Innovations

Evaluation of impact of raw planting technique on wheat production of farmers: the case of Sinana, Bale zone, Ethiopia

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Abstract

Recognizing the importance of agricultural technology in enhancing production and productivity, the Ethiopian government introduced row planting technology to farmers recently. The aim of this study is to evaluate the impact of row planting technology on smallholder farmers' wheat production in Sinana district, Bale Zone of Ethiopia.200 households are sampled and included in the study among which 95 are adopters of the new farming technique and 105 non adopters. Propensity Score Matching (PSM) model is employed for estimation. The result shows that row planting technology has significant positive impact on farmers` wheat productivity. The overall findings of the study underlined the high importance of training and extension service provision to improve farmers' skill and access to information to address the recommended agronomic practices, and facilitating access to supplementary technology/machines that simplify the row planting process. Therefore, development interventions should give emphasis to improvement of such institutional support systems to increase adoption of row planting technology.

Key Words: *1.Row Planting, 2.Propensity Score Matching, 3.Impact Evaluation.*

Introduction

Agriculture in Ethiopia, like in other developing countries, is fundamental for the country`s economy. GDP from agriculture in Ethiopia is 686.4 ETB billion in 2020 which constitutes contributes 40% of the country`s GDP. Agriculture also contributes 80% of export earnings and provides employment for 75% of the population (NBE, 2021).

While Ethiopia has recently experienced one of the largest agricultural growth spurs in SSA (an average of 6.5 percent per year since 2000), maintaining this high growth rate will require successful adoption of new farming techniques.

Improved farming methods such as row planting and transplanting, are assumed to be superior to traditional broadcasting because they allow for weeding, diminish competition between seedlings, and allow for better branching out or tillering of plants (Berhe et al. 2011; Fufa et al. 2016).In Ethiopia, since 2016, agricultural extension activities have been concerned with the promotion, adoption and scaling up of row planting practices. As a result, row planting is becoming one of the recommended agronomic practices of smallholder farmers in the country.

Currently the government of Ethiopia and other partners are promoting row planting to help farmers more easily manage weeds with an objective of increasing long term food production. Because the increase in yield is necessary to reduce food insecurity and promote food self-sufficiency of the country. To assess the potential of the row planting technology, experiments were conducted in small controlled settings where they showed the sign of positive impacts on yields (Berhe et al. 2014; Fufa et al. 2016). As a consequence, the Ethiopian government started rolling out these new technologies on a larger scale. In 2016, the technique was promoted to almost 2.5 million farmers through large efforts by the national extension system and through farm radio partnerships (ATA, 2017).

Following adoption of this new techniques of production by farmers, there is a need to evaluate the impacts of the techniques on productivity of farmers. Thus motivation of this paper is to fill this gap and to provide evidence on the impact of row planting technology on farm production by targeting toward wheat producer farmers. This study also provides important information to help in designing appropriate policy instrument to enhance adoption of improved agricultural technologies.

1.1 Objectives of the Study

The main objective of this study is to estimate the impact of row planting farm technique on wheat production of farmers in Sinana district of Bale zone, Ethiopia.

The specific objectives are:

- To assess the impact of row planting technology on wheat production;
- To assess the difference between treated and non-treated farmers in terms of socio-economic variables.

1.2 Scope of the Study

In terms of the study area, this study is delimited to the farm population of Bale Zone specifically to that of the Sinana district. There are many agricultural technologies and production techniques recently introduced to the farmers in the area among which this study targets toward row planting techniques.

1.3 Significance of the Study

By pointing out the impact of modern farming technique on farm productivity, this study is expected to provide guidance to the agricultural institutes and researchers for enhancing the agricultural technology adoption and its effectiveness.

1. Review of literatures

Even if there are plenty of papers done on the determinants of agricultural technology adoption behaviour, there are limited papers done on evaluating the impacts of technology on farm productivity of wheat producing farmers.

