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Research Article

Technology Innovation in Cocoa-goats Integration System for Increasing of Productivity and Farmers Income in Kulon Progo Regency, Yogyakarta Special Region Province, Indonesia

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Abstract

Background and Objective: The problems on the cacao farmers in Kulon Progo regency is generally low-income, they have not been able to properly manage the cocoa fields so that the productivity is low. Therefore, the aim of this study was to determine the effect of technology innovation on the improvement of cocoa and goat productivity and the increase of farmer's income in the cocoa-goat integrated system. **Methodology:** The materials of the study were 30 farmers in Kulon Progo regency, their goats and cocoa plantation. The method of the study was field observation. The farmers were divided into three models (A, B and C). Each model consisted of 10 farmers. Model A was a farmer model who represented cocoa-goat integration with technology innovation, model B who represented cocoa-goat integration without technological innovation and model C who represented without both integration and technological innovation. The technological innovation on model A consisted of cocoa cultivation, cacao pest and disease control, goats breeding and manure processing to be an organic fertilizer. Variables observed for 8 months (March-October, 2013) in model A and B were the production of cacao and goats, while in model C was cacao production only. Cocoa production was analyzed using one way analysis of variance and continued by Tukey's test for significant differences while, goat's productivity between the models A and B was analyzed using independent-test. **Results:** The results indicated that cacao productivity in model A (560 kg ha^{-1} $year^{-1}$) is 39% higher than model B (402 kg ha^{-1} $year^{-1}$) and 52% higher than model C (368 kg ha^{-1} $year^{-1}$). Goat productivity was not different among the three models. The interesting result was found on farm incomes, model A (IDR 2,620,000.00) higher than model B (IDR 983,000.00) and C (IDR 580,000.00). **Conclusion:** The study concluded that technological innovation and integration of goats in cocoa farming is appropriate to overcome the low productivity and farmer's income. New aspect and implication of the study is the increase of cocoa production can be done by the use of liquid organic fertilizer as much as 1 L per rod, solid organic fertilizer as much as 10 kg per rod and dolomite of 100 g per rod.

Key words: Technological innovation, cocoa-goat integration, productivity, farmers income

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Faming system in Indonesia is generally monoculture farming which is focused on one farming type. Risk of monoculture farming is that the farmer will not get income aside from the farm if the failure occurs. One way to overcome this is that the farmers should carry out integrated farming system. Haryanto[1] stated that integration is a combination or unification of the whole farming system components both horizontally and vertically so that no waste is wasted. The integrated farming system is the eco-friendly and able to expand sources of income as well as to reduce the risk of failure as reported by Adnyana[2]. According to Gunawan and Sulastiyah[3] integrated farming system can reduce of production cost, resources utilization efficient, increase the production and the farmers income.

One form of integrations in the cocoa farming is cocoa-goat integration. The integrated farming system is an effort to integratively develop of livestock agribusiness and plantations as discussed by Subagyono[4]. Cocoa plantations are likely to be a place or land for the goats development due to the availability of abundant feed from the by-product of cocoa fields while, the goat farming produces manure which is used as the source of organic fertilizer for cocoa plant. The by-product of cacao is very potential as goat forage. According to Puastuti[5], the use of cocoa rind as goats forage can save farmer's time to look for grass and overcome the shortage of grass forage in the dry season.

One problem encountered by the cocoa farmers is generally low-income people who have not been able to properly manage the cocoa fields especially for fertilization. Well-managed goat farming can produce manure to be used as organic fertilizer for cocoa plants so can reduce the use of inorganic fertilizers. According to Santiananda *et al.*[6], each hectare of cocoa farm can accommodate about 2-8 goats. Each goat raised in a slat can produce urine of 0.6-2.5 L day^{-1} as reported by Mathius[7] and feces of 2.68 kg day^{-1} as reported by Marton *et al.*[8] which can be processed into organic fertilizer for cocoa plants.

Another problem is that the cocoa productivity of the farmers in Kulon Progo regency, province of Yogyakarta special region, Indonesia is low. The cocoa land area of 3.3 thousand hectares only produces about 778 t cacao seed per year or 235 kg ha^{-1} $year^{-1}$ as reported by CBSDIY[9]. The cocoa production is lower than the national average production which is 924 kg ha^{-1} $year^{-1}$ as reported by AARD[10]. According to Kusnadi[11] crop-livestock integration in farming system and technological innovation is one way to overcome the low productivity of farming system. This study is done by emphasizing on the resource optimization as taken place in cattle and oil palm integration system discussed by Gunawan and Talib[12]. The land resource is optimized using organic fertilization from manure to increase the cocoa production while, the livestock resources is optimized by utilizing the by-product of cocoa plant as goats forage.

