COMPARATIVE ANALYSIS OF TECHNICAL EFFICIENCY OF ROW PLANTATION TECHNOLOGY AND TRADITIONAL SOWING TECHNOLOGY IN BARLEY PRODUCTION IN EASTERN ZONE OF TIGRAY

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Abstract:
Ethiopian GDP highly depends on the production and productivity of agriculture. Agricultural productivity is seen as one of the major contributors to the development process. It is, therefore, essential to study the performance of existing plantation technology systems in order to become informed about this development process. This study examined the factors influencing technical efficiency in barley farming in eastern zone of Tigray using a stochastic frontier production function in which technical inefficiency effects were assumed to be functions of both socioeconomic characteristics of the farmer and farm-specific characteristics of the two seed plantation technologies; namely row plantation system and traditional plantation system. In this research work paper the researchers select randomly 300 farmers comprising 155 row planters and 145 traditional planter farmers. The result from the descriptive statistics indicates that the farmers who use traditional plantation technology are producing on a lower production frontier than the farmers who practice row plantation technology and the result is also statistically significant at one percent in a two tail sample ttest. The results also revealed existence of high levels of technical inefficiencies in barley production, especially among the traditional sowing farmers. The study found that the magnitude of technical efficiency varied from one farmer to another and ranged from 42.4% to 75.4%, with a mean of 68.2%. Consequently, due to technical inefficiency farmers have lost close to 32% of the potential output. The main factors that influenced the degree of inefficiency were age of the household head, family size, livestock quantity, row plantation technology, access to irrigation and cooperative membership. Based on the findings from this study, the researchers recommend that farmers should have to get trainings on how to plant seeds, on the use of better techniques and application of fertilizer and other capital equipment. Moreover, the regional government should have to develop small scale irrigation schemes to enhance the productivity of row plantation technology. Last but not the least, though the result from the Tobit model and ttest statistics are significant, row plantation technology user farmers are on higher frontier than their counterparts. Thus integrating those who use traditional cultivation method can lead to more viable production and productivity in using this technology.

Key words: *Productivity, technical efficiency, stochastic frontier function, two limit tobit model, and barley farming in Eastern zone of Tigray*

Background and Justification:

Agriculture is the backbone of the Ethiopian economy. This particular sector determines the growth of all other sectors and consequently, the whole national economy. On average, crop production makes up 60 percent of the sector's outputs, whereas livestock accounts for 27 percent, and other areas contribute 13 percent of the total agricultural value added. The sector is dominated by small-scale farmers who practice rain-fed mixed farming by employing traditional technology, adopting a low input and low output production system. The land tilled by the Ethiopian small-scale farmer accounts for 95 percent of the total area under agricultural use and these farmers are responsible for more than 90 percent of the total agricultural output (GTP, 2010).

Agriculture is the mainstay of the Ethiopian economy and underpins its development process. It is a sector with great potential for stimulating growth and employment and eradicating poverty. Because of its importance to national food security and poverty reduction, the government has, within the Growth and Transformation Plan (GTP), articulated a clear vision for the sector, placing it at the center of the country's transformation agenda. The initiatives that underlie the agriculture policy and plan aim to stimulate investment and productivity of the sector to promote household and national food security and to rally development partners to deliver effective development aid to the sector. Transformation of the Ethiopia's agricultural sector requires scaling up efforts to increase agricultural production and productivity by among others promoting domestic and foreign investment through agricultural commercialization, increasing public investment in agricultural infrastructure, promoting technology transfer and adoption, ensuring efficient use of land, labor, technology and other inputs, and specifically raising the productivity of smallholder farmers (GTP, 2010). Among thus, row planning is one agricultural technology where high emphasis is given for improving the productivity of small holder farmers in the Growth and Transformation Plan of Ethiopia.

Beyond these investments and interventions, the introduction of new technologies through a strengthened extension system has been a major area of effort for the Transformation Agenda. The efforts in extending the Tef, Improved Seed Variety, Row Planting, Reduced Seed Rate (TIRR) technology package is an illustration of the significant yield increases that can be realized from seemingly simple technologies.

