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Research article

Do smallholder farmers ensure resource use efficiency in developing countries? Technical efficiency of sesame production in Western Tigrai, Ethiopia

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ABSTRACT

The study was designed to analyze the technical efficiency of input use among the sesame producer farmers' in Maykadra Kebelle, Kafta-Humera district, Tigrai, Ethiopia; identified factors that influence farmers' resource use efficiency. Primary and secondary data sources were used and random sampling method was applied to select 187 sample sesame producers. Primary data were collected using structured questionnaire interview. Tobit two-stage model was employed to estimate farmers' resource efficiency of sesame production. In the first stage, Data Envelopment Analysis (DEA) was used to analyze farmers' technical and scale efficiency. In the second stage, factors that influence farmers' resource use efficiency were identified using the Tobit model. The DEA result indicated that the technical and scale efficiency of sesame producer farmers were 52% and 55% respectively. The result also revealed that under-utilization of the production inputs under consideration, especially land size and amount of seed used. Moreover, farmers' planting method (P = 0.030**), age of the household head (P = 0.042**), land size (P = 0.002***), education of the household head (P = 0.001***), and total asset owned (P = 0.024**) were associated with farmers optimal input-output mix of sesame production. As a result, it can be concluded that smallholder farmers in the study area were inefficient in using inputs in sesame production. Therefore, the current inefficiency in sesame production could be improved by giving special attention and working on the factors that affect optimal input-output mix at the farm level.

1. Introduction

The current fast-growing economy of Ethiopia is mostly based on the improving performance of agricultural production (Ethiopian Economic Outlook, 2016). Agriculture accounts for 34–45 percent of the total GDP, 80% of export earnings, and 85% of the labor market (Federal Democractic Republic of Ethiopia, 2016; Pecher, 2019). The sector also contributes to the growth of macroeconomic performance in the nation through income generation, employment creation, and food supply for the majority of the smallholder farmers. However, this sector is dominated by smallholder farmers who suffer from chronic hunger and poverty, lack technical knowledge on how to use resource efficiently, and vulnerable to climate change (Tchale, 2009; Mota et al., 2019). The production of sesame, which is one of the export potential and major sources of foreign currency, is not different from this reality. Thus, supporting the production techniques of these resource-poor farmers is crucial for strengthening the contribution of agriculture to national GDP and more specifically to increase the income and improve food security status of smallholder farmers (Schneider and Gugerty, 2010).

In more recent years, sesame seed has a number of value addition forms: whole roasted sesame seeds (hulled) are sprinkled on bread, bagels, and top hamburger buns; baked into crackers, often in the form of sticks; used in cakes in Greece; sprinkled on Sushi-type-foods. This value addition nature of the crop has attracted many smallholder settlers from different parts of Tigrai regional state. Currently, it is believed that approximately 18 thousand farmers in Maykadra district are based their livelihood source on the farming of commonly used sesame varieties such as Hirhir, Bawaji and Abundeam.

Sesame is among the major export and oldest oil seed crops, which Ethiopia is known in the international market (Gelalcha, 2009: Zerihun, 2012). Evidences show that Ethiopia is the leading country in exporting a large volume of sesame in the world market (FAOSTAT, 2016). It is also

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the major oil seeds in the country in terms of exports next to coffee, accounting for over 90 percent of the value of oil seeds exports (MoFED, 2010). Despite this fact, the production of sesame is showing a declining trend because of different reasons, such as shattering effect and the inefficient utilization of inputs. This is an indication that, unless interventions that improve the production of sesame are made, its contribution to the national economy will gradually decline. Substantial improvements in the production of sesame are important not only to contribute to local economic development but also to the livelihood of the farmers and the international community.