Based on the above description, it is deemed necessary to to conduct study about the effort to increase cocoa and goats productivity in Kulon Progo farmer's through technological innovation and integration of goats in cocoa farming. The aim of this study is to determine the effect of technological innovation on the improvement of cacao and goats productivity and on the increase of farmer's income in the cocoa-goat integration systems. This study was conducted by comparing three farming models, namely the model representing cocoa-goat integration with technology innovation, the model representing cocoa-goat integration without technological innovation and the model without both integration and technological innovation.

MATERIALS AND METHODS

Model and farmers involved: This study was conducted on farmer group "Andum Rejeki" in Banjarharjo village, Kalibawang sub-district, Kulon Progo regency. The number of farmers involved in this study was 30 people divided into three models, namely the models A, B and C. Each model consisted of 10 people. The explanation of the model A, B and C are stated in Table 1 while, the selection criteria of the farmers participating in the model is presented in Table 2.

Table 1: Description of the model and the application of technology in models A, B and C

	Model		
Description	A	B	C
Model explanation	Farmers model who execute the cocoa-goat integrated system with technological innovation	Farmers model who execute the cocoa-goat integrated system without technological innovation	Farmers model who not execute the cocoa-goat integrated system and without technological innovation
Using technology	Cocoa-goats integrated with technology innovation on cocoa cultivation, pest and diseases control as well as goat farming and goat manure processing	Cocoa-goats are integrated by the farmers own method	Cocoa farming without integration with goats by the farmers own method

Table 2: Some criteria used in this study to select the farmers in models A, B and C

	Model		
Farmer criteria	A	B	C
Minimal No. of cocoa crops owned by the farmers (rod)	40	40	40
Farming systems by farmers (integration/non-integration)	Integration	Integration	Non-integration
Minimal No. of goats owned by the farmers (head)	2	2	0
Type of goats barn owned by the farmers (stage/ground floor)	Stage	Ground flour	None

Table 3: Types of technological innovation applied during the study in the farmers model A

Aspect	Technology innovation
Cocoa farming	Cocoa fertilization uses both of solid and liquid organic fertilizer, dolomit, nitrogen, phospate and potasium
Cocoa pest and diseases control	Pest and disease control uses biological agents, fungicide and insecticide
Goats farming	Usage of leaves and rod of cocoa as additional goat feed
Processing of goat manure	Processing of goat manure (solid and liquid) to be organic fertilizer for cocoa plants

Table 4: No. of cocoa plant owned, production and productivity of cocoa raised by farmer in models A, B and C

	Model		
Description	A	B	C
Total of cocoa plant owned by farmers (rod)	68.0	46.0	49.0
Cocoa productivity			
(kg/rod/8 months)	2.8	2.0	1.9
(kg/rod/year)	4.2	3.0	2.8
(kg ha^{-1} $year^{-1}$)	560.0[a]	402.0[b]	368.0[b]
Cocoa production received by farmer (kg $year^{-1}$)	285.6	138.0	137.2

[ab]Different superscripts denote significant differences between means within a row ($p \leq 0.05$)

The study proposal has been approved by Ethical Clearance Commission of Universitas Gadjah Mada and has been awarded certificate No. 297/KEC-LPPT/VI/2015 indicating that the study has fulfilled the ethical procedure for animal use.

Technological innovation: Farmers in the model A employed the technological innovation while, the technology used in models B and C was the farmers own method and there was no technological innovation. The technological innovation used by the farmers in model A is presented in Table 3.

Farming income analysis: Income gained from cocoa and goat farming by farmers in each model was analyzed using farm income analysis according to Soekartawi[13]. Farm income derived from total revenue minus total cost of cocoa and goats farming. Revenue analysis was done to determine the magnitude of the income due to the integration and technological innovation.

Statistical analysis: Observed variables in the models A and B were cocoa and goat production, whereas in model C was only cocoa production due to the fact that model C consisted of farmers without raising goat. Cocoa and goat production was observed for 8 months (March-October, 2013) using farm record keeping.

