Extending wire method for field assessment of surface peat thickness loss due to peat fire incidence in oil palm plantations

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Abstract. This paper contributes the development of a research method for the assessment of surface peat thickness loss due to peat fire incidence in oil palm plantation, since there are oil palm tree stumps still standing in the field after a fire. Peat thickness loss due to peat fire in June 2013 was assessed in an oil palm plantation in Rokan Hilir, Riau Province in April and November of 2015. The total burnt area of up to 114 ha and the surrounding areas that were burned was estimated to be more than 3,000 ha. In order to assess the loss of the surface thickness due to peat fire, the length of rooting system of the oil palm plants above ground was measured. The length of roots is a key parameter of measurement for this study. Since there were parts of the oil palm that was unburned at the burned site the different length of oil palm rooting system above ground was compared between the burnt and unburnt areas. The comparison was conducted with a total of 3,789 sample points of measurement. The result showed that the surface thickness loss is 7 mm in the total burned area.

Keywords: peat fire, carbon stock, peat loss, wire method, fire distribution pattern

1. Introduction

Peatland area becomes an attractive and alternative choice for oil palm expansion area, since the availability of mineral area is limited due to government policies. The availability of peatland area in Indonesia is 16 mio ha, by which 1.7 mio ha is cultivated as oil palm area [1] Gunarso, et al (2013). However, this cultivation is prone to high risk of fire incident that in the last years could not be controlled effectively.

Wildfire smoke is a major source of air pollution that adversely affects human health and productivity in Southeast Asia [2]. About 20% of wildfires across Indonesia can be attributed directly to oil palm plantation practices [3]. The contribution of drier conditions due to climate change is also significant [4]. Drained peatlands are particularly vulnerable to fires [5, 15]. The fire might occur through different ways [6]. Especially in peat soil, natural or anthropogenic spark fire setting would be easier due to the higher organic matter content including flammable resin [7]. The fire incidence risk in peat soils would be much higher, when the plantation undergoes moisture stress or long dry season [8]. Most of the open burned area in Indonesia was accounted by peat area in a dimension of 91.5% of total burned area [9].

An oil palm plantation in peat soil area in Rokan Hilir, Riau Province, Indonesian, that is classified as hemist is an example used in this case study; in June 2013 this plantation was affected by fire incidence covering a small part of the plantation area. The location of the burned area in the plantation is supported by canalization system of the plantation, so that the risk of fire expansion was controlled. The fire incidence and its chronology was reported by Sei Rokan Estate Report in 2014 (unpublished).
An area outside of the plantation was mentioned as source of fire. However the fire, intensified by long dry season and windy condition was able to spread over the canal system and reached the other part of plantation area, which is also a huge peat area with an estimated coverage of more than 10 000 ha as concession area for Industrial Timber Forest. However, this area has not been maintained properly as timber forest, so the local people encroached a part of the area for oil palm cultivation without practicing good agricultural practices. From the field observation in 2014, there was no canalization system properly developed nor installed to control water status and prevent or block any possibility of fire incidence on peat soil. The main water management through canalization system is not installed properly due to high cost and energy. The unmanaged timber forest area is the main factor for fire incident in a remote location from urban area [10]. The fire incident took 3 days in June 2013. The canal blocked by watering system in the field should have been effective enough to stop the fire from spreading instead of manual fighting and small water pump machine (Sei Rokan Estate Report, 2014, unpublished).

In the analysis of hot spots reported by open source NASA MODIS Terra/Aqua Satellite in the covered area, whereas 74 hot spots were found in the area of the plantation during the fire incident time, which covered about 1000 ha. The reports noted that the possibility of hot spots to be considered as fire spot is only about 30%. Ground checking of the area is therefore essential to determine the magnitude of the real total burned area. Particularly it is very critical to identify more exactly, where the burn spots location are and how much the peat depth loss is.

A simple and logical extending wire method for field assessment of surface peat thickness loss due to peat fire incidence in oil palm plantations at the field was developed and accessed originally based on the different peat height in very close distance between burned area and unburned only at the small spot area. In order to identify the surface thickness loss due to peat fire, the comparison of surface height of the top roots between burned area and unburned area as control was conducted. This method is recommended only if the burned area is not totally burned and has a sporadic pattern. It means, not all of oil palm blocks of burned oil palm area was burned evenly. Some of the observed oil palms area in the same block still remained unburned after fire incidence. All of these enabled the subtracting of the surface height of unburned peat soil by surface height of burned peat soil, which its result shows the loss of peat soil thickness due to the fire incidence.

2. Methodology

Field assessment was carried out at the Sei Rokan estate, in two block rows representing a total of 1000 ha area, where apart of these blocks area underwent fire incidence in June 2013. All of the oil palms were planted in 2009. Besides the burned area, the local people encroachment area directly located outside of the estate was also observed and evaluated. Determination of the burned area magnitude was conducted in April 2015 and the peat thickness loss in October 2015. Geographical coordinate of the area is N 01° 54’ 51.1”, E 100° 46’ 41.3”.

To identify the total burned area, each remaining oil palm tree at each sub block was inspected, and then the burned area of each sub block was calculated. From this information the total area of block S and T was calculated totaling 1,200 ha.

