Application of Soil Conservation in Oil Palm Plantation

[1*]Halus Satriawan, [1]Zahrul Fuady, and [1]Zara Yunizar

[1]Almuslim Univesity, Bireuen, Aceh, Indonesia
**Corresponding Author*: satriawan_80@yahoo.co.id

Abstract
Oil palm development in Bireuen very important to increase the regional incomes, however, is also faced with the danger of land resources and environmental damage because it sited in an area with a slope 15-35%, with land capability class III – VII. This study aimed to obtain soil and water conservation techniques are most appropriate and optimal in each land capability class. The studies were conducting by Experimental Method (Standard Erosion Plot). Testing of soil and water conservation techniques was done with land capability base. On land capability class III was tested four treatments, namely: the system of farmers; individual terrace (horseshoe); individual terraces + strips plant; cover crops + organic fertilizer.Land in class IV was tested four treatments, namely: the system of farmers; sediment trap; sediment trap + vertical mulching; sediment trap + cover crops + organic fertilizer. Results of measurements of surface runoff and erosion on land capability class III, soil conservation techniques capable of suppressing erosion compared to the control treatment, in this case the best treatment is the cover crops and organic fertilizers. Cover crops and organic fertilizers is able to suppress runoff and erosion by 23.73% and 27.29% compared to controls. As well as the application of soil conservation techniques in land capability class IV with sediment trap + cover crop and organic fertilizer is very effective in controlling runoff and erosion to 45.81 and 45.63% compared to controls.
Key words: runoff, erosion, oil palm, soil conservation

Introduction

New oil palm plantations today are often being limited to marginal lands which include those in hilly, steep land areas. Oil palm (*Elaeis guineensis* Jacq) are major crops in Bireuen District, which spreadmoredominantonlandwithslopesbetween9% and 45%. The land area for oil palm plantations in Bireuen has increased rapidly, with 4,644 ha of cultivation under 5 years since 2008 (IICB, 2013). But today, oil palm cultivation is limited to marginal areas such as hilly sloping lands where they comprise about 60% of the marginal land areas (Satriawan & Fuady 2012). These areas are frequently related to soil erosion and run off losses caused by excessive rain falls. Litte or no canopy cover can cause large losses to soil, nutrients and organic matter on sloping lands (Ping et.al, 2012). Several Furthermore, without proper conservation methods to retain top soil which is susceptible to soil erosion, reduction on soil productivity will occur (Morgan, 2005). In order to reduce soil erosion on sloping lands, silt pit/sediment trap, cover crops, terrace and ridge have been used by major oil palm plantation.

The aims of soil conservation for growing more production can be achieved by using land in accordance with its capabilities, to apply measures to restore the productivity of the soil where it has been damaged and to prevent further damage from taking place, and to combine sound methods of soil management with other methods and inputs of modern agriculture to obtain satisfactory production on sustainable basis (Hudson 1993). Silt pits/sediment trap, which are long and wide trenches, are dug on to terraces to prevent soil erosion as well. Silt pit retain water, leading to significantly higher soil moisture content in comparision to no conservation practices (Ping et al., 2012). The objectives of this study were to determine the rate of runoff and erosion on oil palm plantation.

Materials and Methods

Study Area

The study experimental plot used to measure the overland flow, sediment and nutrient loss was located on oil palm plantation at Bukit Sudan and Blang Mane Village, Bireuen. Plantation located in three land capability class are III and IV. Land capability Class III is located on land that slopes with a slope slightly sloping or undulating (8-15 %). Furthermore, land capability class IV is located on the slopes gently sloping or hilly (15-30 %). The experiment lasted for three months (April June 2015). The area was cultivated with 2 years old oil palm trees. Total rainfall during experiment in this area was 739 mm, and the daily mean air temperature was 27.6˚C. The soil of the experimental area is classified as Typic Paleudults (USDA Soil Taxonomy), which has sandy clay in the topsoil (0 15 cm depth).