Cocoa production in the model A was compared to model B and C while, model B was compared to model C. Cocoa production was analyzed using one way analysis of variance and continued by Tukey's test for significant differences while, goat's productivity between the models A and B was analyzed using independent-test. If $t_{count} > t_{table}$, it will indicate that between models were significantly different (H_o was rejected) and if $t_{count} < t_{table}$ it was not significantly different (H_o was accepted). The t value was calculated based on the equation below:

$$t = \frac{D}{(Sd\sqrt{n})}$$

Where:
t = Value of t count
D = Average measurement difference
Sd = Standard deviation
n = No. of samples

RESULTS AND DISCUSSION

Cocoa productivity: The study showed that the cocoa productivity of the farmer in model A was higher than models B and C while, the cocoa productivity in models B and C was not significantly different as presented in Table 4. The productivity of cocoa for 8 months also showed that in the farmer's model A was higher than those in models B and C (Fig. 1).

Table 4 showed that the productivity of cocoa in model A was 39% higher than the model B and 52% higher than the model C. The higher productivity of cocoa in model A was

caused by technological innovation. This was similar to the previous study by Munier *et al.*[14] showing that the cocoa production can be increased to be approximately 85% through the introduction of technology. A cocoa plant response to technological innovation is influenced by the age of the cacao plant. In study conducted by Munier *et al.*[14] it was used the productive cocoa plant so that the introduction of technology could improve cocoa productivity upto 85% whereas, this study employed 23-years-old cocoa plants so the response of technological innovation to cocoa productivity is limited.

The most influential technological innovations on the productivity of cocoa was in cocoa cultivation technological innovation especially, the use of Liquid Organic Fertilizer (LOF) and dolomite in model A but they were not used in model B or C as well as the increase of Solid Organic Fertilizer (SOF) usage as presented in Table 5.

Table 5: Fertilizer application on cocoa plant of the farmers models A, B and C during the study period

	Model		
Kinds of fertilizer	A	B	C
Nitrogen, phosphate and potasium (g per rod)	250	200	250
Solid organic fertilizer (kg per rod)	10.0	6.0	2.5
Liquid organic fertilizer (L per rod)	1	0	0
Dolomite (g per rod)	100	0	0

Table 6: Dynamics of goat flock and productivity of goats raised by the farmers in models A and B for 8 months

	Model	
Average number per farmer	A	B
Goat farming in the beginning of activity (head)	5.9	2.0
Birth of goats (head/8 months)	3.0	1.1
Mortality of goats (head/8 months)	1.0	0.6
Buying goats (head/8 months)	1.0	0.6
Selling goats (head/8 months)	1.9	0.6
Addition (head/8 months)	1.1	0.5
Goat farming at the end of activity (head)	7.0	2.5

Table 5 shows that the difference of fertilizer application between models A compared to models B and C was mainly on the content of dolomite 100 g per rod, LOF of 1 L per rod and the use of SOF increased from 2.5-6.0 kg per rod into 10.0 kg per rod. Dolomite and organic fertilizer were suitable for the use in soil that has pH of 5-6. The difference of the fertilizer application caused differences in cacao production as reported by Baon *et al.*[15], Sahara *et al.*[16] and Nappu *et al.*[17] stating that the fertilization had significant effect on the cocoa productivity. Fertilizing cocoa plant employing Solid Organic Fertilizer (SOF) and Liquid Organic Fertilizer (LOF) can be developed by farmers through the utilization of animal solid waste (feces) and liquid (urine) produced by goats. According to Gunawan[18], urine and feces processing into organic fertilizer was appropriate if it was done by famer group.

Figure 1 showed that cocoa production for 8 months in model A was higher than the model B and C. Cocoa production in model B showed a graph that was not different from the model C. This showed that the integration of six goats accompanied by technological innovation have been able to improve cocoa productivity while, raising two goats by farmers without technological innovation was not enough to increase the cocoa productivity of farmers.

Goat productivity: The goat is only raised by farmers in models A and B while, farmers in model C did not raise goats. The number of goats in farmer models A and B during 8 months (March-October, 2013) is presented in Fig. 2.

