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CONTRIBUTION FROM ROOT RESPIRATION AND LITTER DECOMPOSITION TO CARBON FLUX IN TROPICAL PEATLAND

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SUMMARY

There are several components of carbon flux from peatland, i.e. peat decomposition, root respiration and exudates, and litter decomposition. It is important to know the magnitude of the contribution from each component. Lacking knowledge of contribution from these components may lead people to simply assume that the carbon emission from tropical peatland merely comes from the decomposition of the peat itself. To get the certainty in measuring net carbon emission, therefore it is necessary among others to measure the contribution of root respiration and litter decomposition of planted species on peatland. *Acacia crassicarpa* is the main species that is being cultivated on Indonesian peatland as a source for pulp industries. For this reason, this research was conducted in one of the *A. crassicarpa* plantation on peatland in Jambi, Sumatra. Measurement of CO_2 flux from plots of no root no litter and no root with litter were carried out simultaneously with measurement from the plot of no treatments where the chambers were placed on the peatland surface under the *A. crassicarpa* at natural condition. The root-free plots were obtained with sorting out all roots in a specified manner. The measurement of carbon flux was carried out continuously every week for about a year. Comparison of the results obtained from the plot with roots and those from the plot of no roots did not show a significant difference. It was due to inappropriate technique applied in blocking roots to penetrate back into root-free peat mass of the plot. A clear difference was found between the results of no roots with litter and those of no roots no litter. The difference was detected after several weeks in that the plot with litter has higher flux indicating the flux of the plot with litter includes CO_2 released from litter decomposition that increasing with time. At week 50 the difference between both plots was account to about 65 g/m^2/day, meaning that the contribution of the litter decomposition within 50 weeks was happened constantly at around 14% of the total carbon flux.

Keywords: *Acacia crassicarpa, carbon flux, peat decomposition , root respiration*

INTRODUCTION

The contribution of diverse sources to the global CO_2 flux from soils of various ecosystems is very important for the construction of the global, regional and local C balance. A review by Kuzyakov (2006) revealed that over the last view decades, various methods allowing the separation of several CO_2 sources and the calculation of their contribution to total CO_2 flux from soil have developed and used. However the basic assumptions and principles of these methods, and the results obtained, all differ from one to another. The review further concluded that the separation of root-derived CO_2 is still a challenging area to investigate more. Similar situation is happening for the separation of CO_2 flux by decomposition of plant residues.

On the other hand during the last decade numerous publications on the claimed increasing global warming show that Indonesian peatland is massively considered as one of the main sources. The publications says that basically when peatland is changed from its natural condition into any manmade land use, such as that for *A. crassicarpa* plantation, it would then contribute significant emission of greenhouse gases especially of carbon in the form of CO_2. Classical chamber method measurement of CO_2 of different conditions of Indonesian peatland has therefore ever been and still commonly used to get the values of CO_2 flux such as reviewed by Page *et al*. (2011). From the data compiled in the review it was evidenced that the measurement rarely set to separate the CO_2 flux from decomposition of peat mass from those respiration- and plant residue decomposition- derived CO_2. With this situation, the measured data should not be totally considered as the rate of the emitted CO_2 contributing to the greenhouse gas increase in the atmosphere. Unfortunately this misleading is continuously running.

This paper is aimed to show and discuss our results of one year weekly closed chamber measurement carried out in an *A. crassicarpa* planted peatland in Sumatra. The measurement was set to partition the contribution of root respiration and litter decomposition on the CO_2 flux in the plantation system.

METHODS

Data presented here were part of data collected during a research project on carbon dynamics in tropical peatland planted forests conducted in Sumatra. In the research project, CO_2 flux from plots of no root no litter and no root with litter were measured, as well as from the plot of no treatments where the chambers were placed on the peatland surface under the *A. crassicarpa* stand at natural condition. These data however, were not specifically elaborated in the book report written by the research team (Sumawinata *et al*., 2014).

To get the root-free plot of, the roots were sorted out from peat mass collected from a pit of 3 m x 2 m square up to a depth of 40 cm. The pit square wall was covered with an iron plate and the roots and root free-peat soil mass were then put back into the pit. The use of iron plate wall was to block living roots to penetrate back into the root-free peat mass. Litter was put back onto the surface of the half square mimicking the natural litter so then a plot of no roots and no litter and a plot of no roots with litter were ready. After a week conditioning then the weekly measurement of CO_2 flux by close chamber method was started until the weeks 50 paralleled with the measurement on the natural condition plot. It started when the stand age was 3-year old. Each plot consisted of three replications (three points of close chamber base). The chambers were made in 30 cm x 30 cm x 30 cm sizes of acrylic sheets of 0.5 cm thick covered with aluminum sheets. The gas samples were analyzed for their CO_2 concentration using a CO_2 infrared gas analyzer (IRGA).