The core "TIRR" technology package (Tef, Improved seed, Reduced seed rate, and Row planting) prioritized for tef farmers by the agricultural extension system 2013, led to significant increases in crop yields across the country. Detailed analysis of the 2013 TIRR package, with a sample of 1,300 farmers, showed average yield increases of 44% the control group and 72% the experiment group (MoA, 2014/15).

During the GTP period, government aims to double the production of smallholder farmers by implementing measures to raise and sustain high agricultural productivity. The scope to increase production through area expansion is continuously diminishing as land for agriculture gets exhausted, making this approach less sustainable in the long term. In Ethiopia, agricultural productivity among smallholder farmers is as low as 1.25 tons per hectare for teff, there is also great variability in productivity across farmers with the most productive farmer producing 3.66 tons per hectare compared to the average yield of 1.83 per hectare for cereals (MoA, 2014/15).

One crucial element in the process of crop production is land preparation, as it is decisive in obtaining a good harvest. Establishing a good crop, increasing yield per hectare, reducing weed pressure, and improving soil moisture retention all depend on good land preparation (tillage). Farmland is prepared using the traditional ploughing instruments. Row planting is not easy for the farmers as it needs more labor than broadcasting; therefore, many apply the latter alternative. These and other activities, like weeding and soil fertility management, are highly labor-intensive (Atsbaha G. and Tessema B. 2010).

There are many constraints to agricultural inefficiency including the small and diminishing size of farm lands; inadequate extension services and follow-ups by the respective office of agriculture; soil infertility; outdated modes of production; and a lack of correct agricultural information.

This shows that there is great potential to increase production by raising yields per hectare for all smallholder farmers to that of the most productive (model) farmer. Significant productivity differences also exist across agro-ecological zones. These differences provide additional prospects for increasing production and productivity by providing incentives that induce farmers to optimally exploit zonal specific advantages to enhance returns from agricultural investment. Doing so will not only increase agricultural production through specialization and commercialization of agricultural production but will help to raise agricultural household income and employment, and ultimately contribute to poverty reduction in the rural sector.

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Woreda	*Tradition sowing Plantation technology*			*Row Plantation technology*		
	Target	*Actual*	*%*	*target*	*Actual*	*%*
AtsbiWenberta	*6868*	*8810*	*128.28*	*5976*	*3620*	*60.576*
K/Awlaelo	*11556*	*13634*	*118*	*8020*	*4253.5*	*53*
Hawzen	*7007*	*10761*	*153.6*	*9305*	*3488*	*37.5*
S/T/Emba	*13262*	*14752*	*111.2*	*6538.5*	*4427*	*67.7*
G/Afeshum	*6910*	*5441*	*78.7*	*3613*	*4503*	*124.6*
G/Mukada	*7205.5*	*6551*	*90.9*	*3998.5*	*4653.3*	*116.4*
Erob	*634*	*909*	*143.4*	*566*	*200.96*	*35.5*
Total	*53442*	*60858*	*113.9*	*38017*	*25146*	*66.1*

Source: Zonal BOARD 2015

In addition to the lack of agricultural technologies, the problem of low productivity on smallholder farms is inadequate knowledge, skills and resources (inputs such as fertilizer, labor, equipment, seeds and water) to enable them adopt and efficiently utilize existing technologies to enhance production and earning from farming. Thus, researches are necessary to identify the low agricultural productivity. Thus, the existence of steady economic inefficiency for decades in the nation and the prevalence of production differences using different agricultural technologies in the region, inadequate knowledge, absence of scientific research carried out to assess the socio- economic determinants of economic inefficiency are the major factors influencing this research to be realized.

