International Scholars Journals

International Journal of Agricultural Extension and Rural Development ISSN 3254-5428 Vol. 3 (5), pp. 184-196, May, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effect of wheat row planting technology adoption on small farms yield in Ofla Woreda, Ethiopia

Ejegayehu Yifter Wolde

Department of Economics, College of Business and Economics, Mekelle University, P. O. Box: 451, Ethiopia.
Email: wolde.yifter21@gmail.com

Accepted 20 March, 2016

Ethiopian agriculture the back bone of the economy yet is characterized by small scale farming and experienced erratic rainfall as well as drought. The low produce can possibly grow through developing technology adoption and improved practices on the marginal farm lands. This study, therefore, examines the impact of wheat row planting technology adoption on small farms yield in Ofla Woreda, Southern zone of Tigrai, and Ethiopia using a primary data sources from a survey of a random sample of 300 small scale farm household heads. Of which 99 household heads were wheat row planting adopters (users) and the remaining 201were wheat grower households sow in broadcasting method non adopters (non users).To deal with this, propensity score matching (PSM) econometric tool was implemented. Next, the average treatment effects on the treated (ATT) estimated result was obtained using PSM method and has proven that wheat row planting technology adopter small farm household heads was gotten with a range of 40 to 60 quintal of wheat yield per hectare at a cost of sowing 4,800 ETB larger in a single production year unlike to the matched control group which is below 20 quintal at a Birr 3,600 cost of sowing. At the end, the researcher has recommended that scaling up of wheat row planting technology adoption as a package to increase wheat crop output on the marginal land and fasten the anti-poverty policy struggle is indispensable in Southern Tigrai, Ethiopia.

Key words: Impact, adoption, technology, row planting, wheat yield, PSM, Ofla, South Tigrai.

INTRODUCTION

In the case of Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular, economic policy heavily depended on agriculture. Poverty reduction and income growth can generally be achieved through agricultural growth that creates spillover effects to the remaining sectors (World Bank, 2014). African Development Bank/AfDB, (2014) contends that African population living in poverty has fallen larger than 50% in 1981 unlike that of in 2012 which was reduced to 45%. Of which around 48% of the Sub-Saharan countries populations were found under food insecurity. One solution recommended to come up out of this abject poverty is boosting agriculture. However, production and productivity of the agricultural sector in SSA is low due to low technological adoption and techniques among others (Abraham et al., 2014; Berihun et al., 2014; Gashaw et al., 2014; Tsegaye and Bekele, 2012; Lulit et al., 2012; MoFED, 2012).

Ethiopia, the leading SSA economy depends on smallholder farm agriculture. The contribution of the agricultural sector to Gross Domestic Product (GDP) is large (41%); 85% of the employment opportunity, 90% of the export level, and provides 70% of the country"s raw material demand of the large and medium scale industries found from this promising sector (MoFED, 2012). Nevertheless, around 29% of its population yet is living under poverty (World Bank, 2014). Expansion of farm lands and intensification or use of more inputs and new technologies per unit of land are the two possible ways of increasing agricultural productivity. Higher agricultural yield could possibly be obtained both from use of more inputs per unit of land and expanding the cultivable farm land in the agricultural sector (Berihun et al., 2014; Gashaw et al., 2014; Tsegaye and Bekele, 2012). Contrary to the expansion of cultivable farm land, adoption of agricultural inputs and techniques in line with the green development economic policy like Ethiopia today is the best remedy. After the Ethiopian peoples" revolutionary democratic front E.P.R.D.F. led-government to come to power in 1991 the economic management of the country was transformed from a command economic system into market-led systems and the subsequent structural adjustment programs, brought the effect of reversing the collapsed, and healing of the overall economic status of the country (Fredu and Solomon, 2011). To alleviate that severe poverty, Government of Ethiopia (GoE) designed, introduced, and implemented the famous Agricultural Development Led Industrialization (ADLI) strategy since 1991 (Berihun et al., 2014; Lulit et al., 2012). GoE has adopted different new agricultural technologies for adoption as policy like fertilizers, certified seeds, irrigation, and row planting techniques. However, there is practically a limitation in adoption of these technologies and new techniques by small farms.

At the national level, around five million smallholder farmers are participating in producing wheat and produce approximately 40 million quintal (4 ton) of it per annum. Currently, 24-quintal per hectare (2.4 ton) is the national average yield of wheat and implies triple times larger as compared to that of eight quintal per hectare in 1990s production year (CSA, 2013; UNDP, 2014). Currently, the average wheat yield in the National regional state of Tigrai, Ethiopia is estimated 35 to 40 quintal per hectare in the production year 2013 (Abraham et al., 2014). However, lags behind China"s average yield of wheat ranges from 40 to 60 quintal per hectare (Lester, 2012; Gashaw et al., 2014). And even much lesser than the Western Europe, the average wheat yield is about 60 to 80 quintal per hectare (Lester, 2012).

Likewise, 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 (Fetien and Ibrahim, 2010). Around 45% of the regional total wheat production and 46.3% of wheat, area coverage has found from the Southern part of Tigrai and which is the focus of the study area (as cited in Teklay, 2012). Seeding is done until now by broadcasting, not in row and weeding which mainly depends on precise family laborites which contribute negatively to low productivity of crops in Ethiopia (Bezabih et al., 2010).

The result of recent studies prove that row planting method gives better output than most commonly practiced traditional method, conventional broadcasting. Consequently, in order to get higher grain of wheat yield, row planting method is advised by many scholars (Mishra et al., 2001; Mohammad et al., 2001; Abdulai and Huffman, 2005; Attaullah et al., 2007; and CAADP, 2012). Even if Ethiopia is the leading regional producer of wheat in SSA, yet the country spends more amount of US dollar to import about a million tons of the grain every year from abroad (Sarah, 2014). Especially, when there is limited supply of wheat for the industries (manufacturers) engaged in producing flour, spaghetti, macaroni, biscuits and bread over the country (Sarah, 2014). Though the demand for wheat grain has been increased at least among others due to increase in population, urbanization, and massive expansion of food complex processing industries, Ethiopia has not been able to satisfy the high demand and was obliged to import million tons of wheat every year to fill the gap by incurring more US dollars (Rashid, 2010).

