UNIVERSITI PUTRA MALAYSIA

WATER BALANCE STUDY OF TONLE BATI IRRIGATION PROJECT, CAMBODIA

LENG CHREANG

WATER BALANCE STUDY OF TONLE BATI IRRIGATION PROJECT, CAMBODIA

By

LENG CHREANG

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WATER BALANCE STUDY OF TONLE BATI IRRIGATION PROJECT, CAMBODIA

By

LENG CHREANG

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This study on water balance in the paddy field was done to determine crop evapotranspiration and water use efficiency. The experiment was conducted during the main season for three rice varieties, namely: Phcar Khney, Kung Sor and IR66. All varieties were nursed and transplanted in three adjacent plots. Three plots, 100 square meters each, were prepared in a large paddy field. The transplanting spacing in the experimental plots was 20×20 cm and the number of seedlings per hill was 3. The results obtained on seasonal water requirement for evapotranspiration varied with varieties. They were 680, 771 and 454 mm for Phcar Khney, Kung Sor, and

IR66, respectively. Daily average evapotranspiration was 6.1 mm/day throughout the season for all varieties.

Water use efficiency was calculated by using equation (ETc + S&P)/(IR + RF). The results obtained ranged from 50% to 71%, or an average of 63% for the three plots. For an area, where lateral seepage is negligible, the water use efficiency should be 60% for wet season rice.

The cumulative seepage and percolation were –59, 156 and 232 mm for 1st, 2nd and 3rd plot, respectively. Daily average percolation was about 1mm/day throughout the wet season. Water depth of 368 to 484 mm was recorded as supplementary irrigation water requirement at the early part of the season. Drainage water ranged from 282 to 753 mm based on the difference in duration of rice growing periods.

In addition, pan evaporation and effective rainfall were also recorded and calculated. Daily average evaporation was 4.15 mm/day, and for the effective rainfall it was about 55% throughout the wet season.

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KAJIAN KESEIMBANGAN AIR UNTUK PROJEK PENGAIRAN TONLE BATI, CAMBODIA

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Fakulti : Kejuruteraan

Kajian mengenai keseimbangan air di sawah padi dilakukan bertujuan untuk menentukan evapotranspirasi dan kecekapan penggunaan air pada tanaman. Eksperimen dilakukan pada musim utama penanaman tiga jenis variati padi, iaitu Phcar khney, Kung Sor dan IR66. Semua variati disemai di tapak semaian dan kemudian dipindahkan ke tiga petak bersebelahan. Setiap petak adalah seluas 100 meter persegi. Ketiga-tiga petak ini disediakan dalam sawah padi yang luas. Anak-anak padi ditanam pada jarak 20×20 cm dalam petak eksperimen dan 3 anak padi ditanam pada setiap lubang tanaman. Keputusan bagi keperluan air semusim untuk evapotranspirasi adalah berbeza mengikut variati, iaitu 680 mm bagi Phcar Khney,

771 mm bagi Kung Sor dan 454 mm bagi IR66. Purata evapotransprasi harian adalah 6.1 mm/hari sepanjang musim itu bagi kesemua variati.

Kecekapan penggunaan air dikira dengan menggunakan persamaan (ETc+S&P)/(IR+RF). Keputusan adalah dalam lingkungan 50% ke 70% atau purata sebanyak 63% untuk ketiga-tiga petak. Untuk sesuatu kawasan dengan susupan sisi boleh diabaikan, kecekapan air ialah 60% bagi padi pada musim itu.

Susupan timbunan dan resapan adalah -59, 156 dan 232 mm bagi petak pertama, kedua dan ketiga. Purata resapan harian adalah kira-kira 1mm/hari sepanjang musim tersebut. Kedalaman air yang direkod adalah dalam lingkungan 368 ke 484 mm dengan air tambahan dari julat 282 ke 753 mm berasaskan perbezaan hayat pada tempoh pertumbuhan padi.