However, unlike the remarkable achievements in the agricultural sector, there are still gaps in the areas of household production and economic efficiency that require further development, involvements of the government and other development agents to share the fate of sustainable development. In addition, most of the research works done on agricultural technologies focuses on the impact of these technologies on livelihood of households. Thus, they never relate with production and economic efficiency. This calls for the realization of this research work to fill such gaps and provide scientific evidence on the socio economic variables that determine economic inefficiencies.

Even though the interventions, the introduction of new technologies through a strengthened extension system has been given a major area of effort for the Transformation Agenda, however; studies on assessing the economic efficiency of row plantation in comparison to traditional sow plantation is not done yet. And to the best of the researchers understanding there were not researches so far conducted systematically in this region where this study is proposed to be conducted. For this reason, the study aims to compare production and economic efficiency of row plantation system with the traditional plantation system in cereal production using appropriate methods of data analysis.

Objective of the Study:

General Objective:

The general objective of the study is to compare production and economic efficiency of row plantation system with the traditional plantation system in cereal production.

Specific Objectives:

- ✓ To compare the production efficiency (technical efficiency) of row plantation production system with the conventional one
- ✓ To analyze the socioeconomic variables that may explain the differences in the estimated levels of technical inefficiency

Methodology of the Study

Methodology

This study employed a mixed approach with an emphasis given to quantitative household survey supplemented by the qualitative research method. The quantitative research approach is to compare the production and technical inefficiency of row plantation production system with the conventional one and to analyze the socioeconomic variables that may explain the differences in the estimated levels of technical inefficiency. In line with this, to capture some variables which are non-quantifiable (either methodologically or due to other reasons), qualitative methods of data analysis will also be used to describe the cropping patterns of the two production systems.

Research Process

Based on the objectives, the research process with in this study was divided into five stages. In the first stage, review of relevant secondary sources was conducted which, in fact, served as the background for understanding the research problem and hence set a research problem with in the ongoing dialogue in the literature.

In the second stage, the random selection of the study woredas was done from the seven woredas of eastern zone of Tigray based on the implementation of the two production systems.

Thirdly, selection of tabias from different agro ecological zones was undertaken to ensure diversity in the study and hence equal sample of respondents was drawn using a systematic random sampling. In the fourth stage, household survey using structured questionnaire and focused group discussions was under taken. Lastly, since the purpose of the research is to produce findings and the process of data collection is not an end by itself, data analysis, interpretation and presentation of findings was conducted.

Therefore, a total of 300 households were selected from three agro ecological zones from four tabias by using systematic random sampling method individual household for questionnaire survey was selected.

Method of Data Analysis

As part of quantitative research methods, primary data was collected by means of survey questionnaire. In the sample survey, in-depth information regarding the social and demographic characteristic, different agricultural inputs, livestock ownership and institutional variables were collected. All these data were considered during the analysis to compare production and technical efficiency of row plantation system with the traditional plantation system in cereal production.

As part of quantitative data analysis, an econometric model was also used to compare production and economic efficiency of row plantation system with the traditional plantation system in cereal production.

Econometric Model specification

To compare production and economic efficiency of row plantation system with the traditional plantation system in cereal production, a *Stochastic Frontier Analysis* and *two limit tobit model* was employed in this study. Frontier economic programming (version 4.1) software was used for estimating the farm specific economic efficiency scores of cereals producers in the study area. Following that the efficiency score is taken as a dependent variable and is then regressed against farmer specific, demographic, socioeconomic and institutional factors.

Boris et al. (1997) described that Cobb- Douglas functional form is used to specify the stochastic production frontier, which is the basis for deriving the cost frontier and the related efficiency measures. The specific Cobb- Douglas production model estimated is given by:

$$Yi = \beta 0 * \prod_{i=1}^{n} Xi^{\beta i} * e^{vi - ui}$$

By Transforming this in to double log linear model:

$$lnYi = ln\beta 0 * \beta 1 \prod_{i=1}^{6} lnXi \quad + (vi - ui)$$

Where Yi represents cereal yield harvested and Xi represents cereal production inputs by i^{th} farmer. Whereas, $\beta 0, \beta 1, \beta 2, \beta 3, \beta 4, \beta 5 \; and \; \beta 6$ are regression parameters to be estimated. From the error term component$(vi - ui)$, vi is a two sided $(-\infty < v < \infty)$ normally distributed random error (v˜N [0, $\sigma^2 v$]) that represents the stochastic effects outside the farmer's control (e.g whether, natural disaster,…), measurement error and other statistical noise. While Ui is a one sided (Ui≥0) efficiency component which is independent of Vi and is normally distributed with zero mean and constant variance $(\sigma^2 u)$ allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