The production and productivity of sesame has received less attention by the extension services and development actors. Furthermore, how efficient are factors of production or resources utilized in the production system of sesame is scarce. Knowledge on efficient utilization of resources is vital to increase productivity of sesame in order to enhance income of smallholder farmers. It must be also noted that the provision of modern inputs (improved seed, fertilizer, chemicals, etc.) and use of mechanization is not adequate to bring increased and improved productivity to achieve Sustainable Development Goal 2 (Zero hunger). For achieving rapid growth of agricultural productivity, the provision of modern inputs and technologies should be supported through efficient utilization of resources (Mussaa et al., 2011; Jayne et al., 2019; Abate *et al.*, 2019).

Despite the economic and livelihood benefits, production and productivity of sesame in *Kafta-Humera district of* Tigrai region is still low, which is 400 kg/ha. To improve the current production level, scientific investigation on farmers' resource utilization efficiency in sesame production and its associated factors is highly demanding. Moreover, the investigation is also important for policy-makers in order to design evidence-based policy options that can enhance efficient utilization of resources, international market supply and livelihoods of sesame producers. The focus of previous research undertakings on resource use efficiency limited on the production of major crops such as wheat, teff, barley and sorghum. However, technical efficiency of farmers in utilizing resources to produce cash crops, particularly oil seeds such as sesame is scarcely studied. Therefore, the objectives of the current paper were to analyze technical efficiency of sesame producing farmers and identify factors that influence resource use efficiency in Maykadra Kebelle[1], Kafta-Humera district[2] in the Western zone[3] of Tigrai region, Ethiopia.

2. Methodology

2.1. Area description

The study was conducted in Maykadra Kebelle, Kafta-Humera district, located at 512 km away from Mekelle, capital of Tigrai region. Geographically, the study is located in 14^0 05′ 05″ N latitude and 36^0 34′ 45″ E longitudes. It is bordered by Welkayt in the South, Sudan in the West, Tekeze River in the East and Eritrea in the north. Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), the district had a total population of 92,167, of whom 47,909 were male and 44,258 females. With an area of 4,542.33km^2, Kafta-Humera had a population density of 20.29, which is less than the zonal average that is 28.94 persons per km^2. From the total population of the district, 30,234 or 32.80% were urban inhabitants and the remaining 67.2% were rural inhabitants. The major crops grown in the area are sesame, cotton and sorghum whereas sesame production is the major economic source in the district. Sesame production is labor-intensive, especially during weeding and harvesting period, attracting an average of 200,000 workers from the rest of the Tigrai Region, Northern Amhara, and Sudan each year.

The study area is found with an altitude of 950–500m asl. The dominant soil type of the study area is vertisols. Vertisols are deep soil characterized by shrink-swell cracks, Churning, heavy clay soils with texture of >30% of clay between surface and vertic horizon (IUSS Working Group Wrb, 2015). Vertisols generally contains more than 40% clay in the surface horizons and close to 75% in the middle part of the profiles (Shete et al., 2016; Brhane et al., 2017). The sand fraction is low, often less than 20%, is found in the bottom horizons. The subsoil consists mostly of strongly developed fine to medium angular blocky structures with developed slicken sides (Berhe et al., 2020; Debele and Deressa, 2016). And this low land soils are suitable for Cotton, Sorghum and Sesame crop productions.

2.2. Methods and data collection

Both primary and secondary data were collected for this study. Primary data on demographic and socioeconomic profile of sample households, cropping methods of sesame, institutional and infrastructure services of sesame producer farmers and the inputs used by farmers to produce sesame were collected using structured interview. Secondary data were collected from journal articles, textbooks, Kafta-Humera office of Agriculture and Rural Development and ECX (The Ethiopia Commodity Exchange) office of the Kafta-Humera. With regard to the sampling technique and sample size, from the 18 sesame producing Kebelles in Kafta-Humera district, Maykadra Kebelle was purposively selected because of its area coverage in km^2 and relatively high availability of sesame producing smallholder farmers. Random sampling method was used to select 187 (out of 500 households) sesame producer sampled households from Maykadra Kebelle.

