UDC 633.3

GOOD AGRICULTURE PRACTICES IN SHALLOT CULTIVATION USING FRONTIER STOCHASTIC PRODUCTION FUNCTION IN DONGGALA, INDONESIA

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ABSTRACT
The purposes of the study are to describe implementation of Good Agriculture Practices (GAP), the level of technical efficiency and factors affecting the level of efficiency of local shallot cultivation in Donggala Regency, Indonesia. Simple random sampling is applied to select samples among the population of 347 local farmers. The findings show that the farmers participating in GAP are more thoroughly than the non-participants. The average percentage of the implementation of GAP by the former group is 80.25-88.91%, while that by the later group is 66.67-74.10%. Moreover, in terms of level of efficiency, it is revealed that total area for shallot cultivation, farmers, organic fertilizer, SP-36 and KCL fertilizers have positive, significant influence towards level of production when α=5%. Several factors such as level of education, farming experience, family participants, age, as well as active participation in workshop on agriculture influence the farmers' level of technical efficiency.

KEY WORDS
Good agriculture practices, technical efficiency, production, agriculture.

Between 2010 and 2014, there was a 22.08% increase in national shallot production from 1,048.93 thousand tons to 1,233,984 tons. There is also a 22% increase in total harvest area from 109,634 ha into 120,704. Average productivity of local shallot farmers in Sulawesi Tengah Province, Indonesia, is 3 – 5 tons per ha; it can be increased to 10-11 tons per ha with the help of suitable technology (Maskar & Rahardjo, 2008). Furthermore, Terry et al (2000) state that shallot is most frequently used as herbs. It contains calcium, potassium and magnesium up to 10 percents of total number of the substances needed by human body. In addition, the local shallot is used as ingredients for some products. 15.7 tons of fresh shallots are needed to produce 3.45 tons processed shallots (Andi and Nur, 2009).

Increasing farmers' level of technical efficiency is an attempt to increase both production and productivity. Age, level of education, farming experience, number of family participants as well as participation in workshops on agriculture affect the level of technical efficiency. However, farmers have yet been able to apply input they get from the workshops. As a result, Good Agriculture Practices (GAP) principle is needed.

The purpose of the study is to describe the implementation of GAP, level of farmer's technical efficiency and factors that influence the level of technical efficiency.

METHOD OF RESEARCH

The study is conducted in Indonesia, particularly in two villages called Guntarano and Wombo, located in a district called Tanantovea, Donggala Regency, Sulawesi Tengah Province. In both villages, there are 347 households with local shallots cultivation; 212 of them are members of GAP, while the remaining 135 are not. Simple random sampling is the sampling method used to determine the samples.

Parel et al's (1973) formula is used:

$$n = \frac{NZ^2\sigma^2}{Nd^2+Z^2\sigma^2} \qquad (1)$$

Where: n = number of samples; N = number of farmers who become GAP participants and non-GAP participants (347 farmers); z = normal variable when level of confidence is 95% = 1.96; σ = population variance (0.19); d = standard error (0.05).

Based on the equation, it is obtained that the number of samples who become GAP participants are 97 farmers and those who do not become GAP members are 62 farmers.

To describe the implementation of GAP, whether or not it is suitable with the Standard Operating Procedure (SOP), score is given to the following aspects of GAP, namely, (1) land for cultivation and growing media, (2) seed, (3) cultivation and distance between plants, (4) maintenance, (5) fertilizer, (6) pesticide, (7) irigation, (8) harvest, (9) post-harvest activities and storage/ packaging. Equation used to obtain percentage of implementation of Good Agriculture Practice (GAP) is as follow:

$$GAP\ Implementation = \frac{Total\ Score}{Maximum\ Score}\ x\ 100 \qquad (1)$$

Total score is obtained based on how many scores the farmers get from questionnaire distributed by the researchers. The scores are then divided by maximum score that the researchers determined previously and converted into percentage (the division times 100%). It is the percentage of GAP implementation by the farmers.