Two limit tobit model with maximum likelihood estimation

Following Amemiya (1981), Waluse (2011) Essa et al (2011) and Endrias et al. (2013) the two limit tobit model is defined as:

$$yi * TE = \sigma 0 + \sum_{j=1}^{12} \sigma j Zij + ui$$

Where yi^* is the latent variable representing the efficiency scores, $\sigma 0, \sigma 1, \ldots, \sigma 12$ are parameters to be estimated, and TE (technical efficiency) and of the i[th] farmer. Zi is demographic, socio economic and institutional factors that affect efficiency level. And Ui is an error term that is independently and normally distributed with mean zero and variance $\sigma 2$ (Ui˜IN (0, $\sigma 2$)). Farm specific efficiency scores for the smallholder cereal producers range between zero and one. Therefore, two limit tobit model can be presented as follows:

Yi= 1 if Yi*≥1

Yi= Yi* if 0 < Yi*<1

Yi= 0 if Yi*≤ 0

Two limit tobit model allows for censoring in both tails of the distribution (Green, 2003). The log- likelihood that is based on the doubly censored data and built up from sets of the two limit tobit model is given by:

$$lnL = \sum_{yi=Io1} ln\emptyset\left(\frac{Ioi - Xi\beta}{\sigma}\right) + \sum_{yi=yi*} ln\frac{1}{\sigma}\emptyset\left(\frac{Iyi - Xi\beta}{\sigma}\right) + \sum_{yi=I1i} \ln[1 - \emptyset\left(\frac{I1i - Xi\beta}{\sigma}\right)]$$

Where I_{oi}= 0 (lower limit) and I_{1i}= 1 (upper limit) where $\emptyset$ and σ are normal and standard density functions.

In efficiency analysis, it is not only the level of inefficiency that is important, but the identification of the socio economic and institutional factors that cause it. Even though the approaches for the identification of these factors may vary to some extent with the methodology employed, the most commonly followed procedure in both approaches is what is usually referred to as the two step procedure (Jema, 2008). First, the efficiency or an inefficiency index is estimated. Second, the inefficiency or efficiency index is taken as a dependent variable and is then regressed against a number of other explanatory variables that are hypothesized to affect efficiency levels.

In a tobit model, each marginal effect includes both the influence of explanatory variables on the probability of dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. By following McDonald and Moffitt (1980), Greene (2003) and Gould et al (1989) cited in Endriaset al (2013) from the likelihood function decomposition of marginal effects was proposed as follows two limit tobit model:

The unconditional expected value of the dependent variable:

$$\frac{\partial E(y)}{\partial Xj} = [\emptyset(Zu) - \emptyset(Zl)].\frac{\partial E(y*)}{\partial Xj} + \frac{\partial[\emptyset(Zu) - \emptyset(Zl)]}{\partial Xj} + \frac{\partial[1 - \partial(Zu)]}{\partial Xj}$$

The expected value of the dependent variable conditional upon being the limits

$$\frac{\partial E(y*)}{\partial Xj} = \beta m.[1 + \frac{\{Zl\emptyset(Zl) - Zu\emptyset(Zu)\}}{\{\emptyset(Zu) - \emptyset(Zl)\}} - \left|\frac{\{\emptyset(Zl) - \emptyset(Zu)\}2}{\{\emptyset(Zu) - \emptyset(Zl)\}2}\right|$$

