Extended abstract No. 114

EMISSION OF CO_2 AND CH_4 FROM PLANTATION FOREST OF *ACACIA CRASSICARPA* ON PEATLANDS IN INDONESIA

Basuki Sumawinata; Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University; Darmaga Campus, 16880, Bogor, Indonesia, +62-0251-8629357, basukis2@yahoo.com

Suwardi; Department of Soil Science and Land Resources, Faculty of Agriculture, Bogor Agricultural University

Canecio P. Munoz; Sinar Mas Forestry, Indonesia

SUMMARY

Measurement of CO_2 and CH_4 fluxes from land surface of *Acacia crassicarpa* plantation on peatlands in Indonesia has been carried out for a period of one year at 1-weekly interval. This research was aimed to understanding process of the emission as well as the controlling factors to seek for better plantation management. The results show that CO_2 flux fluctuated over the year with no consistent trend with respect to water table but clearly correlates with age of planted trees. There is no clear evidence either to show that pristine peat forest has the lowest CO_2 emission. There are strong indications that respiration contributed greatly to the flux. Flux of CH_4 emission from the peatland was very low.

KEY WORDS: Acacia crassicarpa, Emission, Peatlands, Plantation forest.

INTRODUCTION

Use of peatlands for development activities has been considered as an important source of carbon emissions. In Indonesia, hence, conversion of peatland forests to commercial plantation forests such as *A. crassicarpa* planted forest is intensively assessed. Varying opinions still exist as to what is the net benefit of the planted forest. Data are needed that will be useful for determining best management practices in plantation forestry particularly in controlling environment deterioration and enhancing productivity.

This study aims to collect detailed and comprehensive information and to assess the factors and processes controlling the fluxes of CO_2 and CH_4 fluxes from *A. crassicarpa* plantation on peatlands.

MATERIAL AND METHODS

This research was carried out at three locations in Sumatra Island, Indonesia. The first location is in Riau Province, within an Acacia plantation area directly converted 8-10 years ago from pristine peat forest on deep peat. The second location is in Jambi Province also within an Acacia plantation but on moderate peat depth in an area that was logged previously. The third location is in South Sumatra Province, on shallow peat on an area that was denuded and has been subjected to repeated burning and over drained . Location of plots and characteristics of each are presented in Table1. Two to 4 different sites were selected within each location based on age of the trees and water level, with additional measurements made in adjacent pristine peatland forests at Riau Province location, in adjacent logged-over peatland forests and mineral soil planted with *Acacia mangium* and *Eucalyptus*, sp. at the Jambi Province location.

Table 1. Location and condition of measurement plots.

No	Location	Land Characteristics	Landuse/ Type of Planted Trees	Age (year)	
1	Riau Province	Deep peat (> 9m)	*Acacia crassicarpa* (Ac)	1	3
2	Riau Province	Deep peat (> 9m)	*Acacia. crassicarpa* Ac)		3-R-L
3	Riau Province	Deep peat (> 9m)	Pristine forest		
4	Jambi Province	Moderate peat (3-4m)	*Acacia crassicarpa* (Ac)	3	
5	Jambi Province	Moderate peat (3-4m)	Secondary forest		
6	Jambi Province	Mineral soil	*Eucalptus pelita* (Ep)	2	
6	Jambi Province	Mineral soil	*Acacia. Mangium* (Am)	1	
7	South Sumatera	Shallow peat (1-2m)	*Acacia crassicarpa* (Ac)	1	3
8	South Sumatera	Shallow peat (1-2m)	*Acacia crassicarpa* (Ac)		3-R-L
9	South Sumatera	Mineral soil	Abandoned paddy fields		

Note: -R-L: without fine root and litter

Measurements have been made for a one year period at 1-weekly to 2-weekly intervals, at some plots by collecting CO_2 and CH_4 gases via an acrylic cubic closed chamber having dimension of 30 x 30 x30 cm^3 placed on the peat surface at 3-minute interval for CO_2 and 10-minute interval for CH_4. Three chambers were placed in three adjacent plots at every site as replication. Concentration of the gas samples is determined using an IRGA instrument for CO_2 and using a GC of Shimadzu 14B with FID detector. Soil moisture content of the upper 5 cm peat was measured at every gas sampling. In all plots in peatlands water table was monitored at the same interval using perforated PVC tube inserted vertically through the peat and anchored in the underlying mineral sediment.