Low technology adoption, low use of improved farm inputs, traditional farming, and rain-fall are the prime bottlenecks behind the poor performance of the sector in Ethiopia (Lulit et al., 2012). Though there are plenty agricultural technologies (extension packages) over the country, the study is only limited to evaluate the impact of row planting (seed is sown at low rate) in agricultural technology adoption on wheat yield over smallholder farms" in Ofla woreda[1] of the National regional state of Tigrai, Ethiopia.

As it can be recalled, in LDCs like East African countries including Ethiopia, there is limited work in the literature of agricultural technology adoption at small farm household"s level in general and mainly the impact of the newly introduced row planting technique (sowing in line) on wheat in particular yet is not examined in the local specific study area and in Tigrai regional state of Ethiopia as well. This paper sought to contribute to the limited knowledge on the impact of sowing in line technique that would have good policy relevance on the enhancement of wheat yield on the wheat belt areas of Tigrai. With this

[1] Woreda in this context is an administrative structure of governance next to zone level.

background and understanding, investigating the impact of row planting on small farm household‟s wheat yield, therefore, is imperative in Ofla woreda of the Tigrai region of Ethiopia. The general objective of this study is therefore to investigate the impact of row planting agricultural technique adoption on small holder households‟ wheat yield. The specific objectives are:

1. To investigate the determinant factors that affect adoption of -new agricultural technology on wheat yield.
2. To examine the impact of row planting technology adoption on wheat yield.

The remaining sections of this paper are organized as follows: the second section gives the literature review; the third section presents methods and econometric that was used to estimate the impacts of row planting technology adoption on wheat yields in this paper. The fourth section presents the results of the estimations for selected areas; the fifth and final section concludes and identifies possible recommendation.

LITERATURE REVIEW

The Ethiopian agricultural transformation agency (MoA, 2012) investigated that crop planting with space starts with growing seedlings in a garden center and planting these in the field with sufficient and equal spacing between each seedling. On the other hand, seed grain can be sown in rows with enough spacing between the seeds and rows simultaneously and started since 2011 to 2012. It‟s antonymous to the traditional broadcasting sowing method manually by hand that contributes positively to the lower agricultural produce.

Sowing wheat crops in rows at low rate instead of scattering seeds by hand recommendations were introduced to about 400,000 wheat farmers in 200 *kebeles* located in the four main wheat belt regions of Ethiopia: Amhara, Oromia, SNNP, and Tigrai (Gashaw et al., 2014; Sarah, 2014). Using a reduced-seed rate through row planting is a major piece of the package. However, small farm households were convinced that 50 kilograms (Kg) of the advised seed per hectare was not enough because they traditionally use 75 kg per half hectare. Farmers were very skeptical of the recommendation; some of them even applied additional wheat seed on top of the recommended doze. Small farm households who sow with the recommended amount of seed have got impressive yield (a deviation of 75 to 80 percent per hectare) (Sarah, 2014).

The process of adoption is the change that takes place within individual in relation to innovation starting from adopters initially aware of the innovation to the last decision whether or not to adopt that new technology. Despite, Ray (2001) has defined that adoption does not necessarily follow the stages that starts from awareness creation to adoption of that new technology. Enough spacing between the plants and sowing of two seed grains at one point facilitates needed moisture, aeration, nutrition, and light to the crop roots, as a result; helps faster growth of plants and productivity as well (Ram and Prashanta, 2011). In general speaking, there are two main systems of wheat intensification (SWI) principles of crop production. First, principles of root development and the second one is principle of intensive care.

Principles of root development: For the sake of proper growth of crop plant, it must be well established from its rooting system. It‟s a fact that root development is the first stage of healthy growth of any plant. To be achieved requires enough food and space around the plant. From this principle, then conclude that distance between plants and nourishment are decisive things for the better growth and development of crop plants for that matter enhances outputs. Principles of intensive care: Intensification, here is contrary to the high number of plant density per unit space meaning it‟s proper space maintenance takes care of plants very closely. Finally, so as to increase wheat yield it needs intensive care in each stage plant development including management of weed, insect, disease, irrigation, and organic manure (Ram and Prashanta, 2011).

“The prevalent system of wheat cultivation requires more chemical fertilizers and nearly 120 to 180 kg of seed per hectare. However, system of wheat intensification (SWI) uses only 20 to 30 kg of improved seed in one hectare” (Ram and Prashanta, 2011). For its effectiveness 20 to 25 cm spacing between rows, use of manure, improved seed and organic seed treatment ensures more yield of wheat.

Technology concepts

Rogers (1995; P. 12) often uses “innovation” and “technology” synonymously. He describes as follows: “technology is a design for instrumental action that reduces the uncertainty in the cause effect relationships involved in achieving a desired outcome”. Enos and Park (1988) defined technology as “the general knowledge or information that permits some tasks to be accomplished, some service rendered, or some products manufactured”. Rogers (1995; P. 5) conceptualized that “diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” provided that decisions are not authoritative or collective, each member of the social system faces his or her own innovation decision following a five stage processes.

The innovation decision process is the process through which an individual (other decision making unit) passes from first knowledge of an innovation forming an attitude toward the innovation, to a decision of adopt or reject, to implementation of the new idea, and to confirmation of this decision”-(Rogers, 1995; P. 20 to 21). New technology adoption takes place within the mind of an individual or other decision making unit, however, diffusion occurs among the units in a social system. Finally, there are five main stages in new technology adoption process stated as follows:

1. Knowledge: A decision making individual becomes aware of an innovation and has some idea of how it works is the main idea of this stage. As decision making persons first exposed to an innovation, however; lack information about the innovation and even have no desire to find extra information about the innovation.