The probability of being between the limits

$$\frac{\partial[\emptyset(Zu) - \emptyset(Zl)]}{\partial Xj} = \frac{\beta m}{\sigma}[\emptyset Z(l) - \emptyset Z(u)]$$

Where $\emptyset(l)$= the cumulative normal distribution,

$\emptyset(u)$= the normal density function

$Zl = \frac{Xi\beta}{\sigma}$ and $Zu = \frac{1 - Xi\beta}{1}$ are standardized variables that come from the likelihood function given the limits of Y* and $\sigma = standard\ deviation\ of\ the\ model.$

To attain the major objective of this study, the data collected from the study area were analyzed and interpreted. In the process of data analysis and interpretation, major attention will be given to quantitative analysis although it is going to be supported by qualitative technique.

Variables and their expected signs

Variables	Unit of measurement	Expected sign
Seed	Kg	+
Labor	Person equivalent days	+
livestock	TLU	+
Dap	Kg	+
Urea	Kg	+
Farm size	Tsimadi	+
Access to irrigation	1= yes o= no	+
Sex	Male=1 female= 0	+
Age	Person equivalent	+
Education level of HHH	Years of education	+
Training	Yes=1 no=0	+
Membership of cooperatives	Yes=1 no=0	+
Credit	Yes=1 no=0	+
Family size (adult equitant)	Persons	+/-

Results, Discussion and Analysis

Distribution of respondents by Woreda

We employed a stratified random sampling technique and the following sample size was considered in the five woredas.

Table 4.1: list of woredas

Woreda	Frequency	Percent
GantaAfeshum	75	25.00
GuloMikada	74	24.67
KilteAwlaelo	76	25.33
SaesieTsaedaEmba	75	25.00
Total	300	100.00

Source: Survey data (2016)

Table 4.2: list of Tabias

Tabia	Frequency	Percent
DiblaSiet	75	25.00
Aditesfa	74	24.67
A/tesfa	76	25.33
Sindeda	75	25.00
Total	300	100.00

Source: Survey data (2016)

As table 4.1 above displayed that about 25% of the total respondents were from Ganta Afeshum, 24.67% from GuloMekeda, 25.33% from KilteAwlalo and the remaining 25% were from SaesieTsaedaEmba. And the tabia representation of the households was also depicted in table 4.2.

Household size of the respondents

Respondents' Household size in the four sample woredas may affect the adoption of row planting. Because planting i n rows requires high labor cost, households with large family size may have a greater chance of adopting this technology while households with small family size may find it challenging to apply row planting technology.

As displayed in table 4.3 belowabout43/299 (14.38%) of the total respondents had a small household size ranging between one to three family members, among these 27.95%, 18.6%, 16.3% and 37.2% of respondents were in Gulomekeda, k/awlalo ,Gantafeshum and saesetsaedaemba woredas respectively. Due to this the proportion of respondents that had small family size is relatively small that may not negatively affect the application of row planting technology.About62.21%ofthetotalrespondentshadmediumhousehold sizecomposedoffouruptoseven members of family,of these27.4%, 23.1% 25.3% and 24.2% were from. Gulomekeda, k/awlalo, Gantafeshum and saesetsaedaemba woredas respectively.Amongthetotal respondents23.41%had large family size ranging between eight and ten members.

Table 4.3: Family size of respondents by woreda

Woredas	Household ize						Total	
	1-3		4-7		8-10			
	Nº	%	Nº	%	Nº	%	Nº	%
Gulomekeda	12	27.9%	51	27.4	12	17.1	75	25.1
k/awlalo	8	18.6%	43	23.1	24	34.3	75	25.1
Gantafeshum	7	16.3%	47	25.3	20	28.6	74	24.7
saesetsaeda	16	37.2%	45	24.2	14	20	75	25.1
Total	43	100%	186	100%	70	100%	299	100%