One of the papers done on the issue is the one conducted by Mendola, 2006 which entitled "Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh". This study aims at shedding some light on the potential impact of agricultural technology adoption on poverty alleviation strategies. It does so through an empirical investigation of the relationship between technological change, of the Green Revolution type, and wellbeing of smallholder farmhouseholds in two rural Bangladeshi regions. The paper tackles a methodological issue in assessing the 'causal' effect of technology on farm-household wellbeing through the non-parametric*'p-score matching analyses*. The study finds a robust and positive effect of agricultural technology adoption on farm household well-being suggesting that there is a large scope for enhancing the role of agricultural technology in'directly' contributing to poverty alleviation.

Another paper is the one conducted by Solomon et.al (2012), which entitled "Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia". This paper evaluates the potential impact of adoption of improved legume technologies on rural house-hold welfare measured by consumption expenditure in rural Ethiopia and Tanzania. The study utilizes cross-sectional farm household level data collected in 2008 from a randomly selected sample of 1313 households (700 in Ethiopia and 613 in Tanzania). The causal impact of technology adoption is estimated by utilizing endogenous switching regression. The reveals that adoption of improved agricultural technologies has a significant positive impact consumption expenditure (in per adult equivalent terms) in rural Ethiopia and Tanzania.

Yet there is another study conducted by Berihun,2014 which entitled "Adoption and Impact of Agricultural Technologies on Farm Income: Evidence From Southern Tigray, Northern Ethiopia". The paper employs Cross sectional data which was collected through semi-structured questionnaire administered on 270 randomly selected smallholder farmers. The Probit and Ordinary Least Square (OLS) regression models were employed and the regression results revealed that agricultural technology adoption has a positive and significant effect on farm income by which adopters are better-offs than non-adopters.

Finally, the research conducted by Ogada and Nyangena (2015) which entitled "Impact of Improved Farm Technologies on Yields: The Case of Improved Maize Varieties and Inorganic Fertilizers in Kenya" reveals positive impacts of improved agricultural technologies on farm productivity. This study investigates the impact of package adoption of inorganic fertilizers and improved maize varieties on yield among smallholder households in Kenya with the application of models quasi-experimental difference-in-differences approach and propensity score matching.The study also reveals that impact is greater at the lower end of the yield distribution than at the upper end, and when technical efficiency of the farmers improves. Similarly, a positive effect of partial adoption is experienced only in the lower quantile of the yield distribution.

Generally, the literatures reveal the importance of adoption of agricultural technologies on boosting agricultural productivity. In this paper also I tried to analyze whether the newly introduced farming technique, which is row planting farming techniques improved the productivity of farmers of study area or not.

2. Methodology of the study

3.1. Description of Study Area

Bale is one of the 17 zones in Oromia region located in south eastern part of Ethiopia with the capital city of Robe, which far about 430 km from Addis Ababa. It is the Second Largest Zone of the region after Borena and characterized by a wide variety of demographic land scopes. Bale is bordered in south by Guji on the west by the west Arsi zone, on the north by Arsi, on the north east by West Hararge and on the east by Somali region.

Bale zone has 18 *Woredas*. Among them the study area, Sinana *Woreda,* is located at 60 50‟ N-70 17‟ N latitudes and 400 06‟ E-400 24‟ E longitudes. According to the country`s agro ecological Zone, most part of Sinana district is found in Sub humid tepid to cool highland agro- ecology. 97.46% of the population of the *Woreda* is dependent on agriculture for their livelihood and most of them are living in the area,which considered being potential cereal producers. (SARC, 2012).

3.2. Data source

The study is targeted toward the farmers in Sinana district of Bale Zone Ethiopia. To achieve the stated objectives, the cross-sectional data regarding economic characteristics and agricultural practices are collected from the sampled farmers in 2017/18production season. Since there is no production data of the farmers before introduction to the technique the research is suited to Propensity score matching model.

3.3. The sampling procedures and techniques

The rationales behind selecting Sinana Woreda is that it has high agricultural potential specially on cash crops like wheat, has different type of farmers operating under different agro ecological condition and availability of larger number of raw planting adopter farmers in this *Woreda*.

