access to fertilizer credit is a concern because of the significant role credit plays in the expansion of fertilizer use. Of the three woredas in Jimma, Dedo is the only one that continues to extend a significant amount of fertilizer credit to farmers outside of the NEP. This means that those farmers that have graduated from the SG or NEP program will have to ask to participate in the program again to obtain fertilizer credit. In fact, the MOA/SG graduate survey participants in the Jimma zone were still participating in the NEP and were not sourcing their inputs from the market as intended by the programs. It is reported that the DAs enroll these farmers readily because they are known to repay their loans. However, this practice reduces the chance that a farmer that has not participated in the program will be chosen, given the limited capacity of the DA. Consequently, the transfer of technology may not be spreading as rapidly as intended.

5.3. Description of the Inputs Subsector

5.3.1. Fertilizer Market Development -- Balancing the Need for Decentralization and Competition

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). The government's concurrent objective to decentralize many administrative processes, however, has led to very uneven progress toward this goal. Regional governments have become more instrumental than the national government in designing the rules and regulations that shape fertilizer distribution activities within each region.

Up through 1997 the fertilizer sector (in all regions) was characterized by a high degree of market concentration. The regional market shares of the six fertilizer distributors operating in Ethiopia were determined by the regional governments without any pretense of competition. However, in 1998 the structure of the market in Oromiya Region changed markedly, and there was substantial progress toward the creation of a transparent, competitive market. In many woredas throughout Oromiya fertilizer suppliers were determined by a competitive auction. Meanwhile, other regional governments continued to control market access, usually designating suppliers of their choice without giving the relative prices of all potential suppliers adequate consideration.

5.3.2. The Seed Sector - Much Work Ahead

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 tef seed are available in local shops and markets, but hybrid maize seed is not. 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.

Unlike the fertilizer market, there is no credit for seed purchases outside of the NEP. The inaccessibility of hybrids has important implications for NEP graduates: without hybrid seed the responsiveness of fertilizer declines. In practice, many farmers who have already participated in the NEP for two years find ways to sign up again simply to obtain the seed.[14]

5.4. Key Sustainability Issues

Ethiopia faces a critical challenge at this juncture: assuring that better-off farmers who have already adopted improved technology continue to have access to inputs, while simultaneously adapting the successful SG model to the needs of poorer farmers in riskier environments. Several key issues need to be addressed by NEP to build on this current momentum for improved technology adoption and increased production in Ethiopia. These include:

Maintaining the quality of extension assistance. Our survey found that the high level of supervision by DAs contributed to farmer adoption of recommendations on plant distance and

---

[14] 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.

row spacing, and to increased yields, among program participants. There are concerns that DAs may become overextended with the rapid expansion of the NEP and thus the quality of the extension service may be compromised.

Financial sustainability. Financial sustainability is also another concern for the long-term growth of the program. The Ministry of Agriculture is paying the salaries of the DAs and their supervisors, as well as administrators in the woreda bureaus of agriculture. Many woreda bureaus of agriculture report that they have devoted most of their resources to processing fertilizer loans and have not been able to perform their regular duties. In addition, many of the woreda bureaus of agriculture, particularly in Oromiya Region, report that they have borne unexpected costs to deliver the NEP inputs to the farmers.

Cost reductions in the input system. Input costs (especially fertilizer, but also seed) are a large component of the financial budgets for farmers in the MOA/SG program (see section 3). Reducing the cost of inputs will enhance the accessibility of the program to a broader population. Areas for potential cost reductions that merit further investigation include the timing of fertilizer imports to minimize port and storage costs, and improvements in competition both at the import and distribution stages of the fertilizer marketing chain. At the distribution stage, the practice of holding fertilizer auctions (as conducted in parts of Oromiya Region) may be one avenue for inviting competition and reducing the cost of fertilizer.