The plots of measurement were located within an *A. crassicarpa* plantation compartment in a plantation area on the peatland in Jambi, Sumatra. The peat in this area is categorized as a moderately deep having depth of about 1.5-3 m. The *A. crassicarpa* stand was of second rotation of planting since the area converted into plantation from a logged over peat swamp forest.

RESULTS

Characteristics of peat in the measurement area are presented in Table 1. The peat is tropical peat originated from woody materials of the forest trees. Chemically (Table 1), it is poor of bases and has low pH and and low ash content. Physically (data no shown) it has very low bulk density and dominated by coarse fraction of peat mass especially at depths of deeper than 50 cm. The peat mass meets the category of ―fibric" in term of the decomposition stage. The big difference of water content between that at depths of more than 40 cm and that at shallower depth is related to the depth of water tablel that was at around 40 cm when the samples was taken.

Table 1: Characteristics of peat in the measurement location in Jambi, Sumatra

Depth	Water content	Ash content	pH	C	N	S	C/N	Bases (%)				Micro elements (ppm)			
cm	…….(%)……			……...(%)…....				Ca	Mg	K	Na	Fe	Mn	Cu	Zn
0-5	356	6.53	3.46	48.12	1.98	0.02	24.36	0.23	0.03	0.02	0.02	990.9	34.85	8.00	16.95
5-10	388	4.26	3.45	50.38	1.87	0.03	27.01	0.18	0.04	0.02	0.03	1,014,1	32.63	10.18	16.75
10-20	439	2.82	3.53	52.02	1.55	0.03	33.47	0.17	0.04	0.01	0.02	774.5	8.38	9.72	13.70
20-30	350	2.22	3.40	52.08	1.87	0.02	27.91	0.08	0.06	0.02	0.07	744.4	4.17	6.81	22.17
30-40	453	1.76	3.51	52.96	1.46	0.02	36.17	0.02	0.07	0.01	0.02	648.2	4.01	9.77	11.58
40-50	823	1.38	3.82	53.90	1.35	0.03	39.87	0.01	0.06	0.01	0.09	458.1	Tr	8.19	8.28
50+	1310	1.11	3.84	54.07	1.33	0.02	40.62	0.03	0.06	Tr	0.12	455.2	0.24	9.20	10.69

Note: Tr - trace

The results of the CO_2 flux measurements are presented in Figures 1, 2 and 3. Figure 1 shows the results of the measurements on the plots that before the close chamber measurements carried out were made to a condition that roots (actually the fine roots) within the peat mass up to a depth of 40 cm were removed and the existed litter was either removed as well or left to exist (put back on). Figure 2 shows the minus roots plots data shown in Figure 1 are plotted again together with those of the results derived from the measurements carried on the non-treated plots (natural condition of plantation). Figure 3 shows the weekly accumulation data of the individual weekly data shown in Figure 1.

The data in Figure 1 show that, regardless the fluctuation of the data, there is a trend that the CO_2 flux from the no roots no litter plot was bit lower than that of no roots with litter. This fact different is clearer when the data are plotted in the way as shown in Figure 3. The fluctuation indicates a correlation of the flux with water table depth.

