Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.16, 2016

The Impact of Cropping Pattern and Land Tenure Status to Technical Efficiency of Shallots Farming in Nganjuk Regency, Indonesia

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Abstract
Crop rotation can influence the soil fertility and the sequence of plant pests and decease. Besides, land tenure effects to the allocation of resource. This study aimed at determining the impact of crop rotation and land tenure status to the technical efficiency. This research was done in four districts in Nganjuk,namely Sukomoro, Rejoso, Bagor, and Gondang. The primary data were conducted with 90 farmers through interview method with a guided questionnaire. Data were analyzed with Cob-Douglass production function with frontier stochastic approach. The results indicated that the significant factors influencing production were farm size, fertilizer and seeds. Shallot farming in Nganjuk was technically efficient, in which the efficiency level was 0,749 and 58,59 percent of farming activities having efficiency level was more than 0,7. Twice cultivation in a year, fixed-rent system, and long experience of farmers improved technical efficiency of shallot farming. The yield loss, in addition, is 3.871,86 kg/ha.
Keywords: technical efficiency, crop rotation, land tenure, yield loss

1. Introduction

Shallot is one of vegetable crops having high economic value in terms of the fulfilment of the national consumption, the source of income of farmers and its potency for source of state' foreign exchange. This commodity has great potency for national and international market for it is essential for households as food seasonings and raw material industries which so far are not replaced by other commodities. The number of red shallot needs for consumption, industries, seed and export increases every year. On the other hand, the increasing of demands is not equivalent with the increasing of production. The dispute between demand and production was 48.812 tons in 2005 to 67.341 tons in 2010 (BPS, 2011), and this was predicted to be increased in the coming year (PPHP, 2006).

During the period of 2005-2014, shallot production tended to increase with growth rate of 4.55% per year. The quantity of growth indicated that more dominant source in increasing the production during the period of 2005-2014 was derived form the increasing of harvested area (2.70%) than the level of productivity (1.85%). BPS (2015) noted that national productivity average in 2014 was 102.23 quintal / hectare. It was still under potency for some new preeminent varieties of shallots released by Agricultural Research and Development Beraue (Balibangtan) with potential yield 9-20 tons/ha. Those were *Kramat, Kuning, Sembrani, Ajiba-1* and *Katumi* (Hilman, 2008).

Coelli et al. (1998) found that there were three sources of productivity growth, namely: (1) technological change; (2) increasing the technical efficiency, and (3) the business scale. The new technology contributes to the shift of production curve upward and impact to increase productivity as well as the income of farmers. Technical efficiency, moreover, improves productivity through a combination of input usage.

Empirical results showed that among the factors affecting technical efficiency were crop rotation (Dhehibi, 2012; Musaba and Bwaca, 2014), and tenure (Feng, 2008; Jamal and Dewi, 2009; Susilowati and Tinaprilla, 2012; Laha and Kuri, 2013; Donkor, 2014). Well-constructed crop rotation additionally functioned to cut cycles of pests and diseases (Arifin, 2012), to give a positive effect on soil fertility (USDA, 1996), to increase the production per unit area, per season and per year (Arsyad, 2010), whereas land tenure effected on allocation of resource (Ebong, et al, 2011). Therefore, the difference of land tenure systems resulted in the difference of levels of production efficiency and equity (Jamal and Goddess, 2009).

Furthermore, Hasan, et al (2015) argued that there were three patterns of crop rotation by farmers in Nganjuk, namely 1) planting shallots throughout the year; 2) planting shallots three times in a year by rotating it with rice or corn or vegetables depending on the availability of water and resources; and 3) planting shallots twice a year by rotating with rice and soybean.

Land tenure, moreover, is a critical issue in Indonesia. The fact that the increasing fragmentation of land increases or land holdings decreases eventually. According to BPS (2014) conducting agricultural census in 2013, found that the average land ownership per household farmers was between 0.3-0.4 ha. The choice of land tenure contract for farmers is important because of the increasing absentee ownership and a great number of landless farmers. Besides, to acquire access to the land, there are alternatives in tenure systems for landless farmers including fixed rental and sharecropping, although it is not found sharecropping system on shallot farming in Nganjuk.