Access to credit. There are concerns that (a) the NEP is absorbing more and more of the agricultural credit resources as it expands, and (b) the total amount of credit available for 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 percent between 1997 and 1998. This may explain the reduced quantities of fertilizer sold on credit in the three SG woredas in Jimma from 1997 to 1998. In another example, the amount of fertilizer credit disbursed in East Shoa fell by 23 percent between 1997 and 1998.[15]

Where there were once multiple channels for credit accessible to farmers, now in some areas NEP is the only credit source. Graduate NEP farmers and non-participants are finding it more difficult to obtain fertilizer credit. Overall, the reduced access to credit may mitigate the success of the adoption of new technologies.

Perhaps improved credit targeting and simultaneous development of the fertilizer cash market could expand effective fertilizer demand. The resourceful farmers often join the NEP credit program to obtain the improved seed that are not otherwise available on the market. Perhaps these farmers could be directed toward fertilizer cash sales while relatively resource-poor farmers could purchase on credit.

---

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

Policy uncertainty. 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 many be due to the government's efforts to decentralize the national governing body, but simultaneously 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.

6. CONCLUSIONS

In this report we have analyzed the factors underlying the success of the MOA/SG program and looked at its evolution to the NEP. Four principal conclusions emerge from our research.

6.1. Yield and Income Gains from the Use of Improved Technology are High

Farmers in our study areas who used improved seed and technology achieved yields that far exceeded national and regional averages. For maize, average program and graduate plot yields ranged from 5.5 to 6.8 tons/ha, compared to national and regional averages of 1.9-2.1 tons per hectare. Tef grain yields were 1.4-1.5 tons/ha, 50% higher than national and regional averages of 0.9 to 1 ton/ha.

Net income per hectare and per labor day were also very high for improved technology users. Net income and returns per labor day increased with yield, but variable costs were covered and returns to family and mutual labor far exceeded average daily wage rates (3-6 birr per day) for all program and graduate terciles. In Jimma, net returns from program plots were double those of traditional plots, and returns per labor day were 1/3 higher for program plots compared to traditional plots. In general, returns per labor day for tef in East Shoa were greater than returns per labor day in the maize zones. Net returns per labor day ranged from 14-57 birr/day (at January output prices) for tef in East Shoa, compared to 9-23 birr/day for maize in West Shoa and 6-22 birr/day for maize in Jimma.

Profitability is extremely robust when output prices change. Even if output prices drop by 25% from January 1998 price levels, net income per hectare and per labor day remain positive and returns per labor day exceed average wage rates. If output prices decline by 50%, net income per hectare is positive and net income/labor day is still comparable to average wage rates in all but the lowest yield terciles.

6.2. Gains from Storage are Potentially Great, Especially if Storage Insecticide is Used

In 1998 farmers in East Shoa and Jimma could have increased net income by more than 40% by storing grain and selling in August rather than immediately after harvest (January). Tef grain prices rose by 23% and straw prices doubled between January and August 1998; maize prices in Jimma rose by 72% during the same period.

Unlike tef, untreated maize deteriorates rapidly in storage, losing an estimated 2% of grain weight per month to weevils and other pests. In Jimma, the price rise over time was so steep that farmers storing until August 1998 still achieved net income gains of more than 40%. In West Shoa the price rise was less dramatic, and farmers would have **lost** 4-5% of net income if they had stored and sold maize in August instead of January. None of our survey farmers used storage insecticide in the 1997-98 crop season. If they had used insecticide and storage losses were reduced by half, net income per hectare and per labor day would increase by an estimated 9-17%.

6.3. Improved Seed and Fertilizer are the Most Important Determinants of Yield

Regression analysis indicated that the use of technology itself -- improved seed and fertilizer-- explained the largest part of yield variability. For maize, the package recommended by MOA/SG -- hybrid maize, DAP and urea--clearly outperformed the "traditional" technology of local seed plus DAP only. In West Shoa, even when rains were poor, those who used improved technology still did substantially better than those who returned to traditional technology -- in this case, local varieties and no fertilizer.

For tef, our analysis indicates that farmers' saved seed (also an improved variety) yielded significantly more than the improved variety distributed by NEP in East Shoa for the 1997 season. Farmers used DAP and urea fertilizers on all plots.