2.3. Method of data analysis

The study employed both descriptive statistics and econometric models to analyze the data-set collected. Mean, standard deviation and frequency were used as measures of descriptive statistics. Besides, Data Envelopment Analysis (DEA) method was used to analyze efficiency of sesame production and Tobit was used to identify factors that affect resource use efficiency of sesame production (see Table 1).

2.3.1. Model specification

To analyze the technical efficiency of production, we employed the Data Envelopment Analysis (DEA) method. The non-parametric DEA was first developed by Charnes et al. (1978) to overcome the shortcoming of the previous models used to measure technical efficiency that was introduced by Koopmans (1951), refined by Debreu (1951) and Shephard (1953) and extended to measure cost efficiency by Farrell (1957). Recently, a number of scholars are used DEA to measure technical efficiency of agricultural production such as Gutiérrez et al. (2017); Raheli et al. (2017); Horvat et al. (2019); Long et al. (2020); Hoai (2020). Applying DEA has two advantages: first, it does not require the assumption of a functional form to specify the relationship between inputs and outputs. Second, it does not require the distributional assumption of the inefficiency term. It is also the widely employed approach for estimating the relative efficiency of decision-making units. Besides, it is argued that DEA was used to estimate actual farm performance. Based on these facts, supposing a group of n homogeneous decision-making units (DMUs), in order to produce r number of outputs (r = 1,2,3,…k) s number of inputs are utilized (s = 1,2,3,… m) by each DMUi (i = 1,2,3,…n). In order to maximize the level of weighted output subject to weighted inputs, the following linearly expressed equation developed by Charnes, Cooper and Rhodes (CCR) approach (Charnes et al., 1978) is specified as follows:

[1] Kebelle is the smallest unit administrative in Tigrai.

[2] District/Woreda is the third level administrative division in Tigrai which further subdivide in to many kebeles

[3] Zone, is the second-level administrative division in Tigrai. It is further subdivided into a number of districts/woredas.

Table 1. Definition of variables and their hypothesized signs to efficiency.

Variables	Description	Expected sign on farm efficiency
Agehh	Age of the household heads in years	-
Educhh	Education level of household heads in years	+
Fsize	Family size in number of persons	−/+
Dmrkt	Distance of the household to the nearest market in km	-
Farmexpe	Experience of farmers in sesame production in years	+
CLsize	Cultivated land Size in hectares	-
Totalssownd	Total asset owned by the household in number	+
Planting method	dummy variable 1 if the farm household used row planting method and 0 if broadcasting	+
Access to market information	Dummy variable 1 if the farm household have access to market information and 0 otherwise	+
Membership of the Household to organization	Dummy variable 1 if the farm household is a member in rural associations and 0 otherwise	+
Genderhh	Dummy variable 1 for male headed and 0 for female headed households	+/-
Improved seed	Dummy variable 1 if the farm household used improved seed and 0 otherwise	+
Access to credit	Dummy variable 1 if the farm household have access to credit and 0 otherwise	

Source: Field data, 2017

$$Max_{\mu y} : \theta = \mu_1 Y_{1i} + \mu_2 Y_{2i} + \ldots + \mu_r Y_{ri}$$

Subject to:

$$v_1 x_{1i} + v_2 x_{2i} + \cdots + v_s x_{si} = 1$$

$$\mu_1 Y_{1j} + \mu_2 Y_{2j} + \cdots + \mu_r Y_{rj} \le v_1 x_{1j} + v_2 x_{2j} + \cdots v_s x_{sj}$$

$$\forall i\mu i \, , v_i > = 0 \text{ and } (I \text{ and } j = 1, 2, 3 \ldots k) \quad (1)$$

where θ is the technical efficiency and i represents i^{th} DMU. Y_{ri} is the amount of output r produced by i^{th} DMU; X_{si} represents the amount of input s used by DMU_i. In the expression μ_r is weight given to output r, and ν_s is weight given to input.

