STUDY ON WATER BALANCE OF IRRIGATED T. *AMAN* RICE

A THESIS

BY

A.S.M. ALANUZZAMAN KURISHI

Student NO. :0405004

Session: 2004-05

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MASTER OF SCIENCE (M.S.)

IN

AGRONOMY

DEPARTMENT OF AGRONOMY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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TO

MY BELOVED PARENTS

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The Author

ABSTRACT

The study was conducted at the experimental farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur, with a view to study on water balance of irrigated T. *Aman* rice. The water balance study was conducted in the T. *Aman* season of 2004.The experiment comprised two treatments viz. continuous standing water (1-7cm) and irrigation (5-7cm) after 3 days of disappearing of standing water. The field experiments showed that in T. *Aman* season 7% of the total supplied water (including rainfall) was required for land preparation, 30% was used for evapoptranspiration (ET), 45% was lost as seepage and percolation and the rest 18% was lost as surface runoff due to heavy rainfall and other unaccounted losses. Therefore, from this study it can be concluded that on an average only 30% of the supplied water in irrigated rice field is used as evapotranspiration and the rest 70% is lost by different processes. The irrigation treatment, irrigation after 3 days of disappearing of standing water is not applicable in T. *Aman* season due to rainfall. Therefore, water saving techniques like shallow application of water, if adopted properly may lead to efficient utilization of water through minimizing excessive losses of seepage and percolation.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the main food crop of Bangladesh. It is the staple food for her people and will continue to remain so in the future. It grows in all crop growing seasons of the year and occupies about 77% (10.71 Mha) of total cropped area. At present, rice alone constitutes about 92% of the total food grains produced annually in the country. It provides about 75% of the calorie and 55% of the protein in the average daily diet of the people (Bhuiyan *et al.*, 2002). It also ensures political stability for the country and provides a sense of food security to the people. But the average yield of rice of Bangladesh is quite lower compared to that of other leading rice producing countries of the world, such as Japan, China, Korean Republic and U.S.A where t/ha yield is 6.22, 6.06,7.00 and 6.35 tons, respectively (FAO, 1999).

Rice can grow sandy loam to clay loam type soil. But clay or clay loam type soil is better. Optimum soil pH range is 5.5 to 6.5. Most of the rice varieties are grown in tropical and subtropical regions. But the yield of rice is high in temperate region. Rice grown well on warm and humid weather. For optimum growth and development, it needs 25^0 to 35^0 c temperatures in growing period, 70% to 80% relative humidity is better and well distributed rainfall is also needed (1000-1500mm).

In Bangladesh, rice is by far the largest irrigation user, with over 82% of the total irrigated area. All modern variety (MV) *boro* is irrigated, whereas only a small proportion of the *aus* and *aman* crops (7% and 5% respectively) receive either full or supplemental irrigation. MV *boro* cropping has been the driving force behind minor irrigation expansion. Wheat, potatoes and vegetables are the other main irrigation users, with over 40%, 80% and 40% respectively of their total areas under irrigation. Wheat is the largest user of irrigation after rice, with about 9% of the total irrigated area. The *boro* crop area in 1999-2000 reached to about 3.361 Mha which is nearly of the area irrigated during *rabi* season (NMIDP, 2001) The irrigated single crop *boro* could reach about 4 Mha (WARPO, 2000).

The demand for rice will be increasing in future in the country because of increasing population size. The projected population is about 169 millions by the year 2025 (Bhuiyan *et al.*, 2002) This needs to produce about 27.8 million metric tons (Mmt) of clean rice (41Mmt paddy) to feed the population by the year 2025, which is about 21% higher than the production level of 2000. This increasing demand have to be met from our limited and shrinking land resources. Targeting high yield by providing irrigation facility with a higher cropping intensity is the most logical way of raising the total production at the national level. But the scope for increasing cropping intensity in future seems low since it has already reached at about 185%. So the most important way is to bring more rain fed land under irrigation facility for growing modern varieties. Therefore, strategies have to be developed for sustaining the production to match the demand with the limited land and water resources of Bangladesh.

Irrigation water is a critical factor for crop production in Bangladesh. It is the only factor which can make a crop either success or failure. Although the monsoonal climate, with its high humidity and temperature, is favorable for rice cultivation in Bangladesh but the rainfall is not evenly distributed throughout the year. It is often said that the major problems of agriculture in Bangladesh are excess water and drought. About 96% of the total rainfall occurs during the month of April to October, leaving the remaining five months of the year essentially dry. Drought conditions prevail over most of Bangladesh during the months from November to April, when potential evapotranspiration far exceeds rainfall (Manalo, 1996). A rice crop cannot be sustained during this period from rainfall alone. Due to very limited availability of rain water during dry season (November-April) the *boro* rice is fully dependent on irrigation. Therefore, the expanding demand for food grains in the country will most likely be met from expansion of irrigated area with the available water resources.

Irrigation water is scarce and a costly resource. The cost of irrigation water is increasing day by day as the demand for irrigation is increasing. As a result, now a day, one drop of water is being considered as a valuable national resource. Therefore attempt should be made to utilize this costly water with minimum waste.

