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Does Improved Wheat Seed Adoption Benefit Farmers? Empirical Evidence from Southern Tigrai Ethiopia

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Abstract
Agriculture in Ethiopia yet bases on small scale farming is experiencing frequent drought. The study examines, does improved wheat seed adoption benefit farmer's wheat yield or not in Ofla woreda, Tigrai?. A primary data sources from a survey of random sample 300 small scale farm households were gathered. Of which 100 were certified wheat seed adoptor farmers and the remaining 200 were non users. In dealing with propensity score matching (PSM) was applied. The average treatment effects on the treated (ATT) result revealed that improved wheat seed adoptor household's earn 35 to 54 quintal of wheat yield per hectare at a cost of plowing 9,400 Birr larger in a single production year compared to non adoptors earn below 18 quintal at a cost of Birr 7,000. Adoption of certified wheat seed complementary with other packages is more recommendable to enhance wheat yield at small scale level.
Keywords: Adoption, certified wheat seed, impact, Ofla, PSM, technology, wheat yield. 1.

INTRODUCTION

Ethiopian economy is heavily dependent on small scale farming. The main engine of growth where none oil based of the country's economy has about 112 million hectares of land cover. Of which 65 percent is arable and conducive for farming activity, however, 22 percent of it is yet used (MoFED, 2012). And it contributes the largest share to Gross Domestic Product (GDP) close to 41 percent among other uses (Ibd). Even if the significance of the sector in the economy is decisive, Ethiopia has experienced a food deficiency in the past decades.

In Sub-Saharan Africa (SSA), wheat consumption is anticipated to increase at a faster rate and ranges from 670,000 MT (metric ton) to 1.12 million MT annually from 2010 to 2020 (Celeste Sununtnasuk, 2013). Shahidu Rashid (2010) explained that more than 60 percent of the total calorie diet is covered from four staple cereals (maize, "Teff", wheat, and sorghum) produced by the small scale farm households in Ethiopia. Of which around 20 percentage of daily caloric intake is found from wheat next to maize with 20.6 percent. Wheat is one and ranked fourth staple and strategic food security crops next to maize, "Teff" and sorghum in Ethiopia (Zerihun, 2014).

Although Ethiopia is the leading regional producer of wheat in SSA, yet the country spends more amount of Dollar (USD) to import about a million tons of wheat grain every year from abroad (Sarah, 2014). Especially, there is limited supply of quality wheat for the industries (manufacturers) engaged in producing flour, spaghetti, macaroni, biscuits and bread at national level. This is partly because of low technology adoption. For example; at a country level the purchase of small farm households certified wheat seed from the formal seed system is roughly 10 percent to15 percent, however, it is lowered to 5 percent to 10 percent in Tigrai (Fetien and Ibrahim, 2010). In 2009/10 more than 1.5 million quintal of improved wheat seed was the demand at country level, however, around 0.2 million of it was supplied only by the formal seed system. Of the total supplied amount of improved seed 80 percent to 90 percent comes from the Ethiopian seed enterprise (Ibd). There are around five million smallholder farmers participating in producing wheat thereby they produce close to 40 million quintal of wheat annually in Ethiopia. This time, 24-quintal per hectare is the national average yield of wheat that is triple times larger as compared to that of eight quintal per hectare in 1990s production year (CSA, 2013; UNDP, 2014). The average wheat yield in the National regional state of Tigrai, Ethiopia is estimated 35 to 40 quintal per hectare in the production year of 2013 (Abraham *et al*., 2014). However, both the national and regional average wheat yield is lower than what China's average yield of wheat can produce ranges from 40 to 60 quintal per hectare and Western Europe the average wheat yield is about 60 to 80 quintal per hectare (Lester, 2012).

Moreover, wheat is given due emphasis to increase its production among other cereals in the National state of Tigrai. Its area coverage is around 0.1million hectares and produce 1.93 million quintals of wheat per annum from the total cultivated land of 1.04 million hectares in the region (Ibrahim and Fetien, 2010). Around 45 percent of the regional total wheat production and 46.3 percent of wheat area coverage has found from the Southern part of Tigrai which is the focus of the study area (as cited in Teklay *et al*., 2012). Adoption of improved groundnut seed on small farms resulted households escape from deep rooted poverty (Menale *et al.,* 2010). Bola *et al.,* (2012) in their study were also contended that adoption of agricultural technology gave high increase in yield and leads poverty to diminish meaningfully. Different studies done previously on the adoption of improved agricultural technologies witnessed that it plays great role in enhancing production and productivity of yield (Kijima *et al.,* 2008; Menale *et al.,* 2010; Solomon *et al.,* 2011; Debela, 2011; CAADP, 2012; and Mamudu *et al.,* 2012; Bekele *et al.,* 2013). However, agricultural production still is under traditional methods and techniques in Ethiopia. Therefore, enhancing the productivity of major crops including wheat in particular and agriculture in general is indispensable at country level and Tigrai. It can improve through the adoption of agricultural inputs like certified wheat seed concern of the study. Investigating the impact of improved wheat seed adoption on small farm's wheat yield is the general objective. Whereas, the **s**pecific objectives of the study focused on:

