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COMPARISON OF CONSUMPTIVE WATER ON CONVENTIONAL AND SEMI ORGANIC METHOD POTATO CULTIVATION

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ABSTRACT

Climate change has an impact on the world of water availability. Water use efficiency important to do especially in the agricultural sector which is one of the largest sectors in water use. Potato cultivation in Pangalengan which continues to grow along with the pricing policies of potatoes as a source of diversification of West Java has the potential to deplete the availability of water in these locations. Amount of consumptive water during the cultivation process needs to be known in order to determine the water management policy. Amount of agricultural consumptive water can be influenced by cultivation methods applied. Approach blue and green water footprint was used to determine the amount of consumptive water usage in the cultivation. Purpose of this study was to calculate the amount of blue and green water footprint of potato on two different methods of cultivation they were semi-organic and conventional methods. The calculation of green water footprint in this study used rainfall water evapotranspiration, whereas value of blue water footprint from irrigation water evapotranspiration. Value of green and blue water footprint of conventional potatoes each was 126 m^3/ton and 24.4 m^3/ton. While the value of green and blue water footprint semi-organic potatoes each were 103.3 m^3/ton and 2.5 m^3/ton. Water used in semi-organic method was more efficient than the conventional method. Semi-organic methods can reduce water consumption directly (blue water) up to 89.75%.

Keywords: Blue water, Green water, Potatoes, Water efficiency, Water footprint.

INTRODUCTION

Climate change will have a significant impact on water supplies sustainability in the coming decades (NRDC, 2010). Indonesia is one of the countries that are projected to experience water crisis in 2025 due to its weak water management especially in inefficient water use (Sosiawan & Subagyono, 2009). Atnong water sector users, agriculture sector is a sector with high water resources use. Water demand for agriculture in several Asian countries, including Indonesia, covered almost 90% of the total water availability (Wignyosukarto, 2005).

Potato is world's third most popular crops commodity after rice and wheat (*International Potato Centre,* 2008). Asian countries nowadays start to consider potato as future salvation commodity for world's citizen consumption (Adiyoga, 2010). In National Potato Week 2008, Potato was echoed as crops diversification alternative in Indonesia (Setiadi, 2009).

Water requirement for planting potato is relatively high. According to Haverkorts (1982), potato population of 40.000 plants per hectare needs 100 to 200 liters of water per plant per planting season. This high water requirement tends to potentially cause water conflict with sector other than potato cultivation, especially in water shortage condition such as dry season. In this season, potato watering is carried out up to five times a day (Setiadi, 2009).

The amount of agriculture water use can be determined by cultivation methods applied. Blue and green water footprint approach are used to determine the amount of water usage in one cultivation. Both values (blue and green water footprint) constitute consumptive water which can give us information about real usage overview from potato cultivation production. *Water footprint* is used to calculate total water usage during product or service production process (Chapagain *et al.,* 2006) and can provide information about water source used, i.e. *green water*-the amount of water being evapotranspirated from rain water and *blue water*-the amount of water evapotranspirated from irrigation water (Hoekstra *et al.,* 2009).

The aim of this research was to calculate the scale of blue and green water footprint of potato production from two different cultivation methods, conventional and semi organic method. With information about the amount of real water usage in both cultivation methods, water usage efficiency can be done by selecting cultivation method which uses less amount of water.

MATERIALS AND METHODS

This research was conducted in October 2021. This research was conducted in the forest area of Senamat Ulu, Bathin III Ulu District, Bungo Regency, Jambi Province. Research was conducted in Margamukti Village in Pangalengan District, one of the largest potato centers in Indonesia. To determine real water usage for potato cultivation, water footprint approach was used. Water footprint is use to calculate total water usage during product or service production (Chapagain *et al*., 2006).

Data used to estimate potato's green and blue water footprint were climatic data from climatic station data interpolation using *New Locclim* software ver. 1.1 (FAO, 2005), soil texture data from soil sample analysis, plant coefficient data (Kc) and data about overall potato cultivation process. Those data were then processed to estimate potato evapotranspiration value using CROPWAT program ver 8.0 (Chapagain & Orr, 2009; Hoekstra et al., 2009).

Water footprint calculation for potato cultivation was carried out in every cultivation step in each cultivation method (semi organic and conventional). Water usage calculation was conducted using indirect water use calculation approach through evapotranspiration value estimation during cultivation steps. This evapotranspiration value then represent consumptive water value i.e blue and green water footprint.

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The first step to calculate evapotranspiration is by calculating evapotranspiration rate *{Reference crop evapotranspiration,* ETo) using CROPWAT 8.0 *Penman*- Monteith FAO equation.

$$ETo = \frac{0.408(R_n - G) + \gamma\frac{900}{T+273}U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

ETo : Reference evapotranspiration (mm/day)
R_n : Net radiation at the crop surface (MJ m^{-2}/day)
G : Soil heat flux density (MJ m^{-2}/day)
T : Average daily temperature (°C)
U_2 : Wind (m/sec)
e_s : Saturation vapour pressure (kpa)
e_a : Actual vapour pressure (kpa)
e_s- e_a : Saturation vapour pressure deficit (kpa)
Δ : Slope vapour pressure curve (kpa/°C)
r : Psychrometric constant (kpa/°C)

ETo value obtained is then used in calculating *crop evapotranspiration* (ETc) using equation (Chapagain & Orrm, 2009; Hoekstra & Chapagain, 2008):

$$ET_c = K_c[t] \times ET_0[t] \quad (2)$$

The next calculation step is to calculate evapotranspiration for green water (*green water evapotranspiration,* ETg). This value represents rain water evapotranspiration, so that its value is equal to the wit minimum ETc and *effective rainfall.* ETg calculation is carried out by using equation (Hoekstra & Chapagain, 2008):

$$ET_g = \min(ETc, P_{eff}) \quad (3)$$

ETg = Green water evapotranspiration (mm/day)
ETc = Evapotranspiration by plant (mm/day)
Peff = Effective rainfall (mm/day)

