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The Impact of the Use of New Technologies on Farmers' Wheat Yield in Ethiopia

Evidence from a Randomized Controlled Trial

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ABSTRACT

This study examines the impact of the Wheat Initiative technology package promoted by the research and extension systems in Ethiopia on wheat growers in the highlands of the country. The package includes improved wheat seed, a lower seeding density, row planting, fertilizer recommendations, and marketing assistance. The sample of 482 wheat growers was randomly assigned to one of three groups: the full-package intervention group, a marketing-assistance-only group, and a control group. The results suggest that the full-package farmers had 12–13 percent higher yields after controlling for the type of farmer and household characteristics. Implementation of the Wheat Initiative was successful in terms of the distribution of improved seed and fertilizer, though only 61 percent of the intervention group adopted row planting and few farmers received marketing assistance. The measured yield difference may underestimate the true yield difference associated with the technology because of incomplete adoption of the recommended practices by intervention farmers and adoption of some practices by control farmers.

Keywords: wheat technology package, yield impact, randomized controlled trial, Ethiopia.

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1. INTRODUCTION

This paper aims at measuring the impact on farmer yields of a package of improved technology in wheat production being promoted by the Wheat Initiative and implemented by the Ethiopian Ministry of Agriculture (MOA) with the support of the Ethiopian Agricultural Transformation Agency (ATA). The package includes the use of improved wheat seed, lower seeding rates, row planting, and balanced use of urea and diammonium phosphate (DAP). To promote the package, selected farmers were provided with training in agronomic practices, improved wheat seed on credit, urea for free, and some marketing assistance.

This study, which examines the impact of the Wheat Initiative on wheat yields and productivity, is based on a randomized intervention design combined with both a crop-cut exercise to measure yield and a survey of wheat growers. The sample consists of 482 wheat farmers divided into three groups: a full-package intervention group, a marketing-assistance-only group, and a control group.

This section provides background on the importance of wheat in the agricultural economy and the diet of Ethiopia, as well as information on the patterns of wheat production and imports. Section 2 describes the Wheat Initiative being implemented by the MOA with support from the ATA. Section 3 describes the data and methods used in this study, including the selection of households, the wheat growers' survey, and the crop-cut exercise. Section 4 gives the results of the study, including econometric estimates of the impact of the technology on yield, as well as descriptive statistics on awareness of the Wheat Initiative, services received from the Wheat Initiative, adoption of the recommended practices, and plans for wheat production in the next growing season. Finally, Section 5 provides a summary and interpretation of the findings.

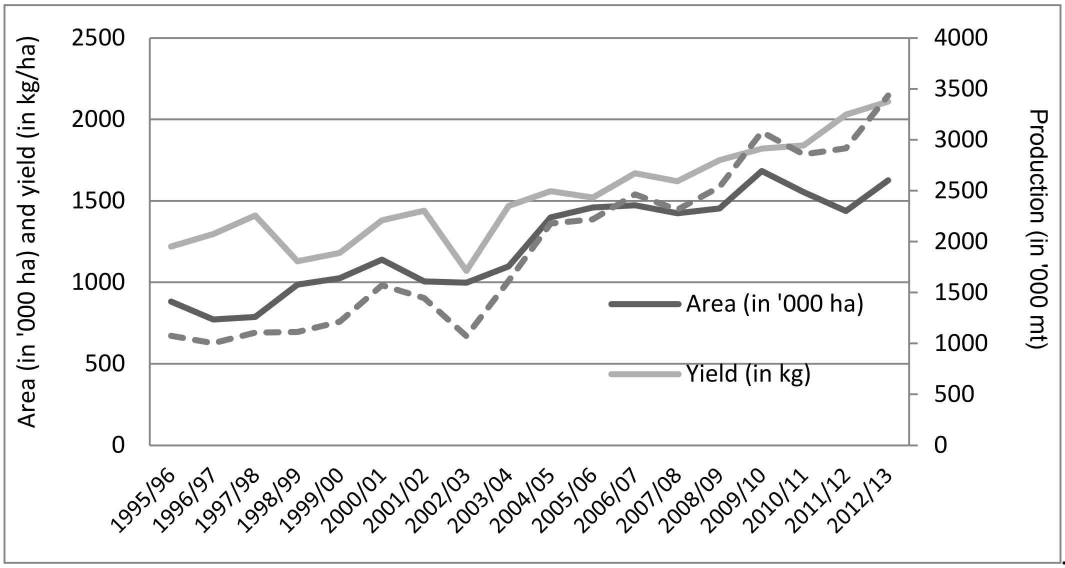
Wheat Production, Consumption, and Import

Ethiopia is the second-largest wheat producer in Africa south of the Sahara, coming after South Africa. Wheat is one of Ethiopia's major staple crops in terms of both production and consumption. In terms of caloric intake, it is the second-most important food in the country behind maize (FAO 2014a). Wheat is mainly grown in the highlands of Ethiopia, which lie between 6°N and 16°N and between 35°E and 42°E, at altitudes ranging from 1,500 to 2,800 m above sea level and with mean minimum temperatures of 6°C to 11°C (Hailu 1991; MOA 2012). Two varieties of wheat are grown in Ethiopia: durum wheat, accounting for 40 percent of production, and bread wheat, accounting for the remaining 60 percent (Bergh et al. 2012). The region of Oromia accounts for more than half of national wheat production (54 percent), followed by Amhara (32 percent); Southern Nations, Nationalities, and Peoples (SNNP) (9 percent); and Tigray (7 percent) (CSA 2013). Of the current total wheat production area, about 75 percent is located in the Arsi, Bale, and Shewa wheat belts (MOA 2012).

In the 2012/2013 *meher*[1] season, about 4.8 million farmers grew wheat, and more than 1.6 million hectares (ha) of land were dedicated to wheat cultivation, constituting 13.5 percent of the national grain area (CSA 2013). Wheat production during the 2012/2013-meher season was 3.4 million metric tons (mt), accounting for 15 percent of the country's total grain output (CSA 2012, 2013). Official statistics indicate that wheat production in 2012/2013 was 18 percent higher than in the previous year; in addition, wheat production has steadily increased over the past decade (Figure 1.1). Data from the Central Statistical Agency (CSA) indicate that the observed increase in wheat production over the past 10 years can be attributed to both expansions of production area and yield improvements. Between 1995/1996 and 2012/2013, wheat production area increased from 0.8 million ha to 1.6 million ha, and yield increased from 1.2 t/ha to 2.1 t/ha (Figure 1.1).

[1] Meher is the long (main) rainy and production season in Ethiopia.

Figure 1.1 Wheat production, area cultivated, and yields in Ethiopia (1995/1996–2012/2013)

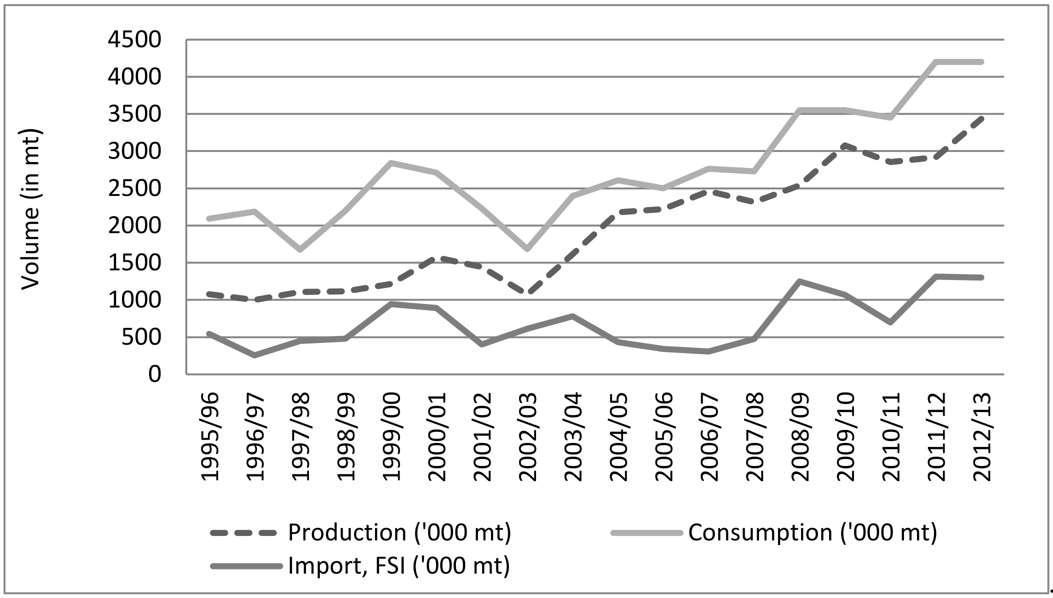


Sources: Ethiopia, CSA (2013); USDA (2013).