In order to determine, level of technical efficiency of the participants of Good Agriculture Practices (GAP) and conventional farmers (those who do not apply GAP principles), the researchers use Coelli et al (1998)'s Frontier Stochastic Production Function. The equation for the approach is as follow:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln X_{ji} + (V_i - U_i) \qquad (2)$$

The assumption is the Frontier Stochastic Production in the study has Cobb-Douglas form that is transformed into the following natural, linear algorithm:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + (V_i - U_i) \qquad (3)$$

Where: Y = production of local shallot in Donggala (kilogram); X_1 = total area (ha); X_2 = mumber of seeds (kg/ha); X_3 = farmers (HOK); X_4 = organic fertilizer (kg/ha); X_5 = urea fertilizer (kg/ha); X_6 = SP-36 fertilizer (kg/ha); X_7 = KCl fertilizer (kg/ha); X_8 = pesticide (lt/ha); V_i = random error; U_i = random variable representing technical inneficiency of the nth sample.

Level of technical efficiency of the cultivation for the nth farmers is obtained using the following equation (Coelli et al., 1998):

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

y_i is actual production obtained as the result of observation while y_i^* is estimated frontier production obtained using the Frontier Stochastic Production Function. Farmer's level of technical efficiency ranges from 0 (zero) to 1 (one) with reversed correlation to level of technical inefficiency.

To describe factors affecting level of technical efficiency, multiple regression analysis is used; the equation is as follow:

$$ET = \delta_0 + \delta_1 PP + \delta_2 PB + \delta_3 JAK + \delta_4 UP + \delta_5 PD + \delta_6 FP + U \qquad (5)$$

Where: ET = technical efficiency (%); PP = farmer's level of education (year); PB = experience in agriculture (year); JAK = number of family members (people); UP = age;

PD = income (IDR); FP = training/ workshop (frequency); U = confounding variable; It is expected that $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6 < 0$.

RESULTS AND DISCUSSION

General Implementation of GAP in Both Groups of Farmers. The implementation of Good Agriculture Practices (GAP) is divided into two categories, that is, average and high based on the continuum. The percentage of GAP implementation is obtained from the total scores based on the questionnaires divided by the maximum score times 100%.

The findings show that the implementation of GAP by the respondents can be divided into two categories namely average and high. The average implementation of Good Agriculture Practices (GAP) is presented in Figure 1.