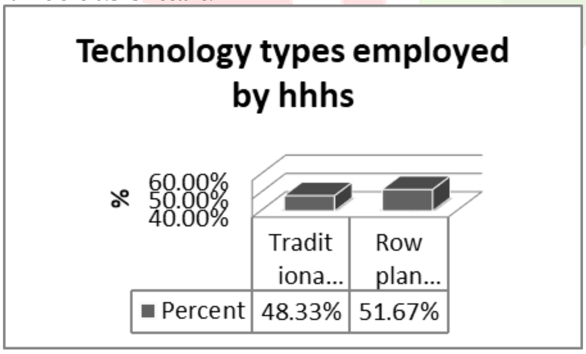
Source: Survey data (2016)

Table 4.4: Description of demographic variables

Variable	Observation	Mean	Standard deviation	Minimum	maximum
HHH Age	300	48.49333	11.50876	25	80
HHH Gender	300	40= Female	260= Male		
HHH experience in farming	300	23.533	13.62	1	60
Plot type	300	0.572	0.321	1= irrigated, 0=otherwise	
Credit take	300	0.653	0.478	1=loan take, 0=otherwise	
Extension service	300	0.87	0.273	1=participate, 0=otherwise	
TLU					

Source: Survey data (2016)

The average age of the household head is 48.493. from the total 300 respondents 260 were male headed households while 40 were female headed households. The experience in farming of the households ranges from 1 year to 60 years with an average of 23.5 years. As the table above depicts the average land holding of the farmers is 0.573 hectare.



Source: Survey data (2016)

From the total respondents 51.67 percent were row plantation users while the remaining 48.33 percent were traditional sowing cultivators.

The average inputs allocated by the farmers are 2.19 Tsimad of land (Check with reality), 15.055 man-days of family labor, 1.81 quintal of fertilizer, 11.9 oxen, and 13.37 compost. Using these inputs they got an average output of 266.5 KG with standard deviation of 142.45 kg of barley.

Table 4.5: summary statistics

Plantation technology	Land size tsimad	Fertilizer kg	Labor days	Oxen days	Compost quintal
Traditional technology	2.206897 (1.189634)	1.501241 (6.327388)	12.689655 (1.01554)	8.758621 (1.141896)	11.86552 (23.30022)
Row technology	2.187097 (1.194071)	2.105645 (8.138873)	18.29032 (1.190109)	14.90323 (1.374006)	14.77742 (16.2549)
Total	2.196667 (1.189976)	1.813517 (7.313725)	15.055 (1.121905)	11.93333 (1.301898)	13.37 (19.99192)

Source: Survey data (2016)

The livestock ownership in the study area was on average of 4.996 TLU for the farmers who use row plantation and 4.145 TLU for the farmers who use traditional plantation while the average TLU of the sample respondents was 4.757.

Descriptive Analysis (Empirical Results)

The statistical summary in table 4.6 depicts that a typical household head who cultivates his land using row plantation have, on average, 7.9% of inefficiency while of the sampled households who use traditional cultivation system have 5.5% have technical inefficiency; the two sample t-test result shows that the difference is statistically significant at 1% level. Thus, from this we can deduce that row plantation is positively contributing to agricultural production and productivity improvement.

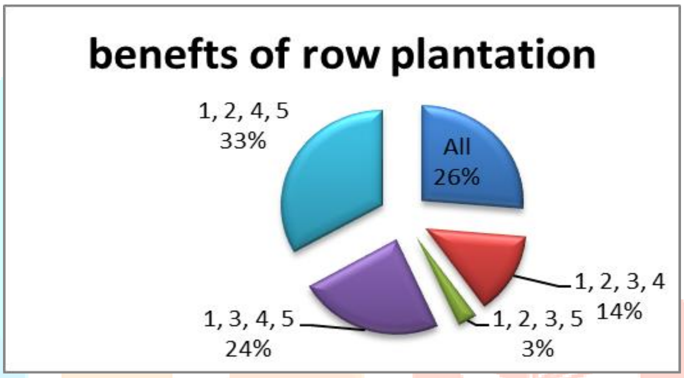
Table 4.6: two-sample t test with equal variances