In addition to technology, some management practices were also found to be important in explaining yield variability. For example, deviations from the recommended row spacing and planting distance significantly reduced maize yields in Jimma and West Shoa, suggesting that the recommended planting technique is a critical component of the improved technology package. The results also confirm the importance of the extension program and its role in conveying management practices to farmers.

6.4. Key Questions: (1) How to Sustain this Successful Program in High Surplus-Producing Regions? (2) How to Expand it Beyond Wealthier Farmers in Better Agroecological Areas?

The MOA/SG program has been extremely successful in demonstrating the powerful impact that improved technology can have on raising yields and household incomes. In our view, the most important factors contributing to this success are (a) good technology, well adapted to the target agroecological zones; (b) the timely delivery of inputs; (c) intensive, high quality extension assistance; and (d) the availability of credit.

An additional important factor is that MOA/SG program households have relatively larger landholdings and are wealthier and better educated than the average population. Up to now the MOA/SG program has focused on these wealthier farmers in better agroecological areas. Other GMRP/MSU research indicates that countrywide, the top 20% of farmers (by production) contribute up to 80% of total marketed production. Continued adoption of technology by this group of farmers is very important and can lead to significant increases in marketed production and result in lower food prices and increased food security for Ethiopia.

At the same time, over the past several years MOA has sought to extend high-input technology to a much broader group of smallholders beyond the better-off agroecological zones through the NEP program. The country faces a critical challenge at this juncture: assuring that better-off farmers who account for most of marketed production continue to have access to inputs, while simultaneously adapting the successful SG model to the needs of poorer farmers in riskier environments.

In our view there are five key lessons that are important to consider as Ethiopia strives to meet the dual goals of sustaining adoption among high-surplus producers and introducing high-input technologies to smaller farmers in riskier agroecological areas. First, the most important concern for graduate farmers is ensuring their continued access to inputs, particularly seed and fertilizer, after they leave the program. In the past the general farming population had relatively easy access to credit through service cooperatives, development banks or private banks. Our analysis indicates that in some areas the expansion of the NEP is drawing credit resources away from these alternative sources, making it more difficult for farmers who are not enrolled in NEP to obtain credit. Another problem is that farmers report it is very difficult to obtain hybrid maize seed if one does not participate in the NEP. Further investigation is necessary and potential actions need to be explored to ensure that surplus producers continue to have access to improved seed, fertilizer and credit.

Second, technology packages will need to be adjusted as NEP moves into riskier areas with less reliable rainfall and poorer soils. Drought-tolerant varieties will be more important, but are likely to yield less than longer-season varieties suited to areas with better rainfall. Fertilizer recommendations may need to be adjusted downward to avoid exposing farmers to too much risk. Technologies that allow farmers to extend cropped area by reducing labor requirements, such as herbicides or improved hand or animal-drawn equipment, may also be important. Computer crop simulation models such as CERES (for maize) can be used to predict how technology packages will perform under different agroecological conditions and can partially substitute for expensive on-farm trials of technology.

Third, it may be necessary to modify credit programs for smallholders in riskier agroecological areas. Up to now repayment rates in the SG/MOA program have been extremely high (over 95%) but yield and income gains have also been high with few incidences of crop failure. With expansion into drought-prone areas, NEP will need to prepare for a greater number of legitimate loan defaults due to crop failure. In a few of our survey villages program graduates said that they had experienced total crop failure because of weather problems. Although the problems were confirmed by the extension agent the farmers were forced to repay the full amount of the input loan. In several cases farmers had to sell their oxen in order to repay the loan. It will be important to explore options for protecting farmers who are affected by natural factors beyond their control from total asset depletion (e.g., crop insurance). These approaches should be pursued in conjunction with efforts to fine-tune technology packages, especially reducing levels of high-cost inputs, with the objective of increasing farm yields while moderating farmers' exposure to risk.