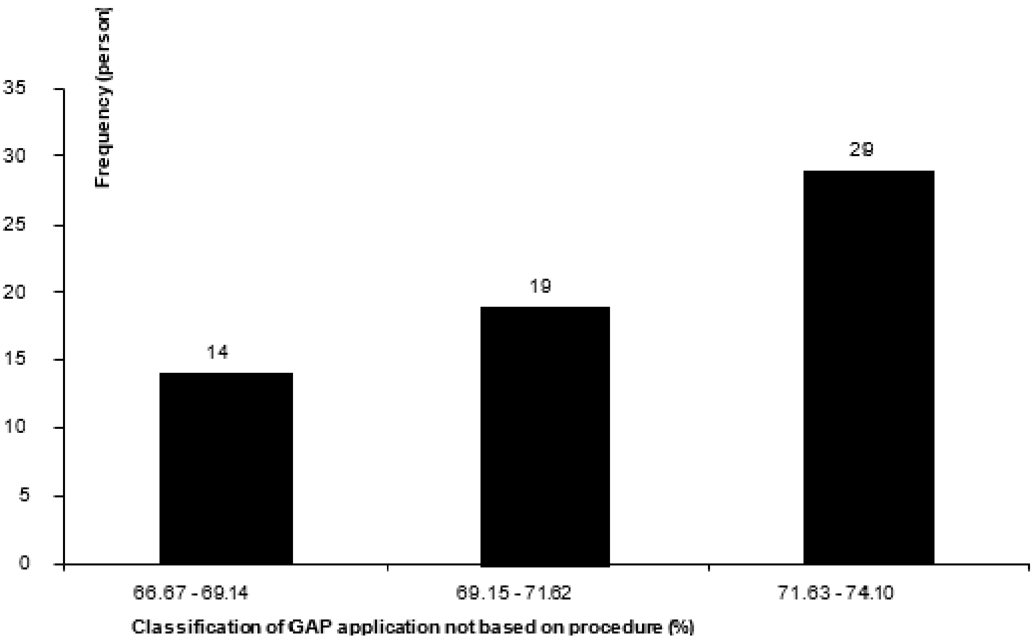

Figure 1 – Implementation of GAP by Conventional Farmers

Figure 1 describes that referring to the Standard Operating Procedure (SOP) the implementation of GAP by the conventional farmers can be categorized as average. The percentage is between 66.67–74.10% and the average percentage is 70.75%. The farmers obtain shallot seeds from the previous cultivation. The farmers do not take quality of the seeds or distance between plants into account. It is in line with a study by Handri, Andi, Bahrudin (2013) which state that seeds influence production component and shallot production. In addition, the farmers prefer inorganic fertilizer that actually prevents the plants from absorbing necessary nutrients. Djafar et al (2004) state that inorganic fertilizer increases nutrients in the soil, enhances size of root vegetables and eventually increases level of production. The farmers also use synthetic pesticides for controlling OPT. Shallot is very vulnerable towards pests and other diseases that may influence the harvest.

Figure 2 describes that referring to the Standard Operating Procedure (SOP) the implementation of GAP by the conventional farmers can be categorized as high. The percentage is between 80.25 – 88.91% and the average percentage is 86.51%. It implies the farmers have carried out most of the Standard Operating Procedure (SOP). Since the price of seeds is relatively high, the farmers should make some adjustment which may compromises level of production (low production). It is in line with Azis et al (2012) who describe that farmers prefer using inorganic fertilizer due to practicality. Such fertilizer increases production but at the same time reduce soil fertility. Furthermore, Asrul (2009) explains that inorganic fertilizer is chemical fertilizer and excessive use of the fertilizer will increase production but does not improve soil fertility. Synthetic pesticide requires less time to eradicate pests and is more affordable compared to organic pesticide. It is in line with Dewi and Idris (2005) who reveal that technical efficiency of irrigated rice field is influenced by inorganic fertilizer.

