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GREEN REVOLUTION TECHNOLOGY TAKES ROOT IN AFRICA: THE PROMISE AND CHALLENGE OF THE MINISTRY OF AGRICULTURE/SG2000 EXPERIMENT WITH IMPROVED CEREALS TECHNOLOGY IN ETHIOPIA

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

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

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

Yield Results and Determinants. ***Maize***. There is strong evidence (Tables 1 and 2) that practices used by MOA/SG participants and graduates resulted in much higher average yields (4.8 to 6.8 t/ha) than those obtained on "traditional" plots (2.8 t/ha in Jimma), and average national and regional yields (1.9-2.1 t/ha). Regrouping the survey plots to

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

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

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

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

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

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

Financial Analysis: The use of improved technology was very profitable for both maize and tef farmers under a range of output price and yield scenarios. We calculated net income per ha and per labor day using 1998 prices for Jan., Apr.-May, and Aug. to assess potential gains from storage. We also calculated returns assuming hypothetical drops in Jan. output prices of 25% and 50%. Finally, we calculated returns to maize for a case where storage losses were reduced by half using storage pesticides. Results (Tables 1 and 2) from these six scenarios lead to four key conclusions about maize and tef profitability.

Improved technology is profitable for both maize and tef, even if output prices decline by 25% or 50%. Net income is high for improved tef and maize under almost every price scenario. Net income/ha ranged from 110-4100 EBr/ha (6.70EBr=1USD) for farmers using improved technology. Returns to family and mutual labor ranged from 1.6 to 48.9 EBr/day for improved technology users, far exceeding average daily wage rates (3-5 EBr/day) in all cases except for tef farmers who used program seed with fertilizer when a 50% output price drop was assumed.

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

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

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

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

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

Economic Analysis: We estimated the value of maize and tef production to the Ethiopian economy by valuing maize, tef, fertilizer and seed at world market parity prices. The economic analysis helps answer the following question: How profitable is intensified production when farmers face international prices (free of taxes and subsidies) for grain, fertilizer, seed and other inputs?

Because Ethiopia has been a net grain importer until recently, the value of maize and tef is estimated in import parity terms[3]. In 1997 Ethiopia exported maize to neighboring Kenya, so an export parity price is also calculated for maize. Economic profitability was estimated for alternative scenarios of high and low world prices for DAP and urea, and high and low export parity prices for maize.

Assuming that intensified production of maize and tef fills a domestic need that otherwise would have to be filled by commercial imports, it is highly profitable from society's standpoint. Even when imported fertilizer and seed are priced at their full international values, intensive production of maize and tef is still highly profitable. Income gains range from 40% in W. Shoa to over 100% in Jimma when farmers use improved technology instead of traditional methods. Net income levels are lower in the economic analysis for tef (compared to the financial analysis) because imported wheat fetches a lower price than tef on domestic markets. However, net income is still highly positive.

The profitability of intensified maize produced for export depends on the prevailing export price. In 1997 Ethiopia was able to export maize to Kenya at a price of $194 (CIF Mombasa). This is

[3]Tef is not traded on international markets, so the import parity price for wheat is used. It is assumed that a decrease in tef production would lead to an increase in wheat imports.

considered to be an unusually high price, influenced by a crop failure in Kenya. Although it is profitable for farmers to produce intensified maize at this high price, it nonetheless implies a lower on-farm price than Jimma and West Shoa farmers actually received in 1997-98. At a lower, perhaps more realistic, export price of $150/ton (CIF Mombasa) it becomes unprofitable for all Jimma farmers and Weliso farmers who are using recommended fertilizer rates to produce maize. The break-even price if all other costs are held constant is about $160 (CIF Mombasa).

Accounting for the costs of operating the credit program could reduce economic profitability considerably. In the economic analysis, net income represents the residual return to factors that facilitate crop production but are not explicitly costed out in the analysis, such as the costs of implementing complementary extension and credit programs. The private sector role in the importation and distribution of inputs is clearly growing stronger, but most farmers still depend on government programs for input credit. Additional research is required, but the interest currently charged on inputs may be insufficient to cover the costs of credit provision, including the time spent by extension agents and local government officials in credit administration and collection. In the past in Ethiopia and other countries promising increases in input utilization have ended abruptly with the withdrawal of special programs such as MOA/SG. Estimating these program costs, and identifying strategies to reduce them, is an important future research task.