Fourth, as the program expands into marginal areas yield and income gains from improved technology use may be far lower than the results we report for the better agroecological zones. To keep profit levels up, it will be important to reduce costs, especially seed and fertilizer costs, which represented 50-80% of total costs for our survey farmers. More research is needed to explore alternatives for reducing costs throughout the seed and fertilizer subsectors. Regions and zones throughout the country are actively experimenting with alternative fertilizer distribution systems. It will be important to track these efforts (such as Oromiya Region's auction system) carefully to understand which systems are best able to procure and deliver fertilizer on time at the lowest possible price.

Finally, intensive, high quality technical assistance from extension agents has been vital to the success of the SG program. Program farmers in our survey reported an average of nine extension visits per season. Farmers in our survey had relatively high levels of education. The expansion of NEP means that future program farmers will be less educated and may need even more assistance from extension agents. Three of the biggest challenges ahead for the program will be to (a) keep the extension agent to farmer ratio relatively low to enable agents to effectively teach and supervise program farmers; (b) maintain high standards for staff qualifications and performance among new extension agents joining MOA; and (c) explore ways to reduce the burden of credit administration on extension agents and other MOA personnel.

APPENDIX 1: FINANCIAL BUDGETS

Table 19. Financial Budgets for Tef (East Shoa)

Budget Item	--------NEP PROGRAM PLOTS--------				--------TRADITIONAL PLOTS--------				--------GRADUATE PLOTS--------			
	1.00	2.00	3.00	Total	1.00	2.00	3.00	Total	1.00	2.00	3.00	Total
n used in calculations	20	20	20	60	20	20	20	60	21	18	21	60
1. YIELD 1/												
1.A. Grain Yield (kg/ha)	891	1312	1964	1389	838	1357	1896	1364	1006	1361	1985	1455
1.B. Straw Yield (kg.ha)	2174	2092	2272	2180	2149	1913	2013	2025	2369	1991	1842	2071
2. PRICE 2/												
2.A. Estimated farmgate price for grain (birr/kg)	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04
2.B. Estimated farmgate price for straw (birr/kg)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
3. GROSS REVENUE 3/	2062	2909	4257	3076	1951	2980	4089	3007	2318	2997	4250	3198
4. TOTAL PACKAGE COSTS 4/	639	685	643	655	454	651	513	540	637	520	545	571
4.A. Treated seed (birr/ha)	131	159	161	150	145	189	166	167	194	193	182	190
4.B. DAP	242	270	239	251	175	266	200	214	264	200	212	227
4.C. Urea	229	227	223	226	114	175	134	141	152	105	125	129
4.D. Herbicide	37	29	20	28	20	21	13	18	27	22	26	25
4.E. Insecticide	0	0	0	0	0	0	0	0	0	0	0	0
4.F. Fungicide	0	0	0	0	0	0	0	0	0	0	0	0
5. INTEREST 5/	30.0	29.7	24.2	28.0	16.6	25.1	18.4	20.0	23.8	15.1	19.5	19.7
6. LABOR 6/												
6.A. Total family/mutual labor days	69	65	56	63	52	65	55	57	92	73	67	78
6.B. Total wage labor (birr/ha) 7/	145	191	241	192	116	121	190	142	169	178	203	183
7. ANIMAL TRACTION COST (birr/ha) 8/	251	279	343	291	153	233	244	210	255	182	228	224
8. HAND TOOLS AND SACKS (birr/ha)	5.5	6.1	11.2	6.5	2.9	5.7	7.0	4.9	4.6	5.5	7.4	5.7
8.A. hand tools (birr) 9/	2.0	2.1	2.5	2.2	1.2	1.8	1.9	1.6	1.7	1.4	1.7	1.6
8.B. Sacks (birr) 10/	3.5	4.0	8.7	4.3	1.7	3.9	5.1	3.3	2.9	4.1	5.7	4.1
9. NET INCOME/HA 11/	991	1718	2994	1904	1209	1945	3116	2091	1229	2097	3247	2194
10. NET INCOME/FAMILY-MUTUAL LABOR DAY 12/	14.4	26.4	53.5	30.2	23.2	29.9	56.7	36.7	13.4	28.7	48.5	28.1

Notes to Table 19

1/Yield estimates based on crop cuts taken as part of the GMRP/MSU/MOA/SG2000 Survey. Assumes no grain or straw was lost during threshing.