However, in the maximization process, DMUs always faces financial limitations or counteracts imperfect competitive markets in conditions where increased amounts of inputs do not proportionally increase the amount of outputs obtained (Coelli et al., 2005; Khairo and Battese, 2005). In order to account for these effects, the DEA model for Variable Returns to Scale (VRS) developed by (Banker et al., 1984) was used for the current study.

Mathematically, the DEA method under VRS assumption for each DMU can be expressed as:

$$Max_i \, \theta$$

Subject to:

$$x_i - X\lambda \ge 0$$

$$-\theta y_i + Y\lambda \ge 0$$

$$N1'\lambda = 1$$

$$\lambda \ge 0 \quad (2)$$

In the restriction $N1'\lambda = 1$, $N1'$ is convexity constraint which is an $N\times1$ vector of ones and λ is an $N\times1$ vector of weights (constants) which defines the linear combination of the peers of the i^{th} DMU. $1/\theta$ defines a technical efficiency score which varies between zero and one. If $\theta = 1$ then the DMU is on the frontier and is technically efficient and if $\theta < 1$ the DMU lies below the frontier and is technically inefficient.

Moreover, the study adopts the two-limit Tobit model to identify factors that affect farmers' inefficiency. The DEA efficiency result falls between 0, the least efficient and 1, the most efficient farmer. The most commonly used model to handle the characteristics of the distribution of efficiency measures and thus provide results that can guide policies to improve performance is Tobit model (Coelli et al., 2005; Tolga et al., 2010; Boubacar et al., 2016; You and Zhang, 2016; Abdulai et al., 2018). Tobin (1958) first introduced Tobit model in the econometric literature and here we adopted the functional equation employed by Amemiya (1985):

$$U_1^* = \beta_o + \sum_{j=1}^{k} \beta_j Z_{ij} + \mu_i,$$

$$U_1 = \begin{Bmatrix} 1, if \ U_1^* \ge 1 \\ U^*, if \ 0 < U_1^* < 1 \\ 0, if \ U_1^* \le 0 \end{Bmatrix} \quad (3)$$

where: i refers to the i^{th} DMU, U_i is inefficiency scores of the i^{th} DMU. U_1^* is the latent inefficiency, β_j are parameters to be estimated and μ_i is an error term that is independently and normally distributed with mean zero and common variance of δ^2 ($\mu_i \sim N_I(0, \delta^2)$). Z_{ij} are host of socio economic, institutional and demographic variables.

3. Result and discussion

3.1. Demographic and socioeconomic background of sampled households

The descriptive results presented in Table 2 showed that the average age of the sampled household heads was 44 years. The same table shows that the average educational attainment of the sesame producer household heads was 2.5 years. Mean walking distance from household's resident to the nearest market was 8.22 km. It is indicated that the average family size of the sample households was 5 persons. It is also shown that the size of land allocated to the sesame crop production in the rainy season was on average 27 ha. Besides, the average experience of the sampled households in sesame production was about 13 years. Gender composition of the respondents indicated that about 9 % of the sampled households were female headed whereas the remaining 91% were male headed. The result further revealed that about 89% of farm households were member in either of the farmers associations. In addition, results indicate that about 76% of the sampled households had access to credit. Moreover, the use of improved seeds and planting methods were also expected to affect the resource efficiency of farmers in sesame production. Accordingly, about 52% of the sampled farm households in the study area were using improved seed and 28 % planted using row planting method.

Table 2. Descriptive statistics result of the variables used in the Tobit model (N = 187).