The top height of oil palm root fibers above ground is adopted as the baseline to determine the height of the peat surface. The thickness loss due to burned peat was obtained after subtracting the height of the top roots of trees in the burned area from the height in the unburned area. The thickness loss due to burned peat was determined as follows:

a. A steel wire was inserted in two closer undamaged trees of oil palm. The distance between the trees is averagely about 9 m. The point belt was positioned at the top root fibers of each tree.
3. Results and Discussion

The fire distribution pattern in the oil palm estate was identical to a flat tunnel pattern. At the mouth located close to the free farmer location exposed wider fire spots with 1500 m width. The very extensive fire spots stopped at the first block, and then came a narrow fire spot with 100 m width into the inner plantation area in a long distance until 5 km. At the end its fire spot width reached only about 50 m. Its fire distribution was situated along the main road of block area. The total burned area in blocks area amounted to 114 ha from the total block area of 1200 ha. This means that the burning area inside was equal to 0.95% of the total block area.

The long tunnel pattern of fire spots was supported by the facts that there was an intensive canalization system bordering the blocks of oil palm. Proper management of the water table between 300-700 mm, prevented the spreading of fire through the ground, underground and horizontally. However, turbulent wind could expand the fire through the air. For this reason, the fire tunnel pattern forming was supported, since there was no blocking area along the main road between Block S and Block T until the fire spot reached the distance of 5 km at the end of the plantation area. Damming the outlet water in the canal increased the water table and was able to stop further fire expansion after the next 3 days. Without proper canalization management the fire distribution would have been much more extensive.

In fact the fire spots area was sporadic, not regular nor even. So some unburned palm trees remained in the burned spot area enable the extending wire method to be used to measure the possible thickness loss.

The variability of the surface height to the top fiber roots of each tree were seemingly high, so that the result of the loss of peat thickness due to fire incidence was insignificant. The result is only 7 mm during the three days fire incidence. The insignificant results support the idea, that the fire fighter group succeeded in a shorter time to control the fire, that the burned material is only the biomass litter on the ground, and 25% of oil palm trees at the burning spot area were still alive post fire. The loss of peat thickness post fire incidence is presented in Table 1.
The loss of peat soil due to fire would include the loss of oil palm roots, the loss of soil depth reached until center of oil palm roots distribution. The 8 year old oil palm roots distribution in the mineral soil in al 100 mm depth was relatively low with an average weight of 0.38 Mg ha\(^{-1}\). This value reached the highest at 100-300 mm soil depth with average weight of 1.46 Mg ha\(^{-1}\) and its value was lower at the deeper soil layer formation [11]. However, at the free farmers area located directly outside of the plantation area peat thickness loss was 99 mm. Most of the oil palm trees were burned in this location.

| Table 1. Peat thickness loss at post fire incidence |
|--------------------------------------------------|
| Description | Burned free farmer area | Control (Unburned Area) | Burned spot of plantation area | Total |
|-------------|-------------------------|--------------------------|-------------------------------|-------|
| No. of extended wires | 5                        | 33                       | 54                           | 92    |
| No. of sampling points | 213                      | 1,394                    | 2,182                         | 3,789 |
| Surface height to root fibre top (mm) | 89                       | 90                       | 97                           | -     |
| Standard Deviation (mm) | 91                       | 55                       | 62                           | -     |
| Peat thickness loss (mm) | **99**                   | -                        | 7                            | -     |

The loss of peat biomass due to the fire incident in plantation area with 7 mm thickness was equal to 14 Mg ha\(^{-1}\) and carbon about 7 Mg ha\(^{-1}\), whereas the contribution of oil palm root biomass could be considered as very low [11]. This loss can be naturally restored in less than 1 year, since the capability of sequestration of oil palm tree in peat area can reach 7.12 Mg C ha\(^{-1}\) year\(^{-1}\) or equivalent 14 Mg ha\(^{-1}\) biomass sourcing only from oil palm plant sequestration rate in peat soil [12]. The capacity of peat carbon accumulation grew, however, in a slower rate thickness in a value about 1.2 mm year\(^{-1}\) and in a mass of 0.96 Mg ha\(^{-1}\) year\(^{-1}\) [13]. The loss of biomass and carbon value is much lower than its potential loss due to fire in secondary forest peat swamp area that can reach at least 86 Mg ha\(^{-1}\) [14]. The value of carbon loss due to fire incidence in a single event was still lower than annual loss due to drainage of oil palm cultivation in peat soil area which was an average of 29 Mg C ha\(^{-1}\) yr\(^{-1}\) [15].

Conclusion
1. The loss of peat thickness due to fire incidence could be assessed by extended wire method, only if some of the unburned trees remain after fire incidence in the burned area.
2. The subtraction of the surface height to the top fiber roots in the burned spot by surface height to the top fibre roots in unburned spot is equal to the loss of peat thickness due to fire incidence.
3. The loss of peat thickness due to fire incidence at the plantation with intensive fire control management amounted to 7 mm during three days of fire incident in June 2013, and at the free farmer area located outside of the Sei Rokan Plantaion without any significant fire control management was 99 mm.
4. The oil palm plantation was able to restore the loss of biomass and carbon naturally contributed by the trees after 1 year.

Acknowledgments
Authors wish to acknowledge Kebun Sei Rokan in Riau Province for the assistance, support and for Facilitating in the assessment. Field technical assistance by Mr. Muhamad Teguh Sudaryanto during the field observation is highly appreciated.

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