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Research article

Technical efficiency of smallholder malt barley producers in Tiyo district (Ethiopia)

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This study analyzed the determinants of technical efficiency of smallholder malt barley producers and estimated their technical efficiency in Tiyo district of Arsi zone, Ethiopia. Data were obtained from 162 randomly selected malt barley farmers. Descriptive statistics and the translog functional form of the production function simultaneously with single stage estimation approach were used to estimate the production of barley output and technical inefficiency factors. The study revealed that the average technical efficiency of the farmers in the production of malt barley is 71%. This reveals that there exists a possibility to increase the level of malt barley yield by 29% utilizing the existing local technical knowledge of efficient farmers. This further implies that it is possible to produce the same output by reducing current input utilization by 29%. The discrepancy ratio (γ), which estimates the relative deviation of output from the frontier level due to inefficiency, was about 61%. This implies that about 62% of the variation in malt barley production among the sample farmers was credited to technical inefficiency while, the remaining 38% comes due to factors outside the control of farmers. The maximum likelihood parameter estimates showed that malt barley yield was significantly influenced by the amount of fertilizers (DAP and UREA), number of oxen, labour, malt barley seed, herbicide usage and land allocated for malt barley. The stochastic production frontier model shows that experience, education status, number of oxen, land size, and extension contact significantly affected technical inefficiency of malt barley production. Therefore, attention should be given to improve the less efficient farmers following the practices of relatively efficient farmers in the area. On top of this, policies and strategies of the government should give due focus for the determinants of technical inefficiencies in malt barley production.

Keywords: Cobb – Douglas; malt barley; stochastic frontier; technical efficiency

Introduction

Agriculture still remains to be the major driver of growth of the Ethiopian economy. This sector contributes to the livelihoods of the community by offering inputs, supplying foods, source of foreign exchange, creating employment opportunities, rising gross domestic product (Ntabakirabose, 2017). It shares about 36% of the GDP, gives employment opportunities to more than 73% of total population, fetches about 70% of the foreign exchange earnings of the country and 70% raw materials for the industries in the country (UNDP, 2018).

Ethiopia is the second largest barley producer in Africa (sharing about 25% of the total barley production in the continent), next to Morocco and ranked 21st in the world (FAO, 2014). Barley is known as the "king of grains" in Ethiopia accounting about 5% of the per capita calorie consumption as a main ingredient in staple foods and local drinks. It is also used as substitute for other cereals in the country and serves as a roof thatch for many households (CSA, 2014).

In Ethiopia, barley is found to have experienced the highest annual fluctuation in area and yield. At the national level from the total area of cereals allocated in hectare, barley covered only 14.65% with the yield of 10.42 quintal per hectare. The total yield of barley has been increased by 5.2% between 2014/15 to the year 2015/16 (CSA, 2016).

The Ethiopian Agriculture is characterized by low productivity which is attributed to different factors (WFP, 2010). Despite the large share of smallholder farmers in agricultural output in the country, they still practicing traditional production technology and using limited modern inputs (WB, 2007). Therefore, improving crop production and productivity is not an issue of preference rather than a must to achieve food security and hence poverty reduction.

According to FAO (FAO, 2011) the average cereal yield for the world and least developing countries were 37.08 and 20.19 qt/ha, respectively, while, the average cereal yield in Ethiopia was limited to 17.60 qt/ha.

Ethiopia is the largest malt barley producer in Sub-Saharan Africa and has a favorable malt barley growing climatic environment. It is primarily grown by subsistence farmers under rain-fed conditions. Although Ethiopia is the largest malt barley producer in Sub-Saharan Africa, it is reliant on foreign malt barley imports to satisfy its annual domestic demand (FAO, 2014). Malt barley is cultivated in the highlands of Ethiopia, mainly in Oromia, Amhara, Southern Nations and Nationalities Peoples and it is the most important cereal crop in Arsi zone, especially Tiyo district.