2. Persuasion: This stage takes place when an individual decision unit creates a favorable or unfavorable attitude toward the innovation. Individual decision unit become interested in innovation and actively seeks information regarding to the new technology.

3. Decision: In this stage an individual typically is attracted to seek innovation-evaluation information, which is the reduction in uncertainty about an innovation‟s expected out comes. Questions like innovation‟s consequences, advantages and disadvantages be in my situation are usually answered by most individuals from their peers whose subjective opinion of the innovation is most convincing. Though this stage is most difficult to endorse by empirical evidence, individuals focus in activities that lead to a choice either to adopt or reject the innovation in weighing the advantages and disadvantages of adopting the innovation.

4. Implementation: Takes place when persons put an innovation in to use. Injunction to that an individual determines the usefulness of innovation as well. When that adopted new technologies give utility to him/her will continue to use the innovation and otherwise.

5. Confirmation: A person evaluates the results of an innovation-decision already made. As a result, individual decision unit decided to use the innovation even up to the fullest capacity.

Types of adoptors in new technology adoption process

Rogers (1995: 246 to 250) conducted a research on „innovation adoption‟ stated that in the new technology adoption process there are five adopter categories. These are:

1. Innovators (Venture some): This category of adopters is very eager to try new ideas and leads them out of a local circle of peer networks and into more modern social relationships. Generally, the adopters of the innovation category are risk takers, under youngest age brackets, have higher social status, nearest to scientific sources, and interact with other technology innovators.

2. Early adopters (Respectable): Characterized by greatest degree of opinion leadership in most social systems, younger in age, have more financial variability, have higher social status, advanced education, greater social relationships, and greater exposure to different mass- media channels.

3. Early majority (Deliberate): Adopt new ideas before the average number of a social system. Similarly, they interact repeatedly with their peers and sometimes hold leadership positions. The innovation–decision period of early majority adopter is relatively longer as compared to innovator and the early adopter.

4. Late majority (Skeptical): Individual decision unit in late majority category characterized by adopting an innovation after the average member of the society adopts the innovation because these are with high degree of skepticism.

5. Laggards (Traditional): Laggards or individual decision unit who falls behind peers are the last category to adopt an innovation. Furthermore, laggards behave as they do have more isolated in social networks, lowest social status, and lowest financial changeability up to the extent little opinion leadership over the average number of a social system (Rogers, 1995: 247).

Previous researches

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 /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 more 3.6 quintals of rice additions per hectare.

A research output revealed that farmers who has adopted selected wheat seed, a lower seeding density, row planting, fertilizer recommendations, and marketing assistance as full-package obtained 12 to 13% higher wheat yields as compared to non users (Gashaw et al., 2014). 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 who 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. Among other important variables age of the household head, family size, number of oxen, access to credit, and off-farm activities positively affect the probability of participation in an agricultural extension program. Of which age, education level, and access to credit, affects significantly.

Yaron et al. (1998) and 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. Bola et al. (2012) revealed that technology complexity has a negative impact on adoption of technologies and this bottle neck could only be solved through education. Ibrahim (2013) on his „constraints to agricultural technology adoption in Uganda‟ panal data using probit model, shows that small farm heads with low educational level and small land holdings are less likely to adopt improved seed and fertilizer technologies. Adoption of improved wheat varieties on small farm households increases food security and small farm households that did not adopt that technology would also have benefited sufficiently had they adopted improved seed (Bekele et al., 2013). Tsegaye and Bekele (2012) conducted a study on the „impacts of adoption of improved wheat technologies on households‟ food consumption in South eastern Ethiopia‟ using a propensity score matching (PSM) over randomly selected 200 farmers stated that improved wheat seed varieties grew based on a recommended planting space (row) which had a robust and positive impact on small farm household level of food consumption. The average treatment effect on the treated (ATT) revealed that 377.37 to 603.16 calories per day increment came on the adopters of row planting method thereby improving household‟s income. Variables like age, education, farm experience, off-farm activities, access to credit, extension contact, and livestock holding affected adoption of wheat technology. Lastly, these reviewed literatures aforementioned have helped for this research to design the potential socioeconomic and demographic factors related to the good quality consideration that support to explain the impact of row planting technology adoption on small farm households wheat yield.

MATERIALS AND METHODS

Description of the study area

Southern Tigrai is one of the seven administrative zones of the Tigrai regional state of Ethiopia. It holds eight Woredas under and is found about 167 km South of Mekelle city. Ofla lies between 12°31 North atitude and 3 °33' East Longitude and bordered by Woreda Endamokeni to the North, Raya Azebo to the East, Alamata to the South, and Amhara regional administrative state to the west. It lies at an altitude range of 1500 to 2800 m.a.s.l. The average annual temperature of the Woreda is 22.3°C as well. However, its annual temperature ranges from 14.6°C to 30°C. Mean annual rainfall of the Woreda also ranges from 450 to 800 mm in the main summer season (June to September) and 180 to250 mm in the Belg season (December to April). Besides, it has 21 administrative Tabias under it. The agro climatic condition of the area is Dega (highland), Weynadega (mid-highland), and Kolla (lowland). Nevertheless, the Dega holds 42% largest proportion which is conducive to wheat crop production, and 29% weynadega and kola, respectively. Ofla Woreda with the total population of 147,000 is the second largest populated rural Woreda in Tigrai. Of the total, 49.7% are male and the remaining 50.3% are female. From this total population, 16% are economically active labor. Total numbers of households of the Woreda are estimated 33,943 of which 69% are male headed and the rest 31% are female headed households. Growth rate of the Woreda„s population is estimated to be 2.2% per annum. The study area accounts for about 144,220 hectare of land meter area. Of the total hectare of land 22,851 hectare is arable and 44,635 hectare is covered by forests while the remaining was covered by grazing, area not under use, settlement and others. 40% landscape of the Woreda is sloppy, 20% flat plain, and 25% flat, and the remaining 15% is gulley and valleys. It‟s potential wheat producer woreda. The dominant economic base of that Woreda‟s rural community is agricultural economic sector. It accounts for 97% of the total population livelihoods (Ibid).

