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REGULAR ARTICLE

TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCIES OF SMALL-SCALE SESAME FARMERS: THE CASE OF WEST GONDAR ZONE, ETHIOPIA

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ABSTRACT

In Ethiopia, sesame is mainly cultivated as a cash crop, important source of foreign exchange and income for many smallholders. Thus, improvement in production efficiency of sesame is crucial for Ethiopian economy and for smallholder farmer's livelihood. Socioeconomic, demographic and institutional factors were collected from randomly selected 385 sample households using multi-stage sampling techniques and interviewed using semi-structured questionnaire. The Cobb-Douglas stochastic frontier production function result shows that all input variables except land was positive and significant effect on sesame production efficiency. Labour inputs have the highest elasticity, followed by sesame seed, pesticides/herbicides and fertilizer accordingly. The model result shows that across all mean technical, allocative, and economic efficiencies estimates are 72, 49 and 35 percent respectively, implies that a substantial level of inefficiency in sesame production. Improvement of production efficiency requires availability of enough labour particularly during harvesting because of its shattering problem. Therefore, the local and regional government needs to devise mechanisms for hired labour availability in the area. Moreover, the econometric model result indicates that sesame production efficiency was positively and significantly influenced by age, education level, livestock ownership, association membership, off/non-farm income, extension contact, credit access, mobile phone ownership and training participation. The key policy implication therefore is that promoting farmer's cooperatives, address farmers in formal and informal education programs, enhancing farmer's access to financial resources through providing easy and affordable credit services, strengthen the extension services in terms of promoting livestock and crop production improving technologies are crucial.

Keywords: Technical, allocative and economic efficiencies, double-hurdle and PSM models
JEL: D13, D24, E23, M11

INTRODUCTION

The oilseeds sector in Ethiopia have been growing fast and the more useful sectors in terms of country's economy as well as income sources for more than 3.7 million smallholders (**CSA, 2014**). The previous study reports indicated that Ethiopia has been ranking 5th in sesame production after Myanmar, India, China and the Sudan until 2010 and recently, some African countries such as Tanzania, Mozambique and Mali have increased their sesame production aggressively by rapidly increasing their area and yield which consequently, Ethiopia gave way its rank to Tanzania since 2011 mainly because of decline in area (**FAOSTAT, 2015**). According to **CSA, (2014)** report on sesame production extent by smallholders and medium/large commercial farms, a total of 420,495 hectares of land devoted for sesame cultivation by about 867,347 smallholder farmers, while 276,701 hectares were cultivated by medium and large commercial farms in 2014. Sesame production was estimated about 95% have been grown mainly for the export market and only 5% is believed to be consumed locally (**CSA, 2014; FAOSTAT, 2015**).

Amhara, Oromiya, Tigray and Benshangul-Gumuz are the major sesame producer regions in Ethiopia with the dominant specific producer areas of *Humera, Gondar and Wollega* (**Wijnands *et al*., 2007; Dawit and Meijerink, 2010; CSA, 2011**). The three well known types of sesame in the international market that have been grown in the country are: the *Humera, Metema* and *Wellega* types. Their names are derived from the areas in which they are produced (**Mbwika, 2003**). The *Wellega* type is used for oil extraction due to its high oil contents. The *Humera* and *Metema/Gondar* types are preferred mainly for confectionery purposes due to the whitish colour, purity, and good taste (**Zerihun, 2012**). In *Amhara* region, sesame is one of the major and economically important commodity crop produced by small-scale and medium/large-scale farmers. According to **CSA (2015)**, the highest proportion of the country's total sesame production comes from the *Amhara* regional state accounts 48.84%, while 24.52% from *Tigray* and 16.59% from *Oromiya* region. Out of the region, West Gondar zone is the main sesame producing area at small-scale and medium large-scale levels. In West Gondar zone particularly in *Metema* and *Quara woredas*, smallholder sesame farming usually involves an area of one to ten hectares per household, however, the average productivity levels estimated by the local *woreda* offices was at between 300 and 500 kg/hectare which shows poor performance as compared to yield potential per hectare under good management condition that reaches as high as 3000 kg/ha (**SBN, 2014; Abadi, 2018**). Despite sesame is the most important crop, its productivity remains too low that might be resulted from production inefficiency. The previous empirical studies conducted on the area of sesame production efficiency, for instance by **Kostka and Scharrer (2011), SBN, (2014)**, **Ermiyas *et al.* (2015), and Abadi, (2018)** focused on volume of sesame production, challenges and opportunity, but no empirical study attempt in the study area. Thus, research in the area of technical, allocative and economic efficiencies of sesame and its determinants are vital for understanding the problems related to sesame production efficiency. Therefore, this study provides knowledge and information for policy makers, extension service providers and helps to share experiences among sesame producers.