Research on the efficiency of shallot farming have been done in some areas, among others were technical efficiency, allocative, and economic efficiency (Fauzan et.al, 2015), relative efficiency (Lawalata et.al, 2015), and effects of pest management on technical efficiency (Wahida, et al, 2014). The different point of study was that previous studies did not correlate the cropping pattern and the tenure of land with technical efficiency.

2. Theoritical Framework

Technical efficiency represents the ability to obtain maximal agricultural input from a given set of inputs. The stochastic production function is a parametric analysis that has been commonly used to estimate technical inefficiency. The stochastic production frontier, in addition, shows the most efficient use of inputs to produce the maximum output (Koirala et al, 2016). The stochastic frontier regression model is a linear regression model having non-normal asymmetric disturbance. It was originally developed by Aigner et al.(1977). It has the general form:

$$Y_i = f(X_i, \beta)\exp(\varepsilon_i) \quad \text{..........(1)}$$

$$Y_i = f(X_i, \beta) + \mathrm{V_i} - \mathrm{U_i} \quad \text{..........(2)}$$

where, Y_i is the output of farm, i (i = 1,2,.. ...,N) ; X_i is the vector of inputs; β is the vector of parameters to be estimated; and ε_i is the error term, which is composed of two independent elements, namely (1) v_i is the error due to external factors that cannot be controlled by farmers who are assumed to follow a symmetric normal distribution $N(0, \sigma_v^2)$ and (2) u_i is an error because of internal factors that can be controlled so that the farmers describe the managerial capabilities of farmers. This component distribution is asymmetrical (one-side error term, $u_i > 0$) and also represents technical inefficiency. If $u_i = 0$, farming is the production frontier (efficient) or produce maximum production and if $u_i > 0$, inefficient farming or production is below its potential

The technical efficiency of the farm *i* is defined as:

$$TE_i = E[\exp(-u_i)|\varepsilon_i] \quad \text{..........(3)}$$

Here, TE is greater than zero and less than one ($1 \leq TE_i \leq 1$)

where *E* is the expectation operator. This is achieved by obtaining the expressions for the conditional expectation u_i upon the observed value of ε_i. The method of maximum likelihood is used to estimate the unknown parameters, with the stochastic production frontier and the inefficiency effects functions estimated simultaneously. The likelihood function is expressed in terms of the variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$ (Coelli *et al* 1998).

3. Research Methodology

This research was conducted in Nganjuk Regency (East Java) during growth season of shallot from September to November 2013. Location of the study were set purposively in four sub districts as canters of shallot production in the Nganjuk, namely, *Sukomoro, Rejoso, Bagor and Gondang*. The primary data were collected through interview method with guided questionnaire. Furthermore, 90 respondents were taken as sample with non probability sampling method by using quota sampling technique, namely the selection of non-random manner according to the quota. Data were analyzed with Cob Douglass production function with stochastic frontier approach which is defined as follows:

$$lnY_i = \alpha_0 + \sum_k \alpha_k lnX_{ik} + v_i - u_i \quad \text{..........(4)}$$

where, the subscripts i, and k represent, respectively, farmer and inputs. The dependent variable $\ln Y_i$, is the log-transformed value of shallot production (kg). The independent variable $\ln X_{ik}$, is the log-transformed factors of production which comprise farm size (m^2), cost of pesticide (IDR), cost of fertilizer (IDR), seed (kg), and labour (per day work). Here, α is parameters to be estimated; v_i represents random statistical noise; and $u_i \geq 0$ represents technical efficiency. In this study, the use of fertilizers was not analyzed specifically for each type of urea (N), phosphor (P), Kalium and NPK, but a combination of the cost of nitrogen, phosphor and Kalium. The merger was done because many farmers use fertilizer compound such as NPK and Phonska in practice. Likewise pesticides, farmers tend to mix two or more types of pesticides in the form of solid and liquid so that the unit used is IDR.

