Economic Efficiency of Resources Use in Potato Seed Tuber Production: The Case of Jeldu District Central Oromia, Ethiopia

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Abstract
Potato is the top tuber horticultural crop grown in Ethiopia that get due attention from different institutions including research and development practitioners of the country to enhance it production and productivity. It is grown by approximately 1.3 million farmers in Ethiopia. Potato is a high-potential food security crop because of its productivity and high-quality product per unit input used with a shorter crop cycle than major cereal crops grown in the country.This study examines the economic efficiency of resources use in potato seed tuber production in Jeldu District of Central Oromia Regional State Government of Ethiopia. It focuses on the relationship between potato seed tuber produce and the various inputs used by potato seed tuber producer farmers, elasticity and economic efficiency of resource used in production of potato seed tuber. Primary data collected by the structured questionnaires administered on 120 farmers producing potato seed tuber sampled by random technique from potato seed tuber producing peasant associations. The Cobb- Douglas function double log model have been employed because it gave us the best fit. The adjusted R^2 of the model was highly significant at 1% level with the value of 77.22%. This implies that 77.22% of the total variations in potato seed tuber yield is explained by combined influence of all the explanatory variables in the regression equation. Four variable inputs out of the ten were significant at 1%, 5% and 10% level, these were access to market place in walking minute,, amount of DAP and UREA fertilizers used and amount of seed rate use. Amount of fertilizers and seed used were positively affect the potato seed tuber production indicating that the more the quantity amount of these inputs used, the more output. The economic efficiency of resource used showed fertilizers and seed used per hectare were underutilized on the farmers farm hence increasing their rate of use per unit will increase potato seed tuber productivity and profitability level. On the contrary, labor and land were excessively used or over utilized hence decreasing quantity of the inputs use will increase productivity and profitability level.

Key words*: Efficiency, economic efficiency, Cobb-Douglas production function, and elasticity.*
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Introduction

Among the horticultural crops that have got due attentions from different institutions including research and development practitioners, potato (Solanum tuberosum L.) is a top tuber crop in Ethiopia. It is grown by approximately 1.3 million farmers in Ethiopia (CSA 2011). It is regarded as a high-potential food security crop because of its ability to provide high yield with high-quality product per unit input used with a shorter crop cycle (mostly < 120 days) than major cereal crops in Ethiopia (Adane *et al.*, 2010). According to Girma *et al.*, 2004, the relative high carbohydrate and low fat content of potato tuber, its potential to supply high quality protein and a substantial amount of essential vitamins, minerals and trace elements make it an excellent energy source for human consumption.

Girma *et al., (*2006); stated that potato production in potato producing areas of Oromia Reginal State of Ethiopia is preferable compared to other food crops because of its contribution to food security, income generation, double cropping advantages, it's comparative advantage in terms of high yield per unit area and ease of utilization. It has been

mainly produced to overcome the transitory food shortage that happens during summer season and it also serves as food and source of income to farmers especially during hunger months when grains deplete from the store.

Though, farmers have had restricted to produce local potato varieties that were low in yield potential and susceptible to major potato diseases and pests recent interventions in central highland potato producing part of Oromia Region State mainly by Holota Agricultural Research Center, have made significant contribution in enhancing productivity and releasing diseases and pest tolerant varieties. As a result of such interventions the contribution of potato to food security and income generation of farmers in that areas increases and currently potato became major cash crop in central part of the region as well as in the country. Accordingly, since the intervention farmers of Jeldu district are beneficiary and have started the supply of high yielding, disease and pest tolerant and healthy seed tubers for market through cooperative and individual bases.

Besides Holeta Agricultural Research Centre, the then local seed business project (LSB) currently ISSD (integrated seed system development), has been contributing its part to support the effort of farmers that meant to increase their income from potato seed and tuber sale and to achieve food self-sufficiency.

Despite the above mentioned interventions by different organizations and numerous improvements made and vast resources consumption to produce potato seeds tuber, there seems to be inadequate supply of potato seed tuber in elsewhere and excess supply of the commodity in the district itself. This scenario leads to the potato seed tuber disposal due to market absence and deteriorating nature of the commodity even though suitable storage system has been developed by these organization in the district. The economic efficiency of these resources used by farmers was not studied yet. Therefore, this paper aims to present the study on economic efficiency of resource use to produce potato seed tuber in Jeldu district.

