EVATRANSPIRATION AND DEEP PERCOLATION LOSSES IN PADDY FIELDS OF TANJUNG KARANG RICE IRRIGATION SCHEME (TAKRIS), MALAYSIA

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ABSTRACT
A study was conducted to determine the evapotranspiration (ETC) and deep percolation losses (DP) of a paddy field using micro-lysimeter in peninsula Malaysia. Realistic estimate of evapotranspiration (ET) is a major factor in agricultural planning and determining crop production potential of a given region. Non-weighing Marriott micro-lysimeter was installed in the field to measure ETC and DP. A constant water level was maintained in the micro-lysimeter with a Marriott tube system and water losses from the manometer were measured. Daily variations of ET and deep percolation (DP) were determined in Peninsula Malaysia for mid (April to August) and rainy (August to February) cropping season. The results of the measured mean ETC for mid-season were between 4.42 mm/day to 6.40 mm/day, while DP losses for the season ranged from 2.0 mm/day to 6.54 mm/day. For the rainy season the mean ETC obtained were between 3.62 mm/day and 6.65 mm/day and the DP for the season obtained ranged from 1.64 mm/day to 4.59 mm/day. The descriptive statistics employed to test the distribution of the ETC data for normality revealed that the data were normally distributed. The skewness and kurtosis values obtained were the conventional acceptable limits. The micro-lysimeter can measure ETC with satisfactory results and can be employed by local farmers and irrigation managers for water resources planning and management.

KEYWORDS: *Micro-lysimter, Evapotranspiration, Mmarriott tube, Deep percolation*

1.0 INTRODUCTION

Water is one of the critical inputs to agriculture. It is not only the vital resource for maintaining all our ecosystems and the survival of all forms of life, but it is also the common vector and essential capital for all types of development whether urban or rural (UNSDSN, 2013). In the present agricultural development, irrigation is the single most important economic activity which provides employment and constitutes a means for livelihood of rural communities. However, most irrigation schemes fall short of the expectations for good water management. This is especially true for water-stressed countries in Africa, the Middle East, Australia, many parts of continental Asia, and island states (Asia-Pacific Peoples' Environmental Network, 1998). Water is expected to be the main issue in the 21stcentury as it becomes increasingly polluted and scarce. It is now the source of quarrels among neighbours, disputes among sovereign states and confrontation among countries (Weng, 2005). The growth of non-agricultural water demand is tending towards exceeding the growth of agricultural water demand in future. This is basically due to fast population growth rates, improvement in living standards, expansion of irrigation schemes and global warming (Vita and Crescimanno, 2009).Effective and efficient irrigation begins with a basic understanding of the relationships among soil, water, and plants. Where improved water management practices are combined with good seeds, increased fertilizer and pesticides, and improved production practices, yields can triple and also provides the mechanism for more effectively managing the environmental impacts of irrigation (Clyma, 1983).

In any irrigation scheme, the amount of water conveyed through network of canals and other related structures is based on crop water requirement of the area. Comprehensive water management and planning is essential for better utilization of this irrigation water. Measurement of evapotranspiration is necessary to understand crop water use and balance between critical users. Evapotranspiration is a controlling factor in both water cycle and energy transport. It plays an important role in agriculture, meteorology and hydrology.

There are several techniques used in determining evapotranspiration. These techniques include water balance, empirical formulae or micro-meteorological approaches (Attarod et al; 2005). Field measurements of evapotranspiration are necessary to provide means of comparison between their results and estimated results obtained from other indirect methods of ET measurement. Direct measurements of evapotranspiration employ the use of lysimeters which are more accurate on paddy fields. Lysimeter is a container that isolates a soil environment from the surrounding soil, but still provides a surface that represents the adjacent land (Chalmers et al; 1992). It measures constantly the changes in soil moisture throughout the growth cycle of crop and gives an estimate of the water demand at different growth stage (Fontenot, 2004). Abdou and Flury (2004) reported that after being exposed to the same environmental conditions, lysimeters are more likely to mimic natural field than columns in the laboratory. They also reported that field experimentation is valuable for comparing water flow and solute transport in lysimeters and field soils. Lysimeters are also used for drainage control, maintaining a controlled soil-water or nutrient environment for precise measurement of their use by crops and mobilization within soil. Two widely used types are weighing and non- weighing lysimeters (Watson and Burnett, 1995). The micro-paddy lysimeter employed in this study is cheaper and has gained more prominence recently. Traditional ET measurements using lysimeter is accurate and easily producible. Lysimetry is widely accepted as being an unparalleled standard against which to compare and validate other ET methods and models. The importance of lysimetry is now also recognized in water rights engineering, with lysimeters used to provide basic data on crop water use (Walter et al;1991). This study was conducted for in-situ measurement evapotranspiration and deep percolation in rice field using non-weighing micro lysimeter under humid tropical condition of Malaysia.