Sebagai tambahan, evaporasi pan dan hujan berkesan juga direkod dan dianalisiskan. Purata harian penyejatan adalah 4.15 mm/hari dan hujan berkesan adalah sebanyak 55% sepanjang musim tersebut.

CHAPTER I

INTRODUCTION

General Situation

The Kingdom of Cambodia is located in the Indochina Peninsular with a total area of 181,035 square kilometres. Its population was estimated at about 10.2 million in 1995, with yearly average growth rate of 2.5% to 2.8%. Cambodia is an agricultural country. About 80% of the Cambodian population lives in rural areas and dependent on agriculture particularly rice cultivation, for their livelihood.

Rice is the dominant crop followed by rubber. Most of the cultivated areas are devoted to rice. Rice consumption (milled rice) was estimated at 151.2 kg per person per year (MAFF, 1996-97). Important cash crops are legumes, maize, vegetable, tobacco, sesame, cassava, sugar cane, jute and potatoes.

Cambodia's climate is dominated by the tropical monsoon that provide two different seasons in a year (Wet and Dry season). Wet season (rainy season) starts from April/May and ends in October/November, while Dry season (dry but cool) starts from November/December and recedes in April/May. The average annual rainfall for most irrigated areas is about 1,200mm to 1,600mm. The average annual temperature ranges from 25 °C to 29 °C, while the mean daily temperature varies from 19 °C in January to 35 °C in April.

The water source of Cambodia is mainly supplied by the Mekong/Tonle Sap/Bassac system. Bassac River is a branch of the Mekong River, while Great Lake-Tonle Sap is a Mekong tributary. The mean annual run-off at Phnom Penh is 413×10^{9} m^3. When the discharge of the Mekong at Phnom Penh rises above 15,000 m^3/sec, its flow not only runs to the Great Lake, but also overflows into channels toward the low-lying areas along the Bassac and Mekong. The annual flooding of the Delta and Great Lake-Tonle Sap areas determines to a large extent the agroecological constraints and opportunities. Flooding limits crop production for deeply inundated areas, except for deep water floating rice.

Rice Production and Cropping System

Farmland occupy about 3,800,000 ha or 21% of the total areas, to which 2,700,000 ha are paddy fields. The cultivated areas are mainly located in the lowland around the Tonle Sap Lake and on both sides of the Mekong River in the south of the country. Rice production was estimated at about 3.4 million-ton with an average yield of 1.83 tonnes per hectare in 1996. Up to now, rice production is mainly concentrated during the wet season. However, there are three distinct rice-cropping systems in Cambodia:

1. Wet season cropping
2. Dry season cropping, and
3. Recession cropping.

For wet season, rice is cultivated under rain-fed condition, with supplementary irrigation using water stored in reservoirs or direct abstraction from rivers by gravity and pumping. The potential yield increase due to the supplementary irrigation is considered small (0.5MT/ha) and usually insufficient to justify the provision of irrigation infrastructure (Halcrow, 1995).

During dry season, rice is grown in part of the area where water is available through irrigation system. Usually, only a small part of the rice areas can be irrigated during dry season, because of water shortage. During dry season, rice cultivation without irrigation is impossible. With irrigation, the risk of drought is reduced and, farmers are encouraged to invest in higher yielding varieties, fertilizers and insecticides. Rice yields under irrigation are higher than under the rain-fed condition.

Recession rice is cultivated during the dry season, on the land that is heavily flooded in the wet season. The cultivated areas are close to the Tonle Sap, Bassac, and Mekong system, and rely on natural flooding to water the field before land preparation. The crop is transplanted and irrigation through the growing season is made by using water held in reservoirs or pumped from the main rivers. The yield under this cropping system, indeed, is higher because the low-lying alluvial associated with recession cropping is usually more fertile. Recession rice in reservoir area itself is also carried out in some other locations.

Background of the Study

To improve food security through expansion in the production of rice and other food crops is the basic goal of the Royal Government of Cambodia in the agricultural sector. The Strategic Plans of the Ministry of Agriculture, Forestry and Fisheries of Cambodia in increasing the production of rice are (1) to increase cultivated areas (land reclamation and double cropping), and (2) to raise the yield per unit area.