Recently, much concern is being expressed about the need for improving the performance of the existing irrigation systems as most of the irrigation projects in Bangladesh are performing much below their potential levels. Planners, administrators and to some extent existing donor agencies seem to be shifting their attention from building new irrigation systems to the need for improving the performance of the existing ones. For realizing such a goal, there is a need to develop methodologies, which irrigation managers can practically implement to upgrade the systems performance and farmers can achieve higher benefits from the use of irrigation water.

Current rice production methods take large amount of water. Research indications are that a fair amount of the total water used is linked to the prevailing customs and practices in handling water in the production system, which can be drastically reduced without affecting rice yields. Most analyses indicate that a major crisis in water availability for agricultural production is likely in the near future in Bangladesh. Such a development would undoubtedly lead to serious rice shortfall. Expansion of irrigated areas using safe sources of water as well as significant improvements in the productivity of water in rice culture is needed to avoid the impending crisis. To avoid the above problems, new information and innovations in managing water for agriculture are needed.

In irrigation projects of Bangladesh, enough water is not available to irrigate the entire project area for rice cultivation under a continuous ponding condition. So, rice should be cultivated adopting techniques other than continuous ponding method of water application, which will allow water saving to a large extent. Developments of irrigation strategies that allow rice cultivation with less water are vitally important to achieve the benefits of irrigation water in large areas. Therefore, water balance of irrigated rice fields has become a crucial factor now a day for optimum utilization of the scarce water resources. There are some literatures available on water balance of wet land rice cultivation reflecting the wide rang of physical and cultural conditions under which rice is grown (Walker, 1994). But major components of the water balance equation are still the cause of considerable uncertainty in the calculation of water requirements, which require further attention particularly conveyance losses and field losses. Many observers have reported high water losses from flooded rice fields but there have been few attempts to explain the losses. Some losses are going unobserved and unrecorded. Therefore, detailed field studies by measuring and recording all losses from the rice field are urgently needed. From all these considerations, the present research work was undertaken to study the water balance of irrigated T. *Aman* rice with the following objectives:

1. To make water balance of irrigated T. *Aman* rice.

2. To increase the water use efficiency and water productivity by supplying adequate amount of irrigation water with a view to achieve potential irrigated area.

CHAPTER II

REVIEW OF LITERATURE

Research work on development of irrigation strategies of rice fields has been done by the researchers throughout the world to achieve the benefits of irrigation water in large areas. Water balance study plays an important role on irrigation strategies of rice fields. Relevant reviews have been presented and discussed in this chapter.

2.1 Water Management

Water management and irrigation are the very important inputs for sustainable and productive agricultural development (Rahman and Azad,1992). Management is a very comprehensive way has been defined as the process and activity of carrying out the task so that a number of diverse activities are performed in such a way that a defined objective is achieved by the combined effort of a group of people (French and Saward, 1975). In agricultural development work, peoples from different disciplines with different backgrounds and interests work together for a defined objectives that is increased production. Very often water (mostly ground water) plays a decisive role in crop production; therefore, improved management of irrigation water is essential for effective implementation of agricultural development programs. Water management for irrigation is the task of proper utilization of the resource based on its availability and quality to increase production without creating any adverse effects.

Khair *et al.* (1980) found that irrigation in sum provides the stage on which all other yield increasing inputs perform their roles. Rahman *et al.* (1996) observed that like HYV seeds, fertilizer, insect-pest and disease control, timely intercultural operation, irrigation is also an important component of improve package technologies proper application of which can be possible to make the crop production double. Lourduraj and Bayan (1999) showed that continuous land submergence is not essential for optimum rice yields.

Ganesh (2000) conducted a field experiment in karnataka, India, and found that the total water consumption which included rainfall and irrigation water used for land preparation, nursery raising and imposing the treatments did not vary much among the irrigation schedules. The result suggest under medium water table situations, the time intervals in the irrigation schedules were not long enough to produce considerable variations in grain and straw yields and total water consumption.

Mawla (2002) found that increased in crop production and sustainable agriculture development depend on the efficient utilization of water. Its temporal variation and partial occurrence are the major constrains to adequate water utilization for maximizing contributions to the national economy.

Abundance of water during monsoon and its scarcity during Boro seasons severely limit agricultural production. Therefore, proper utilization and efficient management of water resources particularly through irrigation is considered as one of the most crucial elements for increasing rice area under cultivation and improving long term productivity and employment irrigation is considered as the leading input for enhancing agricultural production.

2.2 Water Requirement in Rice Fields

2.2.1 Rainfall and Effective Rainfall

Rainfall contributes a significant portion of water requirement in most of the irrigation project in Asia, especially during the monsoon. But rainfall is unpredictable and sometimes uncontrollable at the field levlel beyond certain amount in a day or week. Often excess rainfall drains out the command area of the irrigation system. Rainfall can be more beneficially utilized if storage or pump operation system can adjust irrigation deliveries for maximum use of the rainfall. In field condition effectiveness of rainfall is more important than total amount of rainfall for a day, week, month and season.

Dastane(1974) suggested determination if effective rainfall by a semi empirical method, which is also known as water use-rainfall ratio method. In this method effective rainfall is computed as ratio of potential evapotranspiration plus seepage and percolation to the total rainfall for a certain group of days during the growing period and is expressed in percentage. The number of days in a group is based on soil types, soil moisture properties and weather conditions. Dastane used this approach and computed effective rainfall in some projects in India.