Wheat produced in Ethiopia is used mainly for domestic food consumption, seed, and industrial use. For instance, in 2012/2013, household consumption accounted for 58 percent of the total wheat produced; seed and sales represented about 19 percent each; and the remainder was used for animal feed and as in-kind payments for labor. Of the total wheat sold, about 50 percent was commercialized within farmers' districts to local retailers and consumers (Bergh et al. 2012). On average, households in Ethiopia spend 9 percent of their total per capita food expenditure on wheat, second only to maize (Berhane et al. 2011). Wheat accounts for about 10–15 percent of all the calories consumed in the country (Berhane et al. 2011; FAO 2014a). Moreover, estimated total wheat consumption (for food, seed, and industrial use) is rapidly increasing at the national level (Figure 1.2). Annual wheat consumption reached 4.2 million mt in 2012/2013, up from 2 million mt in 1995/1996 (USDA 2013). According to Abu (2013), wheat consumption growth is higher in urban areas due to higher population growth, changes in lifestyle, and the rising prices for teff.

Although wheat production has significantly increased over the past 15 years, domestic production consistently falls short of consumption requirements, making the country a net importer of wheat (Figure 1.2). Wheat is, by far, the most important staple imported from abroad; most commercial imports and humanitarian food aid take the form of wheat. Although the ratio of imported wheat to domestic production has declined in recent years, wheat production self-sufficiency is only about 78 percent (CSA 2013; USDA 2013). Wheat imports account for about 22 percent of the domestic consumption and 33 percent of the wheat market (Abu 2013). All commercial wheat imports to Ethiopia are controlled by the Ethiopian Grain Trade Enterprise (EGTE), which makes wheat available to flour mills, consumer associations, and organized government and private employed staff at subsidized prices (Bergh et al. 2012; Abu 2013). Although the subsidy on imported wheat aims at keeping wheat prices low for urban consumers, it has the indirect effect of reducing prices paid to wheat farmers, thus discouraging domestic wheat production and sales. Only in the 2012/2013 marketing season did the EGTE resume the local purchase of wheat, after three years of relying entirely on international purchases. However, EGTE only purchased 15,000 mt, which is about 2.5 percent of the 2013 commercial imports; therefore, the local purchase program had a negligible effect in stimulating domestic production.

Figure 1.2 Wheat production, consumption and import in Ethiopia (1995/1996–2012/2013)



Sources: Ethiopia, CSA (2013); USDA (2013).
Note: FSI = Food, Seed, and Industry uses.

Wheat Yield Constraints in Ethiopia

Wheat yields in Ethiopia are relatively low. Recent estimates show that wheat farmers in Ethiopia produce, on average, 2.1 t/ha,[2] which is well below the experimental yield of above 5 t/ha (Hailu 1991; MOA 2010, 2011, 2012). It has also consistently lagged behind Africa's average and the world average wheat yields (Figure 1.3). In 2012, for instance, Ethiopia's wheat yield was 29 percent below the Kenyan average, 13 percent below the African average, and 32 percent below the world average yield (FAO 2014b).

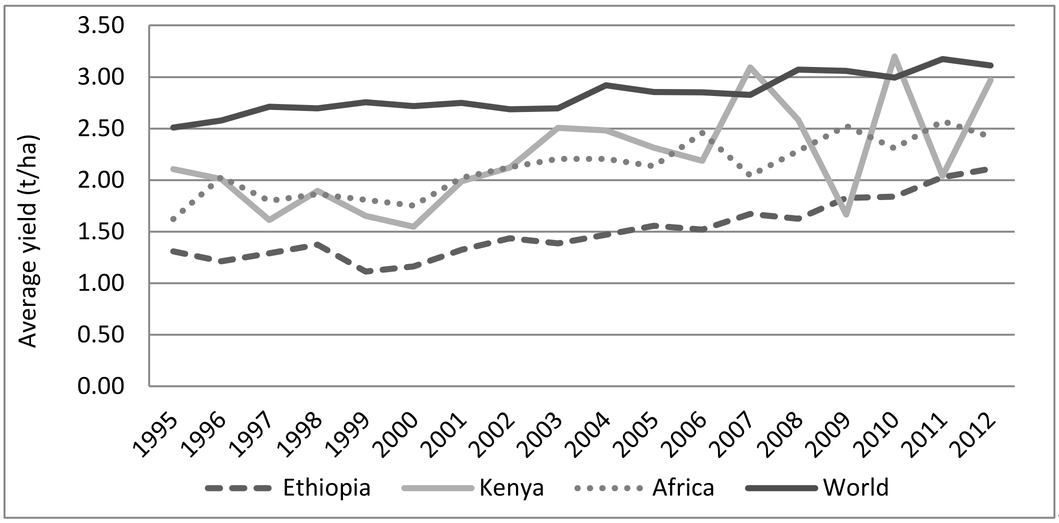
Several socioeconomic, abiotic, and biotic constraints explain these yield gaps. First, the use of modern production-enhancing inputs, such as improved seeds and fertilizers, among wheat farmers in Ethiopia is remarkably low. The 2012 national estimates on input use indicate that only 8.4 percent of wheat areas were planted with improved seed and that 48 percent were fertilized. Fertilizer application rates on fertilized lands are estimated at 48 kg/ha, which is well below the average recommended rates of 200 kg/ha (Spielman, Kelemwork, and Alemu 2013; Endale 2010; MOA 2010, 2011, 2012). Only about 1 percent of the wheat area was cultivated using improved seed-fertilizer packages (CSA 2012), which is unfortunate given the high production response for combined use of improved seeds and fertilizers in Ethiopia (Dercon et al. 2009; Byerlee et al. 2007; Howard et al. 2003). Studies also indicate disadoption of improved seed-fertilizer package over time, due to high costs, insufficient credit, and lack of improved varieties with traits appropriate to farmers' needs (EEA/EEPRI 2006).

Second, abiotic factors, such as low and poor distribution of rainfall in lowland areas, plant lodging in half of the highlands, and soil erosion, are perceived as causes for significant wheat yield losses in the country. Recent estimates indicate that low rainfall and poor distribution problems and plant lodging can cause 10–30 percent of yield losses (Lemma et al. 1990).

[2] There is considerable variation in average wheat yields across regions and zones. For instance, the average wheat yields in some zones of Oromia (Arsi and Bale) and SNNP (Hadiya and Silitie), where farm sizes are relatively large, were between 2.5 and 2.8 t/ha, which is well above the national average wheat yield (CSA 2013). On the other side, average yields are reportedly lower than the national average in most parts of Amhara and Tigray, ranging between 1.7 and 1.9 t/ha (CSA 2013).

Diseases and weeds are the third factor explaining relatively low wheat yields in Ethiopia. Since the 1993/1994 stem rust epidemics, which reduced yields by 65–100 percent during the 1994 meher rains (Shank 1994), rust has become detrimental for wheat production. For instance, estimates indicate that during the 2010/2011 meher season, about 400,000 ha of wheat were affected by rust nationwide (ICARDA 2013), causing a yield loss of 18–29 percent (Tadesse, Ayalew, and Badeboa 2010). Weed infestation is another biotic factor that has been reported as a major constraint for wheat production. Grain yield losses due to weed competition have been estimated by various studies: yield gains with proper weed control have ranged from 35 to 85 percent (Tessema, Tanner, and Hassen 1996; Tessema and Tanner 1997; Desta 2000; Bogale, Nefo, and Seboka 2011).

Figure 1. 3 Average wheat yield in Ethiopia, compared with regional and world averages



Sources: Ethiopia, CSA (2013); FAO (2014b).

Fourth, postharvest losses may undermine wheat yields in Ethiopia (Dereje 2000). According to the African Post Harvest Loss Information System, wheat grain yield losses in Ethiopia during harvesting, drying, handling operations, farm storage, transportation, and market storage in 2012 were estimated at 14.2 percent. Finally, the way farmers plant wheat seeds also contribute to low wheat productivity. Traditionally, Ethiopian farmers plant wheat seed using hand broadcasting. Compared with direct seeding, broadcasting reduces yields due to poorer seed-to-soil contacts and delayed germination, higher competition between plants for inputs because of uneven seed distribution, and difficulty in controlling grassy weeds.