Hypothesis:
HO_1: There is no relationship between the produced potato seed tuber and inputs used in the production.
HO_2: There is relationship between the produced potato seed tuber and inputs used in the production

Description of the Study Areas
The study was undertaken in central highland of Oromia Regional State of Ethiopian, where potato seed tuber has become cash crop. The study district is Jeldu located at 72km to the north-east of Ambo (Zonal town) and 115 Km west of Finfinne-the capital of the region and the country. The district is characterized by its mountain, plateau, and hills and has three major types of soils-nitosol, veritisol and sandysol. According to the data from Agricultural Development Office of the district the elevation of the district on average is 2400m and gets rainfall of the highest and the lowest at 2000mm and 900mm annually respectively. The district comprises mixed farming system where crops are grown for food and cash purposes, and livestock are kept for the same purpose and the two sectors complement each other. Crops grown in the district are ware potato, potato seed tuber, wheat, barley, teff, sorghum, maize, field beans, peas, chickpeas, sweet potato, onion, garlic, enset and etc.

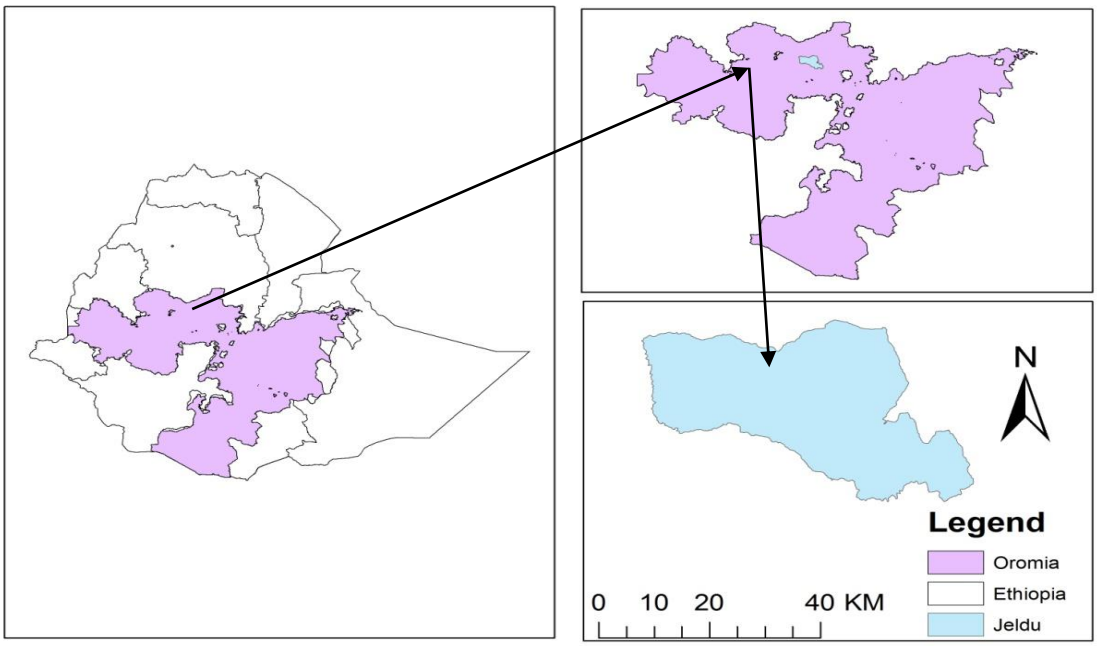

Figure 1. Geographical location of the study area

Data collection

Purposive multistage sampling techniques were employed to select representative sample for the study. These approach involves the choice of Jeldu district of West Shawa Zone of Oromia Regional State purposively, followed by selection of 4 peasant association from 38 PA's of the district purposively and 120 potato seed tuber producer farmers from all PA's were selected randomly. Data like potato seed tuber produce, production inputs, output and inputs prices and socioeconomic characteristics of the farmers of the district were collected.

Production modeling

To estimate the effects of determinants (explanatory variables) on production (dependent variable) of potato seed tuber Cobb-Douglas production function was employed. The function has been used to measure growth, impacts of variables and the like variables on dependent variables (Gujarati, 2004 and J.J. Heckman and E.E. Leamer 2005)).