Sources and methods of data collection

A multi-stage sampling technique was applied so as 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 were purposively selected because of its high potential of wheat and there is a practice of row planting (sowing in line). In the second stage, of the total 21 Tabias‟ [2] of Ofla Woreda administration, four Tabias (Hashenge, Adi-golo, Menkere, and Wenberet) were selected purposively. Similarly, the selected Tabias consisted of both large number of row planting technology adopter households and represent the agro ecological zone as compared to the remaining Tabias.

A total sample of 300 smallholder farmers has been therefore selected in the third stage (Table 1). Random sampling technique was applied in each stratum to select both the treated and control groups. In the fourth stage, of these total sample size, a total of 99 smallholder wheat row planting adopter households from the treatment group and 201 non-adopter households from the control group were surveyed. Finally, the 99 adopter smallholder farmers and 201 non adopters were selected randomly and proportional to the total household heads in the four Tabias. Lists of all respondents were found from the administration centers (*Kebelles*).

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 in order 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 trained well on the detail contents of the questionnaire and techniques of data collection include how to approach households and discuss face to face. In order to develop, check the validity of the instrument

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

Table 1. Sample size of agricultural technology participants and non participant smallholder farm heads on wheat yield (2014) production year.

Name of tabia	Row planting adoptors	Non adoptors	Total number of household heads
Adigolo	492	1,573	2,065
Hashenge	918	1,371	2,289
Menkere	5,80	1,033	1,613
Wenberet	453	884	1,337
Total	2,443	4,861	7,304

Source: BoARD of Ofla, 2014.

and to make some amendments when necessary, 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 row planting technology adoption on wheat yield at household level. In evaluating the impact of row planting technology adoption on wheat yield of adopter households (treated group) and non-adopters (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. Heckman et al. (1997) suggested that 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 in row planting. However, in reality a household cannot hold both a treatment and control group status 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, 1985; Khandker et al., 2010). Consequently, in dealing with selection bias problem the implementation of propensity score matching (PSM) is advised.

Model specification

A binary choice model is applied to estimate the smallholder farmers‟ probability of participation in row planting technology adoption that is, [Y=1 decision of households to adopt wheat line sowing, 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 two discrete choice models are different only on their distribution; the logit model is based on the cumulative standard logistic distribution and the probit model is based on cumulative standard normal distribution. The logit model is a non-linear regression (LR) 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 household‟s probability of participation of row planting technology. Gujarati (2004) stated that the logit model estimates the probability of the dependent variable to be 1. The specification of the logit model in this study is specified as:

P (Yi=1/X) = p (adoption) =

Where,

P (Yi) = is the probability that the household adopts row planting technology

= is a vector of observable household characteristics such as age, sex, education level, and field visit days.

= is a vector of logit index (Coefficient) = is the stochastic (error or disturbance) term.

Propensity Score Matching (PSM)

PSM initially coined by Rosenbaum and Rubin (1985) has been applied in many program evaluations. PSM matches groups based on their conditional probability of receiving a treatment given pre-treatment characteristics (ibid). As far as this impact of agricultural technologies is concerned the impact of both row-planting and improved wheat seed technology 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 s/he had not been part of both row-planting and improved 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 (Y1/D=1) = the production levels of the adopters before they adopt row planting and it is reasonably approximated by the output level of non-adopters 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, can‟t solve the problem of the 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 as:

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 adopter and non-adoptors did not differ before the program implementation. The validity of the result of the PSM method depends on the satisfactions. The two assumptions are:

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

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

2. Common support condition (CSC): Entails the existence of sufficient overlap in the characteristics of the treated and untreated units to find adequate matches (common support). 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 2005). According to Rosenbaum and Rubin (1983) a standardized difference greater than 20% 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 which is advised by Sianesi (2004).

Sensitivity analysis

Caliendo and Kopeing (2008) contend that PSM only controls the observed variables, included in the propensity score, to match both the treated and control groups of the households. Un observable characteristics are left out of consideration. As cited in (Menale et al., 2010) it was stated that before interpreting the base line estimates as evidences of a true causal effect of the treatment, testing the presence of unobserved variable is of great importance, which can be done using a sensitivity analysis. Sensitivity analysis is applicable mainly to check whether and to what extent the estimated average treatment effects are robust to possible deviations from the conditional independence assumption (CIA) (Ichino et al., 2008). Although, the CIA is a basic assumption to identify the true treatment effect in the ATT estimation strategy, the validity of the CIA cannot be tested using non-experimental data (Crino, 2011). One of the prime assumptions of the sensitivity analysis is that assignment to treatment may be confounded provided that the set of observable variables, that is, the common support assumption (CSA) no longer holds. But, it is assumed that the CIA is uncompounded given observed X and an unobserved binary variable, U.

(4)

U is not observed, as a result, the outcome of the controls cannot be credibly used to estimate the counter factual outcome of the treated.

E ((5)

On the other hand, knowing U (together with the observable covariates X) would be enough to consistently estimate the ATT, hence:

$$Pr [D= 1/Y_i^T, Y_i^C, X, U] = Pr [D =1/X, U] \quad (6)$$

The above equation assumes the basic assumption CIA to be violated by the incidence of an unobserved binary variable U {0, 1}. It tries to assess the sensitivity of the point estimate of the ATT to changes in a small set of parameters that characterize the relationship of U with treatment and outcome variable.