The results of on-station and on-farm trials following the System of Wheat Intensification led to optimism about the potential of the comprehensive extension package to increase wheat productivity (Abraham et al. 2014). For instance, on-farm trials in northern Ethiopia and South Wollo showed that optimal use of inputs, row planting with reduced seeding rate, and proper implementation of agronomic best practices increased wheat yield by about threefold on average, compared with control plots (4.9 t/ha on experimental plots versus 1.8 t/ha on control plots). However, systematic evaluation on the yield potential of optimal use of inputs, as well as row planting and lower seeding rate on farmers' fields, is scarce.

Extant research on row planting in Ethiopia focuses primarily on teff. Techniques being studied to boost teff yields include a subset of those in the Wheat Initiative, including row planting and a reduced seeding rate. Studies by Abayu (2012) and Tolosa (2012) found a 27–35 percent increase in yield for teff plots planted following row spacing using reduced seed rates; however, a randomized control trial by Vandercasteelen et al. (2013) found only a 2 percent yield difference between row planting and broadcasting using crop-cut data and a 12–13 percent yield difference using data from farmers' production and area estimates.

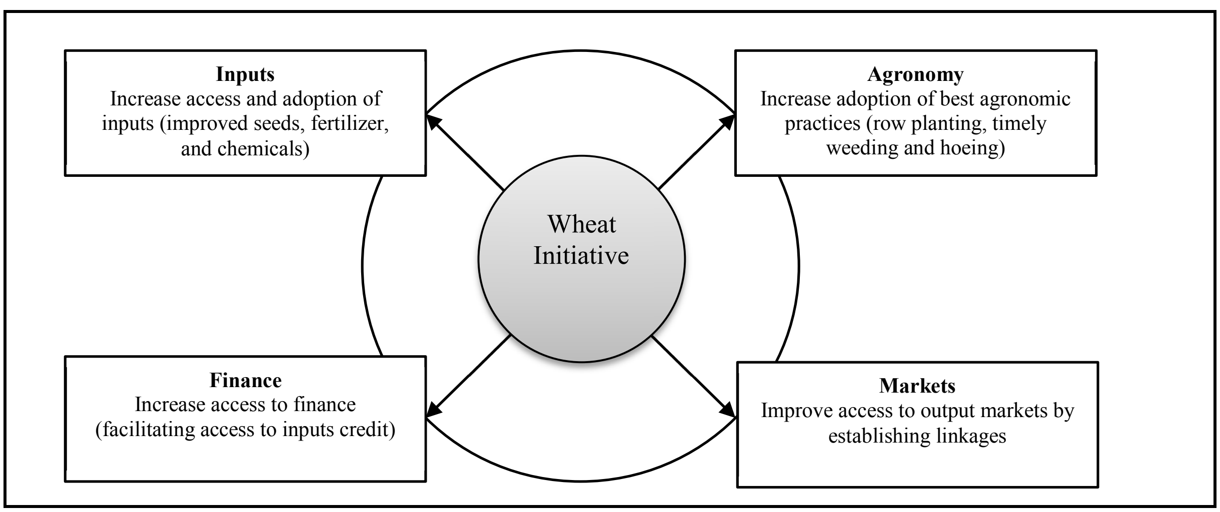
2. DESCRIPTION OF THE WHEAT INITIATIVE

In the 2013 meher rainy season, the MOA, with the support of the Ethiopian ATA, launched a Wheat Initiative that aims to address some of the aforementioned constraints on wheat productivity. The initiative covered about 400,000 wheat farmers in 41 *woredas* and promotes the optimal use of improved technologies and proper implementation of agronomic best practices. A main goal of the initiative is to reduce Ethiopia's reliance on imported wheat by increasing yields and productivity.

To meet this goal, the Wheat Initiative includes a comprehensive input and extension package designed to help farmers attain higher yields. The initiative includes four major components: inputs, best agronomic practices, access to finance, and market linkages (Figure 2.1). The critical ingredient of the input component is to ensure availability, access, and adoption of quality improved seeds and fertilizers. The input component specifically aims to increase the adoption rates of certified improved wheat seeds to 30 percent (from less than 10 percent) and tailored recommendation of fertilizers that require increased use of urea relative to DAP. Traditionally, most of the wheat farmers either used urea and DAP in equal proportion or used less urea, as the benefit of using urea is largely underestimated by wheat farmers in parts of Bale and Arsi, two of Ethiopia's largest wheat-producing regions[3] (MOA 2012; CSA 2013).

The agronomic component of the initiative aims to increase farmers' awareness of best agronomic practices in wheat production. It introduces row planting, lower seeding rates, and early or timely weeding and hoeing. In addition to the comprehensive agronomic training provided for subject-matter specialists, development agents (DAs), and selected benchmark farmers on wheat agronomy, the initiative made an effort to reach a larger number of wheat farmers through radio, manuals, and leaflets. For instance, in partnership with Farm Radio International, a six-week participatory radio program was conducted on wheat production in the Wheat Initiative regions. In addition, wheat agronomy manuals and leaflets were developed and distributed to DAs and wheat producers.

Figure 2.1 Major components of the Wheat Initiative



Source: Authors.

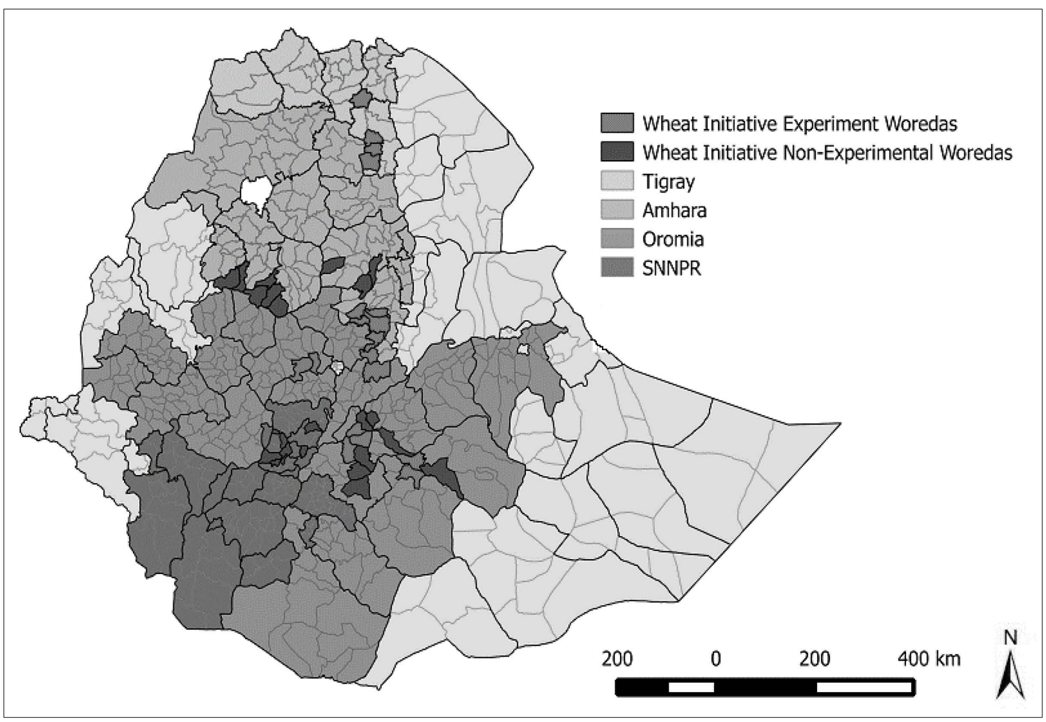
[3] The Bale and Arsi wheat belts account for 22 percent of the total wheat area and 25 percent of total wheat production (CSA 2013).

The Wheat Initiative also attempts to ensure the availability and access of input finance. As part of improving access to input finance, a new input credit delivery system was designed and implemented in some of the Wheat Initiative woredas. The new system introduces input vouchers, which can be redeemed at agricultural cooperatives. The goal of the voucher system is to increase fertilizer use and repayment rates.

Finally, creating market linkages for wheat was considered an indispensable element for the success of the Wheat Initiative. Through collaboration with the EGTE, the initiative made efforts to make wheat farmers aware of newly developed market opportunities. This was done through broadcasting the EGTE's local or domestic purchasing plan for the 2013/2014 marketing season.[4] Local purchase by EGTE is believed to send out a clear demand signal to producers and encourage farmers to invest in inputs and technologies, thus stimulating an increasing supply of domestic wheat.

