Original Research Paper

Effect of Input Production Against Quality of Cocoa Beans

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Abstract: This research aims to: (1) analyze the effect of input production against total beans per 100 g of dry cocoa beans and (2) analyze the correlation of total beans and fat content of cocoa beans. The Cobb-Douglas production function assisted in answering the first goal, while correlation analysis provided a means to answer the second. Results showed that: (1) urea fertilizers, KCl fertilizers, SP-36 fertilizers, pesticides and labour could reduce total beans per 100 g of dry cocoa beans and (2) there was a correlation between total beans per 100 g of dry cocoa beans and total fat content. The more cocoa beans per 100 g, the higher the total fat content. Farmers had to pay attention to the usage of input production such as fertilizers, pesticides and labour because it could increase the quality of cocoa beans.

Keywords: Input, Quality, Cocoa Beans

Introduction

The cocoa cropping condition in the region of Indonesia and specifically Central Sulawesi faced the problem of slowly degrading productivity and quality of its cocoa industry. Cocoa productivity in Central Sulawesi only reached a maximum of 670 kg h^{-1}, whereas its genetic potential that was 1.8-2.75 tonnes ha^{-1} -a huge discrepancy (DPDJP, 2009). A decrease in productivity and quality affected the income of farmers, which reduced farmer enthusiasm for the crop, leading to a further decrease and quality and general slack in the industry as they attempted to replace cocoa with other commodities. This condition threatened the sustainability Indonesian cocoa. Efforts to increase cocoa crop productivity and the quality of cocoa beans which were produced by the farmers should therefore continue to be made.

The supply of qualified cocoa beans must be carried out at this time. This is due to the fact that the quality of beans greatly affects both the quality of final products and market price for cocoa and cocoa-related commodities. High quality cocoa beans must also be fermented, cleaned and dried (Sulistyowati and Wahyudi, 1999; Schwan and Wheals, 2004; Illeghems *et al*., 2012; Trognitz *et al*., 2013). Furthermore, physical characteristics, chemical and organoleptic factors affect the quality of cocoa beans (Wahyudi *et al*., 2008). Physical characteristics include the total beans per 100 g, whether or not they are properly fermented, and the amount of moldy beans per 100 g. Chemical characteristics include total fat content and water content. Industry and consumers in developed countries are very much concerned about the usage of qualified raw materials (cocoa beans). Every effort of current cocoa production (cultivation) must pay attention to all factors that affect the quality of beans produced in order to gain the best compensation in global markets.

Several more components determine the quality of cocoa beans, such as the provision of input production, crop genetics, seasonal weather and maintenance/management. Input production, such as the number and quality, need to be known by a producer (farmer). Input production can be divided into two groups, namely biological factors, such as agricultural land and fertilizers (N, P and K) and socio-economic factors such as labour; control of input production allows farmers to maximize the efficiency of crops and gain higher global market restitutions (Soekartawi, 2003).

Seasonal and genetic factors influence the fat content of cocoa beans (Mulato *et al*., 2009; Wahyudi *et al*., 2008). Mulato *et al*. (2009) stated that the type (clones) of crops, environmental conditions (rainfall) during fruit development, and agronomic conditions strongly influence the weight of the beans. This research aims to: (1) analyze the effects of input production on the total beans per 100 g of dry cocoa beans and (2) analyze the correlation of total beans and fat content of cocoa beans.

Research Methods

This research was conducted in the Palolo Sub-Regency Sigi Regency of Central Sulawesi. The villages of Sejahtera and Tongoa were the research locations. This is because these two villages are central areas of cocoa productions in Palolo Sub-Regency Sigi Regency.

The research includes a total of 238 Household Heads (HH): 106 from Sejahtera Village and132 from Tongoa Village, respectively. The study calculates total samples by using Parel *et al.*'s (1973) formula:

$$n = \frac{N \sum N_h s_h^2}{N^2 \dfrac{d^2}{z^2} + \sum N_h s_h^2} \tag{1}$$

Where:

n = Total samples
N = Total populations
N_h = Total populations in each village
d = Precision was set at = 5%
z = 1.96 (95%)
s_h = Variant of each village
n_h = Total samples in each village

Total samples here involved 144 HH from the villages.

This research used survey methods to determine sampling by probability with the Simple Random Sampling technique, which was a sampling technique done randomly against members of population. The formula determined sampling from each village proportionally:

$$n_h = \frac{N_h}{N} n \tag{2}$$

Where:

n_h = Total samples in each village
n = Total samples = 144 HH
N = Total populations = 238 HH
N_h = Total populations in each village

Sejahtera Village's sample involved 64 HH and Tongoa Village contributed 80 HH.