Variable	Mean (Std. Err.)
Traditional Plantation	0.55 (0.003259)
Row Plantation	0.79 (0.0025703)
Combined	0.682 (0.0021678)
Difference	-0.24 (.0041227)
t = -5.7467***	Obs = 300
degrees of freedom = 298	

Source: Survey data (2016)

The major benefits of planting crops using row plantation are listed by the households. As stated by the farmers, row plantation have five major benefits namely, easier weeding [1], easier harvesting [2], higher crop yield [3], use less seed [4] and easier pest control [5]. On top of that, the benefits of row plantation have multiple benefits. Thus, in the following table the multiple responses are listed with their frequencies.

Chart 4.2: benefits of row plantation



Source: Survey data (2016)

The average family size of the households was 5.56 with standard deviation of 2.07 and minimum of 1 and maximum of 11 members. The average adult equivalent was 4.8 with standard variation of 1.78 members accompanied by minimum of 0.74 and maximum of 10.34 adult equivalent members. The findings of the study depicted that as the number of family members in the household increases, the technical efficiency also increases too. 6.3 percent of the households having family size of 1-2 had technical efficiency of 51.2 percent.

About 34.33 percent of the household with family size of 3-5 had technical efficiency of 68.1 percent. As the number of household members increased to 6-8, the level of technical efficiency also rose to 75.4 percent and decreased to 74.4 percent in 9-10 family size households and further decreased 69.9 percent when the family size is 11 and above. Thus, we might suggest that level og technical efficiency and family size have directly related to each other.

Table 4.7: Family size of households and level of efficiency

Family size	Freq.	Percent	Cum.	Technical efficiency
[1-2]	19	6.33	6.53	0.512 (0.016)
[3-5]	103	34.33	40.67	0.681 (0.011)
[6-8]	124	41.33	82	0.754 (0.013)
[9-10]	24	8.00	90	0.744 (0.029)
5>=11	30	10.00	100	0.699(0.098)
Total	300	100.00		0.682 (0.038)

Econometrics Analysis

The study from its stochastic frontier model found that the magnitude of technical efficiency varied from one farmer to another and ranged from 42.4% to 75.4%, with a mean of 68.2%. The differences in the technical inefficiency among the farmers is probably caused by farm management practices, the socio economic characteristics of the households and other factors related to natural factors.

The results from the Tobit regression model of the technical efficiency indexes showed that scores of the technical efficiency varied from 42.4% to 75.4%, with a mean of 68.2%.

The result from the Tobit model revealed that age, family size, TLU, row plantation technology, membership of cooperative and access to irrigation are among the major determinants factors of technical efficiency of smallholder farmers producing barley. In this study, household age was found to be negatively related to technical efficiency. This might be because of as age increases households' participation in labor related activities is decreased. On the other hand, family size measured in adult equivalent is found positive and significant. This might be because of efficient utilization of the available labor force in the production efficiency of barley.Total livestock ownership was measured using the standard tropical livestock unit (TLU). In this study, TLU was found positive and significant at ten percent. One explanation for positive association between cash technical efficiency and TLU might be livestock are useful in cultivating land and useful in liquidity effect.

Table 4.8: determinants of technical efficiency of barley production (Tobit Regression)

Variable	Coefficient	Robust standard error	P-Value
HHH age	-.0639421	.0205987	0.002**
HHH gender (male)	.0357281	.1106029	0.747
HHH years of education (primary)	-.0019312	.0063909	0.763
HHH years of education (secondary)	-.0014873	.0057688	0.797
HHH years of education (tertiary)	.0005978	.0084691	0.944
Adult equivalent	.1207017	.0332742	0.000***

Extension service (1=yes)	.0861191	.539241	0.190
Credit take (1=yes)	-.118265	.06031515	0.643
Training participation (1=yes)	.0094242	.0467622	0.840
TLU	.005914	.032773	0.074*
Plantation technology (1=row)	.0204387	.0038395	0.000***
Membership of cooperative (1=yes)	.138255	.24471135	0.023**
Access to irrigation (1=yes)	.0333089	.0041482	0.000***
Constant	-1.552087	.4970916	0.002
/sigma	.0319756	.0013127	