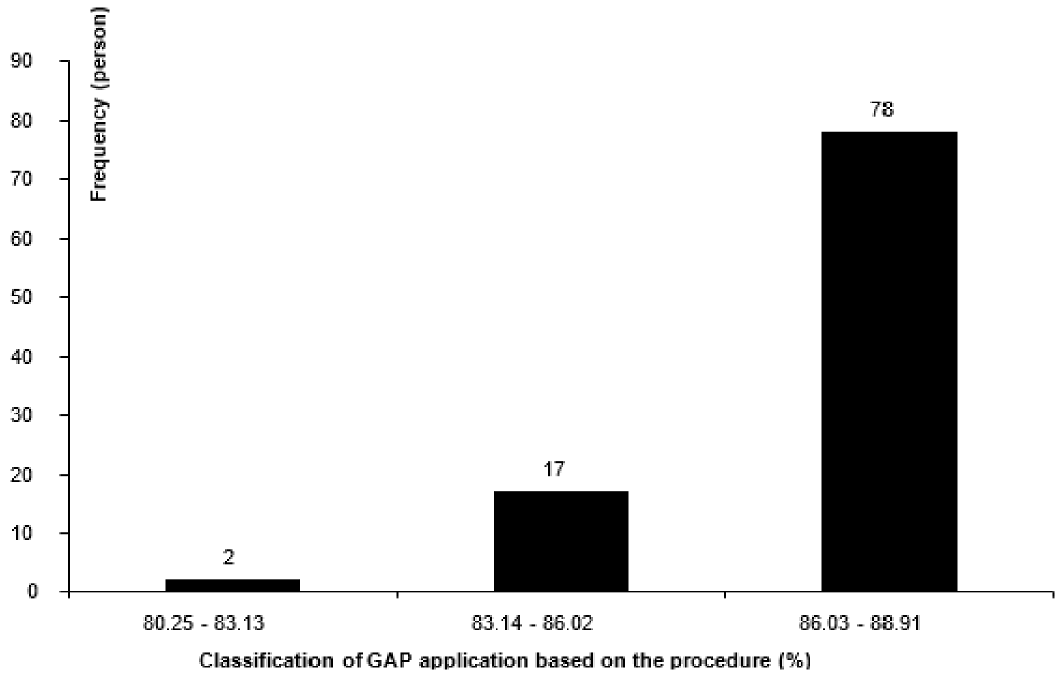

Figure 2 – Implementation of GAP by GAP Participants

Characteristics of Shallot Farmers based on Cultivation Area. At the end of the study, it is found out that there are 32 participating farmers applying the principles of GAP in as much as 86.03 - 88.91% with the total area of their cultivation is between 0.25 ha and 0.50 ha. On the other hand, there are 13 conventional farmers applying the principles of GAP as much as 71.63 - 74.10% with the cultivation areas which are relatively small, so that the level production is low. It is in line with a study by Kune et al (2016) which reveals that cultivation area has a positive, significant influence towards production when α=1%.

Characteristics of Shallot Farmers based on Age. As many as 47 GAP participants who apply 86.03-88.91% of GAP Standard Operating Procedures are between 38-50 years. Furthermore, 17 conventional farmers that carry out 71.63 - 74.10% of GAP Standard Operating Procedures are between 25-37 years old. The farmers are within productive age, so that they run their shallot farms well. Marfin et al (2015) explain that age has a positive influence towards technical efficiency and the level of coefficient for shallot farmers in Bantul Regency is 1.2668. Furthermore, Eka (2014) argues that younger farmers are more responsive towards new inventions in agriculture and actively seek the most current information.

Characteristics of Shallot Farmers based on Level of Education. As many as 35 GAP participants who apply 86.03-88.91% of GAP Standard Operating Procedures are senior high school graduates. Meanwhile, 12 conventional farmers that carry out 71.63-74.10% of GAP Standard Operating Procedures are elementary school graduates. Participants of GAP programs have higher level of education compared to conventional farmers. It implies level of education affect individual's ability to analyze his/her past, present and future activities. Individuals with high level of education can generally merge technology into their daily routines. It is in line with Kurniati (2012) who states that the level of education of corn farmers in West Kalimantan has significant influence towards their information processing abilities. Furthermore, Karim et al (2010) conduction a study in Kerinci describe education is responsible for the chili farmers' abilities to incorporate technology into their farming activities. Finally, Bandolan, et.al (2010) state education affects farmer's ability to run their business well more particularly in selecting the seeds, farming pattern, selecting fertilizer and pesticide and harvesting.

Characteristics of Shallot Farmers based on Experience in Agriculture. The 42 farmers who become the participants of GAP program have 3 (three) to 15 (fifteen) years of experience in agriculture. On the other hand, only 24 conventional farmers have 3 (three) to 15 (fifteen) years experience in agriculture. It is in line with findings of Rasyid (2003) and Rukka et al (2006)'s studies that experience in agriculture determines decision-making ability and responsiveness towards the most current technology of corn farmers.

Characteristics of Shallot Farmers based on Numbers of Family Members. As many as 50 GAP participants who apply 86.03-88.91% of GAP Standard Operating Procedures have 3-4 dependents, while 14 conventional farmers that carry out 71.63-74.10% of GAP Standard Operating Procedures have 1-2 dependents. Dependent refers to a person who relies on the farmers for food, housing, and money. Having more dependents mean having more people to help at the farm once the dependents have reached productive ages. Dewi et al (2005) reveal that farmers with more family members to help them at the farm have higher income than those with less family numbers helping them at the farm.

