วอเตอร์ฟุตปริ้นของปาล์มน้ำมัน ณ โครงการปลูกป่ามูลนิธิชัยพัฒนา-แม่ฟ้าหลวง จ.เพชรบุรี

The Water Footprint of oil palm crop at the Chaipattana-Mae Fah Luang Reforestation Project, Phetchaburi Province

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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาหาปริมาณวอเตอร์ฟุตปริ้น (water footprint, WF)ของปาล์มน้ำมันที่ปลูก ณ โครงการปลูกป่ามูลนิธิชัยพัฒนา-แม่ฟ้าหลวง จังหวัดเพชรบุรี ในช่วงปี พ.ศ. 2549-2553 การประเมินในงานวิจัยครั้งนี้อาศัยหลักการวอเตอร์ฟรุตปริ้นของ Hoekstra et al. (2009) เพื่อประเมินวอเตอร์ฟุตปริ้นท์ของปาล์มน้ำมัน CROPWAT model เวอร์ชั่น 8.0 ใช้ในการคำนวณหาความต้องการใช้น้ำของพืช (green, blue WFs) สำหรับ grey WF จะวิเคราะห์เฉพาะไนเตรท-ไนโตรเจนของปุ๋ยที่ใช้เท่านั้น ซึ่งผลจากการศึกษาครั้งนี้พบว่าผลผลิตปาล์มตลอดอายุการเก็บเกี่ยวเท่ากับ 7.8 ton/ha ปริมาณน้ำที่ใช้ในการเพาะปลูกปาล์มน้ำมันเท่ากับ 2.2×10^4 m^3/ha/yr ประกอบด้วย CWU_{green} 2,880, CWU_{blue} 10,060 และ CWU_{grey} 9,000 m^3/ha ประสิทธิภาพการใช้น้ำในการเพาะปลูกปาล์มน้ำมันคือ 0.2 kg/m^3 ในส่วนของวอเตอร์ฟุตปริ้นของปาล์มน้ำมันเท่ากับ 12,940 m^3/ton (WF_{green} 524, WF_{blue} 1,829 and WF_{grey} 1,636 m^3/ton) การเพาะปลูกปาล์มน้ำมันของพื้นที่ศึกษามีความต้องการใช้น้ำจากชลประทานมากที่สุดและมีแนวโน้มความต้องการน้ำชลประทานเพิ่มมากขึ้นในอนาคต ดังนั้นควรเพิ่มประสิทธิภาพการให้น้ำชลประทาน รวมถึงเพิ่มผลผลิตและความอุดมสมบูรณ์แก่ดินของพื้นที่ให้มากที่สุด จึงจะสามารถช่วยลดค่าวอเตอร์ฟุตปริ้นของปาล์มน้ำมันในพื้นที่ศึกษานี้ได้

ABSTRACT

This study quantifies the water footprint (WF) of oil palms grown at the Chaipattana-Mae Fah Luang Reforestation Project, Phetchaburi province in 2006-2010. The water footprint methodology of Hoekstra et al. (2009) was applied for WFs of oil palm calculation. The CROPWAT version 8.0 model was used in crop evapotranspiration (green and blue WFs) calculation. The grey WF was specific analyzed for nitrate-N of fertilizers. The results had shown that oil palm yields average of life span was 7.8 ton/ha. The crop water used in oil palm plantation was 2.2×10^4 m^3/ha/yr as CWU_{green} 2,880, CWU_{blue} 10,060 and CWU_{grey} 9,000 m^3/ha. The efficiency of oil palm water used was 0.2 kg/m^3.

Key word: water footprint, oil palm, Chaipattana-Mae Fah Luang Reforestation Project

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Oil palm WFs was 12,940 m^3/ton (WF_{green} 524, WF_{blue} 1,829 and WF_{grey} 1,636 m^3/ton). The irrigated water consumption was highest amount in the study area, make the trend of water irrigation demand will be increase. Therefore, not only the efficiency of irrigated water need to be improved but also increased productivity of oil palm and fertilizer in the soil for reduce the WF value of oil palm in this area.