Total Fat Content

Total fat content of cocoa beans was determined based on standard procedures carried out in the Laboratory of Post-Harvest Research Center of Coffee and Cocoa in Jember, Indonesia. Samples of cocoa beans were peeled, then grinded until the mixture reached a size of 150 μ. A total of 5 g of grinded beans were hydrolyzed using HCl 25% (w/w). Furthermore, the extraction of cocoa bean fats used non-polar organic solvents (petroleum benzene; boiling point 40-60°C). Fat content is calculated as follows:

$$\frac{100(M_2 - M_1)}{M_0} x \frac{100}{100 - K_A} \tag{3}$$

Where:
M_0 = Weight of samples (g)
M_1 = Weight of pumpkins and stones (g)

M_2 = Weight of pumpkins, stones and fat (g)
K_A = Water content of samples

Total Beans per 100 g

Weighing on the sample (100 g) followed by counting the total beans determined total beans per 100 g. The test results were set based on total beans in the sample (100 g) and stated: AA with a number of less than up to 85 beans; A with a number between 86-100 beans; B with number between 101-110 beans; C with number between 111-120 beans; and S with a number of more than 120 beans.

The Cobb-Douglas production function answers the first goal, where the function is transformed into a linear form of the natural logarithm as follows:

$$\ln K = \beta_0 + \beta_1 \ln PU + \beta_2 \ln PKCl \\ + \beta_3 \ln PSP36 + \beta_4 \ln PEST + \beta_5 \ln TK + \varepsilon_i \tag{4}$$

Where:
K = total beans per 100 g of cocoa beans (beans)
PU = urea fertilizers (kg)
$PKCl$ = KCl fertilizers (kg)
$PSP36$ = SP-36 fertilizers (kg)
$PEST$ = pesticides (liter)
TK = labors (day people working = DPW)
ε_i = Error

Correlation analysis of Product Moment is used to answer the second goal, with the formulation as follows:

$$r_{KL} = \frac{n \sum K_i L_i - (\sum K_i)(\sum L_i)}{\sqrt{\left\{ n \sum K_i^2 - (\sum K_i)^2 \right\}} \sqrt{\left\{ n \sum L_i^2 - (\sum L_i)^2 \right\}}} \tag{5}$$

L = Total fat content (%)

Results

The Effect of Input against Total Beans per 100 g of Cocoa Beans

This study uses multiple regression analysis to analyze the effects of input production against total beans per 100 g of dry cocoa beans. Urea fertilizers, KCl fertilizers, SP-36 fertilizers, pesticides and labour encompass this research's definition of input production. Results of multiple regression analysis are shown on Table 1.

Correlation of Total Beans per 100 g of Dry Cocoa Beans with Total Fat Content

Product moment correlation analysis provided an avenue to analyze the correlation between total beans per 100 g of dry cocoa beans versus total fat content. The results of product moment correlation analysis showed the value of 0.932 or 93.20%.

Table 1. Estimation of regression coefficients

Model	Regression coefficients	Standard error	t	Sig.	VIF
(Constant)	4.909				
Urea Fertilizers (PU)	-0.009	0.002	-4.636*	0.000	3.711
KCl Fertilizers (PKCl)	-0.012	0.002	-6.825*	0.000	3.061
SP-36 Fertilizers (PSP36)	-0.019	0.001	-14.156*	0.000	1.856
Pesticides (PEST)	-0.013	0.001	-10.375*	0.000	1.587
Labors (TK)	-0.017	0.001	-16.191*	0.000	1.168
Adjusted R^2 was 0.831					

*Significant at α 5%

Discussion

Adjusted R^2 was 0.831, showing that variation of total beans per 100 g of dry cocoa beans (cocoa beans quality) can be explained by the independent variable of Urea fertilizers, KCl fertilizers, SP-36 fertilizers, pesticides and labour simultaneously-as many as 83.10%. At the same time, the remaining 16.90% are explained by other factors not included in the model. The effects of each factor against the quality of cocoa beans are as follows.

The usage of Urea fertilizers had significant negative effects on total beans per 100 g of dry cocoa beans, where t-count = -4.636 with probability 0.000<0.05 (α 5%) two-tail test. Elasticity -0.009 means that every increase in Urea fertilizers, even 1%, reduces total beans in 100 g of dry cocoa beans as much as 0.009%. This is done by assuming other factors considered are constant. It showed that the usage of Urea fertilizers on cocoa crops could cause cocoa beans to grow larger and become more solid, so total beans reduced per 100 g of dry cocoa beans. This research is relevant to the research of Sokri et al. (2013), where nitrate had effects on fruit ripening. This makes sense, as Nitrogen (N) is the primary nutrient for crops and important for all organisms (Vrede et al., 2004).