RESULTS AND DISCUSSION

Results of CO_2 flux measurements are presented in Fig. 1. The figure shows differences between land-uses and soil types. CO_2 fluxes from mineral soil in one year old planted *A. mangium* and from paddy field (shallow peat have completely loss) are lower than those from the peatlands vegetated by different age of *A. crassicarpa.* The 1-weekly interval measurements show that for all the land characteristics including age of the trees, CO_2 fluxes over a year significantly fluctuated with maximum different between the lowest and the highest is more than 100 percent. This fluctuation indicating that the controlling factors of CO_2 flux need to be carefully interpreted.

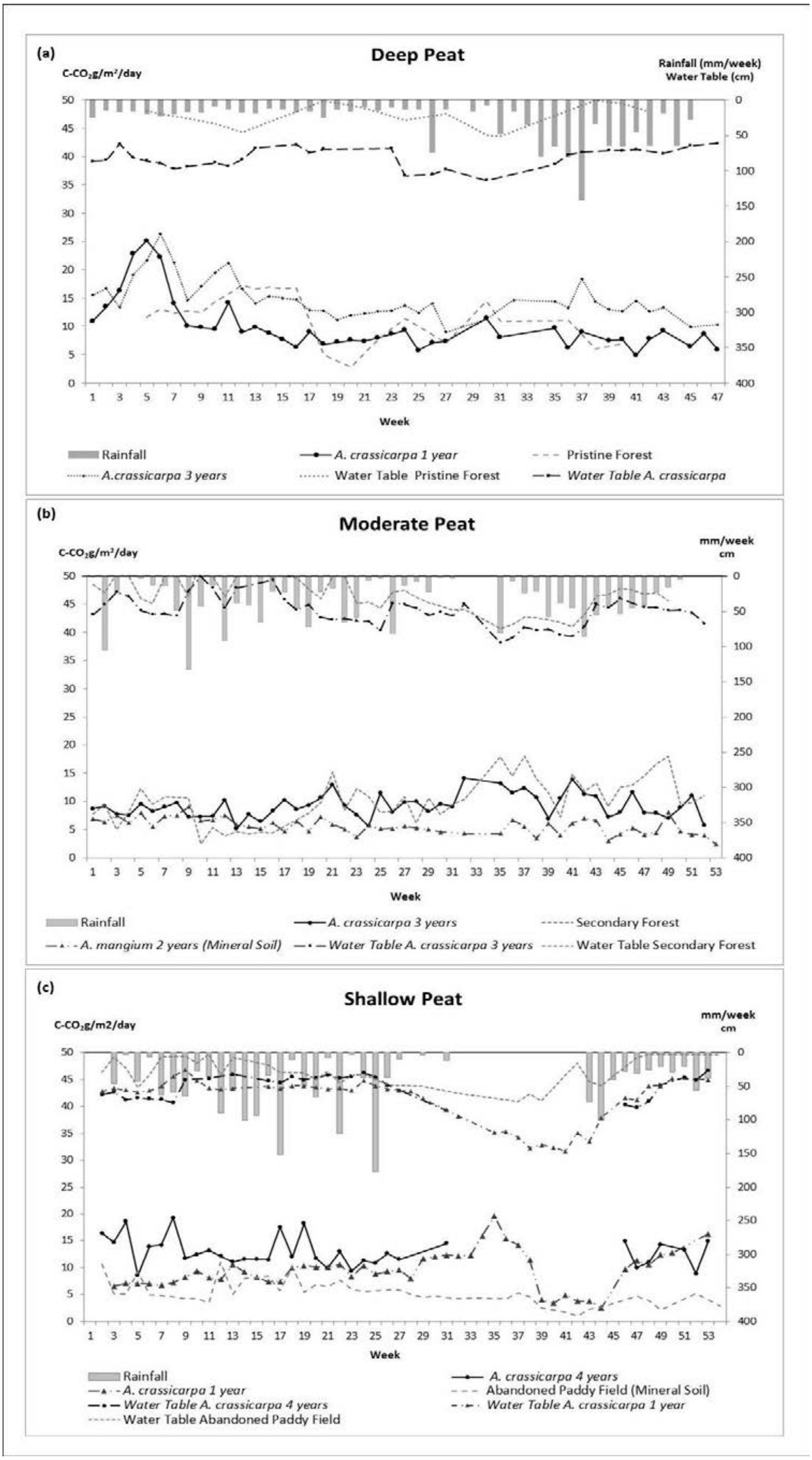

Figure 1. Weekly fluxes of CO_2 from various conditions of *Acacia crassicarpa* planted peatlands and from adjacent pristine forest and mineral soils.