2/Source: EGTE price monitoring unit and GMRP/MSU/MOA/SG2000 Survey. Local market prices collected by EGTE were adjusted to farmgate prices using survey data on prices reported by farmers. Average prices for white tef during January 1998 are used.

3/(1.A*2.A) +(1.B. *2.B)

4/ 4.A + 4.B. + 4.C. + 4.D. + 4.E. + 4.F. MOA tef package consists of (quantities/ha) 35 kg seed, 100 kg DAP, 100 kg urea, U-46 herbicide.

5/Source: GMRP/MSU/MOA/SG2000 Survey and rate information from MOA/SG2000. MOA program participants pay 10% interest annually. Assumes that period of loan is 7 months.

6/Source: GMRP/MSU/MOA/SG2000 Survey.

7/Valued at cash/in-kind payment rates provided by survey participants.

8/Sum of (a) rental costs reported by survey respondents and (b) for owned/borrowed oxen, maintenance + depreciated value of animals and animal traction equipment multiplied by percentage of total farm represented by the program, traditional or graduate plot. Purchase price, life and salvage value of equipment based on supervisors' field reports.

9/Depreciated value of 2 sickles, 2 hoes, and 2 spades. Purchase price, life and salvage value of equipment based on supervisors' field reports.

10/Depreciated value of sacks needed to transport tef marketed in 1998 season. Since sacks are retained by farmer and used for other purposes, cost is apportioned by multiplying depreciated sack value by percentage of total farm represented by program, traditional or graduate plot. Purchase price, life and salvage value based on supervisors' field reports.

11/(3) = (4 + 5 + 6B + 7 + 8)

12/(9)/(6.C.)

Table 20. Financial Budgets for Maize (West Shoa)

Budget Item	--------MOA/SG PLOTS--------				--------GRADUATE PLOTS--------			
	1.00	2.00	3.00	Total	1.00	2.00	3.00	Total
n used in calculations	30	31	31	92	19	19	19	57
1. GRAIN YIELD (kg/ha) 1/	3883	5493	7234	5554	2935	4579	6895	4803
1.A. Adjusted grain yield (kg/ha) 1/	3732	5279	6952	5337	2821	4400	6626	4616
2. FARMGATE PRICE (birr/kg) 2/	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
3. GROSS REVENUE 3/	2575	3642	4797	3683	1946	3036	4572	3185
4. TOTAL PACKAGE COSTS 4/	781	742	709	743	153	171	649.6	325
4.A. Treated seed (birr/ha)	142	136	130	136	74	80	124	93
4.B. DAP	281	268	256	268	56	47	231	111
4.C. Urea	264	252	241	252	19	33	217	90
4.D. Herbicide	4	0	0	1	0	0	3.6	1
4.E. Insecticide	90	86	82	86	4	11	74	30
4.F. Fungicide	0	0	0	0	0	0	0	0
5. INTEREST 5/	0.0	0.0	0.0	0.0	2.2	6.0	39.4	15.9
6. LABOR 6/								
6.A. Total family/mutual labor days 7/	164	143	167	159	177	240	200	206
6.B. Total wage labor (birr/ha) 8/	138	124	108	123	103	75	54	77
7. ANIMAL TRACTION COST (birr/ha) 9/	105	88	87	93	58	73	91	74
8. HAND TOOLS AND SACKS (birr/ha)	19.6	31.1	42.8	28.7	14.3	21.6	42.9	20.5
8.A. Hand tools (birr) 10/	1.5	1.5	1.8	1.6	1.2	1.6	1.8	1.5
8.B. Sacks (birr) 11/	18.1	29.5	41.0	27.1	13.1	20.1	41.1	19.0
9. NET INCOME/HA 12/	1531	2657	3850	2695	1616	2690	3695	2672
10. NET INCOME/FAMILY-MUTUAL LABOR DAY 13/	9.3	18.6	23.1	16.9	9.1	11.2	18.5	13.0

Notes to Table 20

1/Yield estimates based on crop cuts taken as part of the GMRP/MSU/MOA/SG2000 Survey. Assumes (a) no grain was lost during threshing; (b) maize was harvested in November; (c) storage losses were 1.98% per month, the average of various estimates from Abraham et al. 1993.