Determinant of technical inefficiency is defined as:

$$u_i = \beta_0 + \sum_k \beta_k lnZ_{ik} + \delta C_i + \theta L_i + \varphi A_i + \mu \quad \text{..........(5)}$$

where, Z is socio economic characteristics of farmer include age, formal education, and experience on shallot farming; C is cropping pattern (2 time/year=1, 3 times or more/year=0); L land ownership (owner=1, fixed-rent=0); and A is access to credit (yes=1, no=0)

After farm technical efficiency level was known (equation 3), the yield loss could be calculated using the following formula:

$$YL_i = maximum\ production\ (1 - TE_i) \qquad (6)$$

Where YL is the yield loss and TE is the technical efficiency. The individual farmer's maximum production per hectare could be calculated by dividing the actual production per hectare with the technical efficiency level (Rahman, 2003; Kanal et al,2012)

4. Result and Discussion

4.1 Shallot Farming Technical Efficiency Level

According to estimation results (Table 1), the parameter estimated coefficient sigma squared (σ^2) and gamma (γ) are statistically significant at α = 1%. Parameter gamma coefficient (γ) is 0.807, which can be interpreted that 80,7 percent production variation is due to the efficiency difference and the rest is caused by external factors which are not included in the model. The value of γ is significant, indicating that the factor affecting technical inefficiency is important.

The estimation of stochastic frontier production function indicates that shallot production is influenced by farm size, fertilizer, and the amount of seed having coefficient sign in conformity with expectation. (Table 1). If farm size, fertilizer cost, and amount of seed increase (decrease), farm production will increase (decrease), ceteris paribus.

Table 1. The MLE of Stochastic Frontier Production Function on Shallot Farming in Nganjuk Regency

Variable	Coefficient	t-ratio
Constant	0,541	1,111
Farm size	0,303**)	2,069
Pesticide Cost	-0,148	-0,339
Fertilizer Cost	0,112*)	1,914
Labour	0,059	0,468
Seed	0,675***)	4,407
Parameter variance:		
Sigma-squared	0,038***)	4,934
Gamma	0,807***)	4,221

***)significant = 1%, **)significant=5% , *)significant=10%

4.2 Factor Affecting Shallot Farming Production

Technical efficiency was based on the Cob Douglass production function using a stochastic frontier approach. Technical efficiency level of shallot farming estimated with MLE is shown in Table 2.

Table 2. Frequency and Percentage of Technical Efficiency Level

Efficiency Level	Frequency	Percentage
0,50<TE≤0,60	7	7,78
0,60<TE≤0,70	30	33,33
0,70<TE≤0,80	17	18,89
0,80<TE≤0,90	25	27,78
0,90<TE≤1,00	11	12,22
Sum	90	100,00
Average	0,749	
Minimum	0,512	
Maximum	0,964	

Table 2 showed that average of technical efficiency was 0,749. Kumbakar and Lovell (2002) had set efficiency criterion at 0,7, it can be concluded that the shallot farming in Nganjuk Regency is efficient. The farmers having technical efficiency level above 0,7 are 58,59 percent of all farms. Based on the average value of the technical efficiency of farmers are still likely to increase its production in order to obtain higher yields until they reach the expected production. In the short term, shallot farmers have opportunity to increase production by 26.04 percent (1-0,749/0,964). This can be obtained by improving skills and adopting technological innovations as the most efficient cultivation.

4.3 Source of Technical Inefficiency in Shallot Farming

An estimation of results of factors affecting technical inefficiency of shallot farming is shown in Table 3.

Factors affecting the efficiency/inefficiency of the shallot farming in Nganjuk are land tenure status, cropping patterns, and the experience of farmers. Land tenure is the significant effect on the inefficiency with a positive sign, which means that tenants are technically more efficient than the owner because the tenant is more efficient in allocating resources than the owner. Accordingly, it is reliable with the results of research by Ebong, et al (2011), Lema (2006), and Akter, et al (2006).