There is still yield gap between the output obtained from research stations and farmer's field. There are several factors believed to contribute to the low yield including moistures stress, shortage of seeds for improved varieties, degradation of soil fertility, insect pests, diseases and weeds. Previous researches in Ethiopia indicated that there was a broad cereal yield gap among the farmers that might be attributed to many factors such as lack of knowledge and information on how to use new crop technologies, poor management and climate factors (Sisay et al., 2015; Mesay et al., 2013).

Despite the importance of malt barley as a food and industrial crop, its productivity remains far below its potential (CSA, 2013a). Given the existing technology, improvements in the technical efficiency will enable farmers to produce the maximum possible output from a given level of inputs. Hence, improvements in the level of technical efficiency will increase productivity.

Researches on technical efficiency of smallholder agriculture are not extensive, and the conclusion of some of them is not consistent with one another. Therefore, policy inference strained from some observed works may not permit in scheming area specific strategies to be attuned with its socio-economic as well as agro-ecologic circumstances.

Therefore, from the perspective of making successful agricultural policies, improving farm level technical efficiency has a supreme significance in providing valuable information to policy makers which will be used to boost agricultural productivity. This study aims to analyze the technical efficiency of the smallholder farmers' ant its determinants in the study.

Research methodology

This study was conducted in Tiyo district, Arsi zone due to the production potential of malt barley. Arsi zone shares boundaries with East Shewa, West Hararghe, Bale zones and Southern People Nations and Nationalities Regional State. Assela is the zonal capital, located at 175 km south east of Addis Ababa.

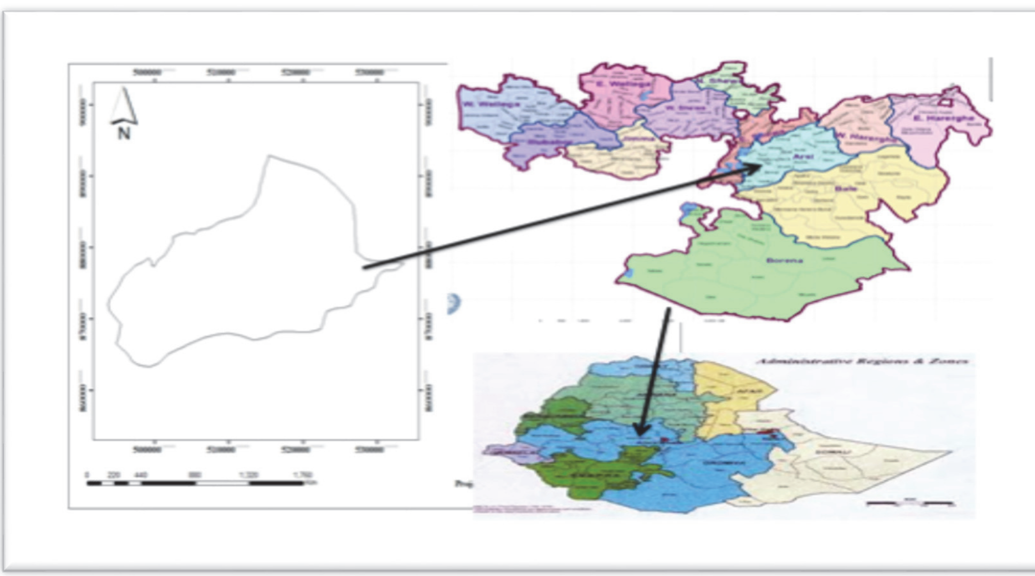

Figure. Location of Tiyo district in Arsi zone

Source: GIS output.

Tiyo district is one of the 24 districts of Arsi zone, Oromia regional state. It is located at 6° 59' to 8° 49' N latitudes and 38° 41' to 40° 44' E longitudes. The farming system of Arsi zone is characterized by crop-livestock mixed farming system. Crop production is carried out in both meher and belg seasons although the main cropping season is meher. Malt barley, wheat, teff, maize, sorghum, faba bean, field peas, lentil, and linseed are the major annual crops grown in the zone.