In addition to the overall Wheat Initiative that addresses all wheat farmers in the intervention woredas, the MOA, with the support of ATA, rolled out a promotional package for 2,000 "benchmark" farmers in 41 woredas in the four major-wheat producing regions (Figure 2.2). The benchmark farmers were selected from 200 *kebeles*[5] within the 41 woredas and, on average, constituted two model farmers, two non-model farmers, and one female farmer. The promotional wheat package was implemented on wheat plots of benchmark farmers, which were roughly half a hectare in size. The package includes improved seeds with proper traits demanded by farmers, urea and DAP fertilizers, gypsum, row spacing and lower seeding rate, and early or timely weeding. Improved seeds and urea support were provided to the benchmark farmers by ATA to enable them to implement the package following the tailored recommendations.

Figure 2.2 Map of the Wheat Initiative regions and woredas



Source: Authors.

[4] During the 2013/2014 marketing season, EGTE planned to purchase 250,000 mt of wheat from the domestic market, which is about 40 percent of EGTE's total previous year import. This plan was broadcasted on national television and radio during the planting period to encourage farmers that investment in wheat can have better access to market and yield better returns.

[5] *Kebele* is the lowest administrative unit in Ethiopia.

The evaluation in this report focuses on measuring the impact of the promotional package on wheat yields in 73 selected experimental *kebeles* spanning 18 woredas in the Oromia, Amhara, and Tigray regions (the 18 experiment woredas are shown in Figure 2.2). The evaluation's design is consistent with the rollout, except that some alterations were done to make sure that the selection of benchmark farmers in these subsample *kebeles* was done randomly and that a suitable comparison group was constructed prior to the intervention. The sample design followed a three-stage approach.

In the first stage, 18 woredas that were able to send a list of 14 farmers by *kebele* were selected for the evaluation; each of these woredas constitutes about 4–10 *kebeles*. In the second stage, 4–5 *kebeles* per woreda were randomly selected. The selected 73 *kebeles* were again randomized into "high intensity" and "low intensity" groups. In the high-intensity *kebeles*, all 14 farmers received the promotional package (518 wheat farmers in total). In the third stage, the 14 farmers in the low-intensity kebeles were randomized into benchmark farmers, market farmers, and control farmers (504 wheat farmers in total). Because the study does not include a comparison group within the high-intensity *kebeles*, the analysis in this report focuses on the 504 wheat farmers in the 36 low-intensity *kebeles*.

The research team did the randomization at all stages and it was stratified by model, non-model, and female farmers in order to ensure that the proper mix of farmers was preserved within each *kebele*.[6] Development agents, with the support of the ATA wheat value-chain team, provided the training and assisting of farmers in implementing the promotional package.

The benchmark farmers are treatment farmers who implemented the promotional package on a small experimental plot ranging between 300 m^2 and 500 m^2, with input and training support from MOA and ATA. The input support includes 50 kg of certified improved seed on credit (free of interest), 50 kg of urea fertilizer, and 25 kg of gypsum for free. The market farmers are another type of treatment farmers who were provided with information about the guaranteed market opportunity but did not receive the subsidized-input package. Control farmers are farmers who are assigned as a comparison group and who, it is assumed, plant wheat following the existing or traditional production practices. However, the latter were not precluded in any way from adopting parts of the ATA Wheat Initiative package.

[6] Randomization took place as follows: Random numbers from the uniform distribution were assigned to each of the 14 farmers on each list using Stata. The two model farmers with the lowest values were then selected for the wheat package treatment; two non-model farmers were selected, and then one female farmer. Similarly, the two model farmers, the two non-model farmers, and the female farmer with the highest values were assigned to the control group. The remaining four farmers were assigned to the market group. Since some farmers could fulfill more than one category (for example, a female model farmer), sometimes more than one female farmer was assigned to the treatment or control group.

3. DATA AND METHODS

Data Description

This report uses two primary sources of data. First, it uses a crop-cut measurement survey, which was conducted in November and December 2013 in the 36 low-intensity *kebeles* where both treatment and control farmers exist. This survey was aimed at measuring wheat outputs and areas of both experimental and control plots before harvesting. Each plot was subject to two types of output measurements: sample crop-cut output measurement (wet weight) and farmers' preharvest estimates of wheat outputs from the whole plot. Experts from the CSA did the technical aspect of the crop-cut exercise. Of the 504 experimental and control farmers in the low-intensity *kebeles*, wheat production was successfully measured on 382 plots.[7]

Second, a wheat growers' survey was conducted in February and March 2014, in both high- and low-intensity *kebeles*, timed to occur after harvest was complete. The survey covered 1,003 experimental and control farmers in 73 *kebeles* (out of 1,022 initially assigned farmers). It used a structured questionnaire that collected information on input use, labor use, land use, wheat production and marketing, and experimental farmers' experience with the promotional wheat package. It also asked questions about farmers' social networks and plans of growing wheat using the promotional wheat package for the next growing season. The data were collected using small laptop computers, which allowed the use of a data-entry program that checked for errors during the interview. Most of the analysis in this paper is based on 482 wheat farmers in the low-intensity *kebeles*.

To help contextualize the information gathered in the two surveys, qualitative data were also collected before and after harvest to understand the perception of experimental and control farmers on the promotional wheat package. After planting and during the tilling and seed-setting stage, 18 focus group discussions (FGDs) were conducted with participating and nonparticipating farmers. The discussions focused on farmers' knowledge about the promotional wheat package, timely availability and affordability of inputs, the quality of the package, and challenges faced during implementation. Five additional FGDs were conducted after harvest, during the wheat growers' survey, during which questions were asked about market opportunities, outputs as compared with the previous year, and assessment of the whole-wheat intervention.

Yield Measurement

The primary outcome variable of interest for this evaluation is wheat yield, defined as the amount of harvested wheat output divided by plot area. The estimation of the average wheat yield on a specific plot thus involves both the estimation of plot area and the quantity of output obtained from the area. However, measuring output and area in this setting is not an easy task, as both can be prone to error and bias. For instance, the local units used for measuring area are inconsistent from one location to another. Thus, the evaluation used alternative estimates of crop area and harvested product to ensure the robustness of yield estimates.

By design, all experimental plots should have had a consistent area of 0.5 ha (5,000 m^2). However, during follow-up field visits, significant deviations from the standardized area were found.[8] Thus, during crop-cut and wheat growers' surveys, both the experimental and control plots were subject to area measurement. The area of experimental and control plots in low-intensity *kebeles* were measured

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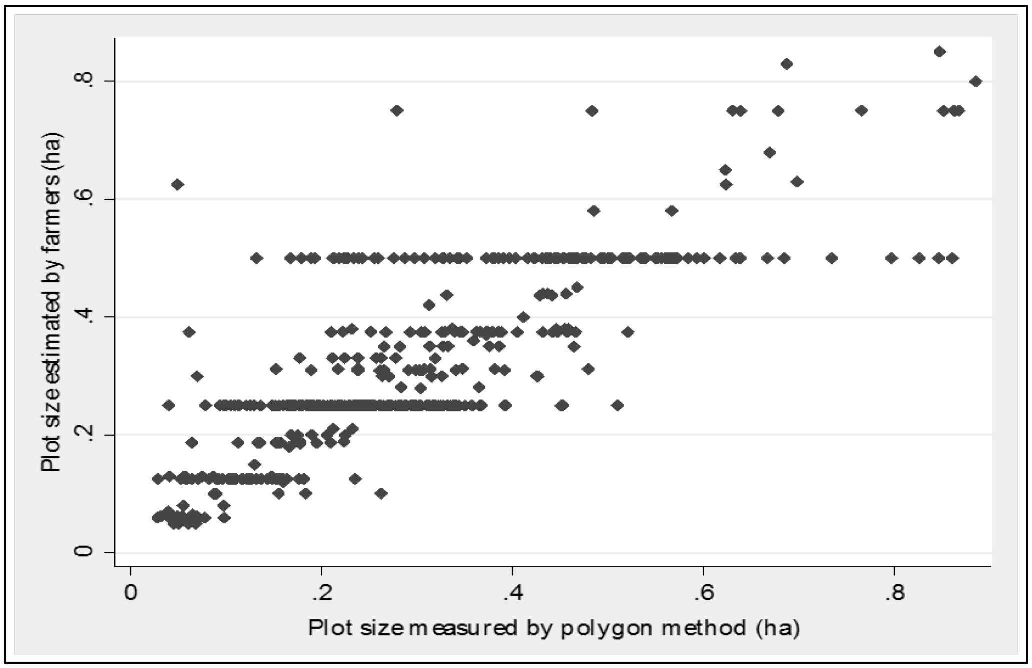
[7] Outputs could not be measured for the remaining 122 plots for three reasons: seven of the farmers had no wheat plot during the 2013 meher season, five farmers could not be identified by anyone in their respective *kebeles* at the time of the household survey, and the remaining 110 farmers harvested their wheat plots early before the crop-cut survey. There were no refusals.