DATA AND METHODS

Study area

The *Amhara* National Regional State of Ethiopia is divided into 13 administrative zones and 139 districts. The study conducted in the West Gondar zone located in the north–western part of the *Amhara* national regional state, 360 km far from the capital of the region, Bahir Dar. The elevation of the study area ranges between 550 and 1600 meters above sea level. West Gondar zone comprises 2 rural districts namely *Quara and Metema* where the study was conducted. These districts are located along the border of Sudan characterized by higher temperatures and fragile soils. The area is categorized under lowland that contains some of the largest tracts of semi-arid natural forest remaining in Northern Ethiopia. According to the projected evidence from the official census of 2007, the two sample districts population reaches about 2,606,963 which male is 50.6% and female is 49.4%. The study area is largely characterized by mixed farming system. The major crops that have been producing by smallholder farmers are sesame, sorghum and cotton used for sale and home consumption. Moreover, the major livestock species kept in the study areas are cattle, goats, sheep, and equine which serves as a source of draught power, transport, income, food, fuel and manure. Despite sesame is the major cash crop in the area, its productivity is very low as compare to the national average. This might be due to farmer's inefficiency of practices. However; there was no a study attempt on sesame production efficiencies and their determinants in the study area. Therefore, this study aimed to obtain information in terms of technical, allocative and economic efficiencies and the factors influencing these efficiencies in order to decide on the mechanisms to improve sesame production.

Sampling techniques and the data

The study applied cross-sectional data of 2017/18 production year. A multi-stage sampling procedure was used. At the first stage, all districts of the zone *Metema*, and *Quara* districts were taken as censured survey. At the second stage, six *kebeles* namely *Shinfa, kokit, Das Michael, Dubaba, Bambaho and Fershaho* were selected randomly out of 48 sesame producer *kebeles*. At the third stage, the list of sesame producers was obtained from respective agriculture development office, and then stratified according to their adoption category. Finally, a total of 385 households selected based on probability proportional to sample size technique.

Analytical methods

Stochastic Frontier Model was introduced by **Aigner *et al.* (1977)** and **Meeusen and Van den Broeck (1977)**; the method takes into account the random error and the inefficiency component simultaneously that technical, allocative, and economic efficiency scores derived by estimating the stochastic production frontier. This study followed the general stochastic production frontier functional form represented by:

$$lny_i = \beta_0 + \sum_{j=1}^{n} \beta_i \, lnX_i + v_i - u_i \quad (1)$$

Where: y is the total quantity of sesame produced in kilogram; X_1 represents the land under sesame cultivation in hectare on the i^{th} farm; X_2 represents family and hired labour used for sesame production (man/days) on the i^{th} farm; X_3 denotes chemical fertilizer in kilogram applied to land for sesame production of the i^{th} farm; X_4 denotes the amount of sesame seed used in kilogram and X_5 represents chemical such as pesticide and herbicide in litters applied for sesame production of the i^{th} farm; β_j j = 1, 2, ...5 are parameters to be estimated; v_i is a symmetric random error which represents random variations, or random shocks assumed to be independent and identically distributed N (0, σ^2). The error term u_i is a one-sided non-negative variable which measures technical inefficiency of the i^{th} household, the extent to which observed output falls short of the potential output for a given technology and input levels.

