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Application of Side-Grafting Technology to Increase Cocoa Productivity: Case Study in Sigi Regency Indonesia

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ABSTRACT
The objectives of this research were to: (1) Analyze the level of technical efficiency of input usage cocoa production without and with the application of side-grafting technology and (2) Analyze the effect of side-grafting technology application level, level of technical efficiency, age of cocoa plant rootstock, fertilizer, pesticide and labor on cocoa productivity. Stochastic frontier production function and multiple regression analysis were used to answer the first and second goals. The results of this research showed: (1) Cocoa farming that used side-grafting technology had a higher level of technical efficiency when compared to cocoa farming without side-grafting technology and (2) Application of side-grafting technology, level of technical efficiency, fertilizer, pesticide and labor had positive significant effect on the productivity of cocoa while the age of cocoa plant rootstock was not significant. Cocoa plants that were not productive in order to be rehabilitated by side-grafting technology without paid attention to age of cocoa plant rootstock. Maintenance of cocoa plants that used side-grafting technology needed to be considered, for example conducted field sanitation and cocoa trees, fertilizers, control of pest and disease.

Key words: Side-grafting, farming, cocoa, productivity

INTRODUCTION

Indonesia was the world's third largest cocoa producer after Ivory Coast and Ghana. In 2012 Indonesia's cocoa production were 740,513 t with the productivity of 850 kg ha^{-1} (Direktorat Jenderal Perkebunan, 2013). Productivity of cocoa in Indonesia has decreased when compared with the productivity of cocoa in 1990 were 1000 kg ha^{-1}. The decrease cocoa production was caused by: Age of plants was old, pests and diseases, decreasing soil fertility, lack of attraction of the next generation to become cocoa farmers and land usage competition between the cultivation of cocoa with other commodities (Lokakarya Kakao Indonesia, 2013).

Central Sulawesi was one of cocoa production areas in Indonesia. In 2012, cocoa productions were about 144,358 t and productivities were 908 kg ha^{-1} (Direktorat Jenderal Perkebunan, 2013). To increase the productivity of cocoa, the government through Production Increasing Movement and National Cocoa Quality (in Indonesian called GERNAS) has applied side-grafting technology. Side-grafting technology was used for the propagation of superior cocoa clones so, unproductive plants would be rehabilitated into productive ones (Departemen Pertanian Direktorat Jenderal Perkebunan, 2009). Cocoa plants that have been rehabilitated by side-grafting technology was already able to bear fruit at the age of 1 year and productivities were about 1.8-2.75 t ha^{-1} (Departemen Pertanian Direktorat Jenderal Perkebunan, 2009).

Side-grafting technology has been developed by farmers in Sigi regency, however until 2012, productivities were still below 1000 kg ha^{-1}. This was due to not all farmers applied the side-grafting technology on unproductive cocoa plants. Effendy *et al.* (2013a) reported there were 56.12% farmers did not do side-grafting on cocoa farming.

The increasing of productivity was not just did side-grafting technology on cocoa plant. There were two main elements that determined productivity of side-grafting cocoa plant, those were: (1) A given nutrient and (2) Maintenance/management. Maintenance of cocoa farming, for example sanitation would affect the technical efficiency of input usage by cocoa farmers, so cocoa productivity would increase. The role of technical efficiency in reaching potential production for cocoa plant in Indonesia has been investigated by Effendy *et al.* (2013b) and other commodities has been

investigated, for example in the study of Rahman and Hasan (2008), Krasachat (2012), Al-Feel and Al-Basheer (2012), Tan *et al.* (2010), Hidayah *et al.* (2013) and other researchers.

The objectives of this study were to: (1) Analyze the level of technical efficiency of input usage cocoa production without and with the application of side-grafting technology and (2) Analyze the effect of side-grafting technology application level, level of technical efficiency, age of cocoa plants rootstock, fertilizer, pesticide and labor on cocoa productivity.

MATERIALS AND METHODS

This research was conducted in Palolo Subdistrict Sigi Regency, Indonesia. Sejahtera Village and Bulili Village were chosen to be research locations. It was done because Sejahtera Village and Bulili Village were central areas of cocoa production in Sigi regency, Indonesia.