Sinana *Woreda* has 20 *kebele*s among which seven *kebele*s are purposively selected. The sampled *Kebeles* are selected to include different attributeslike potential wheat producers, cropping pattern, agro ecology pattern, the number of adopter farmers and the rural based farmers. This is done in consultation with the *Woreda* AGP coordinators and extension experts. Once the *Kebeles* are identified the adopter households are selected based on the proportion of total number of adopter households in their respective *Kebeles*. The selection is based on systematic sampling method by picking every N^{th} household starting from a random start where equal proportion is selected from each kebeles. For this purpose, list of latest round adopter farmersis obtained from respective *Kebele* administration or nearest agriculture development agent office is used as sampling frame. The control group; the non- adopter farmers are selected purposively from the neighboring of adopter farmers. The study covers a total of 200 farming households among which 95 are adopter farmers while the remaining 105 are non-adopter farmers. The details of the *Kebeles* and the sampled farm households are presented in table 1.

Table 1 List of Surveyed *Kebeles* and number of sampled farmers

Woreda	***Kebele***	**Total adopter farm households in the *Kebele***	**Adopter farmers sampled**	**Non-adopter farmers Covered**	**Total**
Sinana	Bassaso	332	13	14	22
	Gamora	375	15	17	23
	Hawusho	312	12	13	21
	hissu	250	10	11	19
	I/sanbitu	410	16	18	25
	Obora	295	12	13	18
	Salqa	420	17	19	27
Total		**2394**	**95**	**105**	**150**

Source: own survey of respective *kebeles*' secondary sources, 2017/18

3.4. Treatment assignment and sampling procedures

Four different kinds of agricultural technologies were offered to the farmers in Sinana district starting from 2015 production period, which are provision of mechanical machine (tractors and combine harvesters), provision of new improved wheat seed variety, introducing improved legume variety and introducing row planting farming techniques to the farmers. Among the treatment of the period, this paper targets toward analyzing the impact of row planting on productivity of the farmers in 2017/18, after two years of introduction of the technique to the farmers.

In order to assess the impacts of the technique on farmer's productivity, the researcher selects 95 adopter farmers out of the 2394 and 105 non adopter farmers. Hencea total of 200 farm households are selected out of which 47.5 % are treatedand 52.5% are non-treated farm households.

3.5. Data Analysis Techniques

Both descriptive and econometric analyses are used to describe and evaluate the collected data. The descriptive analysis is used for comparison studies regarding the main characteristics and economic difference between treated and non-treated farmers. The econometric analyses are also made for impact evaluation of the treatment. The data are analyzed using STATA v.16 software.

3.6. Model Specification

In the study the treatment variable is the row planting technique of farming, where the treated groups are adopter of the technique and controlled groups are non- treated. The impact can be defined as the expected value of the difference between the level of the outcome variable attained by adopter of the technique and that which they would have attained had they not adopted the technology (Wooldridge, 2002; Ravallion, 2001).

To estimate the impact of row planting technology adoption on farm productivity, the researcher used Prosperity Score Match (PSM) technique. In the model, Average Treatment Effect (ATE) is calculated as the mean difference in outcome across these two (treated and non-treated) groups. Hence, its specification is given as follows.
Assume that impact evaluation involves measuring the impact of row planting on household wellbeing, specified as:

$Y_i = \alpha + \beta I_i + \delta X_i + \varepsilon_i$ -- (1)
Where Y is the outcome variable (in this case production) level of household i; I is the treatment indicator (adoption of row planting), where I=1 when a household is adopter and I=0 when a household is non adopter; X captures the exogenous explanatory variables,; β and δ are estimated parameters; ε is the usual error term that captures unobservable factors and potential measurement errors that affect Y.

For adopter households (I=1):

$Y_{1i}/I_i = 1 = \alpha + \beta + \delta X_i + \varepsilon_i$ --- (2)

For non-adopter households (I=0):

$Y_{0i}/I_i = 0 = \alpha + \delta X_i + \varepsilon_i$ -- (3)

The difference between (2) and (3),β is the impact of row planting on household production.

For many households, we must estimate the average outcome across all sample households that are adopter and that are not to obtain the expected value of the average treatment effect, specified as:

$ATE = \epsilon(Y_{1i} - Y_{0i})$ --- (4)

Where ϵ (.) denotes the expected value and sample equivalent is given by:

$ATE = \frac{1}{n}\sum_{i=1}^{n}(Y_{1i} - Y_{0i})$ -- (5)

The researcher estimated the propensity score matching by following the five PSM implementation steps of Caliendo and Kopeining (2008) which stated below.