The addition of goats in the model A was higher than model B because at initial number of goats in model A was higher than the model B (Table 6) however, the development pattern of goats number was almost similar as showed in Fig. 2. In the early of observation, the number of goat raised by the farmers was increased, mainly due to the birth of goats then decreased because of mortality or for the farmers sold

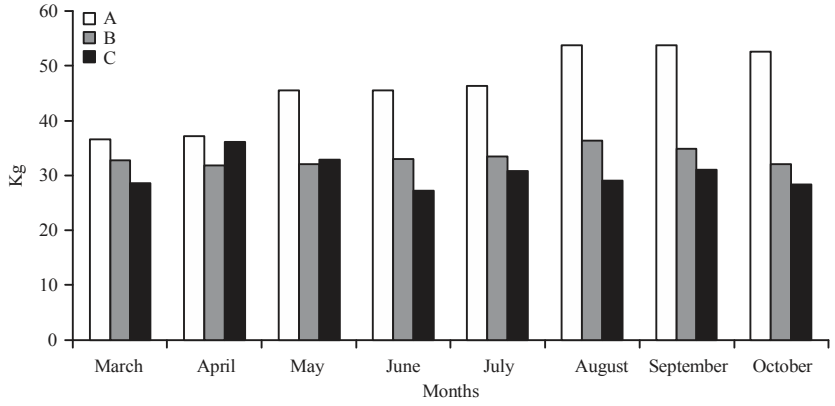

Fig. 1: Cocoa productivity of the farmer models A, B and C for 8 months (March-October, 2013)

their goats. Birth of goats in this study reached approximately 50-80% with mortality of 33-38%, there was no difference between models A and B. Although at the beginning of this study has been carried out training activities for farmers in model A on goats raising but the fact remains that the training has not been able to improve the skills of farmers to improve productivity of goats significantly. Goats productivity of farmer in models A and B can be seen in Table 6.

Table 6 showed that the addition of goat number during 8 months in model A can reach 3.0 heads (50%) from the initial amount of 5.9 heads, where as in model B was 1.1 heads (55%) from the initial amount of 2.0 heads. Goats sold in model A were 32%, it was similar to the model B, namely 30%. Based on this result, raising goats have been successfully carried out by farmers although, productivity was not optimal. Birth of goats need to be increased from 50-55% to 80-100% while, the mortality rate of goats need to be reduced from 30-32% to 10-20%. According to Azmi *et al.*[19] each parent goat ideally can produce three young goats within 2 years.

The observation for 8 months showed that goats model A used more supplementary forage in the form of cocoa leaves and cocoa rind than in model B as shown in Table 7. Using cocoa leaves as supplementary goat forage in model A was higher than model B (Table 7) because cocoa leaves obtained from the cocoa tree trimming in model A was relatively more than that from model B because the trimming of cocoa tree of farmers in model A more often than farmers in model B. Cocoa rinds were used as goat forage by farmers in model A more than model B, because the cocoa production of farmers in model A was more than that in model B.

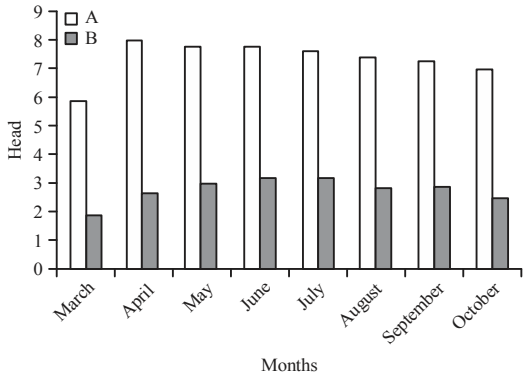

Fig. 2: No. of goats in farmer models A and B during 8 months (March-October, 2013)

The average use of cocoa leaves as goats forage supplement in the model A was 3.1-5.3 kg/head/month and 103-177 g/head/day while, in model B was still limited and it ranged from 0.1-2.0 kg/head/month and 3-67 g/head/day. In this study, the use of cocoa leaves of 2.0 kg/head/day as a supplementary forage for male goats aged 10-12 months old with native grass basal diet can increase the average daily gain from 50 g/head/day to 60 g/head/day.

The average use of cocoa rind as goats forage supplement in the model A was 2.4-4.8 kg/head/month and 80-160 g/head/day, while in model B was still limited and it ranged from 0.8-1.8 kg/head/month and 27-60 g/head/day. Previous study by Munier[20] indicated that the use of 1250-1500 g/head/day cocoa rind and 500-750 g/head/day Gliricidia *sepium* leaves for female goats 8-12 months of age were able to produce 52-70 g/head/day daily gain, it was higher than using grass forage which only produced 10 g/head/day daily gain.