Increasing the yield per unit of area can be achieved in many ways, but one of the most important in Cambodia is improvement of water control and management. Water control and management in Cambodia involve the following:

1. controlling flood and excess water
2. ensuring adequate water supply
3. making efficient use of a limited supply of water

Water availability is a major constraint at present. This is due either to a limited source or the inability of the infrastructure to abstract, store or convey the required amount of water. In many cases, both constraints occur together (Halcrow, 1994). The farmers are suffering from shortage of irrigation water for cultivating rice even in the wet season, particularly in the beginning of the wet season.

In Cambodia there are many areas suitable for double cropping, if water could be made available. In this case, improving Irrigation facilities (designing, rehabilitation and construction) and efficient ways of using limited amount of water available are crucial factors that will determine the success of the Government's goal of increasing food production.

Water balance study in the paddy field can provide the most important data for improving on-farm water management. Crop water requirement varies within different crops, cultivated area, cropping system and others.

This study hopes to provide some data on crop evapotranspiration, pan evaporation, seepage and percolation, irrigation and drainage requirement, rainfall and effective rainfall, and water use efficiency that can be useful to irrigation management for rice crop production in Cambodia.

Statement of the Problem

Rice is the main crop in Cambodia, but rice cultivation mostly depends on rain-fed condition hence results in low yield and unreliable production. Of the total 841 irrigation systems, 176 (21%) are fully operational, 550 (65%) are partially operational, and 115 (14%) are not operational at all (Halcrow, 1994). These irrigation systems have a total existing area of 172,727 ha in the wet season and 103,656 ha in the dry season. These figures excluded systems with an existing or potential area of less than 10 ha.

In 1992, irrigation can only supplement for wet season rice about 173,000 ha (9.4%) and irrigated dry season rice about 104,000 ha (5.7%). Irrigation and drainage systems are presently not functioning well; especially those constructed during the Pol Pot regime (1975-79) because of the poor design. This situation has shown the need for data in designing and management of irrigation and drainage systems.

Six out of the 10 research stations in Cambodia are working on rice experiment and rice seed production and 7 agricultural development centres provide services for water irrigation and farm-input supplies for rice cultivation. However activities of most of these stations and centers have decreased to a limited areas or not active due to the shortage of funds.

In many cultivated areas, data on crop evapotranspiration and related water management data are not available. Master Plan Study and Feasibility Study on Agricultural and Rural Development Project were conducted in Kandal and Takeo provinces. In this study (JICA, 1995), crop evapotranspiration was estimated by using the meteorological data from Phnom Penh, while crop coefficient was estimated with reference to irrigation and drainage paper "Crop Water Requirement" conducted by FAO. On Prek Thnot Multipurpose Project, Reappraisal report (Euroconsult, 1991), crop evapotranspiration was estimated by using climatic data from Phnom Penh too. This also showed the lack of actual evapotranspiration data in the study area.

Pochentong Meteorological Station (Phnom Penh) is the only station that can provide meteorological data (long term record) for computation of crop evapotranspiration. The lack of data on these aspects is the main problem when it comes to the designing and management of irrigation systems and agricultural development projects in Cambodia.

Objective of the Study

The objective of this study is to carry out a water balance study of a paddy field in Tonle Bati Irrigation Project. The specific objectives are:

1-To determine evapotranspiration of rice crop during the main season,

2-To determine the irrigation requirement of paddy field, and

3-To determine water use efficiency of an irrigated paddy plot.

CHAPTER II

LITERATURE REVIEW

Crop Evapotranspiration

Crop evapotranspiration is one of the important elements of the hydrological cycle process. Crop evapotranspiration is defined as "the depth of water needed to meet the water loss through evapotranspiration of a disease-free crop growing in large field under non-restricting soil conditions, including soil water and fertility and achieving full production potential under the given growing environment" (Doorenbos & Pruitt, 1977).