2.0 MATERIALS AND METHODS

2.1 Study Area and Data Collection

The Tanjung Karang rice irrigation scheme (TAKRIS) is a flat plain located on the coastal plain in the Northwest Selangor. The scheme is under Agricultural Development Project (PBLS) and covers an approximate area of 19,000 ha. Stretching a length of 40km long and 5km (Rowshon and Amin, 2010). The Bernam River (source) meanders northwestward and forms the boundaries between Selangor and Perak States. The project area is divided into eight irrigation compartments which are distributed within the three Irrigation Service Areas as reported by Kamal (2010). This study covered the Irrigation Service Area III (ISA III) from which lots in Panchang Badena (PB) and Bagan Tarep (BT) were selected for the experiment.

The micro-lysimeters were installed in the irrigation service area from which some irrigation compartments were selected for field and sampling representation. Each compartment consists of about 100 farm lots and the size of each lot is ab out 1.2 ha. (200 by 60 m) (Mastura et al, 2011).

Irrigation season in the scheme were determined by the irrigation authority. This is to facilitate good water management practices and to promote at least two irrigation activity per year on each compartment. During the study period in 2011 and 2012 irrigation activities were scheduled into Mid-season April to August, 2011, Rainy or Wet-season August 2011 to February, 2012 and Off or Dry-season January to May, 2012

2.2 Micro-lysimeter Components

The micro-lysimeter consists of two parts, the cylindrical lysimeter tank and the marriott system (Fig. 1A). The lysimeter tank is a PVC tank 1.5 cm thick with 20.32 cm internal diameter. It has two side holes each 2 cm in diameter at 51 cm and 55 cm from the base. One of the hole is connected to the marriott tube via rubber tubing to replenish the depleted water due to evaporation and transpiration on paddy field. While the other hole drained excess water due to rainfall or other interference. The marriott tube is made up of 75 cm long, outer and inner glass tubes. The outer glass cylinder is 4.4 cm internal diameter and 1.5 cm thick. It serves as a reservoir to replenish the depleted water from the tank. The inner glass tube is an air compensating tubing 0.82 cm outer diameter. It is inserted into the outer tube and kept in position with the aid of stop cork.

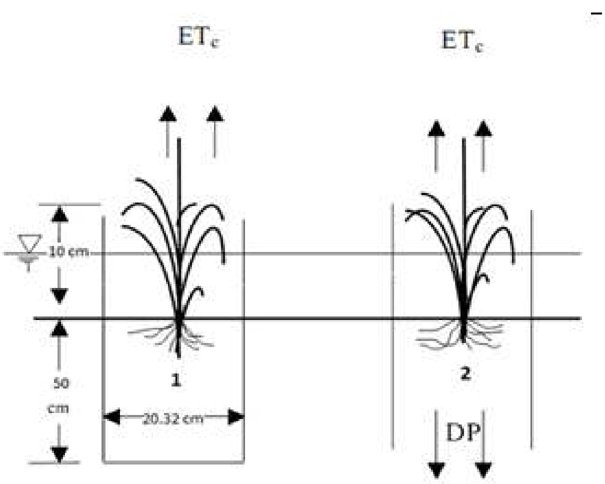

Figure 1A

Figure1B
Source: Abdullahi, 2014

Fig. 1. Cross section of the installed lysimeter and the lysimeter under field condition

2.3 Micro-lysimeter Installation

After site inspection, selection and land preparation on the farm lots two cylindrical micro-lysimeter tanks - opened and closed bottom (60cm x 20.32cm) were installed after excavating the soil to a depth of 50 cm and leaving 10 cm above the ground. The soil column was repacked into the micro-lysimeter immediately after the soil was excavated. The soil in the tank was kept at the same level with the surrounding ground surface. No treatment of either drying or grinding was done. The marriott tube was then connected to the lower opening of the tank via flexible rubber tubing. All connections are made air-tight and leak proof. A stand clamp was used to give a mechanical support to the marriott system.

2.4 Measurement of Rice Evapotranspiration and Deep Percolation using the Micro-lysimeter

A rice hill or rice plant per lysimeter was transplanted into the tank to match the planting pattern in the surrounding paddy environment. The rice variety MR 219 grown under this scheme matures within 80-110 days after transplanting (DAP). All the lysimeters were treated based on farmers' regular irrigation practices throughout the rice growing season (Fig. 1B).

The marriott was gradually adjusted and water level drop in the outer marriott tube was read from graduated tape attached. The component operates in such a way that, when water level drops from the lysimeter tank due to evaporation and/or transpiration in the upper 2 mm diameter hole, the marriott compensate the water lost. Hence, the drop in water level was recorded daily at 17: 00 hr local time. Water lost in 24 hours was obtained from the difference in water level between initial and reset readings. Rice evapotranspiration for closed bottom tank and ET plus DP in opened bottom tank (mm/d) was computed using equation 1. However, deep percolation (DP) was calculated using equation 2.