Characteristics of Shallot Farmers based on Participation in Training/Workshop on Agriculture. As many as 34 GAP participants who apply 86.03-88.91% of GAP Standard Operating Procedures attend 3-4 workshops or trainings on agriculture in one farming season. Smaller number of conventional farmers, 16 farmers, who carry out 71.63-74.10% of GAP Standard Operating Procedures attends 1-2 workshops or trainings on agriculture in one farming season. It indicates GAP participants have more active participation in agriculture training/workshop compared to conventional farmers. It is in line with Sudirman (2007) who argues that training/workshop is an attempt to improve farmer's skills so that the farmers can create more productive farmland.

Level of Technical Efficiency of Local Shallot Farmers. To determine level of technical efficiency of local shallot farmers in Palu, the researchers use the Frontier Stochastic Production Function and Cobb-Douglas's MLE model as seen in Table 1.

Table 1 – Parameter of Frontier Stochastic Production Function with Cobb-Douglas's MLE Model in Local Shallot Cultivation 2014

Variable	Coefficient	standard-error	t-ratio	t-table (5%)
Intersep	8.009	0.008		
Total Area (X1)	0.125	0.007	17.772**	1.987
Seed (X2)	0.226	0.008	27.640 **	1.987
Farmer (X3)	0.204	0.013	15.594 **	1.987
Organic Fertilizer (X4)	0.106	0.013	8.275 **	1.987
Urea (X5)	0.015	0.016	0.904^{tn}	1.987
SP-36 (X6)	0.035	0.004	9.058**	1.987
KCl (X7)	0.088	0.010	8.512 **	1.987
Pesticide (X8)	(0.006)	0.006	$(0.974)^{tn}$	1.987
Sigma-squared	0.093			
Gamma	0.99			
Log likelihood function	71.631			
LR	73.157			

Source: Primary Data, 2014
**** = level of significance when α=5%, two-way test*

Sigma-square (σ) and gamma *(γ)* scores from the MLE method are 0.93 and 0.99 respectively. Sigma-square (σ) score higher than 0 (zero) means technical inefficiency influences the model of function production. Gamma *(γ)* score of 0.99 means error caused by technical efficiency is 99%; the percentage shows that discrepancy between actual production and maximum production is heavily influenced by technical inefficiency effect, while the remaining 1% is caused by random error variable or other variables such as weather or plant disease. Generalized likelihood (LR) of the Frontier Stochastic Production Function is 73.157 that means it can sucesfully explain technical efficiency and technical inefficiency of the faremrs in the production process. The variables that has significant influence when α=5% towards farmers' frontier are relatively the same as the average production function (OLS).

Influence Of Each Production Factor towards Local Shallot Production. Cultivation area has a significant and positive influence towards local shallot production. The coefficient is 0.125, t-ratio of 17.772 is > t-table of 1.987, α=5 % in two-way testing. It is in line with Lawall et al (2013) that 1% increase in cultivation area will increase 0.38 percent of rice production in Nigeria.

Variety of seeds has significant and positive influence towards local shallot production. The coefficient is 0.226, t-ratio of 27.60 is > t-table of 1.987, α=5 % in two-way testing. It is in line with Effendy (2010) that mentions variety of seeds has significant influence towards rice production in Masani, Poso Pesisir Regency.

Farmers have significant and positive influence towards local shallot production. The coefficient is 0.204, t-ratio of 15.594 is > t-table of 1.987, α=5 % in two-way testing. Farmers responsible for production are different from those responsible for other branches of production. Farmer's knowledge in agriculture, skills and knowledge about technology affect level of production tremendously. It is in line with the findings of Tety (2004), Li et al (2008), Effendy et al (2013) and Lawall et al (2013)'s study that farmer is categorized as one of the factors in production and has positive influence towards level of production.