Step 1: Propensity score estimation: - The propensity score is the probability of a unit in the target group (treated and control units) to be treated given its observed characteristics X. Rosenbaum and Rubin (1983) revealed that matching can be performed conditioning only on P(X) rather than on X, where P(X) = Pr(D=1|X) is the probability of participating in the program conditional on X. According to these authors, if outcomes without the intervention are independent of participation given X, then they are also independent of participation given P(X) which reduces a multidimensional matching problem to a single dimensional problem.

Step 2: Check overlap and common support: Comparing the incomparable must be avoided, i.e. only the subset of the comparison group that is comparable to the treatment group should be used in the analysis. Imposing a common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group (Bryson *et al.*, 2002).Hence, an important step is to check if there is at least one treated unit and one non-treated unit for each value of the propensity score.

Step 3: Choose a matching algorithm: this step consists of matching treated and non-treated units that have similar propensity scores using an appropriate algorithm. Propensity score matching algorithms differ not only in the way they measure the degree of similarity between treated and non-treated units (i.e. the way they find twins between these two groups) but also with respect to the weight they assign to the matched units.

Step 4: Matching quality: The quality of the matching procedure is evaluated on the basis of its capability in balancing the control and the treatment groups with respect to the covariates used for the propensity score estimation. There are several procedures for this. Standardized bias, variance-ratio, t-test, joint significance and Pseudo-R^2 are indicators to check for matching quality. (Rosenbaum and Rubin, 1985).

Step 5: Effect estimation: After the match has been judged of acceptable quality, computing the effect becomes a quite easy task: it is enough to calculate the average of the difference between the outcome variable in the treated and non-treated groups.

3.7. Description of important variables included in the regression Analysis

Treatment variable:

ROWPTREAT: denotesraw planting farming technique which is dummy variable that takes the value of 1 if the farmer is treated with the techniques and 0 other wise.

Outcome variable:

PRODUCTION: represents the per-hectarewheat production of the farmers. Wheat is targeted as wheat is the top crop produced by farmers in the study area.

Covariates

AGEHH: It is age of the household head and continuous variable measured in numbers of years from birth.

EDUCHH: denotes formal educational level which is measured as number of schools attained by household head.

TCL: denotes total cultivated land size in hectare which is a continuous variable.

EXTENC: denotes Extension contact which is continuous and represents number of times the farmer is being visited by development agents.

THL: Total household labor which is a number of household member participated on farming activities.

TLU: The number of tropical livestock units (TLU) owned by the household in number.

TECHAB: denotes technology adoption behavior of household heads. It is a dummy variable represented as 1if early adopter of technology, 0 otherwise.

OFI: denotes engagement in Off-farm activity is a dummy variable representing 1 if a household head participates in off-farm activities and 0 otherwise.

CREDIT: denotes the farmer's access to credit like access to input credit, financial credit and etc.… it takes the value of 1 if the farmer accessed the credits, 0 other-wise.

Notes: in addition to the above explained variables, there are also variables which are included in descriptive analysis.

4. Findings and discussions

4.1. Descriptive Analysis

This section presents the analysis description of several variables, correlation analysis and mean comparison between treated and non-treater farmers regarding farmer`s characteristics; personal, economic, institutional and social variables. The standard t- test is used to compare statistical significance of the mean difference of the variables between the two groups.

4.1.2. Description of continuous variables

A. Summary statistics

Table 2: summary statistics of continuous variables

Variable	Obs	Mean	Std. Dev.	Min	Max
AGEHH	200	45.245	9.323606	23	76
FAMSIZE	200	6.37	2.033167	0	13
EDUCHH	200	7.16	5.574926	0	19
TCL	200	4.83335	3.435447	1.2	32
TLU	200	8.84353	4.596559	0	26.612
IMPSEED	150	96.53001	100.4367	0	1000
FERTILIZER	150	89.15663	44.68826	13.7931	314.2857
THL	200	3.26	1.460502	1	8
hiredlabor	199	.8241206	.6546038	0	2
EXTENC	200	3.63	4.542717	0	24
PRODUCTION	200	35.6147	11.18226	15	75

Source: own computation, 2022.