The distribution of the unobserved binary confounding variable U can be derived by specifying the parameters clearly as:

$$P_{ij} \quad Pr [U=1/D=i, Y=j, X] =Pr [U=1/D=i, Y=j] \quad (7)$$

With i, j {0, 1} that give the probability U=1 in each of the four groups defined by the treatment status, the outcome value, and then a value of U is attributed to each unit. As far as the conditions mentioned below holds true; Ichino et al. (2008) found that by simply choosing the parameters P_{ij} it is possible to simulate a “dangerous” confounder or a confounder whose existence might give rise to a positive and significant ATT estimate even in the absence of a true causal effect. Thus,

$$P_{01} > P_{00} \quad P_r [Y_i^C = 1/D=0, U=1, X] > Pr [Y_i^C =1/D=0, U, X] \quad (8)$$

$$P_{1.} > P_{0.} \quad Pr [D=1/U=1, X] > Pr [D=1/U=0, X] \quad (9)$$

Consequently, considering the simplest assumption of $P_{01} > P_{00}$ and $P_{1.} > P_{0.}$ It is possible to simulate a confounding factor that has a positive effect on the untreated outcome Y_i^C and on the treatment assignment conditioning on X respectively can be simulated. The sensitivity analysis approach finally boils and reach to easily interpretable measures of association (both the outcome effect and selection effect) are estimated by the average odds ratios as specified here after. The “outcome effect “of the simulated confounder is given by:

Σ (10)

On the same fashion, the logit model of Pr (Y=1 /U, X) is also estimated at every iteration and the average odds ratio of U is reported as the “selection effect” of the simulated confounder here:

( ) ( ) ( ) (11)

Where, R=indicates the number of replications = represents the outcome effect and =represents the selection effect

It has been argued that if U is simulated under the assumptions that P01> P00 and P1.>P0, both the outcome and selection effects must be larger than unity. Thus, the values of >1 and >1 are always positive and above one (Ichino et al., 2008). Therefore, sensitivity analysis in this paper is incorporated and applied mainly to assure whether the inference taken about the impact of both row-planting and improved wheat seed new technologies adoption have better wheat yield increment over the treated small scale households is reliable or not. As a result, sensitivity analysis supports the robustness of estimated results of the intervention as it can be seen later.

Description of important variables used in the analysis

Caliendo and Kopeinig (2005) clearly investigated that in estimating propensity score matching, only variables that affect the participation decision of households and the outcome variable simultaneously are unaffected by participation to a program or the participation must be incorporated in the logit model. In doing so, different literatures has been reviewed, expertise ideas were

Table 2. Summary of explanatory variables and their expected signs used in the model.

Variables	Description of Variables	Type of the Variable	Expected Sign
Dependent Variable	A household head who has adopted row planting on wheat on his/her farm since last year (2013), otherwise (0)	Dummy (1= if a household adopts wheat row planting, 0 = otherwise)	
Age of hh	Age of the household head in	Continuous	±
Sex of hh	Years Sex of the household head	Dummy(1=Male,0= Female)	±
Education of hh	Education level of the household	Continuous	+
Fie Field visit days	If a household ever get a chance and see row planted demonstration sites in his neighboring or elsewhere organized by their local government	Dummy (1=Yes,0=No)	+

incorporated, knowledge and experience of the researcher were even employed so as to differentiate the determinant factors of the assigned outcome variables used in the study (Table 2).

RESULTS AND DISCUSSION

Descriptive analysis

This part presents the results that were obtained from the sample respondents. The paper applied both descriptive and econometric methods of data analysis. In the first part the descriptive analysis was found. The descriptive analysis is clearly carried out using the tools like mean, percentages, standard deviation, and frequency distribution over both demographic and socio-economic household characteristics. Hence, it is an auxiliary tool to have strong econometric output.

Demographic characteristics of row planting adopter households

Based on the result, about 19% of the sample households were headed by females and the remaining 81% were headed by males. Besides, out of the 100% row planting adopter household heads, 18.2% were female headed unlike to 81.8% male headed households (Table 3). As it can be seen from Table 4, approximately 68.3% of the sample households were found to be non-educated; whereas about 31.7% of the total sampled household heads attained some educational level that ranges from grade 1 to 8. Comparisons by the level of wheat row planting participation reveal that 99 (33% participants) and 201 (67% non-participants) were found educated and non-educated, respectively. Similarly, the sex ratio of educated adopter to non adopter is almost the same. The level of education ranges from non-educated to eighth grade.

About 27.7% from the adopter household heads and 5.3% non adopter sampled households have had a chance to see demonstration agricultural sites organized by their local government either in their neighbours or outside of their Woreda. According to the survey result, above 67% of the respondents did not get a chance to participate in field visit days and keeps them away from gaining best agricultural practices (Table 5). As a result, a household who had participated on field visit days adopts agricultural technology as compared to those who do not. As indicated in Table 6, the average age of the adopter and non adopter smallholder farm head is 48 and 46 years consecutively. Particularly, age of the adopter and non adopter exhibits as there exists a relationship with the probability of adoption of the row planting. Concisely, age of the household head is considered as a proxy for experience. Definitely, education plays a great role in adoption of row planting and other technologies. It assists both adopter and non adopters as a crucial way of collecting information with regard to row planting technology as well. The t-test revealed that significant at 1% probability level is of significance. From Table 6, it can be said that sex of the smallholder farm were statistically significant at ($p < 0.05$). On the other hand, it reveals that male headed households have more probability of participating in row planting technology unlike females. This might be because of the fact that more physical effort is expected to exert on agriculture.

Moreover, a field visit day has an influence on the probability of wheat row planting use. Households with more chance to participate in field visit days were more likely to engage in row planting use than that of their counterparts. It"s also significant at ($p < 0.01$) 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 technique in their plots. From Table 7 above it can be said that around 34, 20, and 13% of the respondents from the survey replied that the main reasons for not participating in row planting were due to lack of working labor availability, infertility of farmland ownership and lack of awareness regarding to the benefits of adopting row planting technology. Moreover, a shortage of working labor by smallholder farms caused largely mistrusts on that technology and leads to not adopting it. And that was partly misperceived simply in observing the high labor demand during wheat sowing season.

Table 3. Sex of the household head.