- Investigate the determinant factors that affect adoption of certified wheat seed on wheat yield.
- Examine the impact of certified wheat seed adoption on wheat yield.

2. Literature Review

Wheat is the major staple food of around 35 percent of the globes population than other food source cereals. It's rich source of protein, minerals, vitamins, and its produce is larger than five billion quintal of wheat in one harvest year in Ethiopia (Mohammed *et al.,* 2001).

*"In Ethiopia, increase crop production one of the pre requisite conditions to attain food security. Most of the required increases in crop productions now and in the future are likely to come from yield growth rather than area expansion. Therefore, among others further deployment of improved variety is critical. Seed production and multiplication in Ethiopia is largely left to a state run seed enterprise. Very few NGOs and private traders are engaged in seed production and multiplication. However, agencies such as the state run Ethiopian seed enterprise (ESE) have been unable to satisfy the seed demand of the vast majority of the nations farmers who are small-holders and subsistence farmers"(*Mesay *et al.,* 2010). A cross-sectional data was gathered from 120 randomly selected households through structured questionnaire and secondary data were also collected from relevant institutions and organization using double-hurdle model revealed that factors that determine farmer's participation in wheat seed multiplication were access to hired labor, distance to the main road, access to improved seed supply and field day visit negatively impacted wheat seed multiplication farming (Mesay *et al.,* 2010). In contrast, farmers' decision on the proportion of land allocated to wheat seed multiplication (intensity of adoption) positively and significantly influenced by number of oxen owned, access to complementary input and field visit days.

Feder and zilberman (1985) made a comprehensive study to summarize factors that affect farm technologies and agricultural innovations. Among other factors whether to adopt or not a technology depends on the profitability of the technology. Among the small farm households manure application could also be a substitute to fertilizer is again important at small farm household level. Usually, the main potential determinants of agricultural technology adoption decisions has been focused on imperfect information, risk, uncertainty, institutional restraints, human capital, input accessibility, and infrastructure (Feder and zilberman,1985; Foster and Rosenzweig 1996; and cited in Uaiene *et al.,*2009). Harper *et al.,* (1998) found that small farm households have a negative correlation between adoption of new technology and land size of small farm households. On the other hand, a number of authors like Kasenge (1998); Abara and Singh (1993); and Feder and zilberman, (1985) found that small farm households plot size was positively related to agricultural technology adoption. Mugisa-Mutetikka *et al.,* (2000) also found a neutral relationship between land size of small farm holders and agricultural technology adoption. The variable education is thought to create a favorable mental attitude for the acceptance of new practices (Caswell, 2001). Rogers (1983); Ehler and Bottrell (2000) technology complexity has a negative impact on adoption of technologies and this bottleneck could only be solved through education. However, the recent agricultural technology adoption decisions literature focused on social networks and education. Bola *et al*., (2012), used a local average treatment effect (LATE) method to examine " the impact of improved agricultural technology adoption on sustainable rice productivity and rural farmers' welfare in Nigeria"; using a cross-sectional data of 481 rice producers stated that the decision of small farm households to adopt improved rice varieties were determined by the different socio- economic or demographic and institutional variables such as number of years of residence in the village, access to media, mobile phone, vocational training, livestock ownership, access to improved seed, and income from other crop production significantly increased the probability of adoption. As a result, adopters received above 3.6 quintals of rice additions per hectare.

Mamudu *et al.,* (2012) made a research entitled "adoption of modern agricultural production technologies by farm households in Ghana" using logit model as a tool over 300 farmers found that plot size, expected returns from technology adoption, access to credit, and extension services are the factors that significantly affect technology adoption decisions of small farm households in the west district area of that country. Debela (2011), agricultural growth can be achieved through better small farm management practices and increased adoption of improved agricultural technologies such as chemical fertilizers, improved seed varieties, pesticides, and organic minerals. Variables like age of the household head, family size, number of oxen, access to credit, and off-farm activities are positively affect the probability of participation in an agricultural extension program. Of which age, education level, and access to credit affects significantly.