INTRODUCTION

The water footprint (WF) concept was initiated by Hoekstra (2003). This concept was developed by Hoekstra et al. (2009). Green, blue and grey water are the components of water footprint concept. Green WF is the volume of rainwater on land has used and evaporated by crop growth. Blue WF is the volume of surface and ground water used (irrigation water) along supply chain. Grey WF is volume of freshwater that is required to assimilate the load of pollutions based on existing ambient water quality standards. The WFs shows overview of the water consumption's of products and it indicates the weak points and the awareness of water used of production. So, product owner need to be improved the efficiency of water consumption. WFs concept is considered as an alternative tool to plan and manage the water used for energy properly under the existence of a limited resource on the global warming (Hoekstra et al., 2009).

Effect of energy crisis is increasing. Thus, the alternative energy like 'bio-diesel' is the good choice to produce the renewable energy from oil palm. Demands of bio-diesel will be increasing. Then the Thai Government gives more support on the oil palm plantation (Khamthep, 2010). Oil palm crop need amount of water for growing (250 L/ plant/ day, at adult stage) that make the water using volume is rising followed the demand of bio-diesel (Chy, 2004). Water resources have stressed from climate change, human activities, over-population problem and increased in industrial activity that make the temperature and rainwater changes. These factors are depending on the specific area and the trends of water scarcity will higher in the future (Bhaktikul, 2010). Agricultural water use is dominated part of withdrawal water demand, and agricultural water scarcity results in the loss of agricultural production. Same as African and Asian region that shows high sensitive to agricultural water scarcity (Motoshita et al., 2009). The experiment of oil palm plots (100 rai) to produce bio-diesel production in Chaipattana-Mae Fah Luang Reforestation Project, Phetchaburi province where set in rain-shadow area so water footprint of oil palm crop in rain-shadow area is study that we are interested and all of them are the goal of this research.

MATERIALS AND METHODS

Water footprint calculated of oil palm cultivation use the water footprint concept followed by frameworks of (Hoekstra et al., 2009). All that as showed in equation (1) and m^3/ton is unit of result that:

$$WF_{oil\ palm} = WF_{green} + WF_{blue} + WF_{grey} \quad (1)$$

Green and blue WF of growing process (WF_{proc}, m^3/ton) is calculated as the green and blue component in crop water use (*CWU*, m^3/ha) divided by yield of palm fruit (*Y*, ton/ha) as equation (2):

$$WF_{proc,green} = CWU_{green} / Y \quad (2)$$

A CROPWAT version 8.0 model (FAO, 2007) was applied to calculate the crop water requirement both green and blue WFs; the model runs on the irrigation schedule option using for a medium soil, effective rainfall based on USDA calculation method, refill soil to field capacity of application timing, irrigated at fix interval per 3 day for irrigation timing, 70% irrigation efficiency and the calculated evapotranspiration is called ET_a as equation (3) and (4):

$$CWU_{green\ or\ blue} = 10 * \sum_{d=1}^{lgp} ET_{green\ or\ blue} \quad (3)$$

ET_{green} and $_{blue}$ means green and blue water evapotranspiration. The factor 10 is meant to convert water depth in mm into water volumes per land surface in m^3/ha and *lgp* stands for length of growing period in days.

In rain-fed scenario: ET_{green} (rain-fed) = ET_a (rain-fed), ET_{blue} (rain-fed) = 0

In irrigation scenario: ET_{green} (irrigation supply)= ET_a (rain-fed) – ET_{blue}(irrigation supply) (4)

ET_{blue}(irrigation supply) = min (total net irrigation or actual irrigation requirement)

For grey WFs assessment was calculated by application rate (*AR*) as equation (5):

$$WF_{grey} = \{(\alpha * AR)/(C_{max}-C_{nat})\}/(Y) \quad (5)$$

When, α is times the leaching fraction, assumed 10% for nitrogen fertilizers, *AR* is chemical application rate per hectare (kg/ha), *Y* is yield of palm fruit (ton/ha), c_{max} is maximum allowable concentration (as 5 mg/L followed Royal Irrigation Department) and c_{nat} is natural concentration. But this study analyzed only Nitrate-N used because nitrogen used is nonpoint source to affect for river. This study focused only water footprint of oil palm crop in 2006-2010 time period but does not means how violence or impact of environmental.