Description	Sample HH	%	Adopter	%	Non-adopter	%
Female	57	19	18	18.2	39	19.4
Male	243	81	81	81.8	162	80.6
Total	300	100	99	100	201	100

Source: Computed from own survey, 2014.

Table 4. Education level of household head.

Description	Non-educated HH	Educated (1 to 8th grade)	Adopter	%	Non adopter	%
Female	41	16	49	16.3	46	15.3
Male	164	79	50	16.7	155	51.7
Total	205	95	99	33 %	201	67%

Source: Computed from own survey, 2014.

Table 5. Access to field visit days.

Description	Sample HH	%	Adopter	%	Non adopter	%
No	201	33	16	5.3	185	61.7
Yes	99	67	83	27.7	16	5.3
Total	300	100	99	33	201	67

Source: Computed from own survey, 2014.

Table 6. Summary of statistics for variables of the smallholder farm characteristics of row planting adoption.

Variables	adopters = 99		Non adopters= 201		t-test
	Mean	Std. Err	Mean	Std. Err	
Age	48	0.83	46	0.71	-2.2624**
Education	1.83	0.1068	0.87	1.293	-5.091***
Sex	0.8181	0 .0389	0.8059	0.0279	-0.254
M	1.757	0.2419	0.5174	0.2419	-5.966***
Field visit days	0.8383	0 .3718	0.0796	0.0191	-20.11***

Source: Computed from own survey, 2014. **significant at 5%, *** significant at 1% probability of significance level.

Table 7. Reasons for not adopting wheat row planting technology on their farm.

Description	Sample households	%
Adopter	101	33.0
Labor consuming	97	34.0
Lack of awareness	42	13.0
Cultivable land infertility	60	20.0
Total	300	100

Source: Own survey, 2014.

Econometric analysis

To estimate the impact of adopting wheat row planting, newly introduced technology on wheat production of small scale households was employed using different ATT estimation algorithms. Lastly, the sensitivity analysis

Table 8. Logit estimate for propensity score for the study area.

Variables	Coefficient	P> /Z/	Marginal effect	
			dy/dx	P> /Z/
Sexhh**	-1.583	0.018	-.3442	0.027
Agehh***	0 .4986	0.007	0.091	0.009
Educ_hh	0 .3933	0.347	0.071	0.350
Fieldvi_days***	4.289	0.000	0.776	0.000
M	0.5505	0.197	0.1	0.198
Age_squar**	-0.0043	0.018	-0.001	0.021
_cons	-15.812	0.000		
Number of obs = 300; Logistic Regression; Wald chi^2 (6) = 220.01; Log likelihood = -80.25; Prob > chi^2 = 0.0000; M = Sexhh*Educ_hh; Pseudo R^2 = 0.58; The region of common support point is [0.01803602; 0.99981767].				

***, ** and* are statistically significant at 1, 5 and 10%, respectively. Figures in parenthesis are standard errors.
Source: Own survey, 2014.

has been implemented to test the robustness of estimated ATTs in the PSM. In dealing with all these econometric estimates, STATA 12 version has been employed.

In order to estimate the propensity scores to match the outcomes of adopter, non adopter households logistic estimation model was also applied. The marginal effects results are provided below in Table 8. The pseudo R-squared is found about 0.5782, meaning all the explanatory (independent) important variables included in the model do exactly explain 58% of the probability of households row planting 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 household‟s is [0.01803602, 0.99981767]. The propensity scores of the non adopter households is less than 0.01 and adopters greater than 1 is excluded. Thus, the balancing property is undoubtedly satisfied in the region.

The result for the logit estimates of households‟ probability of adopting row planting technology is presented in Table 8. At the bottom of the table we see 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 0.58. This implies that 58% of the variation in the households' probability of adopting the technology is explained by the independent variables in the model. The Wald chi^2 (6) 220.01 with a p-value (Prob>chi^2) 0.0000 also tells that the logit model as a whole is statistically significant as compared to the model with no predictors. As reported in the same table, the coefficients for the row planting technology adoption such as sex, age, field visit days, and age square are significant at 1 and 5% probability level of significance. Besides, those explanatory variables have the expected negative and positive signs.

Interpretations of the marginal effects of wheat row planting adoption

The marginal effect estimates of Table 8, shows that keeping other factors constant, a 1 year increase in the age of the household head, increases households‟ probability of adopting row planting technology on wheat by 9%. This seems almost the same in adopting row planting by all age groups other than other factors among household heads. Again, it‟s statistically significant at 1% probability level of significance.

Indeed, a farm field visit day is statistically significant at 1% probability level of significance. Farm field visit day participation plays a great role in obtaining experience and skill in different ways. Therefore, households who participate in farm field visit day programs are 78% higher to adopt row planting new technology than non participant households, (ceteris paribus). Those results are consistent to the researches that had been done before (Tsegaye and Bekelle, 2012; Bola et al., 2012; Ibrahim, 2011; and Mamudu et al., 2012). As household‟s age increase (getting older and older) by one year, the probability of adopting row planting decrease by almost 0.5%, (ceteris paribus). This might be due to the fact that old households might oppose the new technology unlike to youngster farmers.

Impact estimation of ATT for row planting technology adoption on wheat produce

After the propensity score is estimated, the next task is to

Table 9. Propensity Score Matching ATT result: Impact of row planting technology adoption on wheat yield in 2014 production year.

Matching Type	No. Treated	No. Control	ATT	Std. Err.	t-value
Stratification	90	149	9.70	2.169	3.906***
Radius	99	201	15.844	0.915	17.312***
Kernel	99	201	15.844	0.952	16.647***
Nearest neighbor	99	201	15.844	0.988	16.036***
Average			14.258		

Source: Own survey, 2014.

Table 10. Results of simulation-based sensitivity analysis.