Summary statistics shows that with regard to family characteristics, the average value of age, family size and educational status of sampled households are 45.24, 6.37 and 7.16 respectively. With regard to economic base of the sampled farmers, the average total cultivable land size and total livestock owned are 4.83 and 8.84 respectively. Similarly, with regard to agricultural input usage per hectare, for the farmers who used the inputs, the average improved seed, fertilizer, household labour, hired labour and extension services usage are 96.53, 89.15, 3.26, 0.82 and 3.63 respectively. The average wheat production per-hectare in the area is 35.61 quintals. These figures are relatively above national figure average.

B. Mean comparison

Table 2: Mean comparison of variables among treated and non-treated farmers

Variable	Treated farmers		Non-treated farmers		Mean Difference
	Mean	Std. Err.	Mean	Std. Err.	
Age	47.07	.920008	43.59	.9148731	3.48***
Family size	7.05	.213418	5.75	.1742493	1.30025***
Formal education	7.8315	.50053	6.552381	.595	1.279*
Total cultivated land size	5.2937	.35204	4.4168	.331989	.8768**
TLU	10.1434	.4669	7.6673	.42274	2.4761***
Improved seed in KG (per hec.)	98.298	7.190	94.9410	14.218	3.356
Fertilizer usage inKG (per hec.)	86.80309	4.5835	91.2718	5.587	- 4.4687
House hold labor in number	3.90526	.13803	2.6761	.12802	1.229***
Hired labor in number	1.0106	.06143	.6571	.06466	.3534***
Extension contact	4.2421	.4474	3.0761	.4540	1.1659**
Yield per-hectare(in quintals)	43.5514	.9511	28.433	.70364	15.11***

Source: *own computation, 2022*

, ** and * indicates that the difference between the two groups are statistically significant at 10%, 5% and 1% significance level respectively*

Table 3 shows that there is significant difference between treated and non- treated groups in terms of age (farm experience), family size, livestock ownership (TLU), family labor and hired labor at 1% level of significance. Similarly, the difference between treated and non-treated groups in terms of variables like total cultivated land size and extension contact are significant at 5%. But the difference between the two groups in terms of educational attainment is significant only at 10%. On the other hand, there is no significance difference between treated and non- treated groups in terms of input usage; improved seed application per hectare and fertilizer application per hectare.

When we see the difference between the two groups in terms of outcome variable, production per- hectare, there is significance difference between the groups at 1% level of significance. The paper analyses, whether this significance difference between the two groups in terms of outcome variable is coming from the treatment or the stated covariates.

4.1.2. Description of qualitative variables

Table 3: proportion comparison of sample treated and non-treated farm households

Indicators	Category	Treated Farmers		Non-treated Farmers	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	84	88.42	97	53.85
	Female	11	11.58	8	7.62
Farming Training	Trained	82	86.32	73	69.52
	Non-trained	13	13.68	32	30.48
Access to credit	Accessed	39	41.49	33	31.73
	Not-Accessed	55	58.51	71	68.27
Engagement in off farm income generation	Engaged in	21	22.11	26	25.00
	Not-engaged in	74	77.89	78	75.00
Technology adoption	Early adopters	87	91.58	30	28.57
	Late adopters	8	8.42	75	71.43

Source: own computation, 2022

The table shows that, in terms of variables like gender, obtaining farm training, access to credit, and early technology adoption behavior, proportion of the treated household are higher than the non-treated one. But in terms of engagement in off farm income generating activities, the proportion of non-treated farmers are higher than the treated one which shows that the treated farmers are more focused on farming activities than non- farming activities.

4.2. Econometric Analysis

4.2.1. Estimating the Impact of Row Planting on Farmers` Wheat Production and Income

This section describes the impact of row planting technology treatment on smallholder household`s productivity. Propensity score model is applied in order to analyze the impacts of the row planting treatment on household's productivity. A requirement of proper use of propensity score estimation is an appropriate common support region between the treatment and control groups. The region of common support needs to be defined where distributions of the propensity score for treatment and comparison group overlap.