Variables	Description		
	Continuous Variables	Mean	Std. Dev.
Age	Age of the household heads years	44.27	11.65
Educ	Education level of household heads in years	2.55	2.34
Fsize	Family size in number of persons	5.01	1.98
Dmrkt	Distance of the household to the nearest market in km	8.22	8.74
Farmexpe	Experience of farmers in sesame production in year	12.95	7.93
Lsize	Cultivated plot Size in hectares	27.20	110.91
Totalownd	Total asset owned by the household in number	22.09	21.69
	Dummy variables	**Yes**	**No**
Planting method	dummy variable 1 if the farm household used row planting method and 0 if broadcasting	52	135
Access to information	Dummy variable 1 if the farm household have access to information and 0 otherwise	152	35
Membership of the Household to organization	Dummy variable 1 if the farm household is a member in rural associations and 0 otherwise	166	21
Gender	Dummy variable 1 for male headed and 0 for female headed households	169	18
Improved seed	Dummy variable 1 if the farm household used improved seed and 0 otherwise	98	89
Access to credit	Dummy variable 1 if the farm household have access to credit and 0 otherwise	142	45

Source: Field data, 2017

Table 3 shows the variables that were used to estimate efficiency scores using Data Envelopment Analysis. Based on Table 3, the average productivity of sesame was 9866 kg per farm, which is approximately 365 kg/ha, and its estimated average value was ETB 246444.75 equivalent to $12309.74. Results in the same table show that the average amount of fertilizer (Urea and DAP) used for sesame production was 174 kg/ha and the mean cost per quintal of fertilizer was ETB 1577.60 or $78.80. It was investigated that the average land size used for sesame was 27 ha and the average cost of production was ETB 4750. In addition, the mean quantity of seed used was 55 kg/ha and its associated cost was ETB 4826 or $241.3. Further, the average number of wage labourers for sesame production was about 89 per hectare and mean cost of labor was ETB 6503 or $282.74(Table 3) (see Figure 1).

The distribution of technical efficiency of sesame producer farmers is shown in Figure 2. The result showed that only seven farmers (4%) were technically efficient (TE = 1), while the remaining 96% were technically inefficient. And also the mean technical efficiency was estimated at 52%. The result of the one sided sample t-test revealed that the sampled sesame producer farmers were technically inefficient. The inputs used in the production process were sub-optimally utilized. This implies that the current productivity of sesame could be increased if farmers use resources efficiently.

Result in Table 4 displayed that the mean scale efficiency is 55%, this implies that there is a possibility of increasing the current average output of sesame productivity by 45% without using more inputs in the production process. In other words, sesame producers in Western Tigrai could still produce the same amount of output given that their input use level is reduced by 45%. Furthermore, as shown in Table 4, the mean technical efficiency of the farmers under the constant returns to scale, variable returns to scale and the non-increasing returns to scale was 21%, 38% and 31%, respectively.

Table 5 presents the returns to scale of farmers' sesame production under the variables returns to scale (VRS) frontier. Consequently, from DEA result, about 17% of the farmers were producing sesame at decreasing return to scale, around 80 % were producing at increasing returns to scale and the remaining 3% were producing at constant rate of scale. This suggested that the majority of the farmers could produce more output of sesame without increasing input to the production process. Therefore, farmers and policy-makers in developing countries should give due emphasis to the efficient use of agricultural inputs to enhance productivity of cash crops particularly oil seeds.

3.2. *Factors that influence efficiency of sesame production*

Demographic, socioeconomic, cropping technique, infrastructural and institutional factors were found to affect the efficiency of sesame production significantly and thereby contribute to sesame production inefficiency.

As presented in Table 6, the age of the household head was significantly and positively correlated with farmer's technical efficiency in the production of sesame at less than 5% significance level. This implies that, one year increase in the age of the household head increases technical efficiency of the farmer in sesame production by 0.003. This indicates that when farmers' age increases, their experience in efficient use of resource increases as well. This result was consistent with the work of Ibrahim (2014), who showed a positive relationship between farmers' age and agricultural resource use efficiency. It was also similar with the outcome obtained by Daniel et al. (2010), who found a positive

Table 3. Descriptive results input-output used for DEA (N = 187).

