Jurnal Penelitian Kelapa Sawit, 2007, 15(1): 1-9

PRACTICAL INSTRUMENTATION OF WATER BALANCE STUDY IN OIL PALM PLANTATION

W. Darmosarkoro, H.H. Siregar, B. Budianto [1], K. Murtilaksono[2]

ABSTRACT

Research of water balance especially in oil palm plantation requires several instruments that have to record data accurately and continuously. The data needed are rainfall, throughfall, stemflow, soil moisture, percolation, evaporation, surface runoff, and water storage. Computerized data recording is usually gathered by data logger system, and computer can easily download the data. When the research budget is limited and data recording system has to be easier, simplification of devices are then highly needed instead of the data logger system. This paper is shown the practical instruments specification and the data output in determining water budget in oil palm plantation in Rejosari, PT Perkebunan Nusantara VII, Lampung.

Key words: *instrumentation, water balance, oil palm*

ABSTRAK

Penelitian keseimbangan air khususnya pada perkebunan kelapa sawit membutuhkan beberapa peralatan yang dapat merekam data secara akurat dan kontinu. Data yang dibutuhkan meliputi curah hujan, curahan tajuk, aliran batang, lengas tanah, perkolasi, evaporasi, aliran permukaan dan cadangan air tanah. Perekaman data secara komputerisasi biasanya dilakukan dengan sistem data loger dan komputer sehingga dapat dengan mudah memperoleh data. Ketika anggaran biaya penelitian terbatas dan sistem perekaman data yang diperlukan lebih mudah, penyederhanaan perlengkapan menjadi sangat dibutuhkan dengan sistem data loger tertentu. Paper ini mengemukakan spesifikasi peralatan praktis dan luaran data dalam menentukan keseimbangan air pada perkebunan kelapa sawit di Rejosari, PT Perkebunan Nusantara VII, Lampung.

Kata kunci : *peralatan, keseimbangan air, kelapa sawit.*

[1] Faculty member of Dept. of Geophysics and Meteorology, Faculty of Mathematic and Natural Science, Bogor Agricultural University

[2] Faculty member of Dept. of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University

INTRODUCTION

Water availability that is presented as surplus or deficit throughout a year can be determined through study of water balance or water budget. Oil palm plantation requires 1500 – 2000 mm per year of rainfall, and it should be evenly distributed throughout the year (1,2,15). Consumptive used or water requirement of oil palm plantation at least 150 mm/month (18), but it depends on several condition such as climate and plant age.

Research of water balance especially in oil palm plantation requires several instruments that have to record data accurately and continuously. The data needed are rainfall, throughfall, stemflow, soil moisture, percolation, evaporation, surface runoff, and water storage. Computerized data recording is usually gathered by data logger system, and computer can easily download the data. When the research budget is limited and data recording system has to be easier, simplification of devices are then highly needed instead of the data logger system.

Regular rainfall measurement is highly important in sector of agriculture, forestry, industry, education, and many other activities. Rainfall depth, duration, and intensity are varies temporally and spatially. The continuous data of rainfall can be measured by automatic raingauge that is that is installed with tipping bucket device and counter recorder system. Meanwhile, daily total rainfall depth can be measured by observation raingauge. The raingauge types must be spatially installed and representing the studied areas. The tipping bucket and counter recorder system device can be used to measure depth of throughfall and stemflow as well.

Soil moisture data that can represent soil water storage is commonly measured by electrical resistance blocks (Watermark and gypsum blocks) and neutron moisture meter. More recently, dielectric sensors have been developed based on the dielectric constant of the soil. TDR tensiometer and TRIME portable soil moisture meter are commonly used in several researches for monitoring soil moisture content which is funding by international donor. These devices must be expensive and impossible to be installed in developing countries to monitor the soil moisture content regularly. Simple metal stick sensors and modified hand potentiometer would be other practical device that much cheaper than those modern and sosphicated ones (Hymer, Moran, and Keefer, 1998). Models of predicting soil moisture variability with depth and time have been developed in many places (8,13,16,19).

Soil permeability is usually measure by Guelph permeameter, but its modification that must be simple and cheaper can be used to determine the soil permeability as well. Water percolation throughout soil solum is measured by lysimeter.

Water evaporation is just simple measured by evaporimeter of A Class Pan type. Evaporated water is indicated by the lowered water surface or evaporated water in the pan or evaporimeter.

Water discharge of surface runoff (streamflow) is determined through water level of streamflow that is monitored by water level recorder. The generated rating curve is a mathematic formula to calculate the water discharge based on the water level. Actual water level that is read on the staffgauge (pheilschal) is correlated with continuous printed data of the automatic water level recorder (AWLR).

This paper is just shown the practical instruments specification and the data output in determining water budget in three blocks of oil palm plantation in Afdeling III, Unit Usaha Rejosari, PT Perkebunan Nusantara VII, Lampung.