Bhuiyan(1981) used effective rainfall as a component in determining irrigation requirement in measuring irrigation system performance. He mentioned that the specific problem in measuring effective rainfall is that rainfall effectiveness depends not only on duration, intensity and distribution of rainfall but also on water management practice of the farmers. Therefore, for a given rainfall its effectiveness may vary among the fields in the system. So the best method of determining the effective rainfall is to calculate the value based on the field water status and rainfall. To obtain a good representative value of effective rainfall a large number of fields should be monitored but that requires substantial time and resources. Bhuyan concluded that among the various methods, the water use-rainfall ratio method is less expensive and easy to use but gives reasonable results for some rainfall patterns. The limitations of this method are: (1)it does not consider the farmers field management practice as a variable in estimating effective rainfall and (2) it does not consider relative magnitude of rainfall for the group periods in computing the weekly, monthly or seasonal average effective rainfall values. He suggested that the weighted average would be a better representative value over simple average in computing weekly, monthly and seasonal effective rainfall.

Lourduraj and Bayan (1999) showed that rainfall is one of the most important components of water requirement of rice and the estimated values of water requirement vary with rainfall. Cabangon *et al.*(2001) found that the alternate wetting and drying reduces irrigation water compared to continuous flooding. The differences were statistically significantly only in 2000 where rainfall was low and evaporation demand was high. So, it is clear that rainfall is an important component for measurement of irrigation requirement of a crop.

2.2.2 Evapotranspiration

Evapotranspiration is the combined effect of evaporation from the surface of the land and transpoiration and evaporation of water from the leaves of plants (Wickham, 1971). Potential evapotranspiration which is also called reference crop ET is defined as the amount of water vaporized by a short green crop which is of uniform height, is never short of water and which covers the ground completely (Papadakos, 1965). Potential ET has come to mean the maximum possible ET for a wide range of crops and is therefore a climatic factor (Wickham, 1971).

There are many methods available to estimate ET. The selection of a method depends on the objectives of the study and availability of data and resources. According to Hill *et al.* (1983) "there appear to be as many as 50 methods of variations advanced for the theoretical estimation of ET". They also reported "there are always questions as to which method, if any is correct". So field data is essential for determination of actual ET.

Rahman (1980) regarded that potential ET as a standard measure of ET in which soil water availability is not limiting and plant resistances to the evaporation process are minimum. He reported that evaporation from a class A evaporation pan provides a satisfactory means of estimating ET of rice under flooded conditions.

Yoshida (1981) carried out studies at IRRI support that the ET of flooded rice is equal to potential ET and potential ET correlate with class A pan evaporation rate. However, he mentioned about a multiplication factor of 0.93 to convert pan evaporation to potential ET.

Karim and Akhand (1982) estimated evapotranspiration of rice for different seasons using ten years data of different locations of Bangladesh. They used modified penman method for the calculation of evapotranspiration. They found that mean Et of boro rice was 48.5 mm and that for T. aman rice was 534.4m for growing season.

Sevendsen (1983) reviewed that ET and pan evaporation ratios and strongly supported the relationship between a properly situated classes A pan and the ET of continuously flooded rice, that is only marginally different from unity. He stated that the real question is not whether ET increases, but whether the ratio of ET to evaporation increases with plant growth.

In Bangladesh, the actual ET is not measured and such data are not commonly found in literature. Therefore, the two basic information (ET and S &P), needed for proper planning of irrigation project are not available. In absence of those information most of the irrigation projects in Bangladesh are designed by predicting or assuming those values. As a result, the projects are either over designed or under designed resulting low performance of the system. The prediction equation applied under climatic and agronomic conditions are very different from view set of conditions is not tested as the accurate field data are not available. Saleh and Fatema (1988) tested three commonly used methods of predicting evapotranspiration (ET), namely, modified Penman, Blaney-Criddle and Radiation methods for their accuracy in predicting the actual rice ET using long term weather data of ten stations in Bangladesh. They could not find any literature on measured ET of rice in Bangladesh situation. In absence of reasonable actual ET of rice data; the actual ET was estimated from pan evaporation, which was found, to range from 3.59-4.68mm/day during dry season and 3.05-4.54mm/day in wet season. The accuracy of predictions was evaluated by calculating the coefficient of efficiency. The results showed that the Modified Penman method best predicted the actual ET of rice, followed by Radiation and Blaney-Criddle methods

Walker (1994) conducted studies in Indonesia on water requirement of rice, found that the mean daily evapotranspiration rate as measured by the closed lysimeters was 5.7mm/day and the evapotranspiration plus the vertical percolation from the open lysimeters was 7.3mm/day, giving a mean vertical percolation rate of 1.6mm/day.

Renaud *et al.* (2000) conducted a study on Estimation of seasonal rice evapotranspiration. Results indicated that among four methods, relatively simple Cahoon method is appropriate to estimate ETc, While the TDR method with some modifications could also prove a valuable tool during the non-flooded periods.

Tyagi *et al.* (2000) conducted lysimeter experiments on rice during rainy season and sunflower during the summer season. They found tat the average weekly ET of rice varied from <3mm per day in the early growing period to >6.6 mm per day at milking stage. They also found that the peak ETc was 6.61 mm per day and it occurred 11 weeks after transplanting at reproductive stage when LAI was 3.4.