Number of obs = 300

LR chi2(12) = 98.51

Prob> chi2 = 0.0000

Log likelihood = 600.05196 Pseudo R2 = -0.0894

Source: Survey data (2016)

In addition, farmers who have cooperatives are found to be positively affecting technical efficiency. This might be due to the demonstration effect that needs to improve efficiency in production, disseminating agricultural information to the farmers and helped them access to agricultural extension service easily. The result from the Tobit regression model revealed that the production frontier of the farmers who use row plantation as sowing technology is higher than that of the farmers who use traditional sowing technology. This might be due to row plantation technology has benefited like easier weeding, easier harvesting, higher crop yield, use less seed and easier pest control. Last but not the least, the study found that access to irrigation was found to be positive and significant at one percent. This might be because of irrigation might decrease the potential to crop failure and increases the opportunity to multiple cropping.

Conclusion and Recommendation

Conclusion

This paper has attempted to increase the understanding of the technical efficiency and determinant factors of row plantation technology in comparison with traditional sowing technology. More specifically, the aim of this study was to capture the production efficiency (technical efficiency) of row plantation production system with the conventional one using stochastic frontier model and to analyze the socioeconomic variables that may explain the differences in the estimated levels of technical inefficiency.

The results from the two tail test indicate that row plantation technology have a better contribution to farmers production efficiency. Moreover, the result from the Tobit model confirms the significance of row plantation in technical efficiency.

The study found that the magnitude of technical efficiency varied from one farmer to another and ranged from 42.4% to 75.4%, with a mean of 68.2%. Consequently, due to technical inefficiency farmers have lost close to 32% of the potential output. Moreover, the result from the stochastic frontier function revealed that the production frontier of the farmers who use row plantation as sowing technology is higher than that of the farmers who use traditional sowing technology. In line with this, the data collected showed that, the inputs used by the row plantation technology users is much higher than that of traditional technology users.

In general, the result from the Tobit model revealed that age, family size, TLU, row plantation technology, membership of cooperative and access to irrigation are among the major determinants factors of technical efficiency of smallholder farmers producing barley. Thus, the researchers recommend, among others, the farmers who use traditional sowing technology has to upgrade to the row plantation technology to gain the production efficiency. In line with the integration access to irrigation, establishing cooperatives and providing trainings to younger farmers to increase production efficiency.

Recommendation

Policy makers should pay due consideration to these factors that affect the production efficiency.

- Row plantation was found positive and significant in affecting technical production. Thus, farmers should have to get trainings on how to plant seeds, on the use of better techniques and application of fertilizer and other capital equipment. In addition, the regional government should focus in integrating those who use traditional cultivation method to this new technology to achieve more viable production and productivity.
- Encouraging the cooperativeness of youngsters with elders will improve the technical efficiency of old farmers. Thus, the development groups and/or one- five networks should have to consider different age groups to increase efficiency.
- Having many livestock have found to be positively affecting technical efficiency. Therefore, policies that encourage asset accumulation processes through promoting investments in animal traction will create virtuous circle between technical efficiency and assets creation.
- Membership to cooperatives should have to be strengthening to gain extension services and access market information.
- The study found the impact of irrigation on production efficiency is direct and immediate, therefore, there is still potential of integrating farm households' for those who don't use row plantation technology in cropping to gain technical efficiency.
- Lastly, the study leaves for other researchers to study starting from the finding that age of the household head, when gets older, affects production efficiency negatively. That is, is this a lifecycle effect (meaning that the current generation of young farmers may also leave from being efficiency when they get older), or a generational shift? Investigating such questions could assist policy makers in designing strategies to improve currently precarious farming livelihoods, while facilitating a smooth exit from farming for those who wish to take it.

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