Crop production is mainly practiced under rain-fed conditions. According to information from district agricultural office, cereals account for 80% of the land covered by crops. The major crops grown and average yields per hectare in the district for barley, wheat and teff are 11, 10 and 6 quintals respectively.

Data types, sources and methods of data collection

Both primary and secondary data sources were used. The primary data was collected from sample households using a structured questionnaire that was administered by the trained enumerator. Secondary data was collected from local administration offices, governmental and non-governmental organizations, published and unpublished documents and central statistical agency which were used as additional information to strengthen the primary information provided by the sample households in the study area.

Methods of data analysis. Data were analyzed using descriptive statistics and econometric models.

Descriptive analysis. This was used to summarize and analyze the sample households socio-economic, demographic and institutional characteristics, used in the frontier production and in the efficiency model.

Variables definition

Production function variables

Output. This is dependent variable defined as the actual quantity of malt barley produced and measured in quintals during the 2016/17 production year.

Seed. This refers to the quantity of malt barley seed used in kilogram (kg) by each household.

Land size. The amount of land used for malt barley production during 2016/17 production measured in hectares.

Fertilizers (Urea and DAP). This refers the total amount of Urea and DAP used in kg for the malt barley production in 2016/17 production year.

Labour. This input captures family, exchange and hired labour used for different agronomic practices of malt barley production in the 2016/17 production season.

Number of oxen. The number of oxen used for malt barley production.

Herbicide. This is the total expenditure of the farmer on herbicide purchase for malt barley production and measured in Ethiopian birr.

Efficiency variables

Age. This refers to age of the household head measured in years. It was expected that farmers with more years of experience are expected to be more efficient in malt barley production (Gosa, Jema, 2016).

Educational status. It is a continuous variable measured in years of schooling of the household head. Farmers with more years of formal schooling tend to be more efficient, most probably due to their improved ability to obtain practical knowledge, which makes them closer to the frontier (Jema, 2008; Mustefa, 2017).

Family size. It is a continuous variable which was defined as the total number of people living with the household. Family size could have a positive effect in raising the farmer's production efficiency (Musa et al., 2015; Sisay et al., 2015).

Livestock holding. It is a continuous variable which is the total number of livestock owned by farmers measured in terms of Tropical Livestock Unit (TLU). According to the study (Tiruneh, Geta, 2016; Mustefa, 2017) livestock holding were found to positively affect efficiency.

Land size. It is a continuous variable measured hectare. Because of improper input usage and managing skill farmers who cultivated large farms are less efficient than the other (Sisay et al., 2015; Saulos, 2015). This was hypothesized that farm size negatively affects the efficiency of malt barley producers in the study area.

Non-farm activity. It is a dummy variable which takes a value 1 if the household members participate in nonfarm activity and 0, otherwise. According to Kifle et al. (2017), participation in non-farm activity could have positive effect on efficiency. This was hypothesized that participation in non-farm activity positively affects the efficiency of malt barley producers in the study area.

Credit. It is a dummy variable which takes a value 1 when the household uses credit for agricultural reason and 0, otherwise. This was hypothesized that farmers who have used credit were more efficient than others (Musa et al., 2015; Kifle et al., 2017).

Market distance. This is the distance between a household home and the nearest market center measured in km. It was hypothesized that the distance from the market place is negatively related to efficiency (Musa et al., 2015).

Extension contact. This is a continuous variable measured by the frequency of contacts made by development agents in relation to malt barley production with the farmers. It was hypothesized that a high frequency of contact with the development agent positively affects efficiency (Assefa et al., 2016).

Land disintegration. This is defined as the number of plots that the farmer has managed during the production season. Land disintegration leads to inefficiency by creating a shortage of family labour, costing time and other resources (Wondimagegn, 2010).