Variable	Description of variables	Unit of Measurement	Mean	Std. Dev.	p50	min	max
Output variable							
OS	Output of sesame	kg/farm	9866	25098	1400	100	2205
Input variables							
LS	Farm Land Size	Ha	27.308	63.421	3	.5	400
TL	Labor	Man-day in number/farm	2414.8	6961.9	239	10	72500
QS	Quantity of sesame seed	kg/ha	54.735	86.019	14	2.5	120
QF	Quantity Fertilizer (DAP + Urea)	kg/ha	174.14	1609.8	0	0	21900

P50 = 50% quintile (median).
Source: field data, 2017

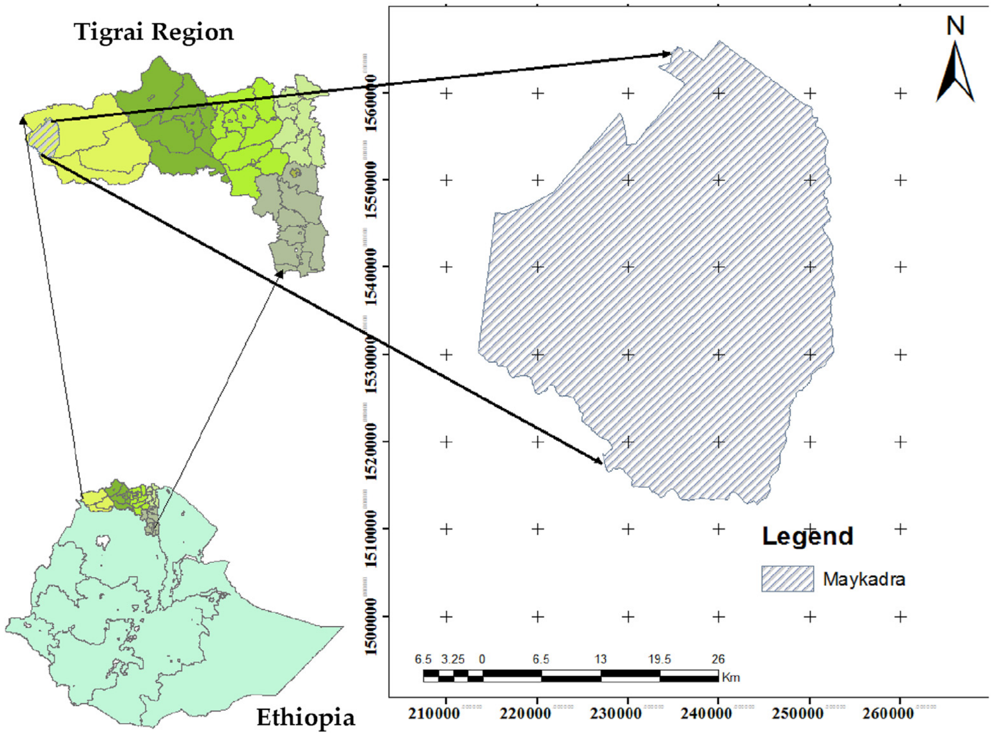

Figure 1. Map of the study area.