[8] The deviation from the standard area size in experimental plots was partly linked with the acceptance by some farmers of the recommended lower seeding rate technology. Benchmark farmers were provided with only 50 kg of improved seeds to cover a half-hectare wheat plot following row planting/spacing. However, farmers with black or verity soil who plant wheat on broad beds following hand broadcasting cover, on average, only 300 m^2 with the seed provided. Moreover, in some *kebeles* with small and fragmented land structure, farmers implemented the package on more than one experimental plot.

using the polygon method (direct area measurement) and farmer assessment of plot area. The polygon method involves using rope and a compass to measure the length of each side and the angle of each corner; this information was then used to calculate the plot size. Farmer assessment of plot area was based on farmers' estimates of the surface area of their plot, all done in the presence of enumerators. The enumerators were present to judge the soundness of each farmer's estimate. Furthermore, the area of experimental and control plots were again measured based on farmer assessment of plot area during the wheat growers' survey. Local units were used for farmer assessments of plot area to reduce potential rounding errors while converting to standard units. The study found a strong correlation (0.76) between these two measures of plot size. Nonetheless, the horizontal lines in Figure 3.1 reflect the fact that farmers often round off their plot size estimation (for example, 1/2 *timad*, 1 *timad*, and 2 *timad*, which are 0.125 ha, 0.25 ha, and 0.5 ha, respectively). On the other hand, the polygon estimates of plot size had a larger share of outliers, perhaps reflecting errors in measuring or recording the angles and distances used to calculate plot size.

Figure 3.1 Scatter plot between plot size measured by polygon method and farmer assessment



Source: Authors' calculation based on crop-cut survey data.

Similar to area measurement data on wheat, output was collected during crop-cut and wheat growers' surveys. Three different measures of wheat outputs were obtained from the two surveys:

1. Before harvest, a crop-cut survey was conducted from one random subplot of a 4 x 4 m2 area within the experimental and control plots. The output from this random subplot was harvested and threshed, and enumerators measured the wet weight.
2. During the crop-cut exercise, which was conducted at the time of maximum crop maturity, treatment and control farmers were asked to predict the output they expected from the whole plot. The prediction was obtained in a setting in which the enumerators and the farmers were in visual contact with the growing wheat crop so that the enumerators could judge the validity of the farmers' estimates.
3. Postharvest estimation of output was obtained from farmers at the time of the wheat growers' survey, which was conducted right after harvesting, drying, and threshing activities were completed.

Each yield measure has its own advantages and disadvantages. Yields from crop-cut measurement are often considered the most reliable and objective measure. However, crop-cut yield estimates do not take into account postharvest losses during drying, threshing, cleaning, and transportation. Moreover, the process of locating a subplot for crop-cut can be subject to selection bias (such as excluding border of the plot). Finally, the 20 percent of farmers for whom crop-cut data could not be collected might systematically differ from other farmers. Although it does not reveal gross yield, farmer recall reflects the economic yield that is of use to the farmer. The benefit of yield estimates based on farmers' preharvest predictions over crop-cut and postharvest reported yields is that the former better reflects the attainable yield (Fermont and Benson 2011). Overall, as is evident in this evaluation, yield measurement based on farmer prediction and recall allows the collection of a larger set of yield estimates than crop-cuts alone.

Estimation Methods

The experimental design described in this section involves the random assignment into three groups: those households receiving the full promotional wheat package, those receiving access only to the marketing component of the wheat package, and those in the control group, which received neither. The basic estimating equation that explores whether the full package or the marketing-only component had an impact on wheat production is as follows:

$$ln\, Y_{ik} = \alpha_k + \beta T_{ik} + \gamma G_{ik} + u_{ik}, \tag{1}$$

where *Y* represents yields; *T* represents the primary treatment group, or the full package; *G* represents the marketing-only group; *u* is a mean-zero error term; *i* indexes households; and *k* indexes *kebeles*. The primary null hypotheses to be tested are whether β (the difference in yields between full-package farmers and control farmers) is zero and whether γ (the difference in yields between marketing-only farmers and control farmers) is zero.

Given that the package was implemented among a variety of different farmer types, the model can be expanded to determine whether model farmers or female farmers have different wheat yields:

$$ln\, Y_{ik} = \alpha_k + \beta T_{ik} + \gamma G_{ik} + \delta_1 M_{ik} + \delta_2 F_{ik} + u_{ik}, \tag{2}$$

where *M* represents model farmers and *F* represents female farmers. The model can be expanded even further to include interaction terms that examine heterogeneous treatment effects—that is, whether the benefits of treatment are different for model farmers and female farmers:

$$ln\, Y_{ik} = \alpha_k + \beta T_{ik} + \theta_1 T_{ik} M_{ik} + \theta_2 T_{ik} F_{ik} + \gamma G_{ik} + \delta_1 M_{ik} + \delta_2 F_{ik} + u_{ik}. \tag{3}$$

Finally, by controlling for some household and plot characteristics (*Z*) that are unlikely to change over time, the specification would be:

$$ln\, Y_{ik} = \alpha_k + \beta T_{ik} + \theta_1 T_{ik} M_{ik} + \theta_2 T_{ik} F_{ik} + \gamma G_{ik} + \delta_1 M_{ik} + \delta_2 F_{ik} + \omega Z_{ik} + u_{ik}. \tag{4}$$

Household and plot characteristics considered in the estimation include age of the household head, education level of the household head, landholding size, household size, soil quality, and distance to plot from home.

4. RESULTS AND DISCUSSIONS

Descriptive Statistics

Farmers were randomly allocated into the three treatment groups (full package, marketing only, and control) in order to create three otherwise similar groups. Comparing them according to several basic household characteristics can test the similarity of the three groups. Table 4.1 compares the main characteristics of households in each treatment group. A Wald test of the equality of means across all three groups was used, with the results shown in the last column.

The strongest differences across groups were in the gender of the farmer and household size, both of which were significant at the 1 percent level. Female farmers make up a larger share of the full-package group (20 percent) than either of the other two groups (10 and 8 percent in marketing-only and control groups, respectively). This difference is due to the fact that we wanted to include at least one female farmer in the treatment group; thus, if the original list of farmers only had a few females, they were likely to be selected for treatment. Farmers in the control group also tended to have somewhat larger households (7.2 members) as compared with the other two groups (6.7 and 6.4 members in full-package and marketing-only groups, respectively).

Table 4.1 Characteristics of households in each treatment group

Variable	Full-package farmers	Marketing farmers	Control farmers	F-test of differences in means
Age ***(year)***	45.5	44.0	47.1	2.87*
Gender ***(1 = male, 2 = female)***	1.20	1.10	1.08	11.84***
Education ***(in completed years)***	2.62	2.63	2.56	0.23
Household size ***(number)***	6.69	6.44	7.20	8.34***
Landholding size ***(ha)***	2.37	2.22	2.30	0.28
Irrigated land size ***(ha)***	0.015	0.018	0.039	0.99
Red-colored soil ***(1 = yes)***	0.218	0.246	0.311	3.10*
Black-colored soil ***(1 = yes)***	0.594	0.540	0.474	3.19*
Gray/sand-colored soil ***(1 = yes)***	0.188	0.214	0.216	0.33
Distance to wheat plot ***(minutes)***	13.7	15.4	14.3	0.55

Source: Authors' calculation based on data from the crop-cutting exercise and the 2014 wheat growers' survey.
Note: Indicates statistically significant difference with the control farmers * at the 10% level, ** at the 5% level, and *** at the 1% level.

There were also differences in age of the farmer and the share of red and black soil, though these differences were significant only at the 10 percent level. Control farmers tended to be somewhat older than those in the other groups, with the difference being two to three years, on average. Control farmers were also more likely to have red soils and less likely to have black soils as compared with the other two groups. There were no statistically significant differences in education, farm size, irrigated area, the share of gray/sandy soils, and distance to plot. Because most of these differences were either statistically insignificant or relatively small in magnitude, the authors are relatively confident that the groups were similar. In any case, the analysis used to measure the impact of the treatment on yields controls for the variables listed in Table 4.1; thus, these differences do not contribute to the yield impact estimate.