Matching algorithms	Outcome Variable	Baseline ATT (A1)	Simulated ATT (A2)	Outcome effect ( )	Selection effect ( )	Absolute difference (A1-A2)	Difference in % (A1-A2/A1)
NNM	Wheat yield using row planting in (2014)	9.4	9.9	7.1	192	-0.5	5.32
Kernel	Wheat yield using row planting in (2014)	9.5	9.6	6.34	94.07	-0.1	1.13
Radius	Wheat yield using row planting in (2014)	12.41	12.1	8.23	80.7	0.31	2.5

Source: Own Survey, 2014.

match the treated with the control groups based on their scores. This can also be 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 row planting production enhancing technology, for the sake of transparency and to exhibit accuracy of the evidence four of the above matching algorithms were implemented. The results illustrated that adoption of new technology have a positive and significant impact on enhancing wheat produce from the ATTs estimations of Stratification, Radius, Kernel, and NN matching methods.

As one can see from Table 9, the results of the matching techniques are statistically significant at (p <0.01) probability level of significance. Similarly, the ATT result lies between 9.7 quintal in the stratification and 15.844 quintal per “Tsimdi” or 0.25 ha a year in the remaining three matching algorithms. Undeniably, the smallholder farms who had adopted row planting technology on their marginal farm land on average has obtained 14 quintal of wheat yield per “Tsimdi” at a cost of sowing around 1,200 ETB greater (40 quintal to 60 quintal per hectare) than that of non adopters in a single production year. However, the matched control group on average has obtained below four and half quintal of wheat per “Tsimdi” at an average cost of sowing 00 ETB (less than 20 quintal per hectare) on the same single production year . Therefore, adopting row planting technology on wheat as a package (row and spacing, improved seed, fertilizer rates /and or compost, early hand weeding and hoeing, tilling repeatedly) is vital.

As can be seen, adopters of row planting technology on wheat as a package increase their wheat yield 50 to 80% as compared to non adopters. The wheat yield increase obtained in this paper is consistent with the previous research outputs (Gashaw et al., 2014; Tsegaye and Bekelle, 2012; Bola et al., 2012; Ibrahim, 2011; and Mamudu et al., 2012). Lastly but not the least, narrowing the gap between adoptors and non adoptor is indispensable in order to enhance wheat yield and get food secured soon in the specified area.

Estimation results of the Sensitivity Analysis

Indeed, in order to check the robustness of the estimated results aforementioned, sensitivity analysis has been undertaken. In case the CIA fails in PSM it can easily solve the pitfall using the comparison between the simulated and baseline ATTs estimates. As it can be seen from Table 10, though U is associated with a large outcome effects (>1) and selection effects (>1) for the NNH, Kernel, and Radius matching algorithms, the overall simulated ATTs of each adopter of both row-planting and improved wheat yield technology are still too much closer to the baseline ATTs. Hence, both values of outcome effect and selection effects are larger than unity each, and also the difference in percentage between the baseline ATTs and simulated ATTs are below 10% which makes it stronger in the credibility of our estimated ATTs as well.

The simulated ATT of each of the household wheat produce is too close to the baseline estimate. Obviously, this implies that it is only when U is simulated to provide incredibly large outcome effect; the ATT can be driven far from the baseline estimates or even closer to zero. Over all, the results estimated support strengthens the robustness of the matching analysis which is the reliable conclusion.

CONCLUSIONS AND POLICY IMPLICATION

The research was motivated to examine the impact of wheat row planting adoption on households wheat produce in Ofla wheat belt district of Tigrai regional state of Ethiopia. It also intended to examine the potential factors that affect smallholder farms decision on whether to participate in row planting or not. Undeniably, the smallholder farms who had adopted wheat row planting technology on their marginal farm land on average had obtained 14 quintal (1.4 tone) of wheat yield per "Tsimdi" or 0.25 ha at a sowing cost of around 1,200 ETB larger (40 to 60 quintal per hectare) than that of non adoptors (use broadcasting) in a single production year. As it can be seen adopter households of wheat row planting technology were increased in their wheat yield 50 to 80%more as compared to non adopter households. However, the matched control group on average has obtained below four and half quintal of wheat per "Tsimdi" at an average cost of sowing 900 ETB (less than 20 quintal per hectare) on the same single production year. Therefore, the research recommended that adopting wheat row planting technology as a package (row and spacing, improved seed, fertilizer rates and or compost, early hand weeding and hoeing, tilling repeatedly) is vital as a policy in enhancing wheat yield on the marginal farm lands. Complementary agricultural technology adoption best yield results when they are taken up as a complete package together, rather than in the individual elements to give high wheat yield.

Conflict of Interests

The author has not declared any conflict of interests.

REFERENCES

Abdulai A, Huffman WE (2005). The diffusion of new agricultural technologies: The case of Cross-bred cow technology in Tanzania. Am. J. Agric. Econ. P 87.

Abraham B, Araya H, Berhe T, Edwards S, Gujja B, Khadka R, Sen D, Koma Y, Sharif A, Styger E, Uphoff N, Verma A (2014). The system of crop intensification: Reports from the field on improving agricultural production, food security, and resilience to climate change for multiple crops. Addis Ababa, Ethiopia. Available at http://www.agriculture and food security.com/content/3/1/4.

AfDB (2014). African Development Group. Tracking Africa"s Progress in Figures.

Attaullah K, Muhammad A, Asad S, Sajid A, Zahira H, Sajjad K (2007). Evaluation of Planting Methods for GrainYield and Yield Component of Wheat.

Bekele S, Menale K, Moti J, Chilot Y (2013). Adoption of improved wheat varieties and impacts on household food security in Ethiopia.

Berihun KH, Bihon KA, Kibrom AW (2014). Adoption and impact of agricultural technologies on farm income: evidence from Southern Tigary, Northern Ethiopia. Int. J. Food Agric. Econ. 2(4):91-106.