Followings the above estimated Cobb-Douglas production function in Equation (1), explain Technical Efficiency (TE) of sesame farming. TE is the ability of a farmer to obtain maximum (optimal) output from a given set of inputs and technology. Estimation of TE for individual farm is predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. The TE for the i^{th} farm can be computed as Eq. 2.

$$TE = \frac{actual\ output}{potential\ output} = \frac{y}{y_i^*} = \frac{\exp(X_i\,\beta + v_i - u_i)}{exp\ (X_i\,\beta + v_i)} = \exp(-u_i) \quad (2)$$

Where: TE is technical efficiency, the inefficiency term u_i is always between 0 and 1, When u_i is equal to zero, then production is on the frontier $y_i^* = exp\ (X_i\beta + v_i)$ and TE = 1, therefore a farmer is technically efficient, when u_i is greater than zero ($u_i > 0$), the farmer is technically inefficient (TE < 1), since production is below the frontier. Similarly, based on the estimated production frontier in Equation (2), the study computed the dual cost frontier in Equation (3) and this forms the basis of computing the EE and AE of sesame production. The dual cost frontier was computed as Eq. 3.

$$lnTC = \beta_0 + \sum_{i=1}^{n} \beta_i \, lnX_i + v_i + u_i \qquad (3)$$

Where: TC is total cost of production in ETB, X_i are prices of land, labour, chemical fertilizer, seed and pesticides, while β_0 and β_i are parameters to be estimated. v_i and u_i are as specified earlier but with positive sign of the inefficiency term since inefficiency factors raise the cost of production. The technical efficiency (TE) and allocative efficiency (AE) can be combined to give the economic efficiency (EE) (Eq. 4)

$$EE = TE * AE \qquad (4)$$

The effect of demographic, socio-economic and institutional factors on sesame production efficiency was analysed using OLS regression model (Eq. 5).

$$y_i = \beta_0 + \beta_{1j} X_{1j} + _{\dots}\beta_{nj} + X_{nj} + e_i \qquad (5)$$

Where, y_i is the efficiency score of sesame production,
β_0 is the intercept
β_{1-n} is the coefficient of j[th] explanatory variable to be estimated and
ε_i is the error term assumed mean zero and constant variance.

Definition of variables, measurement and hypotheses

With regard to this study, the level of sesame production efficiencies is hypothesized to be influenced by a combined effect of demographic, socio-economic and institutional factors. Summary statistics of variables used in the OLS model depicted in Table 1.

RESULTS AND DISCUSSION

Table 2 shows the coefficient of land, labour, fertilizer, seed (improved and local), and chemicals (pesticides and herbicides) of stochastic frontier model of Cobb-Douglas production function in sesame production process. Except land, the signs of all the slope coefficients of the production function are positive and significant. This implies that most inputs (labour, fertilizers, seed and pesticides) have turned out to be significant in determining sesame output; that is, sesame output is responsive to inputs utilization. The coefficients associated with the inputs measure the partial elasticity of output with respect to the respective inputs.

The sum of elasticities of the five inputs (land, labour, fertilizers, sesame seed and chemicals) were 1.229 i.e. scale elasticity is greater than one. The result indicated that sesame production function exhibits increasing returns to scale that the first stage economic region of production function which implies that increasing input utilization is advisable because the proportionate increase in all inputs results less than proportionate increase of sesame output.

The maximum likelihood estimate shows that sesame output elasticities associated with labour, chemical fertilizer, seed (improved and local) and chemicals (pesticides and herbicides) were positive and significant in sesame production, while land size allocated for sesame production was not significant in the overall respondents.

The elasticity of output due to labour input was the highest (0.565) indicating that there was relatively more proportionate change in output due to proportionate change in supply of labour, followed by elasticity of output due to sesame seed (0.271), pesticide and insecticide chemicals (0.145) and fertilizer (0.028) accordingly.