The model can be specified as;

$$Y = AX_1^{\alpha 1}X_2^{\alpha 2}, \dots X_n^{\alpha n} e^{\beta_1 D_1 + \beta_2 D_2, \dots \beta_n D_n + U_i}$$

To linearize the equation, logarithm can be used and transform the function as follows to make it comfortable for OLS estimation.

$$\ln Y = \ln A + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \cdots, + \alpha_n \ln X_n + \beta_1 D_1 + \beta_2 D_2 + \beta_n D_n + U_i$$

Where:
Y: Potato seed tuber production (amount of quintals produced)
A: The intercept that reveals combined impact of production
$X_1, X_2, \dots X_n$: Are continuous explanatory variables
$D_1\ D_2 \dots D_n$: Are dummy variables
$\alpha_1, \alpha_2, \dots \alpha_n$: Are coefficient/parameters of continuous explanatory variables

β_1, β_2,…β_n: are coefficient/ parameters of dummy explanatory variables
Parameters:α_1, α_2,… α_n and β_1, β_2,… β_n were estimated by OLS (Ordinary Least Square) method by using STATA.

Elasticity of production
Elasticity of production of potato seed tuber is the measure of degree of response of potato seed tuber produce to changes in the variable inputs used in potato seed tuber production. Using best fit function; the Cobb-Douglas production function, elasticity of each various inputs was determined by the formula;

dy/dxi * X/Y

Where, Y is the mean average of potato seed tuber produced per hectare (production/harvest)
x's are the various input used in production of potato seed tuber
X is the mean average of input used in production of potato seed tuber

Since the Cobb-Douglas production function is the best fit, the regression coefficients of this model are the elasticities of potato seed tuber production/harvest of small scale farmers of Jeldu district as the responses of various inputs used.

Resource use efficiency: according to (Tian, 2009), economic efficiency of resources use in production of goods/services can be determined by using the ratios of Marginal Value Product (MVPs) to the Marginal Factor Cost (MFC) of that goods/services. The MVP for each inputs used can be calculated by multiplying the marginal physical product (MPP) of each input by the arithmetic mean price of the goods/services produced. According to MPP to MVP figures, on the average and with all other factors held constant, an increase in one variable would increase output by some numerical number per unit used and revenue by some numerical number per unit used (Taru, VB *et al*, 2008). Accordingly, the estimated coefficients/elasticities of each explanatory variables was used to compute the marginal value product of each variable inputs (MVP) and its ratio (r) with marginal factor cost (MFC) that is price per unit inputs used to determine the economic efficiency of resource used. Therefore, the resource use efficiency of small scale farmers of potato seed tuber producers of Jeldu district can be determined by the ratio of marginal value product of each variable inputs used in production with marginal factor cost of these variable inputs used in the potato seed tuber production. The resource use efficiency of the model can be estimated as follows for potato seed tube production;

r = MVP/MFC

Where, r = efficiency ratio
MVP = marginal value product of variable inputs
MFC = marginal factor cost (price per unit of inputs)

Economic theory stated that a firm maximizes its profits with regards to resource use when the ratio of the marginal return to the opportunity cost is one. Alternatively, a firm maximizes its profits when its marginal value of variable inputs equals its marginal factor cost.

The values are interpreted thus,

1. If r is <1; resource is excessively used, that is, over utilized resources hence decreasing the quantity use of that resource increases profits.
2. If r > 1; resource is under used, that is, underutilized resource hence increasing its rate of use will increase profit level.
3. If r = 1; it shows the resource is efficiently used, that is optimum utilization of resource hence the point of profit maximization is at this point.

Before taking the selected variables into the Cobb-Douglas production function models the existence of multicollinearity among the continuous variables were seen. Multicollinearity problem arises when the existence of high linear relationship among explanatory variables; hence, the result could not obtain unique estimates of all parameters (Gujarati, 2004). There are different ways of detecting multicollinearity, among them; variance inflation factors (VIF) technique was employed to detect it in continuous explanatory variables (Gujarati, 2004).

Accordingly, VIF (X_i) can be defined as:

$$VIF_i = \frac{1}{1-R_i^2}$$

Where:
$R_i^2 =$ it is the multiple correlation coefficients between X_i and other explanatory variables.