Bethune *et al.* (2001) conducted a field trial on a rice farm from two different sites near Echuca in Australia for calculating rice evapotranspiration. They found that total ET, measured in the sealed lysimeteres, was greater by 73+41 mm at site A than site B, even though cumulative reference crop ET for both sites was similar.

Dembele *et al.* (2001) measured the water requirements of upland rice with lysimeters in the south western region of Burkina Faso. The cultivar used was IRAT 144 (100day maturing cycle), which was a short cycle cultivar, adapted to the region and considered suitable. The average maximum evapotranspiration (MET) was 542mm. The global crop coefficient and pan factor values calibrated in situ using the rice MET to the pan evaporation (EV) ration, were 1.04 and 1.16, respectively.

Rao *et al.* (2002) conducted a study on water requirements of rice crop at some south Indian stations. They tabulated monthly values of crop evapotranspiration for rice at the selected stations. These values denoted the monthly water requirements for the healthy growth of the crop. They found that in most of the stations the water requirement was the highest in April and lowest during November and December

Shigandhupe and Sethi (2004) conducted an experiment at Central Rice Research Institute, Cuttack, Orissa, India, found that the contribution on ETO Blaney Criddle and Modified Penman method was higher than Hargreave method (r2=0.62 and 0.57). But the climatic variables for estimating of ETO needs larger parameter as well as the sensitivity of these methods are higher as it is measured through RMSE (root mean square error) (2.65 and 2.28 mm/day) compared to Hargreave method (0.87mm/day) considering FAO-56 PM as standard method.

Lee *et al.* (2004) found that the evapotraspiration estimated by all methods shows the same trend throughout the year. Samani-Hargreaves gives the highest estimates followed by the Priestley-tayor and Hargreaves methods. The lowest estimates were by Penman-monteith and followed by the Blaney-Criddle and pan methods. The Penman-monteith, Blaney-Criddly and pan methods estimate lower values of evapotranspiration with no significant difference among them (P=0.05). All the methods are significantly different from these three methods.

Tripathi (2004) conducted an experiment in pantnagar, Uttaranchal, India to determine the lysimetric measurement of water table contribution and evapotranspiration to gather with crop coefficients for rice (CV. Pant 4), Wheat (CV. RR21), Chickpea (CV. PG115), Pea (CV. Rachna) and Lentil (CV. PL 406) under shallow water conditions. The average evapotranspiration of rice grown on medium to fine textured soils less than 50+or-25mm submergence was 668mm. A high evapotranspiration of rice was associated with high yield and percolation in the soil.

From the above reviews, it is clear that the prediction of ET rate by different methods and equations is controversial and conflicting. There are always questions as to which method, if any, correct. Therefore, accurate field data is essential for determination of correct ET.

2.2.3 Seepage and percolation:

Percolation is the downward movement of water through the soil. Its tendency is to reach the water table. On the other hand seepage is the lateral movement of water through the soil. In most cases, a clear differentiation is not possible between these two components and therefore, they are considered together (Wick-ham and Singh, 1978). Seepage and percolation (S & P) remain the most elusive component of water balance and are difficult dry and wet seasons for the same site have been reported by Wick ham and Singh (1978). Therefore, investigations on the nature and magnitude of S &P and development of methodology for its economic control are necessary to reduce irrigation requirements for rice and for saving operation cost of irrigation projects.

Dampen (1970) observed in Central Luzon, Philippines that S &P increased with decrease in clay content of the soils. Similar observation has been reported by Giron and Wickham (1976) and also Wickham and Tadase (1976) found that where S & P rates were 6 mm/day for clay loom soils and that for sandy loom soils were 13mm/day.

Qurban (1974) found that water holding capacity of soil increases in the ploughed layer (top 15 cm) but decreases in the deeper layer. Pande (1975) and Rashid (1976) reported that puddling decreased hydraulic conductivity.

Bhuiyan (1982) reported that seepage-percolation (S & P) are site specific and depend on soil texture, water table, depth,k proximity to drainage outlet and farmers field water management status. Ghani (1978) reported that in addition to the above factors seepage-percolation at the field level are also affected by puddling and standing water depth status of the rice fields and the crop growth stages.

The principal loss of irrigation water is cause by lateral percolation, the movement of water from the flooded fields laterally into the bunds and hence vertically down to the water table.

Walker and Rushton (1986) concluded that the loss due to vertical flow through the low permeability plough layer and hard pan is about 2mm/day and the losses through the bunds may be 8-23mm/day or sometimes higher in irrigated rice field. Normally there is no puddle layer beneath the bund, this means that water can pass from the rice field through the bund into the underlying aquifer. However, it still seems surprising that all the unexplained water can pass through and bund with a width, which is typically 1% of the width of the rice field.

The above study was conducted on a terrace land in Indonesia, which is completely different from Bangladesh situation. So the study may not be applicable in Bangladesh condition. Moreover the study was carried in continuous ponding situation which is also not desired in this country during the main irrigation season (dry season).

Walker and Rushton (1986) mentioned that field efficiencies for irrigated rice crops are often low. Field studies on seven sites in Indonesia showed that the rice crop used only about one third of all water delivered to the fields. Under continuous flow field water use efficiency was found to be 25-30%. Ghani *et al.* (1990) reported that field level water use efficiency varied from 36 to 69% in Aus season in a large scale irrigation project. These low efficiencies are due to excessive losses of water from rice fields as seepage and percolation. The International Rice Research Institute (IRRI, 2000) reported that the overall irrigation efficiency of the selected irrigation systems in major rice growing countries ranged from 30 to 65% and the water productivity ranged from 0.34-0.68kg of rice per m^3 of water.