Soil fertility. This was measured as a dummy variable that takes a value of 1 if a household perceives his/her land as fertile and 0, otherwise. This was hypothesized that a farmer who allocated a fertile land for malt barley production was more efficient than counterparts (Hika, Jema, 2016).

Sex. This is a dummy variable that takes a value of 1 if the household head is male and 0, otherwise. It is hypothesized that male-headed households are more efficient than female-headed households in malt barley production (Fantu et al., 2011).

Results and discussions

Demographic and socio-economic characteristics of sample households. Average age of sample household heads was 46.54 years. The average family size of the sampled household heads was 7.36 with the standard deviation of 2.16. This big family size attached with small land size and traditional production system created difficulty for the farmers in their livelihood.

Education enhances the acquisition and utilization of information on improved technologies by farmers as well as their innovativeness. Education together with increased experience could direct farmers to better management skills. The educational level of the household head, on average, was 5.17 years.

Table 1

Socio-economic characteristics of sample households

Variables	Mean	Standard deviation
Age (years)	46.54	11.00
Education status (grade)	5.17	3.27
Family size (number)	7.36	2.16
Land size (ha)	2.42	1.05
Number of oxen	3.40	1.27
Market distance (km)	76.48	62.68
Annual farm income (1000 ETB)	41.67	22.82
Annual non-farm income (1000 ETB)	3.50	9.46

Source: Authors computation (2016).

Potential crops grown in the study area. Wheat, maize, sorghum, teff, finger millet, barley, and bean are the major crops grown in the study area.

Table 2

Yield of the major crops in the study area

Crops grown	Production (Qt)	Land allocated (ha)
	Mean	Mean
Wheat	26.13	0.88
Sorghum	7.16	0.43
Teff	4.35	0.26
Finger millet	2.60	0.13
Maize	18.73	0.61
Malt barley	17.36	0.67
Bean	1.70	0.17

Source: Authors computation (2016).

Summary of variables used to estimate production function

Table 3

Descriptive statistics of both input and output variables

Variables	Minimum	Maximum	Mean	Standard deviation
Family size (number)	2	14	5.80	9.82
Area (ha)	0.12	2.30	0.80	1.30
Oxen	1	16	2.80	3.56
Output (quintal)	3	51	14.74	8.90
Seed (kg)	15	200	60.23	18.62
DAP (kg)	30	250	60.22	17.16
Urea (kg)	15	150	42.60	16.00
Herbicide(birr)	35	280	122.30	34.51

Source: Authors' computation (2016).

Econometric model results. The model result showed that, from the six variables considered in the production function, four inputs (land, seed, oxen, and labour) had a significant effect in explaining the variation in malt barley yield among sampled farmers. When there is a 1% increase in the area of land, seed, oxen and labour allocated for malt barley production, mat barley yield would increase by 0.29, 0.22, 0.18 and 0.19% respectively. This is consistent with the finding of Mustefa (2014). The diagnostic statistics of inefficiency reveals that sigma squared (δ^2) 0.283 was statistically significant at 1% indicating the goodness of fit and the accuracy of the distributional form assumed for the composite error term.

Efficiency score of malt barley producers in the study area. The model results revealed that there were great differences in technical efficiency among smallholder malt barley farmers in the study area. The mean technical efficiency of sampled farmers was found to be 71%. This shows that malt barley farmers have an opportunity to efficiently utilize resources and hence could increase the current malt barley output by 29% using the existing technology.

Table 4

Summary statistics of efficiency score of sample households

Variable	Mean	Standard Deviation	Minimum	Maximum
TE	0.711	0.211	0.241	0.942

Source: Authors computation (2016).

Determinants of efficiency in malt barley production. To identify the technical efficiency status which was derived from stochastic frontier were regressed on factors that were hypothesized to affect efficiency levels using Tobit model. The results of the Tobit regression model showed that among the hypothesized variables five variables namely education status, family size, soil fertility status, extension contact and credit utilization were found to be statistically significant in determining the producers' level of technical efficiency in the study area.