This study indicated that increasing average daily gain of goats can be achieved by increasing the use of cocoa leaves and cocoa rind as forage supplement. The utilization of cocoa rind as forage supplement for goats ranged from 1.25-1.50 kg/head/day and 2 kg/head/day cocoa leaves could be possible to increase daily gain of the goats.

Farming income: Farming income was calculated from cocoa and goats farming. Cocoa farm income gained from the cocoa production yielded from cocoa farm owned by farmers. Cocoa farm income generally depends on the number of plants owned by farmers and cocoa productivity resulting from each tree. Income from goats is gained from the sale of goats reduced by the number of purchases plus the calculation of the value after the addition of goat owned. Income of cocoa and goats farm in the models of A, B and C is presented in Table 8.

Table 7: Use of cocoa leaves and cocoa rind as goat forage supplement in models A and B during 8 months (March-October, 2013)

		Month							
		March	April	May	June	July	August	September	October
By-product	Model	(kg/head/month)							
Cocoa leaves	A	5.3	3.2	4.2	3.1	3.9	3.5	4.3	3.6
	B	0.4	0.1	1.8	1.2	1.2	0.7	1.0	2.0
Cocoa rind	A	3.8	2.8	3.7	2.9	2.4	2.6	3.6	4.8
	B	0.9	1.8	1.7	0.8	0.8	1.1	0.8	1.5

Table 8: Total farming income obtained by the farmers through cocoa and goats farming in farmers models A, B and C

Description	Model A	B	C
	(IDR year^{-1})		
Cocoa farming			
Acceptance of cocoa production	1.283.000	621.000	617.000
Cocoa production costs	199.000	28.000	37.000
Income	1.084.000	593.000	580.000
Goats farming			
Acceptance of goats	2.236.000	480.000	0.00
Goats production costs	700.000	90.000	0.00
Income	1.536.000	390.000	0.00
Cocoa and goat farming			
Acceptance of farming	3.519.000	1,101.000	617.000
Farming production cost	899.000	118.000	37.000
Income	2.620.000	983.000	580.000

Table 8 showed that cocoa farming income of model A was higher than models B and C due to the differences in the amount of cocoa production produced by each model. The difference was due to differences in the amount of cocoa production owned by farmers and different cocoa productivity levels for each model. Productivity of cocoa in farmers model A was 4.2 kg/trunk/year whereas, in model B and C were 3.0 and 2.8 kg/trunk/year, respectively.

Farming income in the goat raising on model A was higher than model B, primarily because of differences in the number of goat raised by farmer and the sale of male goats that made through goats auction held on a few days before Eid-al Adha festivity. According to Budisatria *et al.*[21] Eid-al Adha has a significant effect on the small ruminants markets, the prices of goats being sold during Eid-al Adha increase, on average by 1.6 compared to normal situation. Goat farmer ownership in model A at the initial stage was 5.9 heads while, that in the model B was 2.0 heads. The number of goats raised by farmers has a significant effect on the farming income received from goat raising as stated by Suryanto *et al.*[22]. Budisatria *et al.*[23] found that the farmers who raised 4 heads of female goats had 38% higher income than those who only raised 3 female goats, it can be explained by slightly higher goat ownership scale and higher prices primarily because farmers sold their goats during the Eid-al Adha festivities.

Farming income from cocoa and goats farming in model A was higher than models B because of the increase of cocoa production by 39% and the high sale of goats on goats auction draw by Eid al-Adha day. This study reported that a touch of technology in cocoa farming integrated with goats can increase the farmer's income.

CONCLUSION

The increase of cocoa production in integrated cocoa-goat farming can be done through technological innovation, particularly by the use of liquid organic fertilizer of 1 L per rod and solid organic fertilizer of 10 kg per rod and dolomite of 100 g per rod. The application of fertilizer would be more effective if the trunk/branches of the cocoa trees was trimmed. The trimmed cocoa leaves and cocoa rinds can be used as a supplementary forage for goats to raise body weight gain.

Farming income of the farmers adopting integrated cocoa-goat farming with technological innovation is higher than that without technological innovation and the cocoa cultivation without integration. The increase of farming income gained from increased cocoa production and more profitable sale of goats.

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