Table 1: Description of the variables hypothesized to influence sesame production efficiency

Variable	Variable description	Measurement	Sign
Demographic characteristics			
Age	Age of the household head	Years	+/-
Household size	Person per household	Adult equivalent	+
Education level	Education level	Years	+
Farming experience	Sesame farming experience	Years	+
Socio-economic characteristics			
Livestock holding	Livestock owned	TLU	+
Oxen	Oxen owned	Number	+
Off/non-farm income	Off and/or non-farm income	ETB	+/-
Soil fertility	Farm land soil fertility	Poor/good	+/-
Mobile cell-phone	Mobile phone ownership	Dummy (1 own, 0 otherwise)	+
Association membership	Association membership	Dummy (1 member, 0 otherwise)	+
Institutional characteristics			
Extension contact	Extension contact	Frequency	+
Training participation	Training participation	Dummy (1 participate, 0 otherwise)	+
Market distance	Market distance from residence	km	-
Farm distance	Distance of farm from agent office	km	-
Access to formal credit	Credit access	Dummy (1 has got credit, 0 otherwise)	+

Table 2: Maximum likelihood estimates of elasticities of output

	ML estimates		OLS estimates	
Variable	Coefficient	St.err	Coefficient	St.err
Constant	3.928***	0.136	3.517***	0.241
Ln(land)	0.220	0. 198	0.210	0.201
Ln(labor)	0.565***	0. 109	0.585***	0.111
Ln(fertilizer)	0.028***	0. 007	0.026***	0.008
Ln(Improved and local seed)	0.271***	0. 081	0.265***	0.088
Ln(chemicals)	0.145***	0.030	0.147***	0.032
Wald $\chi 2$ statistic	1356.68***			
Sigma2 (total error variance)	0.254***	0.033		
Lambda	2.130***	0.069		
Log-likelihood	-132.75			

Source: Model result

The overall mean technical efficiency were 71.8 percent with minimum and maximum technical efficiency of 32.2 and 93 percents respectively. Therefore, given the current state of technology and input levels, there is an opportunity of the scope of increasing sesame output by up to 23 percents on average. The estimated lambda value is the estimate of variance parameter and shows significant at one percent level of significance implying that there is a high variation in sesame output due to the presence of production inefficiency. This result is confirmed by conducting a likelihood ratio test to compare OLS model versus frontier model in representing the surveyed data. Wald chi-square test statistic provided a statistic of 1356.68, which is significant at one percent level of significance implying that the model is well fitted and rejecting the adequacy of the OLS model in representing the data.

Allocative Efficiency

To maximize the profit of sesame production, farmers have to choose the best combination of inputs given the prices of inputs and output. With the optimal combination of inputs, output could be produced at a minimal cost. Thus, for this study, allocative efficiency was estimated from a single sesame output and input variables such as land, labour, chemical fertilizers, sesame seed and pesticides/herbicides. These all variables were transformed into natural logarithms, and Stochastic Frontier Cobb-Duglas cost function was estimated by maximum likelihood method.

The cost of production was measured in Birr, price of land was estimated based on the rental value of land in Birr per hectare per year, daily wage rate was used to value labour, and average prices of DAP and UREA fertilizers are in Birr per kilogram. Average price of improved and local sesame seed and average price of pesticides per kilogram was used. Standing from the estimated parameters, the basis of computing AE (allocative efficiency) is the dual cost frontier given by Eq. 6.

$$LnC_i = 3.321 + 0.297lnC_{land} + 0.465lnC_{labour} + 0.326lnC_{fertilizer} + 0.019lnC_{seed} + 0.032lnC_{chemical} + 0.017lnY_{prod} \quad (6)$$

Where: C_i is the cost of sesame production for the i[th] farmer, C_{Land} is the rental price of land per hectare, C_{Labour} is the price of labour per day, $C_{Fertilizer}$ is the price of chemical fertilizer per kg, C_{seed} is average price of improved and local seed per kg, $C_{chemical}$ is average price of pesticide and herbicide per kg and Y_{prod} is total sesame output in kg of the i[th] farm.

