Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.6, No.20, 2016

Cocoa Cultivation on Suboptimal Land

Sri Budiastuti* Djoko Purnomo Sri Nyoto Salim Widono Mercy Bientri Yunindanova
Agriculture Faculty of Sebelas Maret University, Jl. Ir. Sutami 36A, Surakarta, Indonesia

Abstract
Cocoa cultivation has been introduced at Pacitan East Java in 2009 and until today the production has not well developed as much as hope. Generally geophysics aspect does not support the growth and development of cocoa especially that caused by natural limited factors (water and soil fertility) on suboptimal land. The research propose is to evaluate the role of fertilizer on cocoa production. The soil fertility is in the low level such as C organic, total of N and organic compound as big as 0.63, 4.15, 1.08% respectively and the available of P_2O_5 is 2.72 part per million. Besides soil properties, there is another constrain which no less important to physical aspect, it is the minimum knowledge of cocoa cultivation especially maintenance aspect such as fertilizer and shoots (*chupon*) cutting. Fertilization has been applied three times that are after harvest, initiation of flowering and fruit formation at five samples of cocoa at every location which based on the three levels of altitude. The role of fertilizer has been evaluated from nutrition absorption (leaf tissue analysis), number of seeds per 100 g and the content of protein, fat, phenol in seed. The data has been analyzed by F test and be continued by Duncan multiple range test. N, P and K content of leaves are not significant both before (after harvest) and after fertilization (initiation of flowering and fruit formation) and it means that most of the element have distributed for formatting flower and fruit.
Keywords: Cocoa cultivation, suboptimal land, fertilizer application

1. Introduction

Cocoa is one of plant commodity which needs especially attention to be developed for increasing foreign exchange and farmer's income. Land resources are the main factor for achieving the best cocoa production especially on suboptimal land. Many natural constraints have found on suboptimal land that made the low level of cocoa production. So, good agricultural practices should be done on it to overcome low level of soil fertility and micro climate condition. Technology of cultivation has already been done such as tillage, nursery, maintenance until post-harvest but the limiting of land resources and the low intensity of maintenance caused national production of cocoa has decreased (note: potency of production is 2-3 compared with 0.7 ton per ha per year in the real condition). If the production of cocoa can be reached until 1 ton per ha per year then national production can achieve 1.5 million ton per ha per year (Prabowo, 2015).

Indonesian government in this case is Perusahaan Umum Perhutani has already given cocoa seedling to various locations including at Punung district on Pacitan regency East Java in 2009. However result of research showed that the production of seed only 0.3 ton per ha per year and it means only 50% of national production. The low level of soil fertility is the main limiting factor to cultivate cocoa at Punung which proven by C organic, total of N, organic compound as big as 0.63, 4.15, 1.08% respectively and available of P_2O_5 is only 2.72 ppm (Saputra, 2015). Alfisol is the type of soil at Punung with soil properties condition which contain of total Nitrogen (N), available of Phosphor (P) and Potassium (K) in the low level so that be required the enrichment of N, P, K through fertilization for better growing of cocoa (Minardi, 2002).

The knowledge of soil properties condition especially Alfisol has to be understood properly for determining the level of nutrient requirement. The type of soil like Alfisol only can be cultivated by perennial crops precisely with nutrition enrichment in the form of fertilizer both organic and inorganic. Soil fertility can be increased by considering utilization of existing resources (manure, litter, agricultural waste), or by specific location approaches. Furthermore, it should be known that suboptimal land just more suitable for managing perennial than annual crop because of the ability of root to absorb water and nutrition from the depth of the soil. The dominant tree that has been cultivated at Punung are coconut, teak, mahogany, and cocoa (as the main crop), in a conventional way according to farmer's knowledge. Another constraint to cultivate cocoa at Punung is micro climate condition such as humidity, light intensity, and temperature that can be controlled by cultivation method.

The application of fertilizer aims to complete nutritional needs of plant and it is the first step to enhance nutrition content in the soil. The good application should be based on status and potency of nutrition in soil and plant requirement. Those are appropriate with the philosophy of fertilizer which is an action to increase the role of soil as the best growing media. Besides that, fertilizer is the important factor in determination of quality and quantity product including nutrition content in plant (Stefanelli et al. 2010, Marzouk and Kassem 2011). Plant responses to fertilizer is shown by the absorption power of leaf tissues to nitrogen, phosphor and Potassium and finally reflected on flower, the beginning of fruit formation and fruit ripening (Sohroth *et al*. 2002, Alva *et al*. 2006, Hernita, 2012**).** Therefore it can be evaluated the appropriate dose of fertilizer to form fruit and seed of cocoa.