Table 5

Tobit model results of determinants of technical efficiency

Variable	Technical efficiency	
	Coefficient	Standard Error
Age (years)	0.122	0.0214
Education status (grade)	0.071***	0.0143
Family size (number)	0.213*	0.0072
Livestock holding (TLU)	–0.162	0.0018
Soil fertility (dummy)	0.063**	0.0548
Sex (1 = male, 0 = otherwise)	–0.072	0.0152
Cultivated land (ha)	0.031	0.0217
Extension contact (number per month)	0.082***	0.0100
Credit utilization	0.055***	0.0196
Non-farm income	0.087	0.0321
Distance from market	–0.022	0.0215
Constant	0.421	0.0761

Note: *, **and *** significant at 10, 5 and 1% level of significance respectively.
Source: Authors' computation (2016).

The education status was positively and significantly affected technical efficiency at 1%. This implies that more educated farmers are more technically efficient than those who have relatively less level of education. Besides, one-year increase in educational status of the household head increases the probability of the farmer being technically efficiency by 7.1%.

The coefficient of family size is positive and statistically significant at the 10% significance level. The result implies that farmers with large family size are more efficient than farmers having small family size because family labour is the main input for crop production. This result is similar to the findings of S. Deme et al. (2015).

The result also reveals that soil fertility was positively and significantly related to technical efficiencies at 5% level of significance. This implies that farmers who have allocated fertile land for malt barley production were more technically efficient than their counterparts. Similar result was reported by A.E. Awol (2014).

Frequency of extension contact also found to be significant at 1% level of significance. Farmers who had more contacted with extension workers during the production period were technically more efficient than their counterparts.

Conclusion and recommendations

The stochastic frontier Cobb – Douglas production function depicted that the amount of fertilizers, number of oxen, herbicides and land allocated for malt barley significantly determined production level of malt barley. The mean technical efficiency level of 71% indicates that production can be increased by 29%. The stochastic production frontier model show that age, education status, land ownership, soil fertility, and frequency of extension contact have negative and land disintegration has positive and significant influence on the inefficiency of farmers.

The government has to give due attention for strengthening both formal and informal education using the existing infrastructural facilities like extension agents and Farmers Training Centers.

Development programs need to strengthen land management practices to progress and maintain the fertility of soil to increase efficiency of farmers. Given the existing technology, enhancing the advisory services of extension agents to the malt barley producers can improve the technical efficiency. The commitment of extension workers are highly appreciated an expected in the study area.

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Научная статья

Техническая эффективность малых производителей ячменного солода в районе Тийо (Эфиопия)

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Исследование посвящено оценке технической эффективности малых предприятий – производителей ячменя на примере района Тийо (Эфиопия). Статистической базой послужили данные 162 производителей ячменя. Исследование показало, что средняя техническая эффективность производителей ячменя составляет 71 %, при этом сохраняется возможность повысить уровень урожайности еще на 29 % за счет уже существующих и используемых производителями технологий. Расчеты, проведенные авторами, показали, что коэффициент расхождения (γ), оценивающий относительное отклонение выпуска от пограничного уровня из-за неэффективности, составил около 61 %. Исследование показало, что урожайность солодового ячменя находится в прямой зависимости от объема использованных удобрений, технической оснащенности, качества и количества посевного материала, площади использованных земель. Опыт наиболее эффективных фермеров может послужить хорошим примером для производителей с наименьшей эффективностью и выпуском продукции. Наряду с этим государственная политика и меры в области улучшения технической составляющей фермерских хозяйств могут послужить дополнительным толчком для развития данной отрасли.

Ключевые слова: ячменный солод; техническая эффективность; стохастическая граница; производственная функция Кобба – Дугласа

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