Table 3: Maximum likelihood estimates of inputs

Variable	Coefficient	St.err	z-value	p >z
Ln (land rent)	0.2972***	0.0144	20.60	0.000
Ln (wage)	0.4656***	0.0302	15.41	0.000
Ln (fertilizers price)	0.3260	0.2250	1.45	0.147
Ln (seed price)	0.0192*	0.0116	1.66	0.098
Ln (chemical price)	-0.0321	0.0265	-1.21	0.227
Ln (output)	0.0176**	0.0087	2.02	0.043
Constant	3.321***	0.6076	5.47	0.000
Wald $\chi 2$ statistic	788.05***			
Sigma2 (total error variance)	0.1009	0.0075		
Lambda	29.645	0.0127		
Log-likelihood	152.745			

****, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.
Source: Model results

The Wald test gives significant chi-square statistic (788.05) and proves the rejection of the null hypothesis that the coefficients are equal to zero. This means, the effects of the coefficients are significantly different from zero (Table 3). The maximum likelihood estimates of allocative efficiency revealed that the coefficients of Cobb-Douglas stochastic frontier cost function. Across all sample respondents, except chemical fertilizer and pesticide/herbicide chemicals, all input coefficients are statistically significant at 1 and 5 percent significance levels. The effects of prices (rent) of land, labour wage, prices of sesame improved and local sesame varieties and output were positive on the cost of production. However, the effects of chemicals (pesticide or herbicide) prices were negative but insignificant that indicates when price of chemical inputs increase, farmers tend to use less of them and allocate resources for other inputs (labour, land, improved sesame varieties). The mean allocative efficiency of sample farmers' is estimated at 49% with a minimum of 29.9% and maximum of 90.4%. The calculation of allocative efficiency in the study indicates that, farmer reveals 46 percent increase in output by improving allocative efficiency, with the existing inputs and technology level.

Economic Efficiency

The combined effects of technical and allocative efficiencies provide economic efficiency, that is economic efficiency is determined on multiplying technical efficiency by allocative efficiency. Based on this, the average economic efficiency was 35% with a minimum of 14.3% and a maximum of 83.1%. This result shows that if the average farmer can reach to the economic efficiency level of the most efficient counterpart, then the average farmer could obtain 58% increase in output by improving both economic and allocative efficiencies with the existing technology. In general, the analyses show that the sample households are inefficient technically, allocatively and economically in sesame production. Thus, there is a potential to improve households' sesame output with the existing technology level.

Factors Affecting Technical, Allocative and Economic Efficiency

Using STATA version 13, the coefficients of the factors hypothesized to affect efficiency were estimated along with the elasticities of sesame output with respect to inputs. The efficiency scores were dependent variables while the independent variables were demographic, socio-economic and institutional factors that can affect the efficiency of sesame production. These factors include age, education level, sesame farming experience, family size, livestock holding size (TLU), number of oxen, off/non-farm income, soil fertility, mobile phone ownership, association membership, extension contact, training participation, distance from nearest market, sesame farm distance from development agent office and access to formal credit. Before running the regression model, the multi-collinearity problem was tested using variance inflation factor (VIF) and no problem of multicollinearirty.

The model result shows that age of the household head, education level, livestock owned in TLU, off/non-farm income, mobile phone ownership, association membership, extension contact, training participation and credit access were significantly and positively/negatively affect efficiency of sesame production at 1%, 5% and 10% significance levels (Table 4). Therefore, the significant variables were the main factors affecting household's sesame production efficiency. The positively related factors to efficiency indicate a yield improving effects and raise the level of observed output of the household. On the other hand, the negatively related factors to efficiency indicate yield reducing effects on level of observed output of the household.