Kijima *et al.,* (2008) made a study on 'the impact of new rice for Africa (NERICA) in Uganda' found that NERICA adoption of improved rice seed increase yield and reduces poverty. Mendola (2005), applied the propensity score matching econometric model to examine the impact of agricultural technology adoption in Bangladesh stated that adoption of improved seed varieties has a positive impact on small farm householders well being as compared to local seed users in that country. Similarly, a study conducted in Bangladesh by Hussain *et al.,* (2003) revealed that adoption of improved seed varieties of maize crop leads to a moderate increase in income of the technology adopters. In the mid of 1990s in Upper Egypt wheat yield was around 33 quintal per hectare and this was below potential. The main causes for the lower wheat yield were use of local seed varieties, poor seed multiplication services coupled with high winter temperature that affect negatively (A.Aw-Hassan *et al.,* 1995).

Ibrahim Kasirye (2011) stated that small farm heads with low educational level and small farms size holdings are less likely to adopt agricultural technologies. Besides, peer effects play a great role in influencing small farm household either to adopt improved seed or fertilizer technologies. This low improved seed supply coupled with the low adoption of new agricultural technologies leads to low crop production. Bekele *et al.,* (2013) evaluated the impact of adoption of improved wheat varieties on food security using a recent nationally representative dataset of over 2000 farm households using endogenous switching regression treatment effects complemented with a binary propensity score matching methodology in Ethiopia revealed that improved wheat seed technology adoption has generated a significant positive impact on food security. A research conducted on the productivity and efficiency of agricultural extension package in Ethiopia by the authors Gezahegn *et al.,* (2006) stated that low percentage of small farm households adopt selected seed on wheat crop as compared to that of maize crop thereby contributes negatively on the yield.

Solomon *et al.,* (2011) conducted a study on 'agricultural technology adoption, seed access constraints and commercialization in Ethiopia' stated that knowledge of small farm households about existing varieties, perception about the characteristics of improved varieties, wealth (livestock and land) and availability of labor force are main determinant factors for the adoption of improved technologies. Christensen and Cook (2003), in their study were contended that in Mali for example, even if there were accessibility of certified seed by farm households but farmers definitely were chosen their indigenous traditional seed. Consistently, lack of awareness about the benefits of adopting high yield varieties and shortage of certified seed supply coupled with mistrust of losing original local seeds most farmers are forced to adopt the already deformed, diseased, mixed origin and unmarketable seeds contributes to low output in Ethiopia (Eshetu *et al.,* 2005).

Although the government is intensively working in making a lot of agricultural technologies accessible to universal small farmers like improved wheat seed, yet the intended plan is not achieved in doubling production using new technologies in GTP1(Growth and Transformation one). Having all these in to consideration, the researcher aims mainly to examine the impacts of improved wheat seed adoption versus local seed technology adoption (the usual traditional one) on wheat production of small farm households in Ofla, Tigrai.

3. Materials and methods

Sources and methods of data collection

A multi-stage sampling technique was applied in order to reach at the selection of a sample of smallholder farm households in the study. In the first stage, out of the total five rural woredas' of South zone, Ofla woreda was purposively selected due to its high potential of wheat and where there is a practice of cluster based improved wheat seed production as well as adoption. In the second stage, of the total 21 Tabias'[1] of the woreda administration, four Tabias (Adi golo, Hashenge, Menkere, and Wenberet) were selected purposely. Similarly, the selected Tabias consisted of both large number of improved wheat seed adopter households and represent the agro ecological zone of the study area as compared to the remaining Tabias.

A total sample of 300 smallholder households has been therefore selected in the third stage. In the fourth stage, of the total sample size 100 certified wheat seed adopter farmer's from the treatment group and 200 non adopter households from the control group were surveyed. Finally, these 100 adopter smallholder farmers and 200 non adopters were selected randomly and proportional to the total household heads. Lists of all respondents were found from the administration centers (*Kebelles*). Random sampling technique was applied in each stratum to select the respondents.

[1] Tabia (K'ebele) in this context is a rural administrative structure of governance next to Woreda level.

Table3.1. Sample size of agricultural technology participant and non participant smallholder farm heads on wheat yield production year of 2014.