Table 4.2 shows differences in wheat yield across groups. Dividing outputs from crop-cut, farmer prediction, and farmer recall after harvest by the area of the plot gives three different measures of yield: yield from crop-cut, yield from farmer prediction, and yield from farmer recall. Regardless of how the yields are measured, they are higher among farmers receiving the full package than among those who did not. According to the crop-cut, yields averaged 2.92 t/ha among the full-package farmers, compared with 2.77 and 2.73 t/ha among the market and control farmers, respectively. When using farmer-predicted output or farmer-recalled output as the numerator, the yield estimates actually increase, suggesting a difference between the missed farmers (i.e. sample farmers without crop-cut data) and farmers who participated in the crop-cut. Alternatively, perhaps farmers over reported their production to enumerators, or perhaps crop-cuts were done on less-productive parts of fields. Later in the paper is an examination of this difference in the data.

Table 4.2 Area, production (output), and yield estimates

Variable	Full-package farmers (n = 197)		Marketing farmers (n = 126)		Control farmers (n = 167)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Plot size *(ha)*						
Measured	0.30	0.18	0.37	0.34	0.45	0.56
Estimated by farmers	0.33	0.17	0.43	0.52	0.45	0.48
Output (production)						
Crop-cut (4 x 4 m^2) *(kg)*	4.68	2.60	4.43	2.16	4.37	2.33
Farmer prediction *(t)*	1.19	0.86	1.27	1.67	1.55	2.18
Farmer recall *(t)*	1.98	1.82	2.25	1.86	2.11	2.05
Yield estimates *(t/ha)*						
Yield based on crop-cut	2.92	1.62	2.77	1.35	2.73	1.45
Yield based on farmer prediction	3.56*	1.84	3.13	1.71	3.18	1.70
Yield based on farmer recall	3.18	1.83	3.07	1.74	2.91	1.85

Source: Authors' calculation based on data from the crop-cutting exercise and the 2014 wheat growers' survey.
Note: * indicates statistically significant difference with the control farmers at the 10% level.

Impact of the Promotional Wheat Package on Farmer Yield

The impact estimates based on the randomized controlled trial used the data from low-intensity *kebeles* where all three groups of farmers exist (full package, marketing treatment, and control group). The analysis retains the initial treatment assignment—that is, the sample was not restricted to compliers, because excluding those farmers who did not properly implement the package may introduce self-selection bias (unless the decision to implement the package is itself independent of yield, which seems unlikely).

The study initially investigates the average intent-to-treat effect of the wheat package using the crop-cut wheat yields (Table 4.3). With only the two treatment variables in the regression, no significant impact was found, though the authors do estimate a positive coefficient (0.078) on the full-package indicator (column 1). When the type of farmer (model farmers and female farmers) is controlled, the coefficient estimate increases to 0.094 but is not statistically significant (column 2). Next, the interaction terms between the treatment and the model/female farmer indicators are included. Although neither of the interaction terms is statistically different from zero, adding these variables increases the main treatment effect to 0.124, which is significant at the 10 percent level (column 3). Finally, once the control variables (column 4) are added, the coefficient estimate increases further to 0.134 and remains significant at the 10 percent level. Given that this set of regressions might have lacked statistical power due to the missing farmers, the finding at the 10 percent level of significance is, at the least, a meaningful suggestion of a positive impact (12–13 percent) of the wheat package on yields.

As suggested by descriptive statistics, the econometric results show that the wheat yields of farmers in the marketing assistance group were no higher than the yields of those in the control group. This finding is not surprising given the partial implementation of this component. As discussed later, fewer than 13 percent of the farmers in the marketing assistance group reported receiving any marketing assistance, which is no greater than the percentage of the control group that reported receiving marketing assistance (see Table 4.8). Therefore, the nonresult for marketing does not imply that the guaranteed marketing opportunity does not lead to increased wheat yields; not enough farmers received the guaranteed marketing opportunity to determine whether it could have affected yields or even take-up of the wheat package.

Table 4.3 The impact of the promotional wheat package on farmers' wheat yield based on crop-cut estimates

Variable	Yield based on crop-cut							
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Full package	0.078	0.057	0.094	0.059	0.124	0.074*	0.134	0.074*
Marketing assistance	–0.019	0.064	–0.016	0.064	–0.014	0.064	–0.014	0.064
Model farmer			–0.020	0.055	0.047	0.073	0.038	0.075
Female farmer			–0.098	0.072	–0.190	0.110*	–0.152	0.113
Treatment × model					–0.150	0.110	–0.127	0.110
Treatment × female					0.146	0.147	0.131	0.147
Age of household head							–0.004	0.002
Education of household head							0.001	0.030
Household size							0.024	0.016
Landholding size							0.006	0.012
Black soil							–0.203	0.069***
Gray/sandy soil							–0.051	0.079
Distance to plot							0.000	0.002
***Kebele* fixed effect**	Yes		Yes		Yes		Yes	
Constant	7.748	0.042***	7.762	0.045***	7.752	0.047***	7.938	0.186***
Number of obs.	367		367		367		367	
R-square	0.51		0.52		0.52		0.54	

Source: Authors' calculation based on data from the crop-cut and the 2014 wheat growers' survey.
Notes: *** significant at 1% level, ** significant at 5% level, and * significant at 10% level. In the interaction terms, *treatment* refers to the full-package treatment.

In addition, female farmers may have lower yields, though only one of the three coefficients is significant and only at the 10 percent level. In addition, wheat yields on "black cotton" soils (vertisol) are about 20 percent below yields from other soils, a result that is statistically significant at the 1 percent level. Farm size, education of the head of household, and other household characteristics were not statistically significant predictors of wheat yields.

Table 4.4 presents the yield impact estimates based on farmers' preharvest prediction of output and farmers' assessment of plot size. In this case, the full-package farmers had significantly higher yields (at the 10 percent level), even without controlling for other characteristics (column 1). As variables are added systematically to the regressions, the coefficient estimates rise to 13.5 percent by columns 3 and 4, where they are significant at the 5 percent level. The results thus indicate a strong yield impact of the promotional wheat package on benchmark farmers. Like the yield impact estimates based on crop-cut, the yield impact estimates based on farmer prediction indicate no significant yield impact among those farmers who were supposed to receive marketing assistance.

Table 4.4 The impact of the promotional wheat package on farmers' wheat yield based on farmer prediction of output

Variable	Yield based on farmer prediction							
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Full package	0.102	0.053*	0.102	0.054*	0.135	0.068**	0.135	0.069**
Marketing assistance	0.003	0.059	0.003	0.059	–0.000	0.059	0.002	0.060
Model farmer			0.046	0.051	0.035	0.069	0.041	0.071
Female farmer			–0.047	0.069	0.121	0.105	0.158	0.108
Treatment × model					0.019	0.104	0.022	0.105
Treatment × female					–0.292	0.140**	–0.295	0.141**
Age of household head							0.000	0.002
Education of household head							0.042	0.028
Household size							–0.001	0.016
Landholding size							0.004	0.011
Black soil							–0.085	0.066
Gray/sandy soil							–0.124	0.074*
Distance to plot							–0.000	0.001
Kebele fixed effect	Yes		Yes		Yes		Yes	
Constant	7.942	0.039***	7.935	0.041***	7.924	0.043***	7.849	0.177***
Number of obs.	482		482		482		482	
R-square	0.36		0.36		0.37		0.38	

Source: Authors' calculation based on data from the 2014 wheat growers' survey.
Note: *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

The results in Table 4.4 also suggest a heterogeneous treatment effect. The coefficient on the interaction between the full-package and female farmers is negative and significant at the 5 percent level, suggesting that the female farmers gain less than male farmers from the package.

A third measure of yields used farmer recall of output combined with farmer assessment of plot size (Table 4.5). No significant relationship was found between the full-package indicator variable and wheat yields, though all coefficient estimates are positive in magnitude. It is possible that farmers do not recall yield increases as accurately as they predict them. Note that model farmers reported higher yields by between 13 and 18 percent relative to nonmodel farmers. Because this result does not appear in the other two measures of yield, it may be that model farmers overestimate their yields or that other farmers underestimate their yields.

Table 4.5 The impact of the promotional wheat package on farmers' wheat yield based on farmer recall of output

Variable	Yield based on farmer recall							
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Full package	0.050	0.057	0.034	0.058	0.044	0.073	0.041	0.073
Marketing assistance	0.025	0.063	0.022	0.063	0.023	0.063	0.016	0.064
Model farmer			0.128	0.055**	0.165	0.074**	0.184	0.076**
Female farmer			–0.021	0.074	–0.091	0.113	–0.089	0.116
Treatment × model					–0.078	0.112	–0.082	0.112
Treatment × female					0.113	0.151	0.110	0.151
Age of household head							-0.001	0.002
Education of household head							0.012	0.030
Household size							-0.020	0.017
Landholding size							-0.006	0.012
Black soil							-0.021	0.070
Gray/sandy soil							0.109	0.079
Distance to plot							-0.001	0.002
Kebele fixed effect	Yes		Yes		Yes		Yes	
Constant	7.800	0.041***	7.772	0.044***	7.770	0.046***	7.906	0.190***
Number of obs.	489		489		489		489	
R-square	0.45		0.46		0.46		0.47	

Source: Authors' calculation based on data from the 2014 wheat growers' survey.
Note: *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

To better understand how the impacts occurred, farmers were asked about their knowledge of the components of the promotional wheat package, their experience in receiving the intervention components, and their implementation of the recommendations. In addition, farmers were asked about their opinion of the Wheat Initiative recommendations and their plans for the next year, both of which are indicators of the likelihood that farmers will adopt the recommendations. These results are presented in the following sub-sections.