A negative and statistically significant relationship between age of the farmer and EE at 10 percent level of significance indicates that when a one year increase in age of household head, the probability and level of economic efficiency (EE) decreased by about 0.16 percent. The variable education level of the household head has a positive and significant relationship with the AE and EE of sesame production at 1% significant level. The result implies that better educated household heads are expected easily understand the effect of agricultural technologies and have higher tendency to adopt improved farm inputs that leads to better efficiency than less educated ones. Thus, a one year increase in educational level of the household head could bring an overall increase in the levels of AE and EE efficiencies by 0.67 and 0.6 percents respectively. The number of livestock owned in TLU has also positive and significant effect on AE in sesame production at 10 percent level of significance. The result shows that farmers who owned more livestock are economically more efficient than those who owned less livestock ownership in sesame production. This might be due to farmers who owned more livestock could generate additional income, able to buy farm inputs and able to have a source of power for traction. Therefore, a unit increase in TLU increases the level of AE by 0.18 percent. The relationship of off/non-farm income has a positive and significant effect on TE at 10 percent significance level. Hence, a farm household generating additional income from other sources in sesame production would increase TE by 0.31 percent than those have income from farm activities only. Moreover, the variable association membership with TE in sesame production is positive and significant at 10% level of significance. This is because farmers who are a member of association will have a chance to obtain current information, opportunity to receive credit for purchase of farm inputs, etc. that makes a producer to be more technically efficient in sesame production. Being a member of an association would increase an overall increase in level of TE efficiency by 3 percent. This result is similar with the study done by **Gashaw *et al*. (2014)** used household survey data from Ethiopia and evaluated the impact of agricultural cooperatives on smallholder's technical efficiency in crop production.

The relationship of extension contact with AE and EE in sesame production is positive and significant at 1% and 5% level of significances respectively. That is, farmers who had more number of extension contact during the cropping and marketing period were allocatively and economically more efficient than those who had less number of extension contact during similar period. Thus, extension contacts have contributed significantly to AE and EE of sesame production in the study areas. Increase in the frequency of extension contact by one would increase level of allocative and economic efficiencies by 0.77 and 0.49 percent respectively. Similar finding was registered by **Aye and Mungatana (2011)**, who found that extension agents provide farmers with new information on improved agricultural technologies, thus, farmers who had more number of contacts with such agents improved their access to improved inputs and farming management practices thereby increased their production efficiencies. With regard to the effect of the dummy variable training on sesame farming efficiency, a positive and significant effect was observed on AE and EE at significance level of 5% that implies farmers who participated in training performs better in sesame farming than non-participants. Thus, participation in training increases the levels of AE and EE by 4.3% and 3.5% respectively.

The unexpected results such that the negative and statistically significant effect of credit access and mobile phone ownership at five and one percent significance levels on TE, AE and EE was interesting. With regard to credit access, the reason might be the existing bureaucratic and long process to obtain credit service that causes waste of working time might lead to inefficient in production. Hence, access to formal credit decreases the levels of AE and EE by 3 percent and 2.7 percent respectively. Similarly, the negative effect of mobile phone ownership might be due to lack in analysing and interpreting the inflow of information through the mobile phone. Thus, use of unprocessed data might cause for the wrong decisions and lead to inefficiency of production. Therefore, ownership of mobile phone decreased TE, AE and EE by 4.1, 5.1 and 6.2 percents respectively. This finding is not consistent with the research results of **Sisay *et al.* (2015)**, studied efficiency of maize production and its determinants using parametric stochastic frontier production function applying Cobb- Douglas production function and Tobit model respectively for smallholder maize producing farmers in Jimma zone of south western Ethiopia.

CONCLUSION AND POLICY IMPLICATION

The study found the existence of substantial technical, allocative and economic inefficiency in sesame production in the study area. The Cobb-Douglas stochastic frontier production function result shows that all input variables except land was positive and significant effect on sesame production. Labour inputs have the highest elasticity, followed by sesame seed, pesticides and fertilizer inputs accordingly. The model result shows that the overall mean technical, allocative, and economic efficiency estimates were 72, 49 and 35 percent respectively. This implies that sesame production can be increased on average by 52 percent through improving efficiencies with the existing technology.

The estimated regression model result indicates that technical efficiency (TE) of sesame production was positively and significantly influenced by the variables such as association membership and off/non-farm income and negatively and significantly by mobile phone ownership, while allocative efficiency (AE) was affected positively and significantly by education level, livestock ownership, extension contact and training participation, but negatively and significantly by credit access and mobile phone ownership factors.