INSTRUMENT SPECIFICATION AND INSTALLATION

Automatic rainfall recorder (ARR) or automatic raingauge with interval time between tipping bucket event has 0.25 mm resolution. The ARR instrumented with printing calculator as a counter of the duration of rainfall event that is collected in ombrometer (Figure 1). One ARR was installed nearby to evaporimeter and adjacent to Afdeling III office and block 1 of the research area. Two other observatorium raingauges were installed in other two blocks of the research area.

Throughfall of rainfall was collected by three kind of instruments, i.e. pholivenylchloride gutter (Figure 2), ombrometer (Figure 3) and metal collector (Figure 4) that were installed nearby each other in each block of the research area. Daily depth of throughfall that is generated from the instruments are measured with graded scale glass container in every morning when there is rainfall. These instruments were installed directly under the leaves of selected oil palm trees. This different type of throughfall collectors were designed to get the accurate and reliable data of throughfall.

Figure 1. Automatic rainfall recorder (ARR) or automatic raingauge

Figure 2. Pholivenylchloride gutter

Four jars as water collector of stemflow were installed beneath soil surface near oil palm trees. These jars were connected each other with pipe, while plastic pipe with 10 cm diameter is posted at the oil palm tree to drain the stemflow flowing to the jars via plastic pipe (Figure 5). In the beginning of the research, there was only one jar, but it was not sufficient to collect stemflow when heavy raining is coming. Furthermore, the instrument can be completed with tipping bucket device to measure the stemflow continuously.

Figure 3. Ombrometer

Figure 4. Metal collector

Figure 5. Stemflow instrument with tipping bucket device

Soil permeameter instrument measures soil permeability by monitoring water entering soil in scaled tube (Figure 6). The soil permeability is measured spatially and temporally in each block. It represents soil characteristics, slope variability and seasonal rainfall variability.

Figure 6. Soil permeameter instrument

Soil moisture sensors as much as 40 points were scattered installed in each catchments or block. It represents slopes variability and spatial area. Soil moisture sensor is metal stick, and there are three pairs of metal stick that are installed 25, 50, and 100 cm depth in each point respectively (Figure 7). The metal sticks are coated with plastic film except both of the end of the sticks (5 cm). Resistance of soils of particular depth in 20 cm distance of installed metal sensors is daily measured with voltmeter. Soil samples were collected nearby to the selected sticks of each depth in order to determine its soil moisture. Soil resistance and soil moisture data is then correlated and calibrated.

Figure 7. Soil moisture sensors

Class A of pan evaporimeter was installed nearby the automatic raingauge or ARR (Figure 8), and it is located in the yard of Afdeling III office. It represents the study area in oil palm plantation of Afdeling III, Management Unit of Rejosari, PT. Perkebunan VII, Lampung. The water inside the evaporimeter is always adjusted every morning to read the evaporated water.

Automatic water level recorder (AWLR) is an instrument to record water level of water flow in the channel that is indicated by float position and controlled by appropriate puleys and multiturn potentiometer with 10 minutes interval.