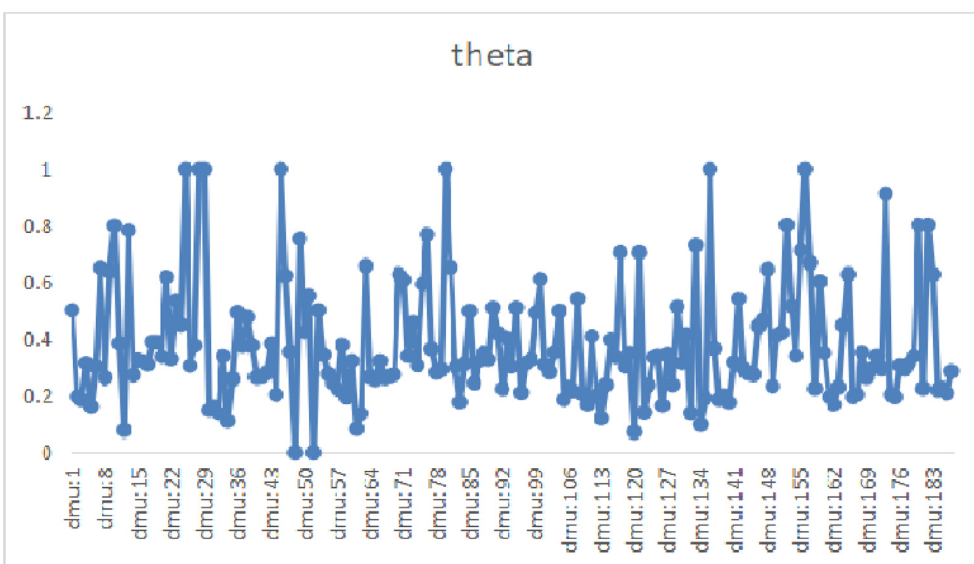

Figure 2. Technical efficiency distribution.

correlation between age and farmer's resource use efficiency in potato production.

The other variable that affected the resource use efficiency of sesame producer farmers was education. Farmer's education and technical efficiency in resource use in the production of sesame in Maykadra were positively related ($P < 0.01$). The result is indicating that farmers with longer years of schooling were able to produce sesame more efficiently than their counterparts. The implication of this relationship is that

Table 4. Distribution of technical efficiency (TE) score (N = 187).

Variable	Obs	Mean	Std. Dev.	Min	Max
CRS_TE	187	0.21	0.18	0.02	1
VRS_TE	187	0.38	0.21	0.07	1
NIRS_TE	187	0.31	0.30	0.03	1
scale	187	0.55	0.24	0.06	1

Source: Field data, 2017 CRS = Constant Returns to scale, VRS = Variable Returns to Scale, NIRS = Non-increasing Returns to Scale,

Table 5. Returns to scale of farmers sesame production.

Returns to scale	Frequency	Percent
Decreasing Returns to Scale	32	17.11
Constant Returns to Scale	5	2.67
Increasing Returns to Scale	150	80.21
Total	187	100

farmers with more years of schooling were able to optimize the input mix and easily accept new technologies such as fertilizers, pesticides and planting materials to enhance productivity of sesame. This result concurs with the findings of Shumet (2011) that indicated education enhances efficiency of farmers. The result was also in agreement with the works of many researchers (You and Zhang, 2016; Yuan, 2010; Uaiene and Arndt, 2009; Bozoğlu and Ceyha, 2007; Bravo-Uretaand and Pinheiro, 1997), who indicated positive correlation between formal education and technical efficiency.

Land size is another variable that indicates the size of the cultivated land during the extended rainy season. This variable was found significant ($P < 0.05$) and negatively correlated with resource use efficiency in sesame production. When land size allocated for sesame production increases, resource use efficiency of farmers' declines. This is because when the size of land allocated to sesame becomes large, it would be difficult to manage at household level resulting in under-utilization of the land resource. This result is in harmony with the finding of Mussaa et al. (2011), who indicated that a negative relationship between efficiency and plot size in smallholders' major crop production. It was also consistent with the finding of Boubacar et al. (2016), who indicated farm size and rice production efficiency were negatively correlated. However, the result was in contradiction to the finding of Yuan (2010), who indicated positive correlation between farm size of farmers and resource efficiency. Although this relationship is contrary to the expected hypothesis of the current work, this correlation can be justified by the introduction of labor saving machines that can contributed towards efficient land management.

Total asset owned is a variable indicating the total agricultural equipment that household's own and was measured in number. This variable has a positive influence on the technical efficiency of sesame production. Additional one more asset increase leads to 1.7 increases in farmers' technical efficiency. The result implies that households with much agricultural equipment had a greater technical efficiency. This implies that the household with strong asset value will have the possibility to demand new technologies like fertilizer, and planting method that improve technical efficiency of sesame production.