The usage of KCl fertilizers had significant negative effects on total beans per 100 g of dry cocoa beans, where t-count = -6.825 with probability 0.000<0.05 (α 5%) two-tail test. This elasticity of -0.012 means that every increase in KCl fertilizers, as many as 1%, could reduce the total beans in 100 g of dry cocoa beans as much as 0.012%. This assumes that other factors were constant. It showed the usage of KCl fertilizers on cocoa crops could cause cocoa beans to become bigger and solid so that total beans reduced per 100 g of dry cocoa beans. Potassium (K) plays a key role in osmoregulation, the regulation of stomata, photosynthesis and cell extension (Porras-Soriano et al., 2009). Adding higher K uptake can help to mitigate salt stress in crops (Thomas et al., 2003).

The usage of SP-36 fertilizers had significant negative effects on total beans per 100 g of dry cocoa beans, where t-count = -14.156 with probability 0.000<0.05 (α 5%) two-tail test. An elasticity of -0.019 means that every increase in SP-36 fertilizers, so far as much as 1%, could reduce the total beans in 100 g of dry cocoa beans as much as 0.019%, so long as research assumes other factors are constant. It showed the usage of SP-36 fertilizers on cocoa crops could cause cocoa beans to grow larger and far more solid so that total beans reduced per 100 g of dry cocoa beans. Phosphorus (P), the primary nutrient for crops and important for all organisms (Vrede et al., 2004), is an important element in the production of ribosomes (Agren, 2008). Protein synthesis requires P in promoting growth (Elser et al., 2000; Hessen et al., 2007). However, excessive usage of organic P can cause suppression of the Arbuscular Mycorrhizal Fungi (AMF) community (Jordan et al., 2000). AMF has been proven to increase crop growth and production by increasing nutrient uptake in various agroeco systems (Sensoy et al., 2007; Meghvansi et al., 2008).

The usage of pesticides had significant negative effects on total beans per 100 g of dry cocoa beans, where t-count = -10.375 with probability 0.000<0.05 (α 5%) two-tail test. Elasticity -0.013 is definable by every usage of pesticides on crops attacked by pests and diseases, as many as 1%. These could reduce the total beans in 100 g of dry cocoa beans by as many as 0.013%, so long as the equation assumes other factors are constant. These results showed that the usage of pesticides on cocoa crops attacked by pests and diseases could cause cocoa beans to malform. Cocoa beans that grew in a healthy manner enlarge and increase in solidity so total beans decreased per 100 g of dry cocoa beans. However, excessive usage of pesticides can cause disease in humans, endangering the local population (Slusky et al., 2012; Navaranjan et al., 2013).

The usage of labour had significant negative effects on total beans per 100 g of dry cocoa beans, where t-count = -16.191 with probability 0.000<0.05 (α 5%) two-tail test. This elasticity -0.017 could be defined to mean every increase in labour on cocoa crops, as much as 1%, could reduce the total beans in 100 g of dry cocoa beans as much as 0.017%, by assuming other factors remained constant. It showed that variations in the usage of labour in cocoa crops could cause cocoa beans to enlarge and become more solid so that total beans reduced per 100 g of dry cocoa beans. Input usage improved with increases in labour investment, so the nutrient needs were fulfilled. This research is relevant to Li et al. (2008), who stated labour correlate positively with agricultural production.

The correlation coefficient 0.932 meant the correlation of total beans per 100 g of dry cocoa beans with total fat content was very strong. The fewer total beans per 100 g of dry cocoa beans or the greater cocoa beans then the higher total fat content. Additionally, the usage of fertilizers heavily influenced the largeness and density of cocoa beans, showing that this is one the factors that should be considered by farmers in order to increase the total fat content of cocoa beans. This would result in better market prices and improve the attractiveness of cocoa beans as a crop.

The results showed that the average of total beans per 100 g of dry cocoa beans was 136 beans and average of total fat content was 45.46%. Total fat content was still less when compared with fat content of the previous research results, which was as much as 50-57% (Hannum and Erdman Jr, 2000). The average of total beans per 100 g of cocoa beans in this research fell into category S, which meant the quality of cocoa beans was still low.

Conclusion

Urea fertilizers, KCl fertilizers, SP-36 fertilizers, pesticides and labour could reduce total beans per 100 g of dry cocoa beans. There was a correlation between total beans per 100 g of dry cocoa beans and total fat content. The more cocoa beans per 100 g, the higher the total fat content. Farmers had to pay attention to the usage of input production such as fertilizers, pesticides and labour because it could increase the quality of cocoa beans.

Acknowledgment

Author Contribution

Effendy and Made Antara were together designed the research, analyzed data and wrote the paper.

Ethics

This paper is original and authors confirm that all of other authors have read and approved the paper.

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