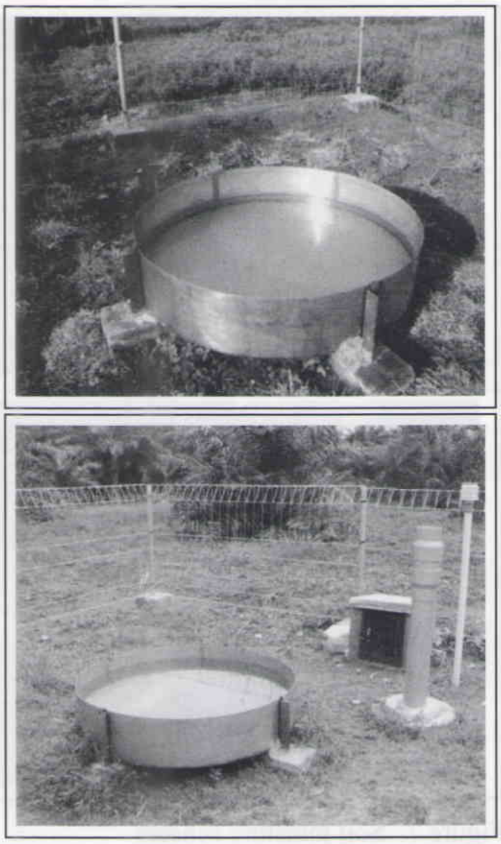

Figure 8. Evaporimeter instrument, ARR, and solarimeter

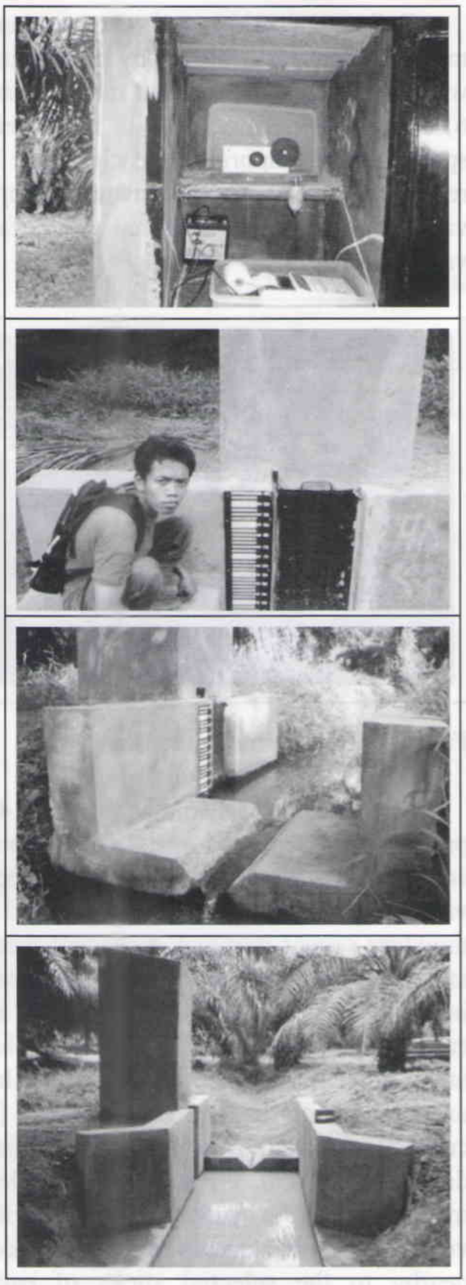

Figure 9. Automatic water level recorder (AWLR) instrument installed in weir

AWLRs were installed at the outlet of each treated catchment. Mini printing calculator with the appropriate auxiliary electronics is employed at each AWLR (Figure 9). Weir is also instrumented with staffgauge (pheischaal) that indicates or measures directly the depth of waterflow.

DATA OUTPUT

Automatic rainfall recorder (ARR) or automatic raingauge generates depth, duration, and intensity of rainfall. Thirty minutes intensity of rainfall (I30) can be calculated based on printed data generated from the ARR. Accuracy of the data is quite high since the resolution is 0.25 mm of rainfall depth. The accuracy of rainfall intensity can be corrected regularly by comparing with scaleglass-measured daily rainfall. Spatial variability of rainfall can be determined by examining the three installed raingauges in the research area.

Pholivenylchloride gutter, ombrometer and metal collector generate daily total depth of throughfall. Duration and intensity of throughfall can not be calculated with these manual instruments, since there is no tipping bucket devices installed at the instruments. However, the obtained data of throughfall is still valid with these kind of instruments.

Volume of stemflow is daily measured from the four jars as water collector that is installed beneath soil surface near oil palm trees. The volume is then multiplied by the number the oil palm trees per block and converted to depth of stemflow by dividing of total area of the block. The data was still manually computed in the first year of research, however in 2007, the second years of the research it is completed with tipping bucket devices. The instrument will, then be automatic stemflow recorder, and depth, duration and intensity of stemflow can be calculated continuously.

Soil permeability is measured directly in the field by soil permeameter. The generated data from the measurement is then computed in order to obtain the flow rate of water transmitted in the soils. The data generates equation of spatial water infiltration in the research area. Meanwhile, lysimeter generates volume of percolated water throughout the soil solum in tipping bucket in the succeeding days of rainfall.

Data of soil resistance of particular depth (25, 50, and 100 cm) is daily measured with voltmeter from the installed metal sensors. The data of soil resistance must then be converted with calibration equation in order to calculate the soil moisture content. Regression equation formula of each sensor is constructed, and representing correlation of soil resistance and soil moisture content. Spatial, depth of soil, and time variability of soil mositure in the research area can be determined well. Soil moisture could not be measured by the sensors in coarse or sand soil texture (3,14).

The installed Class A of pan evaporimeter generates daily water evaporation from free surface water. The evaporation rate is daily measured manually by reading the lowered surface water of the pan in the morning and afternoon. The data of daily evaporation from the evaporimeter is then multiplied with conversion factor to get actual evaporation. Evapotranspiration of the research area can be calculated by multiplying the actual evaporation with crop (oil palm) coefficient (k_c) value. Daily and weekly as well as monthly evapotranspiration can be obtained easily.

Automatic water level recorder (AWLR) generates continuous pulse values of streamflow discharge that are represented by depth of surface runoff in the weir flume. These two figures are correlated with correlation equation. Rating curve is generated by measuring directly the depth of surface runoff and the runoff discharge in the same moment for several time of high variability of discharge. Applying rating curve and the correlation equation, runoff discharge in the channels can be computed continuously with 10 minutes interval based on printed data of AWLR.