Farmers' Knowledge of the Promotional Wheat Package

Although the Wheat Initiative focused on training and implementing the promotional wheat package on randomly selected benchmark farmers in its first year, the three groups of farmers had comparable knowledge about the Wheat Initiative and aspects of the wheat package in general (see Table 4.6). Whereas almost all (94 percent) of the full-package benchmark farmers were aware of the Wheat Initiative, just over half of the marketing-only and control-group farmers knew of it (row 1). Furthermore, more than 90 percent of farmers in all three groups knew about the new wheat recommendations (row 2), and almost all respondents knew they should use improved seed (row 3). Farmers generally also knew about the recommendations to reduce the seeding rate (85–91 percent) and to use row planting (83–91 percent).

There were differences in farmers' knowledge of recommended fertilizer application rates, though all farmers overestimated the recommended fertilizer application rates (rows 6 and 7). Full-package farmers suggested lower recommended rates than other farmers, indicating that their estimates were closer to the actual recommendation rates.

Table 4.6 Farmers' knowledge of the promotional wheat package

Variable	Full package (n = 710)	Marketing (n = 127)	Control (n = 167)
Information about MOA/ATA Wheat Initiative *(%)*	94.5	54.7	57.4
Information about new wheat recommendations *(%)*	96.4	90.4	92.8
New recommendation includes use of improved seed *(%)*	99.4	99.1	99.4
New recommendation includes seeding rate *(%)*			
Higher seeding rate	5.1	5.8	2.5
Lower seeding rate	91.3	84.8	87.9
No change	1.9	2.5	1.2
New recommendation includes planting method *(%)*			
Broadcasting seed	13.0	15.9	8.8
Row planting seed	86.3	83.1	91.1
Recommended application rate for urea *(kg/ha)*	146.0	184.0	164.0
Recommended application rate for DAP *(kg/ha)*	166.5	192.6	185.3

Source: Authors' calculation based on data from the 2014 wheat growers' survey.

Farmers' Experience with the Services Provided Under the Wheat Initiative

We next report on farmers' experiences with the services provided by the Wheat Initiative, again by treatment status (see Table 4.7). As noted earlier, benchmark farmers were supposed to receive three major incentives to participate in the wheat initiative: (1) improved seeds (on credit), (2) urea fertilizer (for free), and (3) training on agronomic best practices. Most benchmark farmers (91 percent) received improved seed on time, whereas 25–29 percent of the marketing-only and control-group farmers did so. About three-fourths of farmers who received improved seed declared it was very good quality, and 95 percent said it was very good or good. Among the few who had problems, most cited mixture with stones, dirt, or weed seed.

Table 4.7 Farmers' experiences with services provided under the Wheat Initiative

Variable	Full package (n = 710)	Marketing (n = 127)	Control (n = 167)
Received training on best agronomic practices *(%)*	67.6	38.1	31.1
Received improved seed *(%)*			
Yes, on time	91.2	25.4	29.3
Yes, was late	5.7	6.3	0.6
No	2.9	68.2	70.0
Quality of wheat-improved seed received *(%)*			
Very good	74.3	72.5	64.8
Good	21.8	22.5	31.4
Fair, poor, or very poor	3.9	5.0	3.8
Received urea for free *(%)*			
Yes, on time	81.2	16.6	16.7
Yes, was late	4.9	3.1	1.8
No	13.0	80.1	81.4
Quality of urea received *(%)*			
Very good	60.3	37.0	37.1
Good	34.0	44.4	60.0
Fair, poor, or very poor	5.7	18.6	2.9
Received gypsum to apply on wheat plot *(%)*	22.5	5.5	4.8
Received assistance in marketing wheat *(%)*	16.4	12.7	13.2

Source: Authors' calculation based on data from the 2014 wheat growers' survey.

In terms of fertilizer, a large proportion of benchmark farmers (82 percent) stated that they received the free urea on time, as compared with just 17 percent of the marketing-only and control-group farmers. More than 90 percent of the farmers who received urea stated that it was of very good or good quality. Small numbers of farmers reported receiving urea that was caked or mixed with sand. More benchmark farmers received training on agronomic practices than did other farmers, but it was only 68 percent. As previously mentioned, only 16 percent of benchmark farmers and 13 percent of marketing-only farmers received marketing assistance.

Farmers' Implementation of the Promotional Wheat Package

As indicated earlier, benchmark (full-package) farmers were randomly selected to implement the comprehensive promotional wheat package, which includes improved seed, reduced seeding rate, application of recommended fertilizer rates, and best agronomic practices (such as row planting and weed control). However, benchmark farmers were not provided with all the components of the promotional package. The assistance from the implementing agencies was focused on training benchmark farmers on agronomic best practices and providing some elements of the package that are less accessible and customarily less used by wheat farmers (such as improved seed, urea fertilizer, and gypsum). Benchmark farmers were asked to complement through investing on and properly applying the remaining components of the package, such as DAP fertilizer, pesticides, and herbicides. Thus, it is useful to look at whether the benchmark farmers properly implemented the package as stipulated and the degree to which control farmers adopted some of the recommended practices.

According to Table 4.8, almost all the benchmark farmers planted improved wheat seeds (97.5 percent), and nearly all applied both urea and DAP fertilizers on their experimental plots. However, benchmark farmers did not always follow the recommendation to reduce the seeding rate; on average, they reported planting 153 kg of seeds per hectare, which is 53 percent higher than the recommended seeding rate of 100 kg/ha. Nonetheless, this rate was lowering than among marketing-only and control farmers (row 2). Whereas fertilizer use rates were high among all farmers relative to the Ethiopia-wide averages reported in Section 2, they remain slightly lower than the recommended 200 kg/ha. Further, benchmark farmers were more likely to use row planting (60 percent) than marketing-only farmers and the control group (both 27 percent). The qualitative data collection suggests that some farmers did not use row planting because of the extra labor requirement, while others felt that row planting was impractical because they had "black cotton" soils (vertisols).

Table 4.8 Farmers' implementation of promotional wheat package

Package components	Full package (n = 197)	Marketing (n = 126)	Control (n = 167)
Improved seed used *(%)*	97.5*	53.2	51.5
Seeding rate *(kg/ha)*	153.2*	167.1	177.9
Urea used *(%)*	99.5*	91.3	91.0
Urea application rate *(kg/ha)*	148.5*	132.5	129.6
DAP used *(%)*	99.5	99.2	100.0
DAP application rate *(kg/ha)*	152.2	150.4	153.1
Gypsum used *(%)*	32.0*	6.4	4.8
Pesticide used *(%)*	15.2*	11.9	9.0
Herbicide used *(%)*	8.1	10.3	12.0
Planting methods *(%)*			
Row planting	60.9	27.0	27.0
Broadcasting	36.6	69.1	68.9
Mixed	2.5	4.0	4.2
Received marketing assistance	16.4	12.7	13.2

Source: Authors' calculation based on data from the 2014 wheat growers' survey.
Note: * indicates statistically significant difference from the control farmers at the 10% level.

Table 4.8 also shows other significant differences in input use among benchmark farmers as compared with marketing-only and control-group farmers. Benchmark farmers are more likely to use gypsum and pesticides, and the difference is statistically significant. However, benchmark farmers are no more likely to use herbicides than are the other two groups. Few farmers in any group received marketing assistance in selling their crop, with the proportion ranging from 13 to 16 percent. Since there is no real difference in input use between marketing-only farmers and the control group, it is unlikely that there is a causal yield difference between the two groups. Moreover, since few farmers in general received marketing assistance and the marketing-only famers were no more likely to receive assistance than the control group, it is unlikely that there would be any differences between the marketing-only group and the control group.