2/Source: EGTE price monitoring unit and GMRP/MSU/MOA/SG2000 Survey. Local market prices collected by EGTE were adjusted to farmgate prices using survey data on prices reported by farmers. Average prices for maize during January 1998 are used.

3/ (1)* (2)

4/ 4.A. + 4.B. + 4.C. + 4.D. + 4.E. + 4.F. MOA/SG maize package consists of (quantities/ha) 25 kg seed, 100 kg DAP, 100 kg urea.
5/Source: GMRP/MSU/MOA/SG2000 Survey and rate information from MOA/SG2000. MOA/SG2000 program participants pay no interest; NEP program participants pay 10% interest annually. Assumes that period of loan is 10 months.
6/Source: GMRP/MSU/MOA/SG2000 Survey.
7/Includes shelling labor.
8/Valued at cash/in-kind payment rates provided by survey participants.
9/Sum of (a) rental costs reported by survey respondents and (b) for owned/borrowed oxen, maintenance + depreciated value of animals and animal traction equipment multiplied by percentage of total farm represented by the program, traditional or graduate plot. Purchase price, life and salvage value of equipment based on supervisors' field reports.
10/Depreciated value of 2 hoes, 2 axes, and 2 cutting knives. Purchase price, life and salvage value of equipment based on supervisors' field reports.
11/Depreciated value of sacks needed to transport maize marketed in 1998 season. Since sacks are retained by farmer and used for other purposes, cost is apportioned by multiplying depreciated sack value by percentage of total farm represented by program, traditional or graduate plot. Purchase price, life and salvage value based on supervisors' field reports.
12/(3) - (4 + 5 + 6B + 7 + 8)
12/(9)/(6.C.)

Table 21. Financial Budgets for Maize (Jimma)

Budget Item	--------MOA/SG--------				--------TRADITIONAL PLOTS--------				--------GRADUATE PLOTS--------			
	1	2	3	mean	1	2	3	mean	1	2	3	mean
n used in calculations	22	24	23	69	15	16	16	47	13	13	13	39
1. GRAIN YIELD (kg/ha) 1/	4113	5446	6907	5508	1579	2666	4119	2814	5073	6901	8369	6781
1.A. Adjusted grain yield (kg/ha) 1/	3953	5234	6638	5293	1517	2562	3958	2704	4875	6632	8043	6516
2. FARMGATE PRICE (birr/kg) 2/	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
3. GROSS REVENUE 3/	2153	2851	3616	2883	827	1396	2156	1473	2656	3612	4381	3550
4. TOTAL PACKAGE COSTS 4/	603	679	634	640	247	306	280	279	585	635	596	606
4.A. Treated seed (birr/ha)	122	137	128	129	45	37	37	40	118	128	120	122
4.B. DAP	248	279	260	263	202	269	243	239	240	261	245	249
4.C. Urea	233	263	245	248	0	0	0	0	226	246	231	235
4.D. Herbicide	0	0	1.2	0.4	0	0	0	0	0	0	0	0
4.E. Insecticide	0	0	0	0	0	0	0	0	1.3	0	0	0.4
4.F. Fungicide	0	0	0	0	0	0	0	0	0	0	0	0
5. INTEREST 5/	0	0	0	0	4.0	4.2	0	2.7	38.1	39.1	37.6	38.3
6. LABOR 6/												
6.A. Total family/mutual labor days 7/	122	142	141	135	84	99	91	92	123	145	150	140
6.B. Total wage labor (birr/ha) 8/	51	59	76	62	20	39	48	36	63	52	97	71
7. ANIMAL TRACTION COST (birr/ha) 9/	86	106	101	98	89	101	143	112	175	165	300	213
8. HAND TOOLS AND SACKS (birr/ha)	27.8	43.9	47.8	39.2	7.6	12.6	17.8	13.5	54.3	94.1	84.7	77.7
8.A. Hand tools (birr) 10/	2.6	3.0	2.9	2.8	2.7	3.1	3.0	2.9	4.9	4.2	7.4	5.5
8.B. Sacks (birr) 11/	25.3	40.9	44.9	36.3	4.9	9.5	14.8	10.5	49.4	89.9	77.3	72.2
9. NET INCOME/HA 12/	1385.2	1962.9	2756.6	2043.7	458.9	932.8	1667.3	1029.8	1739.8	2627.2	3265.6	2543.2
10. NET INCOME/FAMILY-MUTAL LABOR DAY 13/	11.4	13.8	19.6	15.1	5.5	9.4	18.3	11.2	14.1	18.1	21.8	18.2