Table3. Determinan of Inefficiency on Shallot Farming in Nganjuk Regency

Variable	Coefficient	t-ratio
Land tenure (owner =1,fixed rent=0)	0,107*)	1,672
Cropping pattern (2x=1, 3x or more=0)	-0,168**)	-2,440
Access to credit (yes=1, no=0)	0,013	0,213
Age	0,208	0,121
Formal Education	-0,094	-0,857
Experience	-0,153*)	-0,186

**)significant = 5%, *)significant=10%

The cropping pattern, furthermore, has a negative sign (Table 3), which means that farmers planting shallot twice per years are more efficient than three times or more per year. In this patterns, the farmers also include soybean in their cropping pattern. Soybeans is planted after rice and before shallot. Theoretically, the soybean crop is one type of legume plants that can be symbiotic mutualism with soil microorganisms like *rhizobium*. This symbiosis will eventually be able to increase the levels of nitrogen in the soil (Sari and Prayudyaninsgsih, 2015).

Farmers experience has significant effect to the efficiency, the negative sign indicates that the long experience of farmers decrease levels of inefficiency or improve technical efficiency. This also increases the ability to allocate resources optimally. As farmers gaining more experience, they become better equipped and more knowledge-able in shallot farming. Thus, they are more efficient in the use of labour, seeds and fertilizer inputs, in which those are more responsive to the output (Revina-Molina, et al, 2015)

Access to credit, age, and education have no significant effect on the technical efficiency (Table 3). Credit provides convenience of farmers to obtain inputs but it is not automatically efficient in its allocation. According to Hasan, et al (2015), shallot farmers in Nganjuk accessed the credit in cash from the Bank and the chemical of production input (pesticide and fertilizer) from farmer groups and agricultural supply stores. Credit in form of production input was paid cash when they harvested with higher price. Age has no significant effect on technical efficiency, but it has a tendency that the younger farmers are more efficient. This can occur due to many farmers who started farming shallot after they are getting old. However, formal education has no significant effect, it has a tendency that the higher the education level decrease inefficiency or improve technical efficiency. Formal education will improve farmers' ability to understand the modern agricultural activities with a view of increasing their efficiency on shallot farming (Wakili and Isa, 2015)

4.4 Shallot Farming Yield Loss

Technical efficiency level of shallot farming of (Table 2) indicates the existence of a yield loss. This also indicates a probability to improve by looking for the factor of the source of yield loss. Generally, higher production loss exist at a lower efficiency level (Table 4), and yield loss has also negative relation with farming actual production.

Table 4. Production Loss According to Technical Efficiency on Shallot Farming

Efficiency Level	N	%	Actual Production (kg/Ha)	Production Loss (kg/Ha)
0,50<TE≤0,60	7	7,78	8.805,15	6.593,95
0,60<TE≤0,70	30	33,33	9.665,08	5.280,64
0,70<TE≤0,80	17	18,89	11.020,11	4.016,39
0,80<TE≤0,90	25	27,78	14.431,84	2.504,83
0,90<TE≤1,00	11	12,22	16.417,75	1.180,99
Sum	90	100,00		
Average			12.003,57	3.871,86
Minimum			7.142,86	578,29
Maximum			20.000,00	8.501,09

Potential yield loss per ha according to cropping pattern and land tenure are shown in Table 5. Three time or more of cropping pattern shallot per year is inefficient (technical efficiency level 0,69) and potential yield loss per ha is 4.703,98 kg

Table 5. Yield Loss According to Land Tenure and Cropping Pattern

Characteristics	N	Technical Efficiency	Actual Yield (kg/ha)	Yield Loss (kg/ha)
Land Tenure				
- Owner	28	0,73	12.002,91	4.378,58
- Fixed rent	62	0,76	12.013,87	3.870,40
Cropping Pattern				
- 2 times	39	0,82	13.522,11	2.992,97
- 3 times or more	51	0,69	10.842,34	4.744,31

5. Conclusion

Factors affecting shallot farming production are farm size, fertilizer, and amount of seeds. Shallot production will increase by the increasing of farm size, fertilizer and amount of seeds. The shallot farming in Nganjuk is efficient (0,749). Twice cropping patter in year, fixed rent system, and long experiences effectively increase technical efficiency. The yield loss, in addition, is 3.871,86 kg/ha.

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