According to Gujarati (2004); for those variables, if the value of VIF is 10 and above, the variables are said to be collinear (if the value of R_i^2 is 1, it would result in higher VIF and causes perfect multicollinearity between the variables).

Results

The output of the production function model that was used to determine the nature of inputs-output relationship per a hectare of land in potato seed tuber production is shown in Table 1. There are different functional forms that can be fitted to the model. These are linear, semi-log, double-log and exponential functional forms. Among these functional forms of production function double-log was employed in the analysis of input-output data to measure the contribution of each input to production, when the inputs interacted together to produce the output potato seed tuber. The selection of the lead equation was based on the comparison of coefficient of multiple determination (R^2), the previous expectation, the magnitude of standard error of the estimated parameter and statistical significance of the estimated regression coefficients.

The final output of the model result was computed by entering 10 continuous explanatory variables (access to market, age of the household head, educational level the household head, farm experience of the household head in potato seed tuber production, family size of the household, seed rate per hectare used, number of oxen owned to cultivate potato seed tuber, land size for potato seed tuber and fertilizer rate used to produce potato seed from a hectare) in to STATA version 10 and regressed using OLS method. The OLS method was used because the Cobb-Douglas production function which was not leaner in its parameters is changed to double-log which is now linear in its parameters and become comfortable to run the regression using OLS method.

Table 1 shows estimated values of the elasticity of production and related statistics of Cobb-Douglas production function used in the production analysis. The F ratio was significant at 1% probability level indicating that there is a significant linear relationship between the independent variables taken together and production of potato seed tuber in the study area. This finding of F test has resulted in the rejection of our null hypothesis which was stated as there is no relationship between the output and variable inputs used in potato seed tuber production and leads to the acceptance of the alternative hypothesis which was stated as there is relationship between socio economic variables which are assumed to be variable and potato seed tuber output.

Among the variables expected to affect potato seed tuber production in the study area access to market centre expressed in walking minute, amount of DAP fertilizer applied, amount of UREA fertilizer applied and seed rate amount used per hectare for potato seed tuber production by farm households were statistically significant (Table1). All coefficients of these variables had positive signs except for access to market centre which is negative sign. The interpretations of individually significant variables were presented below.

Increasing DAP fertilizer amount used per hectare by 1% tend to increase the production of potato seed tuber by 0.797% keeping other variables constant. This is because, quantities of DAP fertilizer per hectare used by households were relatively underneath or the farmers have been used below the recommended rate of fertilizers in the study area and intern it leads to low yielding of potato seed tuber per hectare. Similarly, increasing UREA fertilizer amount used per hectare by 1% tend to increase the production of potato seed tuber by 0.397% keeping other variables constant. This is because; quantities of UREA fertilizer per hectare used by households were relatively underneath and lead to low yields of potato seed tuber per hectare (Table 1).

The coefficient of access to market centre expressed in walking minute was negative and statistically significant at 10%. The negative coefficient of this variable suggests that a unit increased in the walking minute to the market centre will lead to decreases of potato seed tuber production volume level when other explanatory variables are held constant. An increase in walking minute to the market centre by a unit will led to decreases in potato seed tuber production by 0.073% keeping other variables constant. This figure may show that farmers who are far from market centre produce less commodities compared with their counterpart who are near to the market centre and this counterpart are better off because they can easily access market and market information. On the other hand, market infrastructures, especially

all season round roads which are expected to decrease the walking minute and give opportunities for car and cart transportations have direct impact on amount of a commodity production.

Increasing seed rate by 1% tend to increase the production of potato seed tuber by 0.316% keeping other variables constant. This is because, quantity of seeds per hectare used by households were relatively below agronomic recommended rate per hectare for seed production. This finding is in agreement to the research finding of Taru *et al.*, (2008) and Gezahegn, (2010) who conducted research on economic efficiency of groundnut production in Nigeria and eastern Ethiopia respectively by using Cobb-Douglas function.