Seasonal studies were conducted in selected locations of G.K. project to determine the S & P rate and was found that the average (S & P) rate was 8.6 mm/day for clay loam soil (Ghani 1987).

The above study was conducted in the G.K. project, which is a large-scale gravity flow irrigation project, where uniform distribution of irrigation water over the whole project area is quite impossible. The tail end farmers suffer very often due to shortage of water. On the other hand, the up-reach farmers use more water than the actual crop demand. Therefore most of the service area receives periodic standing water i.e. alternate wet and dry condition. As a result, the (S & P) rate varies widely from 2-20mm/day. So the S & P rate of 8.6mm/day obtained by Ghani (1987). So the question still remains, what is the actual (S & P) rate in G.K. area.

Ritu and Mondal (2002) conducted studies on the effect of various standing water depths on seepage and percolation (S & P) rate from the rice fields and observed that S & P increases with the increase of water depth in rice field. The depth of irrigation water varied from 2.5cm to 12.0cm with and increment of 0.5cm and the S & P rate varied from 5mm/day to 17.5 mm/day.

Jecheon *et al.* (2001) conducted an experiment and found that soil water percolation in the first year was 2141litres/m^2 in clay loam, 1228 litres/ m^2 sanly loam and 862 litres/m^2 in clay soil. During the second year, the highest water percolation of 4448 litres/m^2 was measured in sandy loam. Distribution ratio of rice roots measured in 0-10cm of soil depth was 56% in sandy loam, 61.4% in clay loam and 72.1% in day soil respectively. It is concluded that the soil water percolation in rice paddy soil was affected greatly not only by soil texture but also the growth of rice root.

Bethune *et al.* (2001) found that half of the measured deep percolation occurred within the first 24 hours of ponding. Shinkai *et al.* (2002) found that breaking the hard pan of the soil enhances the infiltration rate but also increases the seepage ratio.

Momoki *et al.* (2002) conducted a study in rice paddy area in the middle reaches of Chicago River in Japan and found that during rainy season, conditions became saturated and percolation value become smaller since the ground water level inscrease.

Kukal (2002) conducted a study on a sandy soil and found that average percolation rate decreased to the extent of 54-58 percent with medium puddling but it did not increase any further significantly with high puddling. Puddling depth had no effect on percolation rate of soils.

Rakshit *et al.* (2002) conducted an experiment on sandy loam soil of kharagpur, West Bengal, India and found that the percolation rate in conventional puddled soil was 1.27mm h^{-1} as compared to power tiller (0.29mm h^{-1})

Kukal and Aggarwal (2003) found that percolation losses decreased by 14-16% with the increase in puddling intensity from medium to high, where as the amount of irrigation water required decreased by 10-25% . Puddling depth did not affect percolation losses or the amount of irrigation water applied.

Kukal and Sidhu (2004) conducted an experiment at Panjab Agricultural University, Ludhiana, India and found that during an irrigation cycle, the percolation rate of soils decreased with the time (days 1-4 after irrigation).

Tripathi (2004) conducted an experiment in Pantnagar, Uttaranchal, India and found that high evapotranspiration of rice was associated with high yield and percolation in the soil. Percolation was initially 6 times higher than evapotranspiration but declined below evapotranspiration after the fifth week from transplanting.

In the past, a limited number of studies were conducted in this country on seepage and percolation losses from rice fields but no such studies are found in Barind situation, the S & P rate is site specific and depends on many factors. So the S & P rate in rice fields of Barind area is still not known. As a result, the actual demand of water for rice in not determined. So field measurements are needed on S & P losses from rice fields of the Barind area.

2.2.4 Land preparation period:

Land preparation for lowland rice involves land soaking to saturate and soften the soil, ploughing and harrowing to bring is to a puddle condition. The purpose of this thorough land predation is to (a) provide weed free, level and soft soil surface for transplanting, (b) incorporate organic matters like weed, rice straw, organic and inorganic manures, (c) level land for better water management; and (d) formation of puddle layer for minimizing S & P.

Water requirement for land preparation comprises a significant part of total water requirement for rice cultivation. Kampen (1970) summarized experimental results of water requirements for land preparation in different rice growing countries, such as Sri Lanka (330 mm), India (230-390mm), Japan (130mm) Malaysia (176-225mm), Surinam (420mm), Taiwan (120-210mm), Thailand (300-400mm) and Southeast Asia as a region (220-240mm).

Wickham and Sen (1978) have suggested that the land preparation requirement can be reduced by shortening the duration of land preparation period.

Studies in the Ganges-Kobadak project (BRRI, 1985) in Bangladesh indicated that under researchers management conditions the average water requirement for land preparation during *Aus* and *Aman* seasons were 237 and 261mm, respectively which were less than 20% of total water requirement for the growing season. Similar studies in the following year in the same area resulted to a land preparation requirement of 284m and 215mm during *Aus* and *Aman* seasons, respectively (BRRI, 1986).