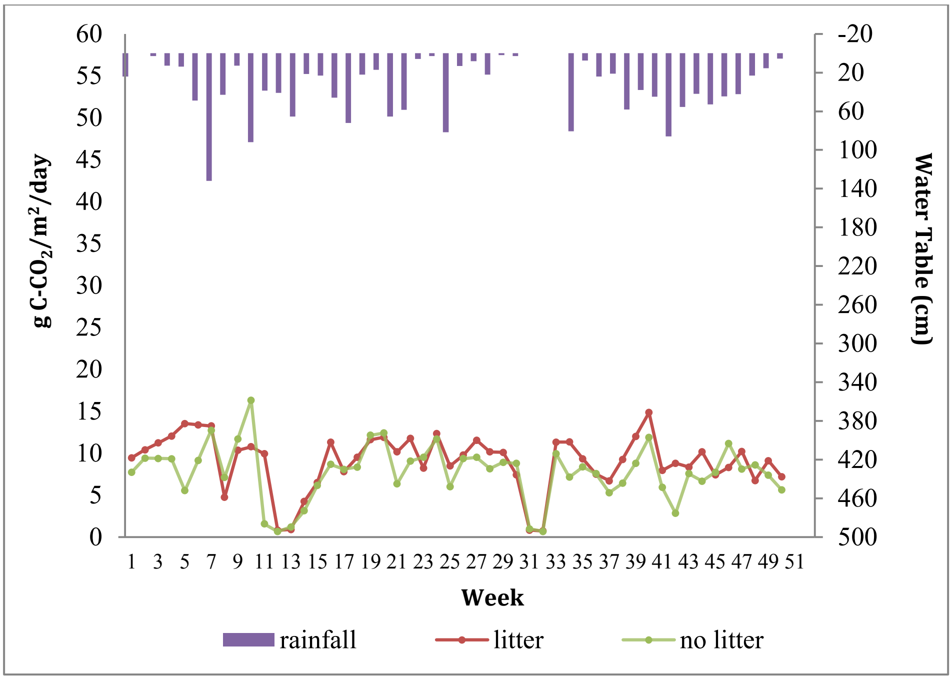

Figure 1: Weekly CO_2 flux in 3-year old (2nd-rotation) *A. crassicarpa* in moderately-deep peatland in Jambi-Sumatra, plots of no roots no litter and of no roots with litter

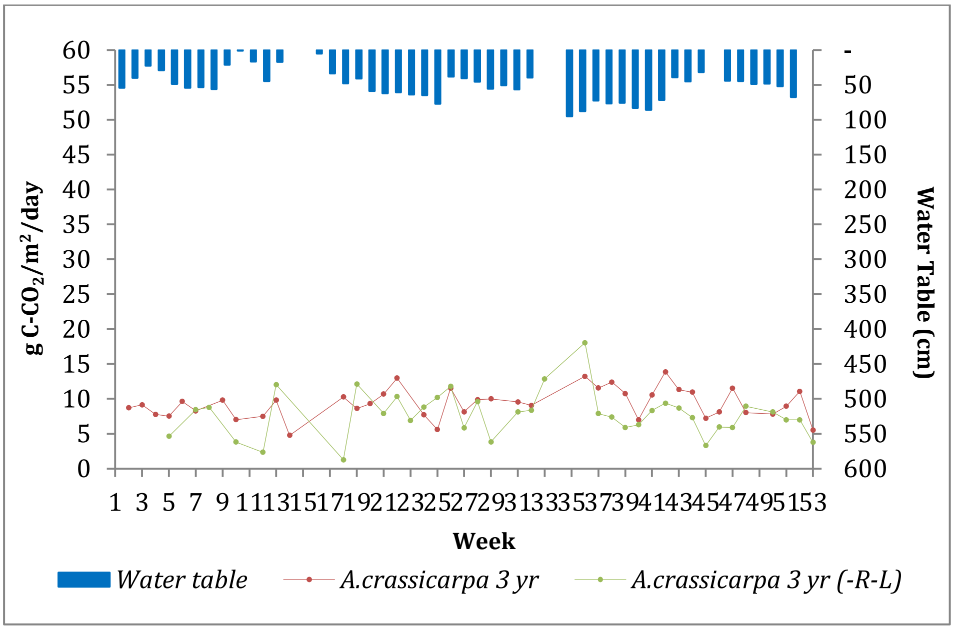

Figure 2: Weekly CO_2 flux in 3-year old (2nd-rotation) *A. crassicarpa* in moderately-deep peatland in Jambi-Sumatra, plots of no treatment and of no roots no litter

Data in Figure 2 show that the flux of the plots of no roots is also somewhat lower than that of the untreated plot. However the graph show an intensive fluctuation during the one year measurement and hence difficult to conclude confidently that with no roots the flux will be certainly lower and therefore the obtained data cannot be used to figure out a certain value for use in any prediction model.