Experimental Design

The field experiment layout has a completely randomized block design with three replicas. The conservation practices were not the same for each land capability class. Four treatments were tested for oil palm plantation where located at land capability class III (three conservation practices and the conventional treatment as control), it was (1) control (no soil conservation); (2) individual terrace; (3) individual terrace + crops in strip; (4) cover crops + manure. For oil palm in land capability clas IV it was: (1) control (no soil conservation); (2) sediment trap; (3) sediment trap+slot mulch; (4) sediment trap + cover crops + manure.

The erosion plots was an acreage of 80 m^2 (4 × 20 m) (Figure 1). Each erosion plot consisted of a galvanized enclosure, drawer collector, sediment and runoff collector (Θ 0.6 m, 0.8 m high). The application rate of chemical fertilizer during the study was (150 kg N/ha, 100 kg P/ha, and 75 kg K/ha) for each treatment.

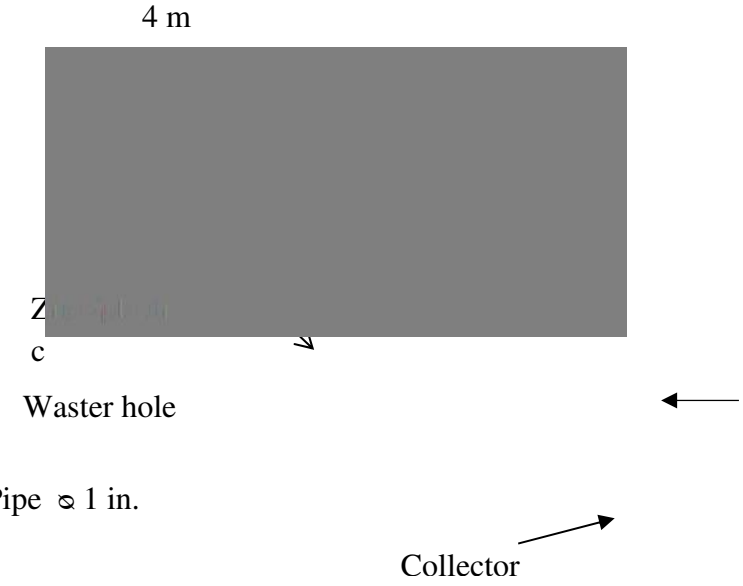

Figure 1.Sketch the experimental plots

Measurement of runoff and erosion was conducted for each rainfall event during the period of the experiment. Erosion measurements involved the measurement of the runoff volume and the measurement of eroded soil. The weight of soil sediment was measured by filtering the water samples using filter paper. The soil left on the filter paper was dried in an oven at 60° C until the sediment weight became constant. The amount of sediment (E) is calculated using the following equation:

$$E = \frac{C_{ap}\, x V_{ap}\; x10^{-3}}{A}$$

where:

E	is the eroded soil[t/ha],
C_{ap}	is the concentration of sediment load [kg/m^3],
V_{ap}	is the volume of runoff [m^3],
A	is the wide of area [ha],
10^{-3}	is unit conversionkg toton.

The amount of runoff and erosion was subjected to ANOVA procedure, and means separation test was done by protected Least Significant Difference (*LSD*) test at 5% level of significance.

Resuts and Discussion

The results ofsurface run off anderosion measurements on land capability III cluster obtained soil conservation techniques can reduce thee rosion compared to the control treatment. The lowest erosion was found in cover crops and organic fertilizers treatment. Table 1 presents all runoff and erosion events monitored during the experiment. The runoff fluxes from tested treatments ranged from 12.05 m^3/ha for individual terrace + crops treatment to 15.80 m^3/ha for control plot.

Furthermore, the soil conservation with cover crops + manure consistently produced the lowest erosion as compared to three other methods (3.73 t/ha) and as compared to the control treatment, the erosion under cover crops + manure decreased by 27.29%. Then, implemented of IT + crops also shows a high ability for controlling the erosion (3.86 t/ha), slightly lower than cover crops + manure, but it is much more effective than individual terrace and control absolutely, decrease by 24.78%.

Table 1. Runoff and erosion on oil palm at land capability class III

Treatments	Runoff (m^3/ha)	Erosion (ton/ha)
Control	15.80ab	5.13b
Individual Terrace	14.47ab	4.07a
IT + Crops	12.05a	3.86a
CC+Manure	12.80a	3.73a
LSD 0.05	2.86	0.38

In the same column, values with different indices are significantly different from one another at the *LSD* test at $P \leq 0.05$.