Table 1. Factors affecting households' and elasticity of potato seed tuber production in Jeld District

Variable inputs	Production Elasticity	Standard error	t-value	p>t
Access to market in walking minute	-0.073*	0.04	-1.91	0.06
Age of the household head	-0.048	0.12	-0.41	0.68
Education level of household head	0.010	0.03	0.33	0.74
Labor (in man equivalent)	0.032	0.06	0.50	0.61
Farming experience of the household head	-0.009	0.05	-0.18	0.85
Land allocate for potato seed production	0.040	0.027	1.50	0.14
Number of oxen owned	-0.034	0.053	-0.64	0.52
Amount of DAP fertilizer used	0.797***	0.279	2.85	0.00
Seed rate used per hectare	0.316***	0.114	2.77	0.00
Amount of UREA fertilizer used	0.397**	0.194	2.05	0.04
CONS	-4.784***	1.063	-4.50	0.00

Number of observations = 120, F (11, 108) = 10.68, Probability > F = 0.0000, R-squared = 0.8210, Adjusted R-squared = 0.7722, ***, ** and * indicate, statistically significant at 1%, 5% and 10% respectively. Source: own computation.

Resource use efficiency: The economic efficiency of resources use in potato seed tuber production in the study area was determined using the ratios of their Marginal Value Product (MVPs) to the Marginal Factor Cost (MFC) Table 2. The MVP for each inputs was calculated by multiplying the marginal physical product (MPP) of each input by the arithmetic mean price of the potato seed tuber produced. The MVPs and their ratios of MFCs of the four variable resources in potato seed tuber production are presented in Table 2. Accordingly, the MPP to MVP figures, on the average and with all other factors held constant, an increase in a kg of DAP and UREA fertilizer used would increase potato seed production volume by around 40kg and increases revenue by 288.90 and 263 birr per hectare of land respectively. While an increase in quantity of seed planted would increase output by 3.79kg and increases revenue by 758.4 birr per hectare of land.

The marginal value products (MVP) of labor, land allocated for potato seed tuber production, amount of inorganic fertilizers and seed rate used per hectare were calculated and compared with their marginal price/unit prices to determine their degree of efficiency in their use (Table 2).

Table 2.Estimated resource-use efficiency in potato seed production

Farm inputs used	Production Elasticity	MPP	MVP	MFC
Access to market in walking minute	-0.073	-4.052	-	-
Age of the household head	-0.048	-1.781	-	-
Education level of household head	0.010	0.059	-	-
Labor (in man equivalent)	0.032	0.100	3.00	30
Farming experience of the household head	-0.009	-0.039	-	-
Land allocate for potato seed production	0.040	0.022	44	2000
Number of oxen owned	-0.034	-0.075	-	-
Amount of DAP fertilizer used	0.797	39.85	288.913	7.250
Seed rate used per hectare	0.316	3.792	758.40	200
Amount of UREA fertilizer used	0.397	39.700	263.013	6.625

Economics of Return to Scale (ERTS),	1.428

The Economics of Return to Scale (ERTS); which was calculated by, summing up of the production elasticities of the inputs amount to 1.428 which is more than unity and thus characterized by increasing return to scale. This implies that the production of potato seed tuber in Jeldu district was in the irrational zone of production (stage 1) where total physical production and marginal product increases at an increasing rate and that the percentage change in the variable input also increases in increasing rate. That is factor inputs were not efficiently allocated and utilized while output of potato seed tuber was optimally produced in the study area (Table 2). In this stage of production marginal product can be increased by increasing in a variable factor, at the same time in this stage there is a scope for more efficient utilization of fixed factors by employing more units of a variable factor. A rational producer would not therefore, like to produce in this stage of production but will expand further.

Table 3.Ratio of MVP to MFC and MFC of significant variable inputs

Variable Inputs	MFC	MVP/MFC (Px)
Amount of DAP fertilizer used	7.25	39.852
Seed rate used per hectare	200.0	3.792
Amount of UREA fertilizer used	6.625	39.70
Labor (in man equivalent)	30.00	0.10
Land allocate for potato seed production	2000.00	0.022

Comparison of the ratio of the MVP to MFC shows that three resulting ratio were greater than unity; amount of DAP and UREA fertilizers and seed used per hectare, indicating that the inputs were being underutilized on the farms hence increasing their rate of use will increase potato seed tuber productivity and profit level. On the contrary, two resulting ratios were less than unity; labor and land allocated for potato seed tuber production, the inputs were excessively used or over utilized hence decreasing quantity of the inputs use will increase output and profit level. This confirms that resources are not efficiently utilized in the study area (Table 3).

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