Crop evapotranspiration is the sum of two processes: (1) evaporation and (2) transpiration. Evaporation is the loss of water in vapour form from the free water surface, while transpiration is the amount of water entering plant's roots and used to build plant tissues and the excess is passed through the leaves of the plant to the atmosphere. Crop evapotranspiration is usually expressed in depth of water per unit of time such as mm/day or mm/month.

Crop evapotranspiration can be measured directly from the field by several methods such as lysimeter, water balance study and soil analysis method. Lysimeter method provides complete information on all components of water balance. But due to the difficulty of obtaining accurate field measurement, prediction method for crop evapotranspiration is used. To predict crop evapotranspiration, reference crop evapotranspiration and crop coefficient are needed for estimation.

Reference crop evapotranspiration is defined as "the rate of evaporation from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water" (Doorenbos & Pruitt, 1977).

The relation between crop evapotranspiration and reference crop evapotranspiration is given as follows:

$$ET_c = K_c \times ET_o \tag{1}$$

where, ET_c = Crop evapotranspiration, mm

ET_o = Reference crop evapotranspiration, mm

K_c = Crop coefficient

Reference crop and actual evapotranspiration vary under different climatic condition. Its value increases with increasing temperature, sunshine, wind speed and less of humidity. Doorenbos & Pruitt (1977) recommended fours methods for estimating reference crop evapotranspiration, including:

-Blaney-Criddle method

-Radiation method

-Penman method, and

-Pan Evaporation method

Meteorological data, including temperature, radiation, wind velocity, sunshine duration, and humidity are needed in computing reference crop evapotranspiration.

Measurement of evapotranspiration of rice crop, in general, can be achieved by using lysimeter, since it grows with standing water. Lysimeter can be divided into two groups: (1) non-weighing lysimeter and (2) weighing lysimeter.

Weighing lysimeter can measure evopotranspiration in short period (hourly) with high accuracy. Unfortunately it is very expensive. For a good installation, the total cost may be very prohibitive.

For non-weighing lysimeter, however, the accuracy is lower. It is a large container filled with soil, in which crops are grown under natural condition. Water loss or gain can be measured. The container is fitted with suitable inlets for irrigation and outlets for drainage. The lysimeter is buried in the field and the same crop, as grown inside, surrounded it.

Rice lysimeters used to measure evapotranspiration, percolation and effective rainfall are tank lysimeter, drum technique, and micro-lysimeter. In 1971 Sugimoto used tanks, 91×91×61cm, to measure evapotranspiration of rice crop in Telok Chengai Padi Experimental Station and Sala Kanan Padi Test Station in Malaysia. Van De Goor and Zijlstra in 1977 also used two square tanks with bottom, 91×91×91cm, to measure evapotranspiration of rice crop in lowland rice of Malaysia.

Dastane *et al* (1966) used 3 drums for assessing evapotranspiration, percolation, water requirement and ineffective rainfall of rice crop. The drum was 50 cm in diameter and 125 cm in height (Figure 2). It was embedded in paddy field leaving about a quarter of its height above ground level. Dastane (1974) suggested that the drum technique gave promising results. The method requires replications to give accurate data. This is an inexpensive method.

Ramlee (1991) used micro-lysimeter, with PVC tubes of 20cm diameter and 60 cm height, to measure evapotranspiration and percolation in the paddy field of Project Bersepadu Seberang Perak in Malaysia.

However, rice is generally grown with standing water, hence evapotranspiration is never restricted by the lack of soil moisture, and it will always be at the maximum possible under the climatic condition i.e. potential evapotranspiration.

Evapotranspiration, however, is fairly constant throughout the growing period, except for the minor variation due to the influence of cloudiness, humidity, and wind. Shortly after transplanting, evapotranspiration is mainly evaporation, but as the crop develops, the share of transpiration increases and evaporation decreases, until evapotranspiration is mostly transpiration when the crop is vegetatively developed (Van De Goor, 1977).

For lowland rice, daily evapotranspiration rate vary with a narrow range from 6 mm to 8 mm per day during the whole growing season, irrespective of