Farmers' Opinions of the Promotional Wheat Package after the Harvest

Table 4.9 presents the perceptions of wheat farmers on the four major components of the promotional wheat package. The descriptive results suggest greater acceptance of the ideas of using improved seeds, reduced seeding rates, row planting, and recommended fertilizer application rates. Overall, most of the farmers (97 percent) appreciated the components of the promotional wheat package, irrespective of their treatment status. The high approval of row planting is somewhat surprising in that many benchmark farmers declined to adopt this practice.

Table 4.9 Farmers' opinions of the promotional wheat package

Variable	Full package (n = 710)	Marketing (n = 127)	Control (n = 167)
Perception on using improved wheat seed *(%)*			
Very good	71.1	62.0	68.5
Good	26.7	36.0	31.4
Fair, poor, or very poor	2.2	2.0	0.0
Perception on lower seeding rate *(%)*			
Very good	61.9	58.7	58.6
Good	35.9	39.1	37.9
Fair, poor, or very poor	2.2	2.2	2.5
Perception on row planting *(%)*			
Very good	63.8	75.6	71.7
Good	34.5	21.6	28.2
Fair, poor, or very poor	1.7	2.8	0.0
Perception on using more fertilizer than usual *(%)*			
Very good	59.4	55.5	50.7
Good	37.2	44.4	47.6
Fair, poor, or very poor	3.4	0.0	1.7

Source: Authors' calculation based on data from the 2014 wheat growers' survey.

Farmers' Plans for Growing Wheat in 2014

Although impacts on wheat yields among benchmark farmers is one goal of the Wheat Initiative, the success of the package depends on its adoption by benchmark and other neighboring farmers in the future, particularly once subsidies are removed. Table 4.10 presents farmer plans for the next wheat-growing season (meher 2014/2015), focusing on the practices recommended by the Wheat Initiative. Given that some of the inputs were provided on credit or for free, it is probable that some of these incentives may have influenced farmers' decisions to adopt all or part of the package components. Therefore, farmers were asked whether they would implement the package on their own without any external assistance.

More than 80 percent of the farmers stated their willingness to plant improved wheat seeds for the next season, even if they have to pay cash for them. However, from the field observations, it was evident that availability of seeds with appropriate traits required by farmers matters most when it comes to adopting improved seeds. As Table 4.7 shows, about 30 percent of the market and control farmers planted improved wheat seeds; such lower use of improved seeds can be partly explained by seed supply constraints.

Table 4.10 Farmer plans for growing wheat in 2014

Variable	Full package (n = 710)	Marketing (n = 127)	Control (n = 167)
Interest in purchasing improved wheat seed next season *(%)*			
On cash	84.1	82.5	85.6
On credit	72.8	73.8	82.6
Preferred planting method for next season *(%)*			
Broadcasting	22.2	22.2	25.7
Row planting	36.8	34.1	28.7
Combination	40.8	43.6	45.5
Major reasons for not using row planting next season *(%)*			
Not sure it will increase yields	4.4	13.8	11.4
It didn't increase yield this season	2.5	0.0	4.6
Increased yield but too much work	20.1	10.3	29.6
Increased yield but labor costs too high	18.9	24.1	20.5
Plan to use the recommended reduced seeding rate next season *(%)*	96.4	90.4	89.8
Major reasons for not planning to use reduced seeding rate *(%)*			
Not sure it will increase yields	46.1	41.6	29.4
It didn't increase yield this season	11.5	25.0	11.7
Increased yield but too much work	0.0	0.0	5.8
Increased yield but labor costs too high	19.2	8.3	11.7
Plan to use fertilizer application rate compared to previous years *(%)*			
More	45.8	46.8	45.5
Less	10.2	12.7	16.7
Same	43.8	38.8	37.1
Major reasons for planning to use equal/less fertilizer than previous years *(%)*			
Not sure it will increase yields	7.7	11.5	7.4
It didn't increase yield this season	1.7	1.4	4.2
Increased yield but not enough to justify cost	5.0	10.1	14.8
Increased yield but can't afford that much fertilizer	8.0	13.0	15.9
Already using recommended rate	69.8	62.3	56.3

Source: Authors' calculation based on data from the 2014 wheat growers' survey.

About 90 percent of the farmers plan to implement the recommended reduced seeding rate, and 45 percent plan to use the recommended fertilizer application rates for the coming season. Those who decided to maintain the traditional seeding rate indicated that they are not sure whether the reduced seeding rate increases yields. In some contexts, farmers also stated that the reduced seeding rate may lead to weed infestation and lower production of straw. With regard to fertilizer, the remainder (about 60 percent) indicated that they have been applying the recommended fertilizer rates and will continue to do so.

Consistent with the first year adoption rate, only about 30–35 percent of farmers are willing to implement the row-planting component on all their wheat area, though another 40–45 percent will use row planting on some of their wheat area. Farmers indicated that even if row planting increases yields, the additional labor requirement, coupled with the higher labor costs, is the main reason for their preference for traditional hand broadcasting.

5. CONCLUSIONS

This study was designed to assess the impact of the ATA Wheat Initiative on wheat yields in Ethiopia. Starting with a list of 482 farmers provided by the woredas, the authors randomly allocated the farmers into three treatment groups: a full-package group that was to receive production and marketing assistance, a marketing group that was to receive marketing assistance only, and a control group that would receive neither.

Data were collected in a crop-cutting exercise, by a wheat farmer survey, and by DAs. Wheat yields were measured in three ways: using crop-cuts on a 4 x 4 m^2 area, using farmer predictions at harvest with farmer assessment of plot size, and using postharvest farmer estimates combined with farmer assessment of plot size. Among the farmers surveyed, there was a high level of awareness of the Wheat Initiative. More than 85 percent of the farmers in all three groups were aware of the main recommendations: use of improved seed, lower seeding rate, and row planting. However, many farmers overestimated the recommended application rates for urea and DAP.

Implementation of the program was generally successful. Almost all full-package farmers received improved wheat seed. The seed arrived on time, and almost all recipients said the quality was good or very good. More than three-quarters of full-package farmers received free urea on time, and almost all recipients found the quality to be good or very good. However, only about two-thirds of full-package farmers reported receiving training in best agronomic practices. The marketing component had the weakest implementation, with the share of farmers who reported receiving marketing assistance ranging from 13 to 16 percent across all three groups.

Adoption of the Wheat Initiative recommendations was good but not universal. Almost all full-package farmers (97 percent) used improved wheat seed. The average seeding rate was below the traditional rate but still above the recommended rate of 100 kg/ha. Almost all farmers used both urea and DAP, though the application rates were higher than recommended. About 61 percent of these farmers adopted row planting, with the others declining to do so because of the extra labor requirements or because they had “black cotton” soils.

Regarding wheat yields; the promotional wheat package appears to have increased wheat yields by about 12–13 percent among full-package farmers relative to the control group. This yield increase was measured from both the crop-cut yields and the farmer-predicted yields, after controlling for other factors such as model farmers, female farmers, and household characteristics. The farmer-recall data showed a smaller and statistically insignificant yield increase, probably because of measurement error.

The wheat yield increase is smaller than the yield increase found in research and demonstration settings. There are several possible reasons for this difference:

- In the implementation of the Wheat Initiative, it was not possible to deliver all the inputs to all benchmark farmers. As mentioned earlier, most farmers reported not receiving marketing assistance, one-third reported not getting training, and a few did not get improved seed or urea.
- Farmers in the full-package intervention group did not implement all components of the package recommended by the Wheat Initiative. As mentioned earlier, they applied seed and fertilizer at higher rates than recommended, and 39 percent did not use row planting.
- Some farmers in the control group adopted some components of the package recommended by the Wheat Initiative. For example, half of the control farmers used improved wheat seed, more than a quarter adopted row planting, and 17 percent received free urea.
- Farmers were probably not experienced in applying some of these practices, given that it was the first year for some of them. To the extent that there is a learning process, it is likely that the same practices will generate larger yield increases in future years.

Thus, the difference in yield between the two groups underestimates the full impact of adopting the Wheat Initiative package, because the full-package farmers did not fully adopt the package and because control farmers adopted some parts of the package.

In addition, it is important to recognize that if the 12–13 percent yield increases could have a substantial impact on wheat marketing and imports, then it could be scaled up to the national level. Such an increase, implemented at the national level, could reduce wheat imports significantly.

In terms of their plans for the next season, almost all respondents said they planned to adopt the reduced seeding rate in the next season. A majority said they would like to use improved wheat seed even if they had to pay for it. In the case of improved seed, the binding constraint may be supply rather than demand. In contrast, only one-third of the farmers said they would use row planting on all their wheat next season. The main objection to row planting seems to be the difficulty of doing it with "black cotton" soils and the additional labor requirements. The development of laborsaving tools for row planting could accelerate the adoption of this practice.

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