Table 4: Regression results on technical, allocative and economic efficiency

Variable	Technical efficiency		Allocative efficiency		Economic efficiency	
	Coefficient	Std.error	Coefficient	Std.error	Coefficient	Std.error
Age	-0.0000	0.0011	-0.0016	0.0011	-0.0016*	0.0009
Education	-0.0023	0.0026	0.0067**	0.0026	0.0060***	0.0023
Experience	-0.0010	0.0011	-0.0002	0.0011	-0.0002	0.0010
Family size	0.0005	0.0059	-0.0022	0.0058	-0.0020	0.0051
Livestock	-0.000	0.0010	0.0018*	0.0010	0.0014	0.0009
Oxen	0.0042	0.0034	-0.0037	0.0033	-0.0010	0.0029
Off/non-farm income	0.0031*	0.0017	0.0007	0.0017	0.0016	0.0015
Soil fertility	0.0031	0.0149	0.002	0.0146	0.0181	0.0128
Mobile phone	-0.0414**	0.0174	-0.0514***	0.0170	-0.0624***	0.0150
Association	0.0308*	0.0178	-0.0284	0.0174	-0.0049	0.0153
Extension contact	0.0014	0.0028	0.0077***	0.0027	0.0049**	0.0024
Training	0.0129	0.0163	0.0431***	0.0159	0.0359**	0.0140
Market distance	-0.0020	0.0012	0.0007	0.0012	0.0010	0.0010
Farm distance	-0.0011	0.0010	0.0005	0.0010	-0.0001	0.0009
Credit access	-0.0075	0.0163	-0.0337**	0.0150	-0.0273**	0.0132
Constant	0.7298***	0.0444	0.6440***	0.0434	0.4948***	0.0382

****, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.
Source: Model results

The economic efficiency (EE) was also influenced by age of the household head, credit access and mobile phone ownership negatively, while positively and significantly by education level of the household head, extension contact and training participation variables. In view of the study results, smallholders were inefficient in sesame production in the study areas that needs attention as it provides significant source of enhancement in sesame output. Therefore, in order to raise sesame production and improve the livelihood of smallholders towards food security, the attention of policy makers should give due attention on improving the existing level of the inefficiencies of sesame producer farmers besides improved farm inputs. These inefficiencies, however, can be improved if major factors that determine sesame production efficiencies are identified.

The significant positive effect and higher elasticity of production inputs indicates the importance of production inputs in sesame production. This implies that enhanced access and better use of production inputs could lead to higher sesame production in the study areas. Therefore, the key policy implication is providing easy or free of bureaucratic and affordable credit services as the high cost of hired labour, improved sesame variety and chemical fertilizer are most frequently mentioned problems. Sesame farming requires availability of enough labour particularly during harvesting period because of seed shattering problem. Therefore, among the production inputs, labour input was the first crucial and very important factor in order to improve farm efficiency. Thus, local and regional government needs to plan in facilitation of hired labour availability in the area using different mechanisms.

Moreover, education level is an important factor in AE and EE improvement. Creation of education opportunity for all farmers and encourage them to attend formal and informal education is the key policy issue in the study area. Thus, farmers can change their perception towards the benefit of current information, able to search and use it properly. Household's livestock holding size affected AE of sesame producing farmers positively. Therefore, the study suggested that enhancing the existing livestock production system by providing improved health service and skill training on livestock management leads to improved efficiency. Similarly, association membership of a household plays a positive role in affecting the TE. This need strengthening the existing association structures and organizing new farmer's associations such as farmers marketing groups and cooperatives for common benefits that can improve efficiency.

The positive effect of extension service on AE and EE requires strengthening the existing extension service provision mechanism in terms of providing technical support through applying frequent visit of development agents to the farmer's sesame farming fields. The significant influence of training on AE and EE needs policy focus in terms of providing skill training particularly on sesame farming like improved farm inputs and information utilization techniques.

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