Name of Tabias	Improved wheat seed adoptors (certified users)	Non adoptors (local seed or traditional users)	Number of household heads
Adigolo	492	1,573	2,065
Hashenge	918	1,371	2,289
Menkere	580	1,033	1,613
Wenberet	453	884	1,337
Total	2,443	4,861	7,304

Source: Office of Ofla administration, 2014.

Data type and source

The research was conducted using primary (cross-sectional) data. Due to the nature of small farm households primary data source is dominantly used. In the primary data, a well designed and organized questionnaire was prepared so as to collect all relevant data from the smallholder farmers in the study area. The socioeconomic aspects of the representative farms have been collected. A total of ten data enumerators were selected on the basis of their level of education. And they qualify equivalent to degree, data collection experience, and proficiency on the local language *Tigrigna.* Next, the selected enumerators were well trained on the detail contents of the questionnaire and techniques of data collection including how to approach households and discuss face to face. Lastly, to develop and check the validity of the instrument and to make some amendments important, a pilot survey using some randomly selected households was conducted. Therefore, the main sources of data for the research were collected mainly from sample smallholder farmers, agricultural development agents; agricultural inputs supply expertise, and administrators of the study area.

Econometric method of data analysis

Propensity Score Matching (PSM) method was applied to estimate the robust impact of certified wheat seed technology adoption on wheat yield at household level. In evaluating the impact of certified wheat seed technology adoption on wheat yield of adoptor households (treated group) and non adoptors (control group), it is obvious that a researcher faces selection bias estimation problem. Thus, to evaluate the impact of a treatment on performance indicators, it is indeed to draw a counter factual group that can serve as a comparison group. Our prime aim for using matching econometric method was to find a group of treated households (adoptors) similar to the control group (non-adoptors) in all relevant pretreatment characteristics, where the only difference was that one group adopted certified wheat seed technology and other group did not.

According to Heckman *et al.* (1997) the counter factual can be compared with the treated group to evaluate the impact of the treatment on the performance indicators. In the context of this study, the treated groups counter factual would be the situation where wheat is produced in the absence of the participation certified wheat seed. However, in reality a household cannot hold both a treatment and control group condition at a time. As a result, counter factual for the treated is possible by constructing a treatment factual group that resembles the treatment group in the absence of treatment. In order to eliminate selection bias, there is a need to compare the performance levels of both treated and control groups which are statistically comparable (Rosenbaum and Rubin, 1983; Khandker *et al.,* 2010). In dealing with selection bias problem the implementation of PSM is advised.

Model Specification

A binary choice model is applied to estimate the smallholder farmers' probability of participation in certified wheat seed technology adoption that's [Y=1 decision of households to adopt certified wheat seed, 0 = otherwise] on observable characteristics. As emphasized by Caliendo and Kopeinig (2008), since PSM is a conditional probability estimator, any discrete choice model such as logit or probit can be used equally so long as they give almost the same output. The logit model is a non-linear regression and is applicable when the dependent variable, like in the study, is binary (dummy); which takes values of either 0 or 1. It is implemented to estimate small scale farm's probability of certified wheat seed adoption. Gujarati (2004) stated that the logit model estimates the probability of the dependent variable to be 1. The specification of the logit model is specified as follow:

P (Yi=1/X) = p (adoption) = $X^{/}\beta + \in$

Where,

P (Yi) = is the probability that the household adopts certified wheat seed technology

$X^{/} =$ is a vector of observable household characteristics such as age, sex, education level, and field visit days.

β = is a vector of logit index (coefficient) $\in$ = is the stochastic (error or disturbance) term.

Propensity Score Matching (PSM)

PSM initially coined by Rosenbaum and Rubin (1983) and has been applied in many program evaluations. PSM matches groups based on their conditional probability of receiving a treatment given pre-treatment characteristics. As far as this impact of agricultural technologies is concerned the impact of certified wheat seed is found by comparing the average wheat yield of adopter and non-adopter households. The correct evaluation of impact of technologies requires identifying the "average treatment effect on the treated" (ATT). ATT is the difference between the outcome variables of being treated and its counter factual (outcome of a beneficiary if she or he had not been part of certified wheat seed technology). The average treatment effect on the treated (ATT) is given as;

ATT= E (Y1/D=1)-E (Y0/D=1)…………………………. (1) Where;

E (Y0/D=1) = the production levels of the adopters before they adopt certified wheat seed and it is reasonably be approximated by the output level of non-adoptors during data collection.

E (Yo/D=0) = is a counter factual and is not observed.

E= mathematical expectation operator

D= dummy variable that takes the value 1 if the individual is treated, 0 otherwise.