Organic fertilizer has significant and positive influence towards local shallot production. The coefficient is 0.106, t-ratio of 8.275 is > t-table of 1.987, α=5 % in two-way testing. Organic fertilizer has certain nutrients that can be absorbed easily by the root vegetable (local shallots) and improves structure of the soil. It is in line with Wahyunindyawati, Kasijadi, and Abu (2012) who state that "Biogreen Granul," a type of organic fertilizer has positive influence towards growth of shallot and contributes to 23% increase or 2.8 tons per hectares of the harvest compared to conventional shallots cultivation in Probolinggo, Jawa Timur Province.

Urea fertilizer does not have significant influence towards production of local shallots. The coefficient is 0.015, t-ratio of 0.904 is < t-table of 1.987, α=5 % in two-way testing. The significant influence of urea fertilizer may be caused by irregular application of the fertilizer. In addition, the method the farmers used to apply the fertilizer makes the nitrogen in the organic fertilizer (manure) fulfill the need of Nitrogen the local shallot plants have. It is in line with Alam (2015) who argues that flooding, as irrigation system washes away urea residue more effectively than other irrigation system.

SP-36 fertilizaer has a significant and positive influence towards production of local shallot. The coefficient is 0.035, t-ratio of 9.058 is > t-table of 1.987, α=5 % in two-way testing. Phosphor has the role of protein preparation and in the process of metabolism. Alam (2015) describes that phosphor functions as component of protein, coenzyme and nucleic acid. As an addition, Jones and Jacobsen (2001) state that phosphor also has significant role in substrate metabolism, energy transfer and is part of RNA and DNA structure.

KCl fertilizer has a significant and positive influence towards production of local shallots. The coefficient is 0.088, t-ratio of 8.512 is > t-table of 1.987, α=5 % in two-way testing. Potassium helps photosynthesis, carbohydrate translocation protein synthesis and is enzyme activator. It is line with Jones and Jacobsen (2001) and Alam (2015) who mention that potassium is one of the most essential nutrient plant needs and is a catalyst that turns protein into amino acid. It is also the component of carbohydrate, helps developing root vegetables and quality of plants as well as enhances physiological metabolism of plants .

Pesticide does not have significant influence towards production of local shallots. The coefficient is 0.006, t-ratio of 0.974 is < than t-table of 1.987, α=5 % in two-way testing. It means there is an excessive application of pesticides, more than the recommended dosage. It is in line with Khazanani and Nugroho (2011) who explain that pesticide does not have any influence towards the production and technical efficiency in chili plantation in Temanggung.

Influence of Each Factor towards Level of Technical Efficiency. The influence of several factors towards level of technical efficiency in the implementation of Good Agriculture Practice (GAP) can be seen in Table 2.

Table 2 – Estimated Parameter of Technical Efficiency in Local Shallot Plantation (2013)

Variable	Parameter	Coefficient	Standard of Error	t-test	t-table 5%	P
Intersep	δ_0	0.789	0.008			
Education	δ_1	0.052	0.009	6.316	1.987	,000
Experience	δ_2	0.048	0.009	5.636	1.987	,000
Dependent	δ_3	0.058	0.008	6.663	1.987	,000
Age	δ_4	0.029	0.009	3.689	1.987	,000
Training/ workshop	δ_5	0.057	0.016	6.229	1.987	,000
GAP and Non GAP	δ_6	0.035	0.008	2.146	1.987	,033
Determinant coefficient (R^2) = 0.633						

Source: Primary Data, 2014
**** = level of significance when α=5%, two-way test*

Table 2 shows determinant coefficient is 0.63 where level of technical efficiency of the shallot farmers who carries out GAP program is described based on their level of education, experience in agriculture, numbers of dependents, age, and participation in agriculture training/workshop. The level of technical efficiency is 63.3% while remaining 36.7% is described by other factors. For better illustration on the influence of each factor, the data captured by Table 2 can be elaborated as follow.

Education has positive influence towards level of technical efficiency where t-ratio 6.316 > t-table 1.987 with probability of 0.000 < 0.052, α=5% in two-way testing. Regression coefficient of 0.052 means 0.052 average annual increase will improve the farmer's knowledge as much as 0.052% with the assumption that other factors remain constant. It is in line with Mohapatra (2011) who state that level of education enables Indian sugarcane farmers to get more benefit from their sugarcane plantation. It is also in accordance with the study by Krasachat (2012) which concludes that level of education affects level of efficiency of organic durian farmer in Thailand.