Data collections were the climatic data of past 25 years from Thai Meteorological Department, soil type from Office of Soil Survey and Land Use Planning, water quality and standard of water quality from Royal Irrigation Department, crop date, crop practice and yield harvest from field (Chaipattana- Mae Fah Luang Reforestation Project).

RESULTS AND DISCUSSION

1. Oil palm harvesting

Yield of oil palm (*Tenera* variety) data was obtained from field and fresh fruit bunch yield (FFB) of oil palm average over full life span was 7.8 ton/ha. Palm fruit was 2.16 ton/ha as 70% of FFB.

2. Crop water used of oil palm cultivation (CWU)

The assessment found that the green (rain water) and blue water (irrigation water), oil palm had CWU_{green} and CWU_{blue} were 2,880 and 10,060 m^3/ha/year, respectively (Table 1). Total crop water used of oil palm was 12,940 m^3/ha/year. As for water used of oil palm cultivation was found only in the growing stage. Crop evapotranspiration of oil palm was 1,294 mm/growing period/year. For blue water used is the main water used for oil palm cultivation. Because the trend of rainwater will be declined, the demand of blue water will be increased in 2015 as predicted in Figure 1.

Table 1 Water requirement for oil palm cultivation in 2006-2010.

CROPWAT option	ET_{green}*	ET_{blue}*	CWU_{green}	CWU_{blue}	CWU_{total} ($CWU_{green+blue}$)
	mm/growing period/year		m^3/ha		
Irrigation schedule option	288	1,006	2,880	10,060	12,940

*Crop evapotranspiration (*ET)* was simulated by CROPWAT 8.0 model.

3. Water footprint of oil palm crop (WF)

The WFs of oil palm was 3,989 m^3/ton; 524 green, 1,829 blue and 1,636 m^3/ton grey WFs, respectively as Table 2 and Figure 2. The results show the blue WF was higher than grey and green WFs, respectively.

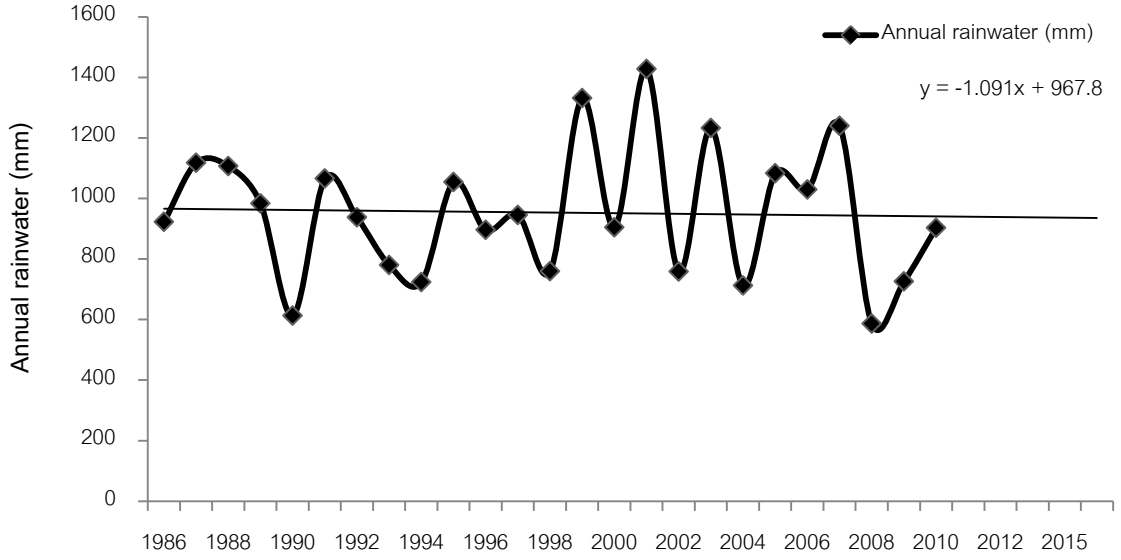

Figure 1 Annual rainwater in study area in 1986-2010 periods (predict to 2015).