Using the mean outcome of non-beneficiaries, which is more likely to be observed in most cases, cannot solve the problem of society provided that there is a possibility that the variables that determine the treatment decision also affect the outcome variables. Now, the outcome of treated and non-treated individuals might differ leading to selection bias. To clarify the mean outcome of a program, we can further specify ATT like:

ATT= {E [Y1/D=1]-E [Y0/D=0]}-{E [Y0/D=1]-E [Y0/D=0]}……… (2) Where;

E[Y1/D=1]-E[Y0/D=0]= is the selection bias which will be equal to zero if the program was given randomly and at the event where adoptor and non adoptors did not differ before the program implementation. The validity of the result of the PSM method depends on the satisfactions of two assumptions. These are:

i). Conditional Independence Assumption (CIA): meaning outcomes of the adoptors and non adoptors are independent of the treatment status or after controlling for observable characteristics. The treatment assignment is "as good as random", and specified as:

$Y0, Y1 \perp D/X$ …………………...…………………...... (3)

ii) Common support condition (CSC): requires the existence of sufficient overlap in the characteristics of the treated and untreated units to find adequate matches (common support).

In order to provide a robust result of the PSM, we use four methods of matching. Namely: Nearest Neighbor matching (NNM), radius, Kernel, and stratified matching (Caliendo and Kopeinig 2008). According to Rosenbaum and Rubin (1985) a standardized difference of greater than 20 percent should be considered too large and an indication of the matching has failed. Additionally, the pseudo R^2 should be lower and the joint significance of covariates should be rejected or the p-values of the likelihood logit values should be insignificant advised by Sianesi (2004). Lastly, a sensitivity analysis was also implemented for ensuring the robustness of the PSM output.

Description of variables

Caliendo and Kopeinig (2005) clearly investigated that in estimating PSM, only variables that affect the participation decision of household's and the outcome variable simultaneously and are unaffected by participation to a program [or the participation of it] must be incorporated in the logit model. In dealing with, different literatures has been mentioned and reviewed, expertise ideas used, knowledge, and experience of the researcher even were employed.

Improved wheat seed agricultural technology adoptor household's wheat yield in 2014 production year **[Y1]:** Four important variables have affected this Y1 differently. Analogously, the explanatory variables which were expected to affect the clearly stated dependent variable selected and incorporated in this model were provided here after.

1. Age of the household head (age hh):- is a continuous variable measured in terms of years. It is expected to affect all outcome variables. The older the household's head, the more risk averse she or he become on newly introduced technologies. On the other hand, it's assumed that younger farmers are more innovative and hence more willing to adopt new agricultural technologies than older farmers. Of course, its effect was hypothesized that mixed (Bekele *et al.,* 2013; Solomon *et al.,* 2011; Rahmeto, 2007).

2. Sex of the household head (sex hh):- is dummy variable with values of either 1 if the household head is male and 0 female. Male headed household's often have better control to the households resources and decisions concerning to adoption of agricultural inputs and technologies. Due to the physical effort exertion that the agriculture in rural economies demands, male headed households are higher crop production gainers as compared to female headed households. The effect might be positive and/ or negative or neutral like in the previously studies (Menale *et al.,* 2010; Wilfred and Ogada, 2014).

3. Education level of the household head (educ hh):- A continuous variable measuring the formal school years completed by the household head. In many adoption researches for example; (Debela, 2011; Menale *et al.,* 2010; Rahemeto, 2007) identified that more educated farmers show higher tendencies to adopt new agricultural technologies as compared to less educated.

4. Field visit days (field visit-days):- It is a dummy variable with the description of value 1 if the household participates in field visit days and acquire new knowledge and skill 0, otherwise. Participation and experience sharing in demonstration sites is expected new agricultural technology adoption and impacts positively. Hence,

enhances agricultural produce (Mesay *et al.,* 2010; Rahmeto, 2007; Abdisa *et al.,* 2001).

4. RESULT AND DISCUSSION

Descriptive Analysis

The descriptive analysis is clearly carried out using the tools like mean, percentage, standard deviation, and frequency distribution over both demographic and socio-economic household characteristics. Hence, it is an auxiliary instrument to have a strong econometric output.

Demographic Characteristics of improved wheat seed Adopter Household's

Table4.1. Sex of the household head

Description	Sample household's	%	Adoptor	%	Non-adoptor	%
Female	57	19	18	18.2	39	19.4
Male	243	81	82	81.8	161	80.6
Total	300	100	100	100	200	100

Source: Computed from own survey, 2014.