The type of sesame seed/variety that households use was negatively correlated with farmers technical efficiency ($P < 0.05$). Households who used improved seed/quality seeds were less efficient than those who used local seeds. I.e. Households who demand improved sesame seed each year were less efficient than their counterparts. This implies that the use of improved seed per season could not improve farmers' resource efficiency. This might be because of the assumption that improved seeds in the market could be less quality than the one farmers saved from their previous harvest. This is in agreement to the fact that use of improved technologies by itself is not a guarantee to the resource use efficiency. The result was in line to the studies of Gebrehaweria et al. (2012), negative correlation between use of improved seed and technical efficiency. Nevertheless, the finding was in contradiction with Maruod et al. (2013), indicated that adopting improved seed improves farmers' efficiency, food security and economic growth. The result was also in opposition to the findings of Shavgulidze (2017), who indicated that the use of quality seeds was positively correlated with technical efficiency of potato growers.

Various methods of planting are practiced in crop farming. In this study, the planting method refers to sowing by row or broadcast. The variable planting method had positive and significant influence on the technical efficiency of sesame production ($p < 0.05$). There was a significant difference in production of sesame between households who applied row sowing method and those who applied broadcast method. Households who applied the row sowing method were more productive (16.9 kg more) than those who applied the broadcast method. This suggests that row spacing and seed rate are important features to optimize crop production. This was in agreement with the findings of Donkor et al. (2018), who indicated that row-planting increases efficiency by reducing overcrowding decreases competition for nutrients and water intake. It was also in agreement to the study by Ijoyah et al. (2015), who preferred row planting method over broadcast for improved production.

4. Conclusions

Resource use inefficiency was observed among sesame producing farmers in Maykadra kebelle of Western Tigrai. The study indicated that

Table 6. Results of the Tobit model variables that influence resource use efficiency.

tefficiency	Coef.	Std. Err.	t	P Value
Constant	.1364	.1429	2.95	0.004
Demographic factors				
Age of the household head	.0034	.0018	2.57	0.042**
Education of the household head	.0504	.0145	3.49	0.001***
Gender of the household head	.0036	.0589	0.06	0.951
Family size	.0073	.0088	0.83	0.406
Farm infrastructure and institutional factors				
Distance to the nearest market	-.0007	.0020	-0.35	0.730
Access to information	-.0364	.0435	-0.84	0.404
Access to credit	-.0259	.0393	-0.66	0.511
Membership to organization	-.0027	.0551	-0.05	0.961
Socioeconomic factors				
Landsize	-.0028	.0002	-3.65	0.002***
Total owned asset	.0018	.0008	2.28	0.024**
cropping technique applied to sesame				
Improved seed	-.0738	.0376	-2.96	0.0051***
Planting method	.1691	.0774	2.18	0.030**

*** and ** represent significance level at 1 and 5 percent respectively.
Source: Model result based on STATA Version 10, survey data, 2017

the current output could be increased by 48% if resources are optimally utilized. In addition, most resource use inefficient farms were operating under increasing returns to scale, which implies that farmers were using inputs below the recommended level. More importantly, education level of households, cultivated plot size of households in hectares, the planting method of sesame practiced by households, the total asset households owned, type of variety used and age of the household head were found to be the determinant factors for farmers' resource use efficiency.

4.1. Policy implications

Farmers should be encouraged to use certified or quality improved seeds and motivated to apply row-planting method to increase their efficiency and productivity. Furthermore, encouraging farmers to be educated and build agricultural assets could improve the current level of production efficiency of sesame.

Declarations

Author contribution statement

Gidey Kidu: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Dawit Gebregziabher; Kidane Tesfay: Conceived and designed the experiments; Wrote the paper.

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Data availability statement

The data that has been used is confidential.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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