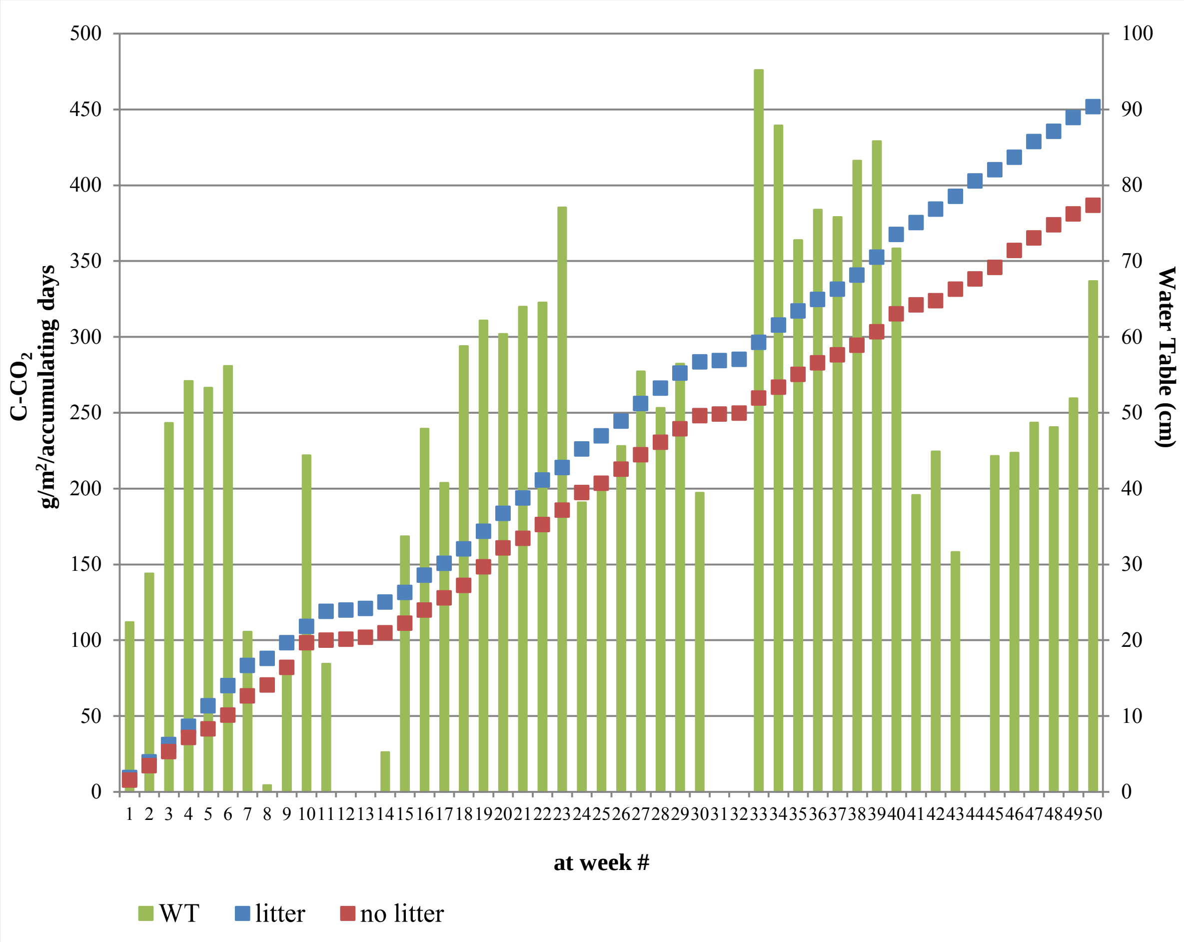

Figure 3: Accumulated CO_2 flux during 50 weeks in 3-year old (2^{nd}-rotation) *A. crassicarpa* in moderately-deep peatland in Jambi-Sumatra, plots of no treatment and of no roots no litter

Data of no roots plots in Figure 3 show that during the one year measurement in accumulation the difference between CO_2 flux of no litter and with litter is quite significance. The graph shows that at week 50 the flux count to about 450g C-CO_2/m^2/50 weeks for the plot with litter and about 390g C-CO_2/m^2/50 weeks for the no litter plot.

DISCUSSION

The difference of no litter with of with litter derived CO_2flux is somewhat clear evidenced in this study and the gap in accumulation is quite significant. Suggesting that for field measurement to get real data of peat decomposition derived flux only, the exclusion of litter is a must. In addition the data obtained for this study point may be useful for in any further study to quantify the contribution of litter decomposition on the total flux.

Comparison of the flux data obtained for the root excluded plots with those for the untreated plot did not show a clear effect of the excluding root treatment. Considering the way the roots were excluded at the plot preparation, there is no doubt that the manner was correct. But the way to block roots from penetrating back into the peat mass by covering the pit wall was not effective. In the following weeks after the blocking the living roots extending and penetrated into the root-excluded peat mass in the plot from the bottom edge of the iron plate. Probably the height of the iron plate was not enough hence the bottom edge the plate inside the peat was not deep enough to hinder the root to propagate that way.

CONCLUSION

The findings in this study confirmed that excluding litter in close chamber measurement of CO_2 flux to get the flux of peat decomposition derived only is must and the way how to do is easy. However the root exclusion measurement is not that easy.

ACKNOWLEDGEMENT

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