2. Material and Method

Research is conducted on Punung district especially at Jatisari, Pakis and Bangunsari villages with the positioning geographic as follows 08°06'428''S dan 111°01'55,5''E (observed by GPS/*Global Positioning System* Garmin eTrex 30), from July until October 2016. The average of rainfall is 1800 mm per year, daily temperature is 30° C, and with relative humidity is around 50-60%.

This is the descriptive quantitative research with the application of fertilizer on cocoa at the three level of altitude (389, 374, 28 m above sea level) with five samples of tree on every altitude. The fertilizer is applied three times that is after harvest **(**435 g N; 278 g P; 200 g K), initiation of flowering ((174 g N; 834 g P; 300 g K) and fruit formation (261 g N; 278 g P; 500 g K). Micro climate condition is collected from relevant agencies, relative humidity is observed by soil tester, light intensity is measured by lux meter Lutron LX-103, soil chemical analyzes are N total (Kjeldahl method), available of P (Olsen method), Cation Exchange Capacity and available of K (ammonium acetate saturated method).

Leaf tissue analyzes consists of N content (Kjeldahl method), Total of P (HNO_3 destruction), Total of K ($HClO_4$ destruction method) on the leaf tissues at every level of altitude that is after harvest, initiation of flowering, fruit formation and harvest. The quality of seed is obtained from caffeine content analyzes (spectrophotometer method), protein (Kjeldhal method), fat (Soxhlet method), and phenol (spectrophotometer method), and the number of seed per 100 g. Leaf tissue analyzes has been held in the laboratory of soil chemical and seed analyzes in Department of Food Technology, both of them are in Agriculture Faculty of Sebelas Maret University. The data are processed by F test (ANOVA), and be continued with Duncan Multiple Range Test.

3. Result and Discussion

3.1 Discription of Research Location

Punung is situated at altitude 350 m above sea level be dominated by Alfisol which has already undergone weathering intensively, so that there were nutrients, organic compound, silica leaching and leave a waste in red color (Darmawijaya 1992). The condition of soil just precisely is managed by perennial plant because of their root as water movement in the ground. Many kinds of tree is planted at Punung and cultivated in the yard including cocoa. Cocoa is cultivated among coconut (*Cocos nucifera*), banana (*Musa* sp), jackfruit (*Artocarpus heterophyllus*), *Artocarpus camansi* ((*Artocarpus communis*) and kind of fruit trees.

Soil fertility is in the low level which based on soil analyzes (nitrogen, organic compound, phosphor, Potassium and carbon organic), and just only Cation Exchange Capacity in the high category. Results of discussion with cocoa's farmer can be concluded that the maintenance of cocoa still in the low intensity, especially fertilization n technique of pruning. Truly the micro climate condition at Punung is suitable for cocoa cultivating manly atmospheric condition (Ojo and Sadiq, 2010), but if there is no good agricultural practices (especially technique of fertilization) so cocoa production will discrepant expectation.

3.2 Nitrogen, Phosphor, Potassium Content of Leaves

The content of N and P are not significant both before (after harvest) and after fertilization (initiation of flowering and fruit formation) but especially the content of K increases on fruit formation phase (Figure 1). This shows that the nutrient has been absorbed by the plant and be used to form tissues and organ, compound of energy, forming secondary metabolites and is stored in the vacuole. The absorption of nutrient will be distributed to the entire of plant body and when entering generative phase be remobilized to fruit and seed or the storage of photosynthesis product (sink) such as stem (cane) and tuber (Taiz et al., 2015). Nitrogen of leaves describes protein and enzyme because the characteristic of C_3 always dissolves the protein more than 50% which came from Rubilose Biphosphat Carboksilase (Sinclair and Horie, 1989) as an essential enzyme of photosynthesis. Phosphor is the high compound of energy (ATP) that involved in the entire of metabolism process, whereas K as enzyme cofactor.