The next step is to calculate the amount of irrigation water requirement (*irrigation requirement,* IR) and effective irrigation (effective irrigation, leff) from the entire potato growth period. I R will be calculated using equation (Hoekstra & Chapagain, 2008):

$$IR = \max(0, ETc - P_{eff}) \quad (4)$$

IR = Irrigation Water Requirement (mm/day)
ETc = Evapotranspiration by plant (mm/day)
Peff = Effective rainfall (mm/day)

leff value is a part of irrigation water supply which is stored in the soil as soil moisture and available for plant evaporation. Blue water evapotranspiration value *(blue water evapotranspiration,* ETb) is subsequently calculated. This value is derived from IR value which represents evapotranspiration value aggregate with effective rainfall value (Peff). ETb value is calculated using equation (Hoekstra & Chapagain, 2008):

$$ET_b = (0, ETc - Peff) \quad (5)$$

ETb = Blue water evapotranspiration (mm/day)
IR = Irrigation Water Requirement (mm/day)
Leff = Irrigation effective (mm/day)

The next calculation step is calculating water usage value for plant or *crop water use* (CWU). ETg and ETb value obtained previously are then use to calculate *CWUblue* and CWUgreen. Calculation is carried out using equation as followed (Hoekstra e/ a/., 2009; Hoekstra & Chapagain, 2008):

$$CWU_g = 10 \times \sum ET_g \quad (6)$$

$$CWU_b = 10 \times \sum ET_b \quad (7)$$

CWU_g = Green water use by plant or green component crop water use (m^3/ha)
CWU_b = Blue water use by plant or blue component crop water use (m^3/ha)
ET_g = Green water evapotranspiration (mm/day)
ET_b = Blue water evapotranspiration (mm/day)

Total ETg and ETb are multiplied by 10 in order to convert from mm to m^3/ha (Hoekstra & Chapagain, 2008). Water usage calculation in potato cultivation steps is carried out from first planting day until harvest day.

Lastly, consumptive water calculation is carried out. Potato consumptive water is the calculation for green and blue water. Calculation is carried out using the equation as follow (Hoekstra *et al.* 2009):

$$WF_g = \frac{CWU_g}{Y} \quad (8)$$

$$WF_b = \frac{CWU_b}{Y} \quad (9)$$

WF_g = Green water footprint (m^3/ton)
WF_b = Blue water footprint (m^3/ton)
CW_{Ug} = Green water use by plant during potato cultivation (m^3/ha)
CW_{Ub} = Blue water use by plant during potato cultivation (m^3/ha)
Y = Yield (ton/ha)

RESULTS AND DISCUSSION

Consumptive water (WFblue and *WFgreen)* value for conventional method was 150.4 m^3/ton (Table 1), whereas consumptive water for semi organic method was 105.8 m^3/ton, or 30% significantly lower than conventional method.

Table 1. Consumptive water comparison between conventional method and semi organic method

Method	*WFprodc,green* (m^3/ton)	*WFprodc,blue* (m^3/ton)	*Total* (m^3/ton)
Conventional	126	24.4	150.4
Semi organic	103.3	2.5	105.8

(Source: Primary data, 2011)

Calculation results suggested that green water footprint for semi organic method was 103.3 m^/ton. This value was lower than green water footprint for potato cultivated conventionally which has green water footprint value of 126 m^3/ton.

Blue water footprint of semi organic method was 2.5 m^3/ton (Table I). This value was much lower than conventional blue water footprint which reached 24.4 m^3/ton. Irrigation water consumption value in semi organic method saves 89.75 % water compared to conventional method. This may be due to planting period for semi organic method was conducted in sufficient rainfall period so that blue water footprint could be minimized. Suitable planting time for potato is at the end of rain season until ahead of dry season (Susila, 2006). According to SAI (2010) water should be applied in appropriate amount in appropriate time in order to achieve proper crop results.

Utilization of water from irrigation water *{blue water)* give greater environmental impact compared to rain water utilization. Irrigation water used for plant consumption will evaporate via evapotranspiration and reduce available surface water reserves. Blue water potentially leads to environmental problems such as water resources depletion (FAO, 1999). Therefore, blue water usage should be reduced as much as possible. One way to achieve this is by applying cultivation methods which is more efficient in terms of its water usage.

Water resources management strategy is thus key to ensuring that agricultural production can withstand the stresses caused by climate change (Ngigi,2009). Management strategy with upgrading agricultural activities, through integrated rainwater *green water)* harvesting system. Applying semi organic method which utilizes rain water during potato cultivation, so that the needs of irrigation water (blue water) could reduce.

Smallholder farmers are the most vulnerable to climate change, and they have no alternative but to adapt their livelihood systems to changing climatic conditions (Ngigi, 2009). Fortunately, there are practical options for adaptation existing by applying efficient cultivation method.

Semi-organic farming methods showed more efficient water usage compared to the conventional one. Selection of proper cultivation methods can reduce the use of water as a form adaptation to climate change phenomena that can potentially lead to drought and water scarcity in many places in the world.

CONCLUSION

The use of water in semi-organic method is more efficient than the conventional method. Semi organic method can reduce direct irrigation water usage (blue water) up to 89.75%. Additionally, it can reduce conventional total consumptive water by 30%. Water use efficiency on potato cultivation is an adaptation of potential drought that might be occurred due to climate change.

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