$$ET_C = \left[\frac{\pi R^2 - \pi R^2}{A}\right] \times \Delta H \quad \text{.................................(1)}$$

where:
R = inner radius of the outer marriott tube (mm),
H = daily change in water column height (mm)
A = effective cross sectional area of the micro-lysimeter tank (mm^2)

$$DP = (ET + DP)_{opened\,tank} - ET_{closed\,tank} \quad \text{.....(2)}$$

3.0 RESULTS AND DISCUSSION

3.1 Rice Crop Evapotranspiration ETc and Deep percolation from Micro-lysimeter

The ET_C measured from the farm lots in Began Terap and Panchang Bedena of the Irrigation scheme are presented in Table 1. The rice ET_C reported varied from 4.42 - 8.5 mm/d and 3.62 - 6.65 mm/d for mid and wet seasons, respectively. Typical ET values of rice in the tropics are 4 – 5 mm/day in the wet season and 6 –7 mm/day in the dry season (De Datta, 1981). An ET rate of 3 – 4 mm/day during initial stage and 5 – 7 mm/day during productive to medium dough stages were reported by (Weerasinghe, 1988). According to Tabbal (2002), for 100-day crop growth duration of a modern short-duration variety, total ET flows are about 400 - 500 mm in the wet season and 600 – 700 mm in the dry season. This is typical for MR219 variety which covers 105 days growth period.

The highest DP observed from April to August was 6.5 mm/day with the lowest value recorded as 2.13 mm/day. However, in the wet/rainy season the DP ranged from 1.30 to 7.32 mm/day. These values are in agreement with the findings of Bouman and Tuong (2001).

Table 1: Mean of rice crop ETc and DP for mid-season April-August 2011 and Rainy season August to February

Period (Days)	Mid-Season						Rainy Season			
	ETC (mm/day)			DP (mm/day)			ETC (mm/day)		DP (mm/day)	
	PB 16513	BT 4517	BT 965	PB 16513	BT 4517	BT 965	BT 4517	PB 16513	BT 4517	PB 16513
10	4.86	4.56	4.6	4.23	3.89	4.37	4.07	3.84	4.32	4.09
20	5.05	4.96	5.23	4.51	3.83	5.32	5.37	4.31	2.62	4.47
30	5.26	5.2	5.7	2.97	2.96	6.25	5.40	5.39	3.19	4.59
40	5.93	6.2	5.99	2.09	3.27	2.94	5.65	5.95	2.63	1.64
50	5.95	6.18	6.40	2.13	2.57	2.44	5.85	6.41	2.93	1.91
60	6.25	5.99	6.21	2.83	2.06	3.24	6.13	6.65	3.66	2.96
70	5.99	5.78	6.26	3.11	2.73	3.52	5.96	6.00	3.59	1.30
80	5.8	5.61	5.52	2.93	3.21	6.54	5.77	5.65	5.64	3.13
90	5.13	4.77	5.12	2.72	5.21	2.47	5.41	4.77	5.55	6.47
100	4.40	4.50	4.42	4.86	4.79	4.03	4.17	3.62	7.32	5.27
Season Total	546.2	537.5	554.5	323.79	345.23	411.2	537.8	525.9	414.5	358.3

PB = Panchang Badena, BT = Baden Terap

3.2 Descriptive Statistics and Normality Test on Rice Crop Etc

Table 2 shows the descriptive statistics of the rice ETc values obtained from the farm lots in the study site. The mean ETc obtained were5.39 mm/day in Bagan Terap (BT) and 5.31 mm/day in Panchang Badena (PB) for rainy season. For mid-season, 5.46and 5.40 mm/day in BT and 5.61 mm/d in PB were obtained. Not much temporal and spatial variations were identified. The values are within the typical results obtained by Tabbal et al, (2002).

Normality test to determine the distribution of ET data in the study area was done as in (Field, 2009). The skewness and kurtosis values of ETc in Table 2 were within the conventional acceptable limit of ±2, indicating that the data were normally distributed. Both values are in the range of 1.07 to (-1.20), 0.80 to (-1.18) and 0.31 to (-0.62) for rainy, mid and off-seasons respectively.

Table 2: Descriptive Statistics of Evapotranspiration (mm/day) Values on Paddy Field for wet and mid seasons

Wet-Season	BT	PB	Mid-season	BT	BT	PB
Farm ID/no	4517	16513	Farm ID/no	4517	965	16513
Mean	5.39	5.31	Mean	5.46	5.4	5.61
Variance	0.85	1.45	Variance	0.63	0.66	0.77
STDEV	0.92	1.2	STDEV	0.79	0.81	0.88
Skewness	-0.49	-0.25	Skewness	-0.45	-0.32	-0.42
Kurtosis	0.15	-0.54	Kurtosis	-1.18	-0.33	-0.6

PB = Panchang Badena, BT = Baden Terap

4.0 Conclusion

Evapotranspiration at the basin, watershed and regional scale plays an important role in planning and managing water resources. There are many methods for estimating ET. Lysimetry is widely accepted as being an unparalleled standard against which other ET models are compared and validated. Besides, it is accurate and easily producible with little skills. Evapotranspiration and deep percolation rates using micro-lysimeter in Panchang Badena and Bagan Tarep paddy fields, Malaysia were determined. ET obtained ranged from 3.62 to 6.65 mm/day, while the DP obtained were between 1.64 to 6.54 mm/day. All the data obtained were normally distributed. The micro-lysimeter employed in this study could be used for an in-situ measurement of ET_C and DP in paddy fields and can be fabricated locally.

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