Usual water management practices during land preparation are: (a) flooding the field for certain number of days before plowing (2 to 7 days, depending on hardness of the field); and (b) keep the field flooded to about 1cm of water from initiation of plowing to transplanting in order to prevent soil from drying and hardening. However, some people practice dry plowing of field immediately after harvesting of previous crop and flood the field two to three days before final preparation of land, which includes pudding. Transplantation of rice seedlings is done 2 to 3 days after final land preparation, usually on saturated soil, or soil with a thin depth of water. Dry plowing may require less water for land preparation than the traditional way (Ghani, 1987).

Cabangon and Tuong (2000) found that higher water loss during land preparation of soils for rice *(Oryza sativa)* production results from by pass flow through cracks. Shallow tillage formed small soil aggregates which made the crack water flow discontinuous and impeded ground water recharge from the water flow through cracks reduced total water input for land preparation by 31-34% equivalent to 120 mm of water. The average surface irrigation water flow advanced faster and less time was needed for land preparation in the shallow tillage plots compared to the control. Shallow tillage offers a practical means for improving water use efficiency of irrigation systems.

Singh *et al.* (2001) conducted an experiment on rice crop during summer season (June) in India and found that during land preparation puddling depth was significantly influenced by the puddling intensity but not by the prepuddling tillage. On the other hand, further increase in puddling intensity did not significantly increase puddling depth.

Mohanty *et al.* (2004) conducted an experiment in central India and found that higher intensity of puddling favored more soil wetness at harvest, as the puddled soil maintained 25% more water than no puddling soil.

2.2.5 Growing period

Chow (1965) summarized findings of number of studies conducted to compare rice yields under continuous and intermittent flooding. Studies conducted in Taiwan indicated no yield reduction of water in paddy fields in delivered intermittently, but 20 to 50% water savings can be achieved by adopting intermittent flooding method compared with the continuously flooded fields. De Data *et al.* (1973) found that continuously saturated plots produced similar grain yields to continuously flooded plots. However, submergence has other advantages such as higher efficiency of fertilizer and better control of weeds insects.

Doorenbos and Kassam (1979) indicated that maintaining moderate submergence during critical periods and keeping soil water at 75% or more of saturation in the foot depth during rest of the growing period can save water up to 50 percent.

From the above studies it cannot be estimated that how much water was needed for optimum growth of the crop. So it is not clear whether the supplied amount of water was adequate, surplus or deficit for the crop. The soil type was also not mentioned, which is the main factor for variation of water requirement for growing rice.

Mowla *et al.* (1992) carried out experiments in the Ganges Kobadak (G.K.) irrigation project area to determine the amount of water required for rice cultivation in wet season. They supplied water on rotational basis and the depth of water in each irrigation was 5-7 cm. They found that water needed for land preparation and growth period were 241mm and 1453mm, respectively including 783mm of rainfall during the growth period. They also mentioned that farmers used more water than that in the research management plots.

The approach of Mowla *et al.* (1992) was to determine the amount of water required for wet season rice and found that 1453 mm of water was required, of which more than 50% was rainfall. They did not calculate the effective rainfall, but in T. *Aman* season calculation of effective rainfall is very important because a substantial amount of water is lost through direct runoff due to heavy rainfall and is not available for the crop. That is why they reported 1453 mm of water is in the high side than the actual demand. Moreover as the water was supplied on rotational basis, there was not always stranding water in the plot, which may create major cracks in clay soils if the dry period is longer. So it is likely to happen major losses of water through these cracks, which resulted in high water requirement. The soil type was also not mentioned. So the true water requirement during the crop-growing period is not known.

The above studies led to conclude that there is wide variation in water requirement in continuous flooding and alternate wetting and flooding method of rice cultivation. It is site specific and varies from season to season. So the actual amount of water needed for optimum crop yield in Barind area is still not known.

Sarangi and Lenka (2000) conducted an experiment at Bhubaneswar, Orissa, India and found that the mean water use efficiency was 44.15 kg grain/ha/cm water. Water use efficiency was highest (49.9kg grain/ha/cm) under continuous saturated and lowest (38.03kg grain/ha/cm) where 3-5cm standing water was maintained throughout the growth period.

Keun *et al.* (2001) found that evapotranspiration increased during the growing stage but infiltration at the different growing stages did not vary. The ground water transition into the area was predominant during the early part of growing stage, while discharge of ground water from the study area was apparent at the late growing stage.

CHAPTER III

MATERIALS AND METHODS

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5.4.07

The research work was conducted at the Agronomy Field Laboratory, Hajee Mohammad Danesh Science and Technology University during the period from July to November 2004 to study on water balance of irrigated rice fields.

3.1 Description of the Study Sites

3.1.1 Location

A field experiment was conducted to measure crop water requirements and field losses. The principal losses of irrigation water from rice fields are evapotanspiration (ET), seepage and percolation (S & P). The tests were carried out at Agronomy field Laboratory, Hajee Mohammad Danesh Science and Technology University under Dinajpur District. Rice is predominantly grown in this area. The study area lies at 25°36′ north latitude and 88°40′ east longitude. The area was under the AEZ No. 1(Old Himalayan piedmont plain). Here the surface water potential is seasonal and very limited and consequently the area is drought prone.

3.1.2 Soil

Soil of the experimental field was more or less neutral with a pH value 6.5, low in organic matter and fertility level. The soil of the site is less permeable. The land type was medium high with silty loam texture.