Notes to Table 21

1/Yield estimates based on crop cuts taken as part of the GMRP/MSU/MOA/SG2000 Survey. Assumes (a) no grain was lost during threshing; (b) maize was harvested in November; (c) storage losses were 1.98% per month, the average of various estimates from Abraham et al. 1993.

2/Source: EGTE price monitoring unit and GMRP/MSU/MOA/SG2000 Survey. Local market prices collected by EGTE were adjusted to farmgate prices using survey data on prices reported by farmers. Average prices for maize during January 1998 are used.

3/ (1)* (2)

4/ 4.A. + 4.B. + 4.C. + 4.D. + 4.E. + 4.F. MOA/SG maize package consists of (quantities/ha) 25 kg seed, 100 kg DAP, 100 kg urea.

5/Source: GMRP/MSU/MOA/SG2000 Survey and rate information from MOA/SG2000. MOA/SG2000 program participants pay no interest; NEP program participants pay 10% interest annually. Assumes that period of loan is 10 months.
6/Source: GMRP/MSU/MOA/SG2000 Survey.
7/Includes shelling labor.
8/Valued at cash/in-kind payment rates provided by survey participants.
9/Sum of (a) rental costs reported by survey respondents and (b) for owned/borrowed oxen, maintenance + depreciated value of animals and animal traction equipment multiplied by percentage of total farm represented by the program, traditional or graduate plot. Purchase price, life and salvage value of equipment based on supervisors' field reports.
10/Depreciated value of 2 hoes, 2 axes, and 2 cutting knives. Purchase price, life and salvage value of equipment based on supervisors' field reports.
11/Depreciated value of sacks needed to transport maize marketed in 1998 season. Since sacks are retained by farmer and used for other purposes, cost is apportioned by multiplying depreciated sack value by percentage of total farm represented by program, traditional or graduate plot. Purchase price, life and salvage value based on supervisors' field reports.
12/(3) - (4 + 5 + 6B + 7 + 8)
12/(9)/(6.C.)

REFERENCES

Abraham Tadesse, Firdu Azerefagu, Assefa GebreAmlak, and Adhanom Negassi. 1993. Research Highlights on Maize Insect Pests and their Management in Ethiopia in *Proceedings of the First National Maize Workshop of Ethiopia*, Benti Tolessa and Joel Ransom (eds.). Addis Ababa: IAR and CIMMYT.1993.

Central Statistical Authority. 1998. *Agricultural Sample Surveys, Meher Season Crops, 1997/98*. CSA Bulletin 171. Addis Ababa: CSA.

Federal Democratic Republic of Ethiopia. 1997. *Agricultural Sample Survey 1996-97: Vol. 1: Report on Area and Production for Major Crops.* Statistical Bulletin 171. Addis Ababa: Central Statistical Authority.

Habtemariam Abate. June 1997. *Targeting Extension Service and the Extension Package Approach in Ethiopia*. Ministry of Agriculture, Addis Ababa, Ethiopia.

Sasakawa-Global 2000 Agriculture Project in Ethiopia. 1996. *Annual Report Crop Season 1995*. Addis Ababa: SG2000.

World Bank. April 24, 1995. *Staff Appraisal Report, Ethiopia, National Fertilizer Sector Project. Report No. 13722-ET*. Washington, D.C.