Structural Weaknesses in the NEP. Ensuring that the diverse set of activities needed for input use to grow are in place will require attention to a number of problems. Among the most important are:

- Heavy reliance on MOA personnel for management of input credit;
- Use of the local administration (police) for collection of overdue credit payments;
- Reliance on donor funding for foreign exchange allocated to fertilizer imports;
- Lack of transparency and competition in regional fertilizer markets which are often dominated by “private” firms owned and operated by regional government interests;
- Virtually no supply of hybrid maize seed independent of the NEP; and
- Reduction in the amount of credit available for farmers not participating in NEP.

Challenges Ahead. The variety of problems described above are all subsets of the two key challenges now facing Ethiopia: (1) increasing the number of farmers who adopt the improved technologies, and (2) insuring that farmers who have already adopted them are able to sustain their input use and improved yields. The first challenge requires continued support for extension and research to adapt technologies to the production environments faced by future participants--poor farmers in more difficult agroecological zones--and continued efforts to reduce input costs. The second challenge requires developing low-cost, reliable input supply and distribution systems. To meet these challenges:

- Banks and farmers will need to assume responsibility for administering the credit system;
- Adequate funding must be made available for research on adapting improved technologies to new zones and poorer farmers;
- Reliance on donors for foreign exchange must decline; and
- GOE must deal with the lack of transparency in regional fertilizer markets.

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Table 1. Summary of Maize Results: Financial and Economic Analyses by Zone, Plot Type and Input Level

	JIMMA						WEST SHOA					
	Plot Type						Plot Type			Input Level		
Zone/Budget Item	MOA/ SG	Tradi- tional	Graduate	Local seed + DAP	Imp. seed + DAP+ urea < rec. rate	Imp. seed + DAP+ urea >= rec. rate	MOA/ SG	Tradi- tional	Graduate	Local seed, no fertilizer	Imp. seed + DAP+ urea < rec. rate	Imp. seed + DAP+ urea >= rec. rate
YIELD (t/ha) 1/	5.6	2.8	6.8	2.9	6.0	5.9	5.6	n/a	4.8	3.9	5.8	5.7
TOTAL FAMILY/MUTUAL LABOR DAYS												
(adult equiv. days/ha)	135	92	140	93	115	162	159		206	204	158	172
N used in calculations	69	47	39	43	58	50	92		57	33	45	68
FINANCIAL ANALYSIS												
a. Net Income (Birr/ha) 2/												
Jan 98 Price	2042.1	1029.1	2543.2	1053.7	2260.8	2106.7	2781.0		2702.4	2316.1	3102.3	2758.9
April-May 98 Price	2300.8	1160.3	2848.3	1201.0	2564.7	2404.7	2577.7		2521.0	2184.1	2902.9	2562.4
August 98 Price	3257.4	1648.0	4012.6	1715.1	3626.3	3450.5	3010.9		2890.1	2477.2	3340.7	2991.9
Aug 98 w/storage insecticide	3577.2	1811.0	4405.7	1937.2	4082.6	3901.3	3322.0		3159.2	2759.2	3761.4	3405.5
Jan 98 Price - 25%	1321.3	660.8	1655.8	990.9	2130.9	1978.7	1860.3		1906.2	1676.5	2143.4	1816.5
Jan 98 Price - 50%	600.5	292.5	768.4	509.5	1135.2	997.2	939.6		1110.0	1037.0	1184.6	874.1
b. Net Income per Family and Mutual Labor Day (Birr/ha) 3/												
Jan 98 Price	15.1	11.2	18.2	11.3	19.7	13.0	17.6		13.1	11.4	19.6	16.0
April-May 98 Price	17.0	12.6	20.3	12.9	22.3	14.8	16.3		12.2	10.7	18.4	14.9
August 98 Price	24.1	17.9	28.7	18.4	31.5	21.3	19.1		14.0	12.1	21.1	17.4
Aug 98 w/storage insecticide	26.5	19.7	31.5	20.8	35.5	24.1	21.0		15.3	13.5	23.8	19.8
Jan 98 Price - 25%	9.8	7.2	11.8	10.7	18.5	12.2	11.8		9.3	8.2	13.6	10.6
Jan 98 Price - 50%	4.4	3.2	5.5	5.5	9.9	6.2	5.9		5.4	5.1	7.5	5.1
ECONOMIC ANALYSIS												
Net Income (Birr/ha)												
a. Import Parity Hi Fert Price 4/				3274.0	6939.8	6542.4				4975.8	7139.9	6599.4
b. Import Parity Lo Fert Price 5/				3338.6	7075.6	6723.7				4965.1	7274.9	6789.0
c. Export Parity Hi Grain Price (USD 194 CIF), Hi Fert Price 6/				745.1	1709.4	1386.9				1608.5	2107.5	1653.2
d. Export Parity Price Lo Grain Price (USD 150 CIF), Hi Fert Price 6/				(117.9)	(75.6)	(372.6)				435.5	348.9	(75.3)