3.1.3 Climate

The climate of the experimental location was subtropical. During the experimental period (July-December), the maximum rainfall was in October and temperature was in July and low rainfall during the rest period and minimum temperature was in November. Meteorological data of Hajee Mohammad Danesh Science and Technology University Campus, Dinajpur during the study period are presented in Appendix I.

3.2 Test crop and its characteristics

BRRI Dhan34 was used as the test crop for the experiment. This variety was developed at the Bangladesh Rice Research Institute (BRRI) from the BRRI Gene Bank collected from Jessore region (Accession No. 4341) by the procedure of selection. It was released by NSB for cultivation as transplant *aman* crop in Bangladesh. Average plant height of the variety is 115cm at ripening stage. The grains are small and it has a good smell. It is light sensitive plant (BRRI, 1997).

3.3 Estimation of Water Requirements

3.3.1 The water balance equation

Some attempts have been made to reduce the complexities of the water balance to a simple equation including all relevant components. The simple equation use to estimate the water requirements for growing a rice crop is given by: (after Walker, 1994)

$Q = W+R+C+E+F$

Where, Q= Total water requirements

W= Wetting up and land preparation

R= Surface runoff

C= Conveyance losses

E= Evapotranspiration from water and plants

F= Seepage and percolation

This version of the equation assumes for simplicity that there is no net subsurface in flow or outflow and disregards any effects due to the underlying water table.

3.3.2 Components of the Water Balance Equation

3.3.2.1 Wetting up and land preparation

Land preparation includes initial wetting up and saturation of the land, water needed for land preparation by puddling and an amount to establish the field water layer after transplanting the rice crop. Walker (1994) reported that the amount of water needed for land preparation varies with soil type, degree of prior drying out and cracks of the soil profile and the time taken for the clay fraction to swell.

3.3.2.2 Surface runoff

Generally surface runoff does not occur during dry season. But it has to be accepted in periods of heavy rainfall. In times of water scarcity, this runoff should be minimized. Higher bunds increase rainfall conservation within fields.

3.3.2.3 Conveyance losses

In conveying the irrigation water from the water source to rice fields, a part of it evaporation from the water surface of canals and by infiltration through the wetted perimeter. Evaporation from the canal surface is usually negligible when expressed as a percentage of flow volume but infiltration losses can be considerable. Conveyance losses can be reduced by lining the canals.

3.3.2.4 Evapotranspiration

Water is lost from the rice field by evapotranspiration from the soil and water surface by transpiration from the rice plants and various processes of infiltration or percolation into and through the rice field. It is generally believed that evapotranspiratio and infiltration or vertical percolation together accounts for most of the water used in the rice field. There are many empirical equations for estimating the potential evapotranspiration rate by combining the available climatic data.

3.3.2.5 Seepage and percolation

In rice fields under traditional cultivation method, the top soil is saturated and puddled during land preparation to breakdown its structure; this is done deliberately to reduce its permeability. Below this soft and relatively impermeable upper layer (usually 15 to 20 cm thick), repeated ploughing and transplanting create a much harder layer at depth (10cm thick) which is termed as hard pan. It is extremely hard and water loses due to infiltration through it are reduced to as minimum. A horizontal loss sideways in to the bunds or field boundary is called seepage.

3.4 Experimental details

3.4.1. Treatments

The Experiment was conducted at the Agronomy Field Laboratory, Hajee Mohammad Danesh Science and Technology University during T. *Aman* seasons with the following 2 treatments.

T_1- Continuous standing water (1-7cm).

T_2- Irrigation (5-7cm) after 3 days of disappearing of standing water.

Treatments were replicated four times.

3.4.2 Experimental design and layout

The Experiment was laid out in Randomly Complete Block Design (RCBD) with three replications. Treatments were randomly allocated in the experimental plots. The plot size was minimum 4m X 5m. Strong levees were constructed around each plot. The applied irrigation water was measured with V-Notches.

3.5 Instrumentation

A rain gauge was installed at the experimental site at Hajee Mohammad Danesh Science and Technology University farm. Another rain gauge and evaporation pan (Class A pan) were available (Plate 3.1) at a nearby weather station located at Dinajpur, which is about 5 km from the experimental site. Three pairs of lysimeter were installed in three plots. These lysimeters were made locally from unused petrol drums. In each plot there was one pair of lysimeters, one closed bottom and one opened bottom (Plate 3.2). The dimension of lysimeters was 45cm in diameter and 50cm in height. Each lysimeter was provided with a sloping manual gauge to magnify the readings of water level in the lysimeter. The sloping gauge is an iron frame with one arm in inclined position (Plant 3.3) in 1:3 ratio (One vertical to three incline position). A scale graduated in cm and mm was placed along the inclined arm of the sloping gauge. Readings were taken on this scale.

A sloping gauge (Plant 3.4) was also installed in each plot outside the lysimeter to measure the combined ET and S & P from the plot. Each sloping gauge was driven into the soil so that the zero data of the gauges coincide with the soil surface (Plate 3.4).

3. 6 Experimental Setup and Estimation of Water Requirements

The size of the experimental plot was 4m X 5m. The lysimeters were installed at a distance of one meter from the edge of the rice fields. They were installed in such a way that 1.5cm of them was above the ground surface and the rest 35cm was inside the soil so that it penetrated the plough pan. The plough pan was at a depth of 9-17cm from the soil surface. The closed bottom lysimers were installed in a previously excavate pit of same dimensions as the lysimeter. Each soil layer was remove separately, after the lysimeter had been installed and leveled, the soil lavers were re-packed in the correct sequence.