Data that is generated from those installed instruments is compiled and computed in order to construct hydrology abstractions and finally to determine the water balance or water budget of study area. Based on the water balance, period and duration of water surplus and water deficit or dry spell throughout the year can be identified properly. Finally, package technology of soil and water conservation in dry area of oil palm plantation can be produce properly in order to get maximum production of the oil palm.

REFERENCES

1. ABRAHAM, V. K. 1991. Environmental Requirements for oil palm. Indian Oil Palm Journal 1(2) : 15-19

2. ADIWIGANDA, R., H. H. SIREGAR and E. S. SUTARTA. 1999. Agroclimatic zones for oil palm (*Elaeis guineensis* Jacq.) plantation in Indonesia. *In* Proceedings 1999 PORIM International Palm Oil Congress, "Emerging technologies and opportunities in next millennium". Palm Oil Research Institute of Malaysia, Kuala Lumpur. pp.387-401.

3. ALBERTSON, J. D. and N. MONTALDO. 2003. Temporal dynamics of soil moisture variability: 1. Theoretical basis. Water Resources Research Vol. 39 (10): 1274.

4. doi:10.1029/2002WR001616. http://www.agu.prg/pubs/crossref/2003/2002WR001616.shtml (25/04/2006)

5. BELDRING, S., L. GOTTSCHALK, J. SIEBERT, and L. M. TALLAKSEN. 1999. Distribution of soil moisture and groundwater levels at patch and catchment scales. Agric. Forest Meteorology 98-99 : 305-324.

6. HARTSOCK, N. J., T. G. MUELLER, G. W. THOMAS, R. I. BARNHISEL, K. L. WELLS, and S. A. SHEARER. 2000. Soil electrical conductivity variability. In. P. C. Roberts et al. (ed.) Proc. 5th International Conference on Precision Agriculture. ASA <isc. Publ., ASA, CSSA and SSSA, Madison, WI.

7. http://www.bae.uky.e du/.../Soil_EC_Var/soil_electrical_conductivity_var.htm (24 /04/2006)

8. Hymer, D. C., M. S. Moran, and T. O. Keefer. 1998. Monitoring temporal soil moisture variability with depth using calibrated in-situ sensors. American

Meteorological Soc. Special Symposium on Hydrology, Phoenix, Arizona, January 11-16.

9. http://www.tucson.ars.ag.gov/salsa/archive/publications/ams_preprints/hymer.html (24/04/2006)

10. JACOBS, J. M., B. P. MOHANTY, EN-CHING HSU, and D. MILLER. 2004. Field scale variability, time stability and similarity of soil moisture. Remote Sensing of Environment 92:436-446. Elsevier Inc.

11. http://www.unh.edu/erg/./publications/emex02_field_scale_variability_yacobs.pdf (24/04/2006)

12. JI, S and P. W. UNGER. 2001. Soil Water Accumulation under Different Precipitation, Potential Evaporation, and Straw Mulch Conditions. Soil Sci. Soc. Amer. J. 65 : 442-448

13. MANDAL, U. K., K. S. S. SARMA, U. S. VECTOR, and N. H. RAO. 2002. Profile water balance model under irrigated and rainfed systems. Agron. J. 94 : 1204-1211. Amer. Soc. of Agron.

14. ORLOFF, S., B. HANSON, and D. PUTNAM. 2003. Utilizing soil-moisture monitoring to improve alfalfa and pasture irrigation management. Crop Management doi:10.1094/CM-2003-0120-01-MA.

http:/www.plantmanagementnetwork.org/pub/cm/management/2003/moisture (24/04/2006).

15. SIREGAR, H. H., R. ADIWIGANDA dan Z. POELOENGAN. 1997. Pedoman pewilayahan agroklimat komoditas kelapa sawit. Warta PPKS. Vo. 5(3): 109 – 113.

16. TEULING, A. J. and P. A. TROCH. 2005. Improved understanding of soil moisture variability dynamics. Geophysical Res. Letters. Vol. 32. L05404, doi:10.1029/2004GL021935. http://www.dow.wau.nh/whh/pdf/Teuling2005a.pdf (25/04/2006)

17. TUI, L. C. 2004. Pengurusan air di ladang sawit. http://www.felda.net.my/news/arkib/ 2004/06-2004/17-0604BM.htm

18. UMANA, C. W. and C. M. CHINCHILLE. 1991. Symptomatology associated with water deficit in oil palm. ASD Oil Palm paper. 3:1-4

19. WU, W., R. E. DICKINSON, and M. A. GELLER. 2002. Soil moisture profile variability and its potential impact on climate spectra. http://www.climate.eas.gatech.edu/wwu/soilm.htm (25/04/2006).