Positive correlation of CO_2 flux with water table is not detected at all in the Fig. 1, thus this research resulted in a contradictive finding compared to what Hatano *et al*. (2011) and Hooijer *et al*. (2011) published. Fig. 1 shows that the highest fluxes of CO_2 from plots with 1 year and 3 years *A. crassicarpa* occurred at week 7 but the lowest water table occurred at week 30. Similar condition was found for shallow peat (see Fig. 1 c) with 1 year *A. crassicarpa* in that the deepest water table was at week 39 until week 41 but during these weeks the CO_2 fluxes were the lowest. On the other hand, Fig. 1 clearly shows that the CO_2 flux increased with age of *A. crassicarpa* trees indicating that high proportion of CO_2 is released from plant respiration compared to that from peat decomposition (see comparison between Fig. 1 a and b). Another factor that is considered as a control to the flux is soil moisture. Fig. 2 shows that the highest CO_2 flux coincides with soil moisture between the field capacity of 250% (w/w) and the wilting point of 180% (w/w). At week 19 to week 30 when soil moisture decreased to lower than the wilting point, the CO_2 flux dropped to the lowest. During these weeks the water table was the lowest. Fig. 2 also shows that there is no clear correlation of water table with CO2 flux, but the CO2 seem to correspond with the soil moisture. Difference in CO_2 fluxes between that from the 3 years *A. crassicarpa* plantation and that from the similar plantation but with no fine root and litter (-R –L) reflects differences in rate of the respiration and root exudation.