Cover crops between rows of oil palm is more effective in controlling runoff and erosion by 1) reducing rain erosivity through the interception and dissemination of plant canopy, 2) dense root system of plants can strengthen soil aggregates on the upper layer through granulation of soil particles, 3) presence of organic root exudates could increase soil microbial population thereby increasing the porosity of the soil and the impact on the increasing infiltration. The best soil conservation can reduce runoff flow until 23.73% than total highest runoff.

Table 2. Runoff and erosion on oil palm at land capability class IV

Treatments	Runoff (m^3/ha)	Erosion (ton/ha)
Control	235,81d	21,08c
Sediment trap	187,31c	15,27b
ST+MV	160,55b	14,43b
ST+CC+P	127,77a	11,46a
BNT 1%	11,26	1,85

In the same column, values with different indices are significantly different from one another at the *LSD* test at $P \leq 0.05$.

In the application of soil conservation, treatment of sediment trap+cover crop+manure among oil palm trees in land capability class IV shows significantly different on runoff and erosion between control, sediment trap, and sediment trap+vertical mulch treatment.The use of cover crops reduce the rate of runoff and erosion through the increased volume of water infiltration,and use of manure increased the improvement of soil physical properties and reduction of high rainfall impact. High rainfall cause intensive detachment of soil particles, so the soil becomes easily eroded, but alley cropping, fertilization can reduce soil erosion to tolerable level (Noer 2011). Probable mechanisms for the greater sediment reduction in this study are linked with changes in flow dynamics through at least three processes. First, the vegetative barrier and ridges may intercept concentrated flow by decreasing velocity and dispersing runoff; second, increased ponding may promote deposition of sediment; third, the ponding may absorb runoff energy that would cause soil detachment and transport and thus reduce the erosion and transport capacity.

Sediment Trap is one of the recommended soil-water conservation methods on oil palm plantation. Sediment trap function by reducing soil erosion, controlling run-off and sedimentation, increasing oil palm yield through supplying more water specially during dry weather, protecting and increasing soil fertility through reduction of nutrient loss and redistribution of eroded nutrients back into the soil. Sediment trap redistributes collected water and nutrients into the oil palm root zone rather than being lost through deep percolation.

Conclusion

Results from this study show that cover crops + manure most effectively reduces erosion on the oil palm plantation at land capability class III, and sediment trap+cover crop+manure is more effective in the oil palm at land capality class IV.

Referencees

Indonesia Investment Coordinating Board. 2013. Komoditas Unggulan Daerah. Retrieved December 15 from PubMed database on the world wide web: http://regionalinvestment.bkpm.go.id/newsipid/id/commodityarea.php?ia=11&ic=2580

Lord. S, and J. Clay. Environmental Impacts of Oil Palm Practical Considerations in Defining Sustainability for Imp acts on the Air, Land and Water. http://www.nbpol.com.pg/wp-content/uploads/downloads/2011/02/EnvironmentalImpactOfOilPalm.pdf. Accessed on 21st January 2015.

Morgan. R.C.P., 2005. Soil Erosion and Conservation. Third Edition. Blackwell Publishing.

Noer, H. 2011. Optimizing utilization of water resources through improved planting pattern and repair cultivation techniques in farming systems. In*Indonesian Journal of Agricultural Economics*,vol. 2, no. 2, p.169-182.

Ping. L.Y, C.T.B. Sung, G.K. Joo, A. Moradi, 2012. Effects of four soil conservation methods on soil aggregate stability. Malaysian Journal of Soil Science Vol. 16 : 43-56.

Satriawan, H, and Fuady, Z. 2012. Referral Land Use For Agricultural Development in Peusangan Selatan Sub-district. In *Proceedings of the National Seminar and Annual Meeting of the Dean of Agricultural Sciences BKS – PTN West Regional 2012*. Faculty of Agriculture University of Sumatera Utara. ISBN 979-458-597-1.pp 497.