According to the result shown in Table 4.1, about 19 percent of the sample households were headed by women unlike to the 81 percent which were headed by men. Of course, out of the 100 percent improved wheat seed adopter household heads, approximately to 18.2 percent were female headed and the remaining 81.8 percent households were headed by men.

Table4.2. Education level of household heads

Description	Non-educated HH	Educated (1 to 9th grade)	Adoptor	%	Non-adoptor	%
Female	41	16	49	16.3	46	15.3
Male	164	79	51	16.7	155	51.7
Total	205	95	100	33 %	201	67%

Source: Computed from own survey, 2014.

As it can be seen from table 4.2, approximately 68.3 percent of the sample households were found to be non-educated; whereas the remaining 31.7 percent of the total sampled household head's were attained some educational level. The level of education ranges from non-educated to ninth grade. Comparisons by the level of improved wheat seed adoption reveal that 33 percent participants and 67 percent non-participants were found educated and non-educated respectively. On top of that, the sex ratio of educated adopter to non adopter is almost the same but signifies a bit difference.

Table4.3. Household's accessibility to field visit days

Description	Sample HH	%	Adoptor	%	Non-adoptor	%
No	200	33	16	5.3	185	61.7
Yes	100	67	84	27.7	16	5.3
Total	300	100	100	33	200	67

Source: Computed from own survey, 2014.

About 27.7 percent from the adoptor household heads and 5.3 percent non adopter sampled households have been participated in demonstration agricultural sites organized by their local government either in their neighbours or outside of their local areas. According to the surveyed result, larger than 67 percent of the respondents did not get a chance to participate in field visit days and keeps them away from gaining best agricultural practices. As a result, a participant household on field visit days adopts certified wheat seed as compared to those who do not participate. On the same spoken, the one who participated in the form of field visit days out of their local administrations gained more knowledge and technical skills lead them to adopt it.

Table4.4. Statistical summary of certified wheat seed adoption

Variables	adoptors = 100		Non adoptors= 200		t-test
	Mean	Std.Err	Mean	Std.Err	
Age	46	.83	48	.71	-2.2624**
Education	1.83	.1068	.87	1.293	-5.091***
Sex	.8181	.0389	.8059	.0279	-0.253
Age square	2,226	86.265	2,432	65.305	-1.946**
Field visit days	.8383	.3718	.0796	.0191	-20.11***

Source: Computed from own survey, 2014.

Note: **significant at 5%, *** significant at 1% probability level of significance.

As (Table 4.4.) tells us that, the average age of the adopter and non adopter smallholder farm head is

46 and 48 years successively. Particularly, age of the adopter and non adopter exhibits as there exists a positive relationship with the probability of adoption of certified wheat seed adoption. Definitely, education plays a prominent role in the adoption of improved wheat seed and other technologies. Education assists both adopter and non adopters as a crucial way of collecting information with regard to any technology as well as that one. Households headed by who have higher educational background were more likely to adopt improved wheat seed on their farm as compared to none educated. On the same token, a field visit day has positive influence on the probability of improved wheat seed adoption and augment of wheat yield. Households with more chance to participate in field visit days nearby or out of their localities were more likely to engage in improved wheat seed participation as compared to that of their counterparts. Furthermore, it's significant 1 percent probability level of significance. Hence, it serves as easy way to own best technical knowledge and trust more in regard to the benefits of that new technology in their plot.

Table4.5. Causes of not adopting improved wheat seed by small farm households

Description	Sample households	%
Adoptor	100	33.0
Seed not available on time	21	7.0
No weather insurance	95	32.0
No yield difference (mistrust)	84	28.0
Total	300	100

Source: Own survey, 2014.

From table 4.5 close to 32%, 28%, and 7% of the respondents from the survey replied that because of no weather insurance in case of crop failure, believes local traditional wheat seed give better yield than certified wheat seed, and in availability of that certified seed on the peak sowing season were the main reasons for not adopting improved wheat seed on their farmland. Moreover, smallholder farms largely mistrust the contribution of certified wheat seed distributed through government structures and certified wheat seed business associations. Leads small scale farm's not to adopt and have more wheat produce.

Econometric Analysis

So as to estimate the impact of adopting improved wheat seed technology on smallholder wheat produce applied different ATT estimation algorithms as an instrument. In the end, sensitivity analysis has been implemented to test the robustness of estimated ATTs in the PSM. It has been employed STATA 12 version in dealing all these econometric estimations.