Total populations in both villages were 218 household heads (HH). The populations in Sejahtera Village were 106 HH and Bulili were 112 HH. Determining the amount of samples was calculated by using the following equation (Parel *et al.*, 1973):

$$n = \frac{N\sum N_h s_h^2}{N^2\frac{d^2}{z^2} + \sum N_h s_h^2} \quad (1)$$

$$n_h = \frac{N_h}{N} n \quad (2)$$

Where:
n = Number of Sample
N = Number of population
N_h = Number of population each village
d = Precision was set at 10%
z = 1.645 (90%)
s_h = Variance of each village
n_h = Number of sample from each village

The sample that was used in Sejahtera Village were 48 HH and Bulili Village were 50 HH. Stochastic frontier production function was used to answer the first goal. Stochastic frontier production function in this research was assumed into the form of Cobb-Douglas which transformed into a linear form of the natural logarithm as following:

$$\ln Ykt = \lambda_o + \lambda_1 \ln PUK + \lambda_2 \ln PESTI + \lambda_3 \ln TKK + \varepsilon_i \quad (3)$$

Where:
Ykt = Cocoa production (kg)
PUK = Fertilizer (kg)
PESTI = Pesticide (litre)
TKK = Labor (Day People Working where Indonesian called HOK)
ε_i = Error

The level of technical efficiency of farmers was estimated by the following equation (Coelli *et al.*, 2005):

$$TE_i = \frac{y_i}{y_i^*} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i) \quad (4)$$

Where:
y_i = Actual production of the observations
y_i^* = Alleged frontier production

Technical efficiency was about between zero and one.

Analysis of multiple regression was used to answer the second goal, with the following model:

$$PDk = b0 + b1PT + b2EF + b3UT + b4PUK + b5PESTI + b6TKK + Ui \quad (5)$$

Where:
PDk = Cocoa productivity (kg ha^{-1})
PT = Level of side grafting technology implementation (%)
EF = Level of technical efficiency (%)
UT = Age of rootstock cocoa plant (years)
PUK = Fertilizer (kg)
PESTI = Pesticide (L)
TKK = Labor (Day people working where Indonesian called HOK)
Ui = Error

RESULTS AND DISCUSSION

Distribution of technical efficiency levels cocoa farming: One of the methods that could be used to estimate the level of technical efficiency was through stochastic frontier production function approach to Cobb-Douglas. Stochastic frontier production function approach was analyzed with the help of Frontier program version 4.1c. The program estimated the level of technical efficiency.

The level of technical efficiency of cocoa farming was analyzed simultaneously by using stochastic frontier production function Cobb-Douglas models. Distribution of technical efficiency level of cocoa farming by side-grafting technology application was shown in Fig. 1.

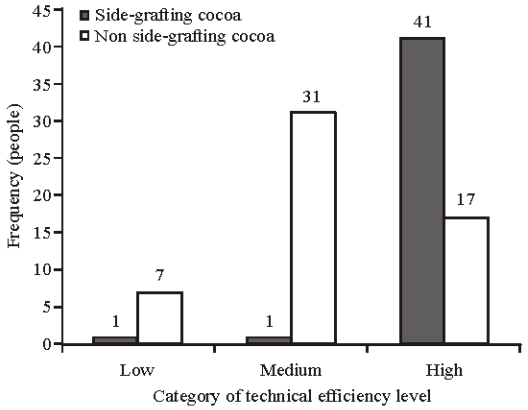

Fig. 1: Level of technical efficiency cocoa farming

Figure 1 showed cocoa farming without side-grafting technology had a low level of efficient technical category (7 people = 7.143%) when compared with more cocoa farming with side-grafting technology (1 people = 1.020%). Cocoa farming without side-grafting technology had a high degree of technical efficiency category were 17.347% (17 people) and cocoa farming with side-grafting technology were 41.837% (41 people). It showed that Cocoa farming that used side-grafting technology had a higher level of technical efficiency when compared to cocoa farming without side-grafting technology.

Side-grafting technology application and productivity of cocoa: Analysis of multiple regression was used to study the effect of side-grafting technology application, technical efficiency, age of cocoa plant rootstock, fertilizer, pesticide and labor on cocoa productivity. The results of multiple regression analysis were shown in Table 1.

Adjusted R^2 was 0.975 showed that cocoa productivity variation could be explained by the independent variable of side-grafting technology application, technical efficiency, age of cocoa plant rootstock, fertilizer, pesticide and labor simultaneously at 97.50% while the remaining 2.50% was explained by the other factors not included in the model. The effect of each factor on the productivity of cocoa was as following.

The application of side-grafting technology had positive significant effect on the productivity of cocoa, where t = 2.031 with probability 0.045<0.05 (α 5%) two-tail test. Elasticity were 0.015 could be defined that each increasing of side-grafting technology application amounted 1% could increase cocoa productivity amounted 0.015%, with assuming other factors were considered constant. It showed the application of side-grafting technology in cocoa farming was one factor that should be considered by farmers in increasing cocoa productivity.