Figure below describes the distribution of the household with respect to the estimated propensity scores. It reveals that there is wide area in which the propensity score of both the treatment and the control groups are similar. As mentioned above, only the subset of the comparison group that is comparable to the treatment group was used in the analysis.

After common support region defined, the next step in propensity score matching estimation is choosing the best algorism. Regarding matching mechanism, there are a number of different algorithms that can be used to find comparable untreated individual to each treated individual. For this paper, the propensity score matching method is the best algorism to analyze the impact of row planting on household production based on a matching estimator that results in the largest number of matched sample size is preferred (table 7).

Once the best performing matching algorithm is chosen, the next task is to check the balancing of propensity score and covariate using different procedures.

Table 4: Propensity score balance and covariate testing

Variable	Raw(R) Matched(M)	Mean		Standardized bias	% of bias Reduction	Variance ratio
		Treated	Control			
AGEHH	R	47.074	43.648	0.373		.9154046
	M	47.074	45.863	-0.0191	94.87	.7290488
EDUCHH	R	7.8315	6.552381	0.2316		.6402848
	M	7.8315	7.12501	-0.027378	88.18	.5627903
TCL	R	5.2937	4.4168	0.25663		1.017381
	M	5.2937	4.75	0.07697	70	.5601868
EXTENC	R	4.2421	3.0761	.2585717		.8783833
	M	4.2421	4.11202	-.1279183	25.36	.7343837
THL	R	3.90526	2.6761	.9249858		1.051722
	M	3.90526	3.8791	-.040554	88.43	1.187186
TLU	R	10.1434	7.6673	.5573089		1.103924
	M	10.26	10.939	.0365035	93.45	.7525047
TECHAB	R	0.9158	0.2857	1.672095	.3782665	.3782665
	M	0.9158	0.87601	-.0202113	165.79	1.00659
OFI	R	0.2211	0.25	-.0842644	.9023267	.9023267
	M	0.2211	0.22109	.0980782	-16.667	1.150747
CREDIT	R	0.4149	0.3173	0.200208		1.124029
	M	0.4149	0.3892	-0.010714	94.6	.9916131

Source: Own estimation result

There are several procedures to check whether the balancing condition is satisfied or not. Reduction in the mean standardized bias between the matched and unmatched households, the variance ration criteria and chi-square test for joint significance of the variables used are employed in for this study.

Rosenbaum and Rubin (1985), highlight that a good matching procedure should reduce the standardized bias for each of the covariates used in the estimation of the propensity scores. Thus, this approach requires comparing the standardized bias for each covariate *x* before and after matching. Hence, the fifth column of table 5 shows the standardized bias before and after matching. The standardized difference in covariates before matching is in the range of 8.4% and 167.2% in absolute value whereas after matching the standardized difference of covariates for all covariates lies between 1.07% and 12.7% after matching. This is fairly below the critical level 20% suggested by Rosenbaum and Rubin (1985). Therefore, the process of matching creates a high degree of covariate balance between the treatment and control samples that are ready to use in the estimation procedure. A similar approach of variance ratio also indicates a good covariate balancing where after the matching, the variance ratio of all covariates is less than 2.

Additionally, Sianesi (2004) suggests re-estimating the propensity score in the matched sample and comparing the *pseudo-*R^2before and after matching. After matching there should be no systematic differences in the distribution of the covariates between both groups. Therefore, the *pseudo-*R^2 after matching should be fairly low. As indicated in table 6, the values of pseudo-R^2 are very low. This low pseudo-R^2 value and the insignificant likelihood ratio tests support the hypothesis that both groups have the same distribution in the covariates after matching. These results indicate that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. Hence, these results can be used to assess the impact of row planting among groups of households having similar observed characteristics. This enables us to compare observed outcomes for treatments with those of a control groups sharing a common support.

Table 5: Chi-square test for the joint significance of variables

Sample	Ps R^2	LR chi^2	p>chi^2
Unmatched	0.209	57.84	0.000
Matched	0.044	11.53	0.318

Source: Own estimation result

All of the above tests suggest that the matching algorithm we have chosen is relatively the best for the data at hand. Therefore, we can proceed to estimating the average treatment effect of the treatment for the sample households.