The pseudo R-squared is found about 0.623 meaning all the explanatory important variables included in the model do exactly explain 62.3 percent of the probability of households certified wheat seed technology adoption. The overall model is proven as it's statistically significant at a p-value of 0.000. And also it was checked for model specification problem via link test and witnessed that the model has already been correctly specified. On the other hand, all important variables are incorporated in the specified model. Similarly, the estimation results also show that the balancing property was satisfied and the common support region for the propensity score of the 300 total sample households was [.0062654, .999]. The propensity scores of the non adopter households less than 0.001 and adopters greater than 1 is excluded. Thus, the balancing property is undoubtedly satisfied in this region.

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Table4.6. Logit estimate for propensity score of improved wheat seed adoption

Variables	Coef.	P> /Z/	Marginal effect (mfx) dy/dx	P> /Z/
Sexhh*	-1.11514	0.054	-.32904**	0.024
	(.5792418)	0.001	(.14578)	0.001
Agehh***	.5643633		.14295***	
	(.1764581)	0.004	(.04349)	
age_sq ***	-.0049282			0.004
	(.0017166)	0.000	-.00128***	
Educ_hh ***	.8704811		(.00045)	
	(.170326)	0.000		0.000
Fieldvi_days ***	4.294504	0.000	.18921***	
	(.4616066)		(.0328)	
_cons	-17.80066			0.000
	(4.450663)		2.05726***	
			(.11456)	

Number of obs = 300 Logistic Regression Wald chi2(5) = 217.96
Log likelihood= -81.2759 Prob > chi2 = 0.0000 Pseudo R^2 = 0.623 The region of common support point is [.0062654, .999]

Note: ***, ** and* are statistically significant at 1%, 5% and 10%

Computed from own survey, 2014.

The result for the logit estimate of household's probability of adopting improved wheat seed technology is presented in (Table 4.6). At the bottom of the table we have seen 300 observations in the data set that were used in the analysis. The Pseudo R^2 is the measure of goodness of fit, which is 0.623. This implies that 62.3 percent of the variation in the household's probability of adopting the technology is explained by the independent variables in the model. The Wald chi2 (5) 217.96 with a p-value (Prob>chi2) 0.0000 also tells us that the logit model as a whole is statistically significant as compared to the model with no predictors. The coefficients for the certified wheat seed technology adoption like sex, age, age square, education level, and field visit days are significant at 1% and 10% probability level of significance. Moreover, those explanatory variables have the expected negative and positive signs.

Interpretation of the marginal effects of certified wheat seed adoption

As the marginal effect estimates in (Table4.6) show that keeping other factors constant, a 1 year increase in the age square of the household head, decreases household's probability of adopting certified wheat seed on wheat yield by 0.13 percent. This seems almost the same to adopt it by all age groups other than other factors among household heads. However, that result reflects the fact that as small farm holder's get older they tend not to adopt certified seed. A one year increase in the age of small farm holder's, leads to 14 percent increase in adopting certified wheat seed, *ceteris paribus*. That is to mean that age increase by itself can be taken as an experience and exposure to adopt certified wheat seed (Bekele *et al.,* 2013; Solomon *et al.,* 2011; Rahmeto, 2007). Adopting certified wheat seed in their small farms increase more likely by around 33 percent on female head's as compared to men, holding other things in to act. This might be because of the fact that women are not certified wheat seed technology resistant farmers compared to men. Lastly; it's significant at 1% probability level of significance. The result is consistent with the previous studies as well (Menale *et al.,* 2010; Wilfred and Ogada, 2014).

Education level of the household head's exhibits a statistically significant (at p<0.000 level of significance) and it positively related with the probability of improved wheat seed adoption. Households with more education level are more likely to participate in improved wheat seed adoption than with less educational background. So, the positive effect of education variable is consistent with the human capital theory due to its innovative capacity of education on information accumulation and technology adoption. As years of schooling of the household head increases by one year, the probability of adopting improved wheat seed technology would also increase by 19 percent of marginal effect, *ceteris paribus.* The output is in line with the previous works (Bola *et al*., 2012; Debela, 2011; Menale *et al.,* 2010; Rahemeto, 2007) told us that more educated small holder farms show higher tendencies to adopt new improved wheat agricultural seed compared to less educated. Moreover, a farm field visit day variable is statistically significant at 1% probability level of significance. It plays a great role in obtaining experience, knowledge, and technical skill on demonstration sites. Therefore, households who participate in farm field visit day programs are double percent higher to adopt certified wheat seed than those of non participant households, *ceteris paribus*. The result is reliable with the researches that had been done before (Mesay *et al.,* 2010; Rahmeto, 2007; Abdisa *et al.,* 2001).