This study was supported by research of Mondal *et al.* (2011) who stated the application of agricultural technology had created sustainable agriculture and environmentally friendly. Mekonnen *et al.* (2010) said, the application of agricultural technology could increase cow milk production. Silva *et al.* (2011), Samaddar and Das (2008) and Muzari *et al.* (2012) stated that the application of agricultural technology could increase agricultural productivity. The application of side-grafting technology on cocoa farming tended to increase the productivity of cocoa, for details were shown in Fig. 2.

Figure 2 showed generally the application of side-grafting technology on cocoa plants could increase the productivity of cocoa. The application of side-grafting technology on cocoa farming meant to rehabilitate cocoa garden that damaged or old (>18 years) by using quality seeds.

The level of technical efficiency had positive significant effect on the productivity of cocoa, where, t = 23.759 with probability 0.000<0.05 (α = 5%) two-tail test. Elasticity were 1.045 could be defined that each increasing of technical efficiency level amounted 1% could increase cocoa productivity amounted 1.045% with assuming other factors

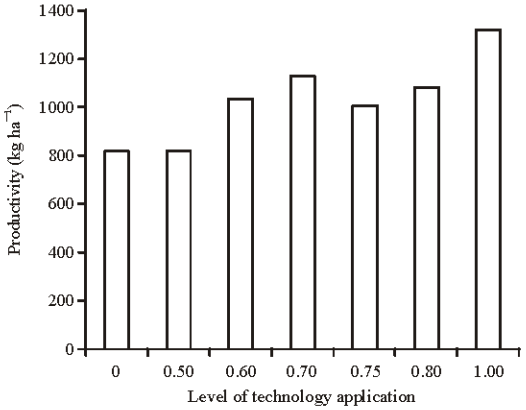

Fig. 2: Side-grafting technology application toward cocoa productivity

Table 1: Coefficients of multiple regression of some factors that affected productivity of cocoa

Variables	Coefficients	Standard error	t	p>|t|	VIF	Elasticity coefficients
Constant	-887.659					
PT	38.163	18.786	2.031	0.045	3.790	0.015
EF	1288.377	54.226	23.759	0.000	3.216	1.045
UT	1.270	1.148	1.107	0.271	4.433	0.016
PUK	0.371	0.061	6.110	0.000	2.250	0.203
PESTI	28.159	5.714	4.928	0.000	2.433	0.155
TKK	3.590	0.269	13.321	0.000	3.018	0.458

Adjusted R^2 was 0.975

were considered constant. It showed the level of technical efficiency in cocoa farming was one factor that should be considered in increasing productivity. The increasing of technical efficiency meant reducing of technical inefficiency of farmers so that farmers could achieve potential production. Effendy *et al.* (2013b) stated characteristics of farmer such as education, cocoa farming experience, frequency of following agricultural extension and sanitation could increase technical efficiency of cocoa farming.

Age of cocoa plant rootstock had not significant effect on the productivity of cocoa, where t = 1.107 with probability 0.271>0.05 (α = 5%) two-tail test. It showed age of cocoa plant rootstock was not be a problem for farmers in increasing cocoa productivity. It meant, unproductive cocoa plants could be rehabilitated with the side-grafting technology without paid attention the age of rootstock.

The usage of fertilizer had positive significant effect on the productivity of cocoa, where t = 6.110 with probability 0.000<0.05 (α = 5%) two-tail test. Elasticity were 0.203 could be defined that each increasing of fertilizer amounted 1% could increase cocoa productivity amounted 0.203% with assuming other factors were considered constant. It showed the usage of fertilizer in cocoa farming was one factor that should be considered by farmers in increasing cocoa productivity.

The usage of pesticide had positive significant effect on the productivity of cocoa, where t = 4.928 with probability 0.000<0.05 (α = 5%) two-tail test. Elasticity were 0.155 could be defined that each increasing of pesticide usage amounted 1% for plant that was attacked by pests and diseases could

increase cocoa productivity amounted 0.155% with assuming other factors were considered constant. It showed the usage of pesticide in cocoa farming that was attacked by pests and diseases became one factor that should be considered by farmers in increasing cocoa productivity.

The usage of labor had positive significant effect on the productivity of cocoa, where t = 13.321 with probability 0.000<0.05 (α = 5%) two-tail test. Elasticity were 0.458 could be defined that each increasing of labor usage amounted 1% could increase cocoa productivity amounted 0.458% with assuming other factors were considered constant. It showed the usage of labor in cocoa farming was one factor that should be considered by farmers in increasing cocoa productivity. The addition of labor would cause activities in cocoa farming would be done right on target and on time, for example pruning, weeding, fertilizing, pest and disease control, etc., which would tend to increase cocoa production.