Bezabih E, Hadera G, Nigatu R (2010). Impacts of Improved seeds and agrochemicals on Food Security and Environment in the Rift Valley of Ethiopia: Implications for the Application of an African Green Revolution. Available at: http://www.eldis.org/go/home&id=56723&type=Document#.V6BwxdIr KM8

Bola AA, Aliou D, Omonona BT (2012). Impact of improved agricultural technology adoption on sustainable Rice productivity and Rural Farmers" welfare in Nigeria: A local Average Treatment Effect (ATE) Technique.

CAADP (2012). Climate-Smart Agriculture Program Design Work Shop. Improved Seeds and Planting Materials Factsheet.

Caliendo M, Kopeinig S (2005). Some practical guidance for the implementation of propensity score matching, Discussion paper No. 1588, University of Cologne.

Caliendo M, Kopeinig S (2008). Some practical guidance for the implementation of propensity score matching. J. Econ. Surv. 22(1):31-72

Crino R (2011). Imported inputs and skill upgrading. University of Brascia, LdA, and IAE-CSIC. Development studies working papers N.323.

CSA (Central Statistical Agency) (2013). Agricultural sample survey: area and production of major crops, meher season. Vol.1. Addis Ababa, Ethiopia.

Debela G (2011). Impact of agricultural technology on farm production: the case of Beressa and Umbullo Watersheds.

Enos JL, Park WH (1988). The adoption of imported technology: The case of Korea. New York.

Fetien A, Ibrahim F (2010). Local seed business news letter. Mekelle, Mekelle University, Ethiopia. 4:7-9

Fredu N, Solomon ZN (2011). Base line socio-economic survey report of Tigrai region.

Gashaw T, Alan B, Nicholas M, Tanguy B (2014). The impact of the use of new technologies on farmers wheat yield in Ethiopia. International Food Policy Research Institute (IFPRI). Washington, DC

Gujarati ND (2004). Basic Econometrics. 4^{th} ed. McGraw-Hill Companies.

Harper JK, Rister ME, Mejelde JW, Drees BM, Way MO (1998). Factors Influencing the Adoption of Insect Management Technology. Am. J. Agric. Econ. 72(4):997-1005.

Heckman J, Ichimura H, Todd P (1997). Matching as an Econometric Evaluation Estimator: Evidence from evaluating a job training program. Review of Economic Studies. 64p.

Ibrahim K (2013). Constraints to agricultural technology adoption in Uganda: Evidence from the 2005/06-2009/10 Uganda National Panel Survey.

Ichino A, Mealli F, Nannicini T (2008). From temporary help jobs to permanent employment: What can we learn from matching estimators and their sensitivity? J. Appl. Econ. 23(3):305-327.

Khandker SR, Koolwal GB, Samad HA (2010). Handbook on Impact Evaluation Quantitative Methods and Practices, the World Bank, Washington DC.

Lester RB (2012). From Full Planet, Empty Plates: The New Geopolitics of Food Scarcity. Earth Policy Institute.

Lulit M, Ermias E, Zelalem H (2012). Public investment in irrigation and training for an agriculture-led development: a CGE approach for Ethiopia. Addis Ababa, Ethiopia.

Mamudu AA, Emelia G, Samuel KD (2012). Adoption of modern agricultural production technologies by farm households in Ghana:

What factors influence their decisions? J. Biol. Agric. Healthcare 2(3). Menale K, Bekele S, Goffery M (2010). Adoption and impact of improved Groundnut varieties on rural poverty. Evidence from rural Uganda. Available at: http://www.rff.org/files/sharepoint/WorkImages/Download/EfD-DP-10-11.pdf

Ministry of Agriculture (MoA) (2012). Ministry of Agriculture. Animal and plant health regulatory directorate. Crop variety register, Issue No.15. Addis Ababa, Ethiopia.

Mishra Y, Shukla RS, Rawat GS (2001). Correlation Coefficients and Selection indices in bread wheat(*Triticum aesticum aestivum* L.) Under different Growing Situation. Indian J. Agric. Res. 35:161-165.

MoFED (2012). Ethiopia‟s progress towards eradicating poverty: An interim report on poverty analysis study. Addis Ababa, Ethiopia.

Mohammad TJ, Haider A, Amanullah J (2001). Influence of sowing methods and Mulching on yield and yield Components of Wheat. Pak. J. Biol. Sci. 4(6):657-659.

Ram BK, Prashanta R (2011). System of Wheat intensification (SWI): A new concept on low input technology for increasing wheat yield in marginal land. Available at: http://sri.ciifad.cornell.edu/countries/nepal/Nepal_SWI_Khadka11.pdf Rashid S (2010). Staple food prices in Ethiopia. Maputo, Mozambique. Available at: http://ageconsearch.umn.edu/handle/58552.

Ray GL (2001). Extension communication and management. 2nd Edition. Callcuta: Naya prokash.

Rogers E (1995). Theory of diffusion of innovations. Free press, New York.

Rosenbaum PR, Rubin DB (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. Am. Stat. pp. 33-38.

Sarah M (2014). IFPRI evaluates a new wheat package rollout in Ethiopia. Available at: http://reap.ifpri.info/2014/04/01/ifpri-evaluates-a-new-wheat-package-rollout-in-ethiopia/.

Sianesi B (2004). An evaluation of the active labor market programs in Sweden. Rev. Econ. Stat. 86(1):133-155.

Tsegaye M, Bekele H (2012). Impacts of Adoption of Improved Wheat Technologies on Households‟ Food Consumption in Southeastern Ethiopia. Selected Poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Teklay A (2012). Distribution and physiologic races of wheat rust in Tigrai, Ethiopia. J. Plant. Pathol. Microbiol. 3:142.

UNDP (2014). First Quarter Report (January 1st to March 31st).Enhancing National Capacity for Agricultural Growth and Transformation (ATA). ATA.

World Bank Group (2014). Ethiopia poverty assessment. Document of the WB for official use only.

Yaron A, Hutzubal A, Davis M, Lavon I, Amit S, Manning AM, Anderson JS, Mann M, Ben NY (1998). Identification of the Receptor Component of the Ikba-Ubiquitinligase. Nature P 396.