Table 2. Summary of Tef Results: Financial and Economic Analyses by Plot Type and Input Level

Zone/Budget Item	MOA/SG	Traditional	Graduate	Prog. seed, recommended quantities DAP, urea	Saved (imp) seed, near recommended DAP, urea	Saved (imp) seed,near recommended DAP, 50% urea
	EAST SHOA					
	Plot Type			Input Level		
GRAIN YIELD (t/ha) 1/	1.4	1.4	1.5	1.1	1.5	1.5
STRAW YIELD (t/ha) 1/	2.2	2.0	2.1	2.1	2.1	2.1
TOTAL FAMILY/MUTUAL LABOR DAYS	64	58	77	68	67	66
N used in calculations	60	60	60	35	63	69
FINANCIAL ANALYSIS						
a. Net Income (Birr/ha) 2/						
Jan 98 Price	1903.6	2090.5	2193.4	1331.4	2192.1	2306.0
April-May 98 Price	2008.9	2192.6	2299.5	1431.6	2385.0	2494.0
August 98 Price	2602.7	2771.9	2912.5	1912.0	3139.7	3227.8
Jan 98 Price - 25%	1134.6	1338.6	1394.0	721.8	1356.4	1493.8
Jan 98 Price - 50%	365.6	586.8	594.5	112.1	520.7	681.6
b. Net Income per Family and Mutual Labor Day (Birr/ha) 3/						
Jan 98 Price	29.7	36.0	28.5	19.6	32.7	34.9
April-May 98 Price	31.4	37.8	29.9	21.1	35.6	37.8
August 98 Price	40.7	47.8	37.8	28.1	46.9	48.9
Jan 98 Price - 25%	17.7	23.1	18.1	10.6	20.2	22.6
Jan 98 Price - 50%	5.7	10.1	7.7	1.6	7.8	10.3
ECONOMIC ANALYSIS						
Net Income (Birr/ha)						
a. Import Parity Hi Fert Price 4/				628.4	1268.4	1411.8
b. Import Parity Lo Fert Price 5/				752.6	1387.4	1494.8

NOTES TO TABLES 1 AND 2

Source: Survey and secondary data

1/Estimated from crop cuts. **Maize** assumes storage losses of 2%per month. Yield differences were significant at the 95% level between all groups within the program and input level categories EXCEPT improved seed, DAP, urea < rec. rate and imp.seed, DAP, urea >= rec. rate in both Jimma and West Shoa.

Tef assumes no grain or straw lost during threshing and no storage loss. Yield differences between program groups were not significant. For input level groups, yield differences between program seed and saved seed categories were significant at the 95% level. Differences between the saved seed groups were not significant.

2/All prices are in Ethiopian birr. During the study period the average exchange rate was USD 1 = EBr 6.7. Net Income=Gross revenue - (cash costs + interest + purchased labor + animal traction costs + hand tool and sack cost). Prices used were as follows (birr/kg) (from EGTE and survey data):

Maize -Jimma: **Jan.** .54, **April-May** .65, **Aug.** .93; **Maize-West Shoa**: **Jan**..69, **April-May** .72, **Aug**..89

Tef -East Shoa: **Jan.** 2.04, **April-May** 2.11, **Aug.** 2.51

3/Net income/total family and mutual labor days

4/Assumes the following CIF Assab/Djibouti prices: DAP USD 275, urea USD 244 (based on NFIA 1997 and World Bank 1995 estimates)

5/Assumes the following CIF Assab/Djibouti prices: DAP USD 200, urea USD 136 (based on NFIA 1997 and IFDC 1994 estimates)

6/Assumes the following prices CIF Mombasa: hi price USD 194 (estimate 1997, T. Jayne), low price USD 150