Experience in agriculture, particularly experience in the implementation of GAP, has positive influence towards level of technical efficiency where t-ratio 5.636 > t-table 1.987 with probability of 0.000 < 0.048, α=5% in two-way testing. Regression coefficient of 0.048 means 0.048 average annual increase in agriculture experience will improve the farmer's knowledge as much as 0.048% with the assumption that other factors remain constant. It is in line with Wollini and Brummer (2012) describing that experience in agriculture that affects farmers' skills influence technical efficiency of Costa Rican coffee farmers besides active participation in agriculture training/ workshop.

Numbers of dependents has positive influence towards level of technical efficiency where t-ratio 6.663 > t-table 1.987 with probability of 0.000 < 0.058, α=5% in two-way testing. Regression coefficient of 0.058 means 0.058 average annual increase in number of dependents increases numbers of people working on the farms as much as 0.058% with the assumption that other factors remain constant. It is in line with Bello, et.al (2012) that farmer's characteristics i.e. age, family members, social participation, experience in agriculture, cultivation area, income and training contributes 67% variance in the cancellation of agricultural technology by rice farmers in Nasawa, Central Nigeria.

Age has positive influence towards level of technical efficiency where t-ratio 3.689 > t-table 1.987 with probability of 0.000 < 0.029, α=5% in two-way testing. Regression coefficient of 0.029 means 0.029 average annual increase in farmer's age will improve the farmer's knowledge as much as 0.029% with the assumption that other factors remain constant. Farmers within productive age and sufficient knowledge in agriculture are able to incorporate technology easily and more effectively According to Kebede (2001), farmer's age affects farming experience.

Farmer's participation in agriculture trainings or workshops, especially the ones related to Good Agriculture Practice (GAP), has positive influence towards level of technical efficiency where t-ratio 6.229 > t-table 1.987 with probability of 0.000 < 0.057, α=5% in two-way testing. Regression coefficient of 0.057 means 0.057 average annual increase in agriculture training will improve the farmer's knowledge as much as 0.057% with the assumption that other factors remain constant. It is in line with Rahman and Rahman (2008) who reveal that the use of technology increase farmer's efficiency in Bangladesh. Furthermore, Jahan and Pemsi (2011) state that technical efficiency, total productivity and net profit have significant impact towards agriculture training/ workshop.

The implementation of Good Agriculture Program (GAP) has positive influence towards level of technical efficiency where t-ratio 6.229 > t-table 1.987 with probability of 0.033 < 0.035, α=5% in two-way testing. Regression coefficient of 0.035 means 0.035 average annual increase in GAP implementation will improve the level of technical efficiency as much as 0.035% with the assumption that other factors remain constant. It is in line with Astuti (2010) that mentions GAP implementation has significant influence towards productivity and contributes to 46.37% increase in farmer's average income compared to the average income of conventional farmers. In addition, according to Sriyadi et al (2015), the rice farmers in Bantul, Yogyakarta practicing the Standard Operating Procedure of GAP have higher income compared to conventional farmers who do not carry out GAP.

CONCLUSION

The findings of the study show that percentage of GAP implementation by the farmers who become participants of GAP program is between 80.25 – 88.91% with the average percentage of GAP implementation is 86.51%. On the other hand, the percentage of GAP implementation by the conventional farmers is between 66.67 – 74.10% with the average of 70.75%. Cultivation area, seeds, farmers as well as organic, SP-36 and KCL fertilizers have significant influence towards technical efficiency, while urea fertilizer and pesticide do not. Farmer's level of education, experience in agriculture, number of dependents, age and participation in agriculture training/ workshop are factors that influence the level of technical efficiency of the farmers who become the participants of GAP program as well as the conventional farmers.

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