Table 2 The WFs of oil palm in 2006-2010 periods.

CROPWAT option	Palm fruit	$WF_{proc,green}$	$WF_{proc,blue}$	$WF_{proc,grey}$	$WF_{proc,total}$
	ton/ha		m^3/ton		
Irrigation schedule option	5.5	524	1,829	1,636	3,989

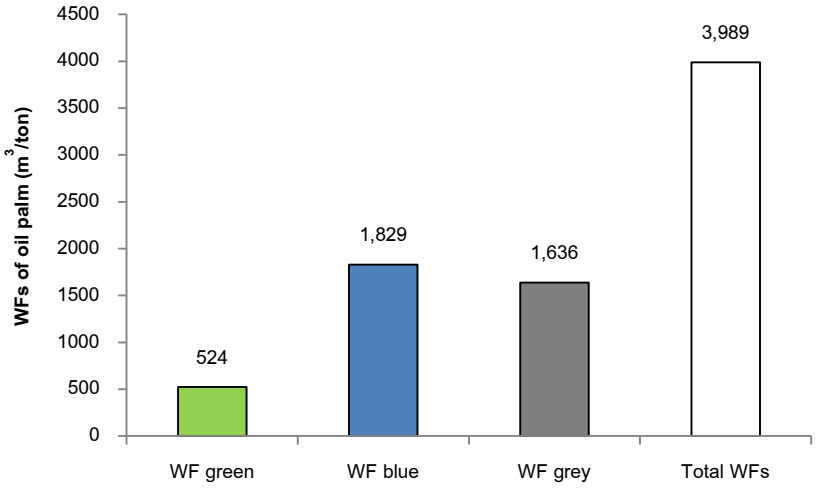

Figure 2 Green, blue and grey WFs of oil palm in 2006-2010 periods.

For oil palm crop WFs of study area in 2006-2010 periods was higher than in (Lienden et al., 2010) studied because the harvested yield in the study area was lower than the normal standard of *Tenera* variety (Chy, 2004). Difference factor such as agricultural practice, climatic condition, location, soil type and yield that effect on the WFs value as previously studied by Hoekstra et al. (2009) and

Mekonnen and Hoekstra (2011). Because the study area is located in rain-shadow area that makes the rainwater is not enough for water consumption. So, the irrigated water was the main water used for oil palm plantation and blue WF was higher than green and grey WFs. In summary, the climatic condition and poor soil were main cause for low of oil palm yield. The ways for reduce to oil palm WFs should be improved the water management, increased oil palm productivity per area as much as possible and fertility of the soil created as suggested by Hoekstra et al. (2009) and Pongpinyopap and Mungcharoen (2011). From the knowledge base of annual rainwater since 1986-2010 periods show the trend of rainwater will be decline in 2015. So, the demand of irrigated water used in 2015 will be increase.

CONCLUSION

The water footprint of oil palm crop based on the yield average over full life span at Chaipattana-Mae Fah Luang Reforestation Project was 3,989 m^3/ton in 2006-2010 periods (524 green, 1,829 blue and 1,636 grey WF m^3/ton). FFB average yield over full life span was 7.8 ton/ha. For oil palm cultivation, the irrigated water was main source of water used and crop water used was 12,940 m^3/ha/year. In year 2015, the trend of blue crop water used will be increased so the efficiency of irrigated water needs to be improved, productivity of oil palm and adding fertilizer in the soil need to be increased. All of these options can reduce the WF value of oil palm.

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