CONCLUSION

Cocoa farming that used side-grafting technology had a higher level of technical efficiency when compared to cocoa farming without side-grafting technology. The application of side-grafting technology, level of technical efficiency, fertilizer, pesticide and labor had positive significant effect on the productivity of cocoa. Cocoa plants that were not productive in order to be rehabilitated by side-grafting technology without paid attention to age of cocoa plant rootstock. Maintenance of cocoa plants that used side-grafting technology needed to be considered, for example conducted field sanitation and cocoa trees, fertilizers, control of pest and disease.

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REFERENCES

Al-Feel, M.A. and A.A.R. Al-Basheer, 2012. Economic efficiency of wheat production in Gezira scheme, Sudan. J. Saudi Soc. Agric. Sci., 11: 1-5.

Coelli, T.J., D.S.P. Rao, C.J. O'Donnell and G.E. Battese, 2005. An Introduction to Efficiency and Productivity Analysis. Springer Science and Business Media, New York, ISBN: 9780387258959, Pages: 367.

Departemen Pertanian Direktorat Jenderal Perkebunan, 2009. [Handbook of cultivation technical of cocoa (Theobroma cacao L.)]. The Increasing Production Movement and National Cocoa Quality, Jakarta.

Direktorat Jenderal Perkebunan, 2013. [Production and productivity of cocoa based on province in Indonesia, 2008-2012]. http://ditjenbun.pertanian.go.id/.

Effendy, N. Hanani, B. Setiawan and A.W. Muhaimin, 2013a. Characteristics of farmers and technical efficiency in cocoa farming at Sigi Regency-Indonesia with approach stochastic frontier production function. J. Econ. Sustainable Dev., 4: 154-160.

Effendy, N. Hanani, B. Setiawan and A.W. Muhaimin, 2013b. Effect characteristics of farmers on the level of technology adoption side-grafting in cocoa farming at Sigi Regency-Indonesia. J. Agric. Sci., 5: 72-77.

Hidayah, I., N. Hanani, R. Anindita and B. Setiawan, 2013. Production and cost efficiency analysis using frontier stochastic approach, a case on paddy farming system with Integrated Plant and Resource Management (IPRM) approach in Buru district Maluku province Indonesia. J. Econ. Sustainable Dev., 4: 78-84.

Krasachat, W., 2012. Organic production practices and technical inefficiency of Durian farms in Thailand. Procedia Econ. Finance, 3: 445-450.

Lokakarya Kakao Indonesia, 2013. [In the framework of Indonesia cocoa day celebration with theme]. Improving Productivity and Quality Towards Sustainable Indonesia Cocoa. Jakarta, September 18, 2013.

Mekonnen, H., G. Dehninet and B. Kelay, 2010. Dairy technology adoption in smallholder farms in Dejen district, Ethiopia. Trop. Anim. Health Prod., 42: 209-216.

Mondal, P., M. Basu, P.B.S. Bhadoria, A.A. Emam and M.H. Salih et al., 2011. Critical review of precision agriculture technologies and its scope of adoption in India. Am. J. Exp. Agric., 1: 49-68.

Muzari, W., W. Gatsi and S. Muvhunzi, 2012. The impacts of technology adoption on smallholder agricultural productivity in sub-Saharan Africa: A review. J. Sustainable Dev., 5: 69-77.

Parel, C.P., G.C. Caldito, P.L. Ferrer, G.G. de Guzman, C.S. Sinsioco and R.H. Tan, 1973. Sampling Design and Procedures. Agricultural Development Council Inc., New York.

Rahman, S. and M.K. Hasan, 2008. Impact of environmental production conditions on productivity and efficiency: A case study of wheat farmers in Bangladesh. J. Environ. Manage., 88: 1495-1504.

Samaddar, A. and P.K. Das, 2008. Changes in transition: Technology adoption and rice farming in two Indian villages. Agric. Hum. Values, 25: 541-553.

Silva, C.B., M.A.F.D. de Moraes and J.P. Molin, 2011. Adoption and use of precision agriculture technologies in the sugarcane industry of Sao Paulo state, Brazil. Precis. Agric., 12: 67-81.

Tan, S., N. Heerink, A. Kuyvenhoven and F. Qu, 2010. Impact of land fragmentation on rice producers' technical efficiency in South-East China. NJAS-Wageningen J. Life Sci., 57: 117-123.