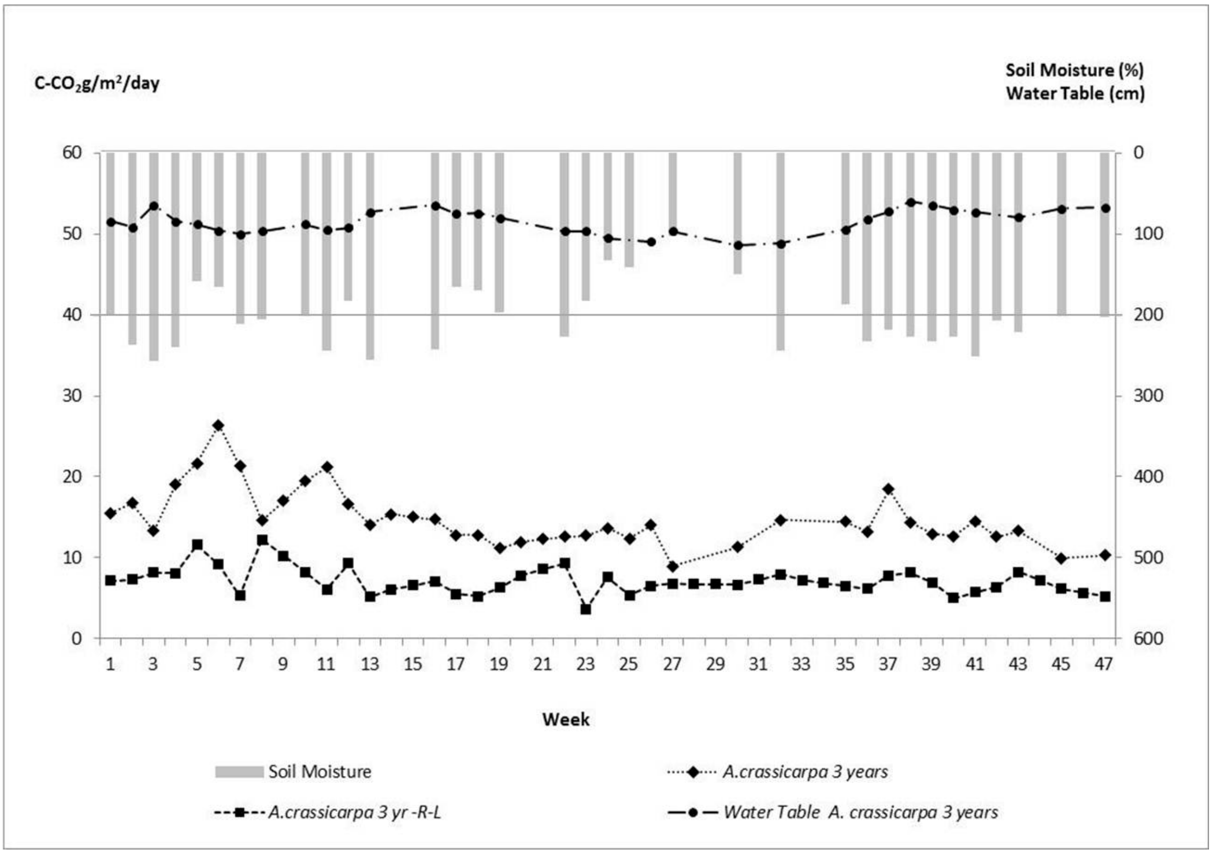

Figure 2. Comparison of weekly fluxes of CO_2 from measurement plots with and without fine root and litter within *Acacia crassicarpa* plantation on peatland

Fluxes of CH_4 are presented in Fig. 3. The figure shows that the fluxes were much lower than those from paddy field. Suprihati *et al*. (2006) published that CH_4 flux from paddy field of mineral soils was around 7.5 mg C-CH_4 m^{-2} h^{-1}, whereas Inubushi *et al*. (2003) reported that the flux from rice plantation on peatland was 1.9 mg C-CH_4 m^{-2} h^{-1}.