Average treatment effect

The econometrics result of impact evaluation (table 7) indicates that the adoption of row planting technology has resulted in a positive and statistically significant difference between treated and non-treated of the technique in terms of wheat production per hectare. Five different impact models of matching are employed to show the robustness of the results obtained.

Table 6: ATE on treated, Econometrics estimation result of impact evaluation models

Outcome Variables	Matching method	ATE coefficient	Robust standard error	z-value	P>|z|
Wheat production (in quintals per hectare)	✪ Propensity score matching	11.41796	1.205659	9.47	0.000
	✪ Nearest Neighbor Matching	11.18202	1.69256	6.61	0.000
	✪ Regression adjustment model	10.10869	1.329156	7.61	0.000
	✪ Inverse probability weights estimator	10.18474	1.683125	6.05	0.000
	✪ Augmented inverse probability weight	9.800629	1.122602	8.73	0.000

Source: Own estimation result

As can be seen from the table 7, adoption of row planting had brought significant impact on farmers` wheat production in the study area who are operating under SARC. The row planting has impact on wheat production on all impact evaluation estimation models as shown in column (6) of the table 7. The best model among presented model is the propensity score matching model which produces highest average treatment effect (ATE). Accordingly, the adoption of the row planting method has brought about 11.418more quintals per hectare, on average in comparing with the production of the farmers who did not adopt the technique. For comparison purpose the nearest -neighbor matching method also produces similar result with ATE of 11.182 while the AIPWE produces ATE of only 9.8. Generally the econometrics estimation result shows, that the farmers who are treated with row planting farming technique significantly produces higher yield per - hectare in comparing with farmers who are farming with traditional seed dissemination farming technique.

5. Conclusions and recommendation

This study is conducted in Sinana Woreda, which is located in Bale zone, Ethiopia. The main objective of the study is to estimate the impact of row planting technology on smallholder farmers' productivity. A total of 200 sample households (95 adopters and 105 non adopter farmers) are included in the analysis of the study. In this study row planting technology adoption is considered as treatment variable while productivity per-hectare is taken as the outcome variable. There are also covariates included in the study.

Several descriptive statistics are computed to show the status of both treated and non-treated farmers in terms of economic variables, farm level, personal and institutional variables. comparing the treated with non-treated groups, larger proportions of treated farmers, accessed credit, early adopts agricultural technology, trained in different technical areas while larger proportions of non-adopter farmers are late adopting agricultural technology and engaged in off-farm income generating activities. Similarly, there is significant difference between treated and non-treated farmers in terms of total household labor (family size), live stock ownership and extension contact in favor of treated one. But the study found that there is no significance difference between treated and non-treated farmers in terms of input usage like fertilizer and improved seed.

On the other hand, in this study, propensity score match model was used to evaluate the impact of row planting technology on farmer household`s production of wheat per hectare. Before comparison of treated and non-treated groups was made, the five different impact evaluation models are deliberately employed to show the robustness of the results obtained. Then, ATE is estimated to show the difference between the treated and non-treated households. The result of this study shows a large and statistically significant difference between the two household groups in terms of the outcome variable, production.

Hence here I recommend that the government and concerned bodies should focus on scaling up of these kinds of best practices to other farmers in other areas and also should focus on providing newly improved farming techniques and farm inputs in order to increase farmer's productivity, to become food self-sufficient and achieve millennium development goals.

The government should also provide training on newly improved techniques of farm production, should create awareness to the farmer so that they change their technology adoption behavior and should increase access of the farmer to improved techniques of production and improved farming tools either by providing credit or providing with fair price. In line with this the row planting technique consumes more time and more labor. Hence the government should supply the farmers with improved tools which are designed for row planting purpose.

Abbreviations

ATA: Agriculture Transformation Agency
AGP: Agriculture growth program
GDP: - Gross Domestic Product
MOFED: - Ministry of Finance and Economic Development
NBE: National Bank of Ethiopia
SARC: - Sinana Agricultural Research Center

SSA: - Sub-Saharan African

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