Impact Estimation of ATT for certified wheat seed adoption

Estimating the propensity score, the next task is to match the treated with the control groups based on their scores. It's done using different matching methods like NNM, radius, kernel, and the stratification matching methods. Although it was worthy enough to deploy only one PSM matching method to show the impact of adoption of certified wheat seed production enhancing technology, for the sake of transparency and exhibit accuracy of the evidence four of the aforementioned matching algorithms were implemented.

Table4.7: Propensity Score Matching of ATT result: Impact of improved wheat seed adoption on wheat yield in 2014 production year.

Matching Types	No. treated	No. Control	ATT	Std. Err.	t-value
Stratification	91	59	8.70	2.719	3.115***
Radius	100	201	15.844	0.804	19.697***
Kernel	100	201	15.844	0.789	20.090***
Nearest neighbor	100	201	15.844	0.988	16.036***
Average			14.058		

Source: Own survey, 2014.

From the (Table 4.7), the results of the matching techniques are statistically significant at ($p<0.000$) probability level of significance. Similarly, the ATT result lies between 8.7 quintal in the stratification and 15.844 quintal per "Tsimdi" or 0.25 hectare a year in the remaining three matching algorithms. Definitely, the smallholder farms who had adopted certified wheat seed on their marginal farm land on average has obtained 14 quintal of wheat yield per 0.25 hectare at a cost of plow 1,500 ETB, cost of weeding 600 ETB, and cost of harvesting 250 ETB. Those smallholder household's who has adopted certified wheat seed types (Digelo, Danfe, Kekeba, and Mekelle) with the recommended 150 Kg doze and other packages per hectare of their marginal farm land obtained 35 quintal to 54 quintal than that of non adoptors in a single production year. However, the matched control group on average obtained below five quintal of wheat per "Tsimdi" (less than 20 quintal per hectare) on the same single production year. Adopting certified wheat seed as a package keeping all these things were available (improved seed, fertilizer rates and or compost, early hand weeding and hoeing, tilling rate, fertile land, and full rain fall) is important to obtain the maximum 54 quintal of wheat per hectare. In the end, narrowing the gap between adoptor and non-adoptor is vital in the study district.

Sensitivity analysis is useful to proof the robustness of the estimated results that have been undertaken earlier. All the matching output strengthens the outcomes robustness.

Table4.8. Output of simulation based sensitivity analysis.

Matching Types	outcome variable	baseline ATT(A1)	simulated ATT(A2)	outcome effect (Γ)	selection effect (Λ)	absolute difference (A1-A2)	difference (percentage) (A1-A2/A1)
NNH	wheat yield using certified wheat seed in 2014	15.8	16.04	4.66	12.04	-0.24	1.52
Kernel	wheat yield using certified wheat seed in 2014	15.8	14.53	3.55	10.14	1.27	0.08
Radius	wheat yield using certified wheat seed in 2014	15.8	13.8	3.71	11.8	2	0.13

Source: Own Survey, 2014.

5. CONCLUSION AND RECOMMENDATION

The study was provoked to examine the impact of improved wheat seed adoption on small scale farm's wheat yield in Ofla district of Tigrai regional state of Ethiopia. A cross-sectional primary data were collected; in dealing with, logit- PSM econometric tool was implemented as an instrument. Representative sample small farms data were collected from a total of 300 household heads (100 adoptors and 200 non-adoptors) for the analysis of the research.

The smallholder farms who had adopted improved wheat seed technology on their marginal farm land on average has obtained 14 quintal of wheat yield per "Tsimdi" or 0.25 hectare at a total cost of around 2,300 ETB larger (35 quintal to 54 quintal per hectare) than that of non-adoptors (use traditional local seed) in a single production year. Adoptor households were increased their wheat yield more than 50 percent as compared to non-adoptor household heads. However, the matched control group on average has obtained below five quintal of wheat per "Tsimdi" at an average total cost of 7,000 ETB (less than 20 quintal per hectare). The results revealed that not sensitive to unobserved selection bias; therefore, we can be confident that the estimated adoption effect indicates a pure effect of improved wheat seed technology adoption. Straight forward technical support and creating fair market to sell the certified wheat seed produced in the cluster form by the small scale farms is vital. Consequently, the research recommend that adopting improved wheat seed as a complementary package and introducing weather crop insurance to wheat producer farmers and supplying certified wheat seed early on the peak seasons were essential as a policy in boosting wheat yield on the marginal farm lands.

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