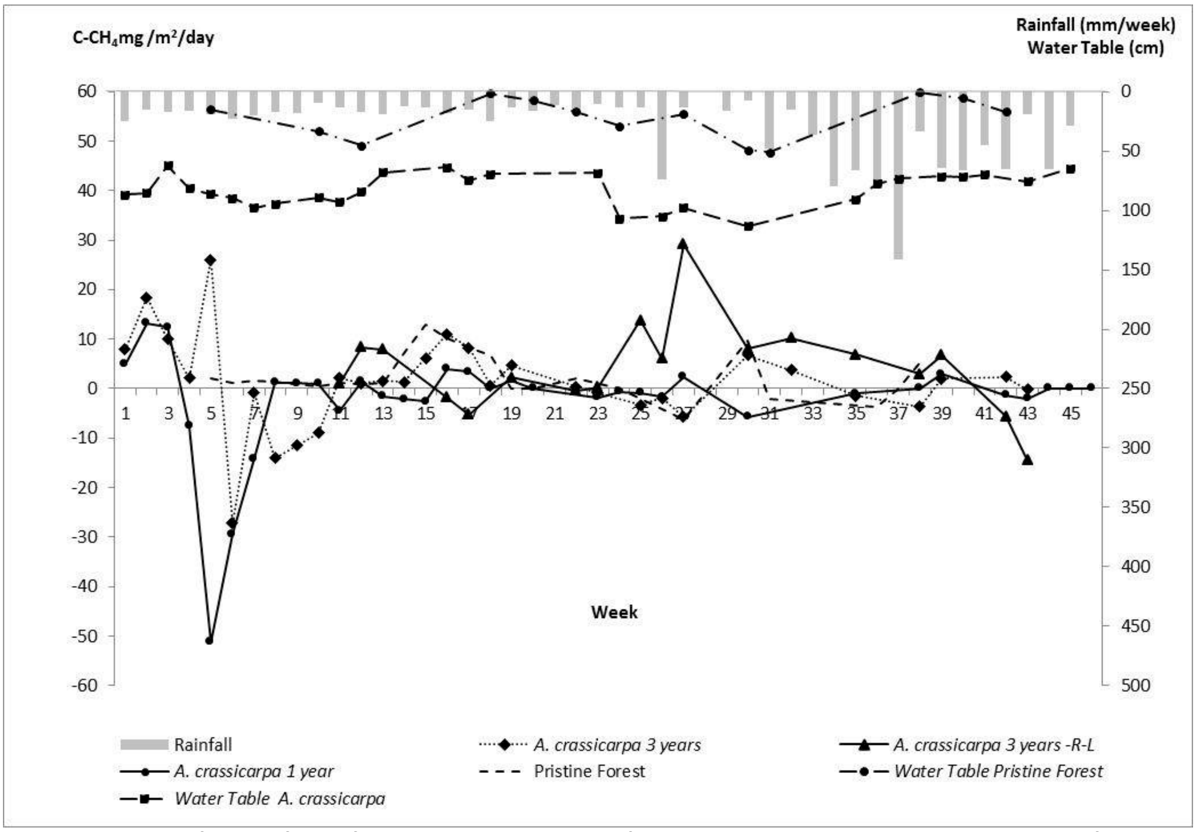

Figure 3. Weekly fluxes of CH_4 from various conditions of *Acacia crassicarpa* planted peatlands and from adjacent pristine forest.

Some data of CH_4 fluxes from the *A. crassicarpa* plantation and from the pristine forest are presented in Fig. 3. The fluxes from the pristine forest were also low and the highest was only 13.0 mg C-CH_4 m^{-2} day^{-1} or 0.54 mg C-CH_4 m^{-2} h^{-1}. For the 1 year and 3 years *A. crassicarpa* plantation the highest fluxes range at 9.6 – 13.2 mg C-CH_4 m^{-2} day^{-1} or 0.40 – 0.55 mg C-CH_4 m^{-2} h^{-1}. Fig. 3 also shows that there is no correlation at all of the fluxes and water table.

Year's fluxes of CO_2 and CH_4 are presented in Table 2. The table shows that CO_2 from the peat are higher than that from the mineral soil. However it is not necessarily that those from the deep peat are higher than those from the shallower peat. Table 2 also shows that CO_2 released from decomposition of litter and fine root are significant. All measurements at the condition of no fine root and litter (-R –L) show almost similar results in a range of 20.31 – 26.38 ton C-CO_2 ha^{-1} y^{-1} for both the deep and shallow peat, and the pristine forest. The highest CH_4 flux of all plots is only 7.29 kg C-CH_4 ha^{-2} y^{-1} that is surprisingly obtained from the –R –L measurement plot of the 3 year old *A. crassicarpa* plantation that is never inundated .

Table 2. Yearly fluxes of CO_2 and CH_4 from different plots of *Acacia crassicarpa* planted peatlands and from adjacent pristine forest and mineral soils.

Land Characteristics	Landuse (age)	CO_2 Fluxes (ton C-CO_2ha^{-1}y^{-1})	CH_4 Fluxes (kg C-CH_4ha^{-1}y^{-1})
Mineral soil	*Acacia mangium,* 2y	20.23	0.77
Mineral soil	*Eucalyptus,* sp 2y	18.10	0.32
Mineral soil	Abandoned paddy field	15.97	-0.28
Peat soil, deep	*Acacia crassicarpa* 1y	35.77	-7.52
Peat soil, deep	*Acacia crassicarpa* 3y	52.43	3.73
Peat soil, deep	*Acacia crassicarpa* 3y –R-L	26.04	7.29
Peat soil, deep	*Pristine forest*	33.04	4.39
Peat soil, deep	*Pristine forest* –R-L	20.31	4.33
Peat soil, moderate	*Acacia crassicarpa* 3y	34.31	2.20
Peat soil, moderate	Secondary (logged-over) forest	36.52	0.24
Peat soil, shallow	*Acacia crassicarpa* 4y	37.59	2.43
Peat soil, shallow	*Acacia crassicarpa* 4y–R-L	26.38	1.12

Note: -R-L: without fine root and litter

CONCLUSION

The fluxes of CO_2 varied with land condition and fluctuated over a year but did not show a consistent trend with respect to peat depth, land-use type, and water table, but correlated with soil moisture and age of the *A. crassicarpa* trees. There is no clear evidence either to show that pristine peat forest has the lowest CO_2 emission or that the lowest water table has the highest CO_2 emission. There are strong indications that respiration contributed greatly to the flux.

The fluxes of CH_4 fluctuated over a year and varied with land condition but the range were low if compared to the fluxes from paddy fields.

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