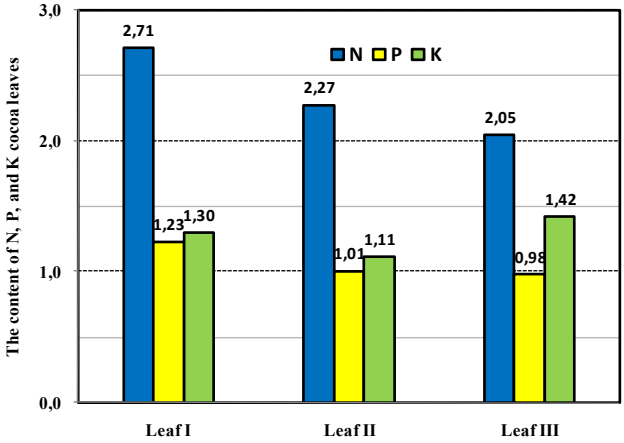

Figure 1. The content of N (%), P (ppm), and K (Cmol.kg^{-1}) Cocoa leaves after harvest (leaf I), initiation of flowering (leaf II), and fruit formation (leaf III)

3.3 The Number of Seed per 100 Gram

The quality of seed can be described from the number of seed per 100 g. Seed of cocoa at Punung not affected by altitude which is shown by relatively the same of seed number per 100 g especially at 389 and 28 meter above sea level (approximately 94 seeds). Meanwhile the number of seed at 374 meter above sea level is 62 seeds per 100 gram and this is statistically significantly different. Generally, the factor of altitude does not determine the number of seed so that can be concluded that micro climate (light intensity, temperature and relative humidity, soil fertility) is the important factor to make cocoa grow well.

The number of seed per 100 gram that are less than 85 units describes the high quality of seed and be entered on AA classification (first level), while the number of seed between 85 until 100 be entered on A classification (second level) (Pusat Penelitian Kopi dan Kakao, 2015). Seed formation phase needs the main nutrient P and K as a support of carbohydrate mobilization to ovarium that so seed formation goes well and preventing loss of flower and fruit (Siallagan, 2014). Seed is a main product of cocoa and can be called as a sink because it is formed by mobilization of carbohydrate from the part of vegetative (leaves) as a source. The production of fruit and seed are determined by light intensity not less than 70%. It proves that there is no constraint to produce fruit and seed at Punung.

Some of cocoa produces a relatively small number of seed so that be classified as a low quality (110-120 seeds per 100 gram). The forming of small seed is caused by detention of seed filling that caused by low of light intensity, low of soil fertility and interference of pest organism (ICCRI, 2015). Good agricultural practices (GAP) will decrease all of constrain of cocoa growing. Actually, the action of GAP consists of pruning (to increase light intensity and reduce relative humidity), to cut useless shoot and to apply both organic and inorganic fertilizer.

3.4 Protein, Fat and Phenol Content of Seed

The quality of seed is determined by protein, fat and phenol contents. The result shows that seed of cocoa at Punung contains the high content of fat (34-37%), protein (8%) and the low content of phenol (0.6-1.7%) (Figure 2). The low content of phenol (<2% be compared with generally condition as big as 5-6%) (Hii et al., 2009) describes the detention of phenol remobilization from vegetative part to the seed.

Phenol has many advantages such as anti-carcinogenic, anti-atherogenic, anti-ulcer, anti-thrombotic, anti-inflammatory, immune modulating, anti-microbe, analgesic (Hii et al., 2009). Based on the benefits of phenol it should be prepared the good agricultural practices that began from soil tillage and maintenance of plant growing.

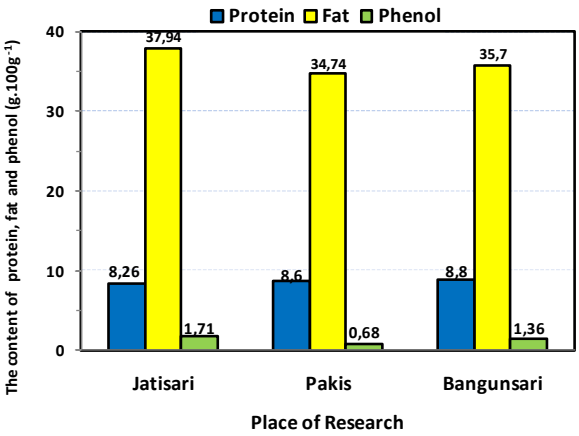

Figure 2. Protein, fat, and phenol content of cocoa seed at Punung

4. Conclusion

The conclusions of research are:

1. N, P and K content of leaves are not significant both before (after harvest) and after fertilization (initiation of flowering and fruit formation) and it means that most of the element have distributed for formatting flower and fruit.
2. Number of seed per 100 gram is less than 85 and it means that cocoa seed on the high quality (AA categories).
3. Protein and fat of cocoa seed are still on the same quality with national standard but the content of phenol is very low.
4. The low levels of soil fertility at Punung needs a special application of fertilization at least three times (after harvest, initiation of flowering and fruit formation)
5. The cultivation of cocoa has been done at Punung with the limitation condition of light intensity. Cocoa is cultivated in the yard which many variation of tree's canopy that shade it and reduce light intensity

Acknowledgment

This research is financed by PNBP (Penerimaan Negara Bukan Pajak) scheme research in 2016. Thanks goes to the Institution of Research and Community Services of Sebelas Maret University, Villages officials at Punung, the owner of cocoa and the undergraduate student of agriculture which have already supported from the beginning until the end of research.

References

Alva. A.K, Paramasivamb,S, Obreza, TA, and Schumann, A.W (2006). Nitrogen best management practices for citrus tress, I. Fruit yield, quality and leaf nutrition status. *Sci. Hort*.,vol. 107, no. 233-44

Darmawijaya. (1992). *Klasifikasi Tanah*. Gadjah Mada University Press, Yogyakarta

Departemen Perindustrian. (2007). *Gambaran Sekilas Industri Kakao*. Sekretariat Jendral Departemen Perindustrian. Jakarta

Dirjen Pengolahan dan Pemasaran Hasil Pertanian. (2014). "Market Intelligence" Kakao Andalan EksKr Indonesia. *Jurnal Pengolahan Dan Pemasaran Hasil Pertanian*. Kementerian Pertanian. Jakarta

Hernita, D. (2012), Penetapan rekomendasi pemupukan N, P dan K tanaman duku (*Lansium domesticum*) berdasarkan analisis daun. Disertasi. Institut Pertanian Bogor, Bogor

Hii C.L., C.L. Law, S. Suzannah, Misnawi, and M. Cloke. (2009). Klyphenols in cocoa (*Theobroma cocoa* L.). *As. J. Food Ag-Ind*. 2(04): 702-722

Indonesian Coffea and Cocoa Research Institute (ICCRI). (2015). *Cocoa Kd Borer, Currant Status and Recommended Control*. Presentation Matter

Marzouk, HA dan Kassem. (2011). Improving fruit quality, nutritional value and yield of Zaghloul date by the application of organic and/or mineral fertitizers, *Scientia Horticulture*, vol. 127, pp. 249-54

Ojo A. D. and I. Sadiq. (2010). Effect Of Climate Change On Cocoa Yield: A Case Of Cocoa Research Institute (Crin) Farm, Oluyole Local Government Ibadan Oyo State. *J. of Sustainable Development in Africa* 12(1): 350-358

Prabowo, H.E. (2015). Produktivitas Kakao Rendah Karena Kurang Pemeliharaan. *Kompas, 21 Desember 2015*

Pusat Penelitian Kopi dan Kakao. (2015). *Pedoman Teknis Budidaya Tanaman Kakao* (*Theobroma cocoa* L).

Saputra, Diki. (2015). *Aspek Ekologi Sebagai Penentu Keragaman Ketebalan Kulit Buah dan Kualitas Biji Kakao*. Skripsi. Universitas Sebelas Maret Surakarta

Siallagan, I, Sudradjat dan Hariyadi. (2014). Optimasi Dosis Pupuk Organik dan NPK Majemuk pada Tanaman Kelapa Sawit Belum Menghasilkan. *J.Agron.Indonesia* 42 (2):166-172.

Sinclair, T.R and Horie. (1989). Leaf Nitrogen, Photosynthesis, and Crop Use Efficiency. A review *Crop Science*. 29, 90-97. http://dx.doi.org/10.2135/cropsci1989.0011183X002900010023x

Sohroth, G, Elias, Macedo, JLV, Mota, MMS, MEA. (2002). Mineral nutrition of peach palm in Amazonian agroforestry and recommendation for foliar analysis. *Europe J. Agron*.,Vol. 17, pp. 81-92

Stefanelli, D., Goodwin, I., and Jones, R. (2010). Minimal nitrogen and water use in horticulture: Effects on quality and content of selected nutrients. *Food Research International*, 43(7):1833 – 1843

Taiz L., E. Zieger, I.M. Moller, and A. Murphy. (2015). *Plant Physiology and Development* 6th ed. Sinauer Assosiates, Inc. Pub. USA.