The closed base lysimeters therefore recorded losses only due to evapotranspiration.

The open bottom lysimerers were installed without disturbing the soil column. A slit trench was dug to accommodate the sides of the lysimeter. The lysimeter was then lowered into the trench and gently hammered in to place. Moist loose soil was pocked firmly around the sides to ensure a water-tight fit. The soil in the rice field and in each lysimeter was ploughed and puddle as usual before transplanting. Open bottom lysimeters therefore recorded the combined losses of evapotranspiration and vertical percolation.

The sloping gauges in the rice fields (outside the lysimeters) were installed after the normal land preparation and transplanting. They were driven into the soil so that the lower end of the sloping gauge is at the soil level of the rice field. Water loss from the sloping gauge the outside the lysimeterd, therefore include evapotranspirantion, vertical percolation and lateral seepage through the undisturbed soil below the bunds. The lysimeters and the adjacent rice fields were filled with water to a depth of about 5 to 7cm before the readings began. Inlets and outlets of the experimental plot were then closed and water levels in the fields and in the installed lysimeters were measured at 9 am each day until the field water refilled from the lost. The open and closed bottom lysimeters and the rice fields were refilled from the irrigation canal. Therefore, the water level was maintained in between 0-7cm. The bunds were inspected each day for leaks due to rats, crabs and other field fauna, and where holes were found, they were blocked up. Corrections for rainfall were based on observations were continued throughout the life cycle of the crop. The rates were calculated for each day and the effective readings were averaged for each month and expressed in mm/day. The irrigation supply was stopped before 15 days of harvest, as the crop was mature and irrigation was not required during that period.

3.7 Data recorded

The following parameters were recorded at crop growing season

- Wetting up and land preparation
- Surface runoff
- Conveyance losses
- Evapotranspiration
- Seepage and percolation

The amount of water supplied for wetting up and land preparation for the experimental plot was measured by V-notches. The actual requirements for land preparation including prostration, saturation, and established of field water layer for transplanting was calculated and was expressed in mm of depth. The evapotranspiration and seepage percolation were measured by monitoring water level changes in pairs of open and closed bottom lysimeters, respectively at all stages of crop growth. The amount of water lost due only to evapotranspiration was obtained from the three-closed bottom of lysimeters and due to a combination of evapotranspiration (ET) land vertical percolation from the three open bottom lysimeters. The lysimeters measuring 45 X 60cm were installed in pairs, one open and one closed, I meter from the edges of the rice fields, was planted in and around them.

3. 8 Agronomic Management

3.8.1 Collection of seeds

The experimental seeds were collected from the Agronomy Field Laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.8.2 Raising of seedling

Seedlings were raised in well prepared seedbed at the Agronomy Field Laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Before sowing in the nursery, seeds were water soaked for 24 hrs and then these were kept in gunny bags in dark condition. After sprouting, the seeds were sown in the wet seedbed on last week of June'2004. Due care was taken to see that there was no infestation of pests and diseases and no damage by birds.

3.8.3 Land preparation

The land was first opened in early July'2004. Firstly, two ploughings were given with a tractor mounted disc plough. After a few days the land was further ploughed with the country plough followed by laddering to get a good puddle condition. Weeds and stubbles were removed from the field prior to transplanting of seedlings. The bunds around the individual plot were made firm enough to control water movement between plots. The layout of the experiment in the field was done according to the experimental design adopted.

3.8.4 Fertilizer application

The experimental plots were fertilized with full doses of P, K, S and one third of N, the first installment, one day prior to transplanting. Since N fertilizer was applied installment wise, the second installment was applied after 23days and the third installment after 45days of transplantation. The fertilizer was applied at the rate of 130 kg, 15 kg, 60 kg, 33 kg and 5 kg as Urea, TSP, MP, Gypsum and Zincsulphate, respectively.

3.8.5 Uprooting of seedling

The seedbed was made wet by application of water both in the morning and in the evening on the previous days of uprooting of seedlings. Seedlings were uprooted carefully without causing any injury to the roots and were kept in the shade.

3.8.6 Layout of experiment

The experiment was laid out on 25July 2004 according to the experimental design. The experimental design was Randomly Complete Block Design.

3.8.7 Transplanting

Transplantation was done on 27th July. Rice seedlings were transplanted in and around the lysimeters. Every effort was made to keep crop growth uniform with in and outside the lysimeters. Plant to plant distance was 15cm and row-to row distance was 25cm. Three (3) seedlings were transplanted per hill and 2-3cm depth of transplanting was maintained. 30days old seedlings of BRRI Dhan -34 were used.

3.8.8 Intercultural operation

The experimental field was frequently observed to see if insects and diseases damaged the plants. The experimental field was weeded thrice on 15, 35, 55 DAT to keep the weed competition at a minimum level. Top dressing of Urea was done on the days previously mentioned. Irrigations were done as experimental specification. There was no pest infestation during the growth period of the crop.

3.8.9 Harvesting

Maturity of crop was determined when 90% of the seeds become golden yellow in colour. The crop was harvested at full maturity on 16th November'2004.

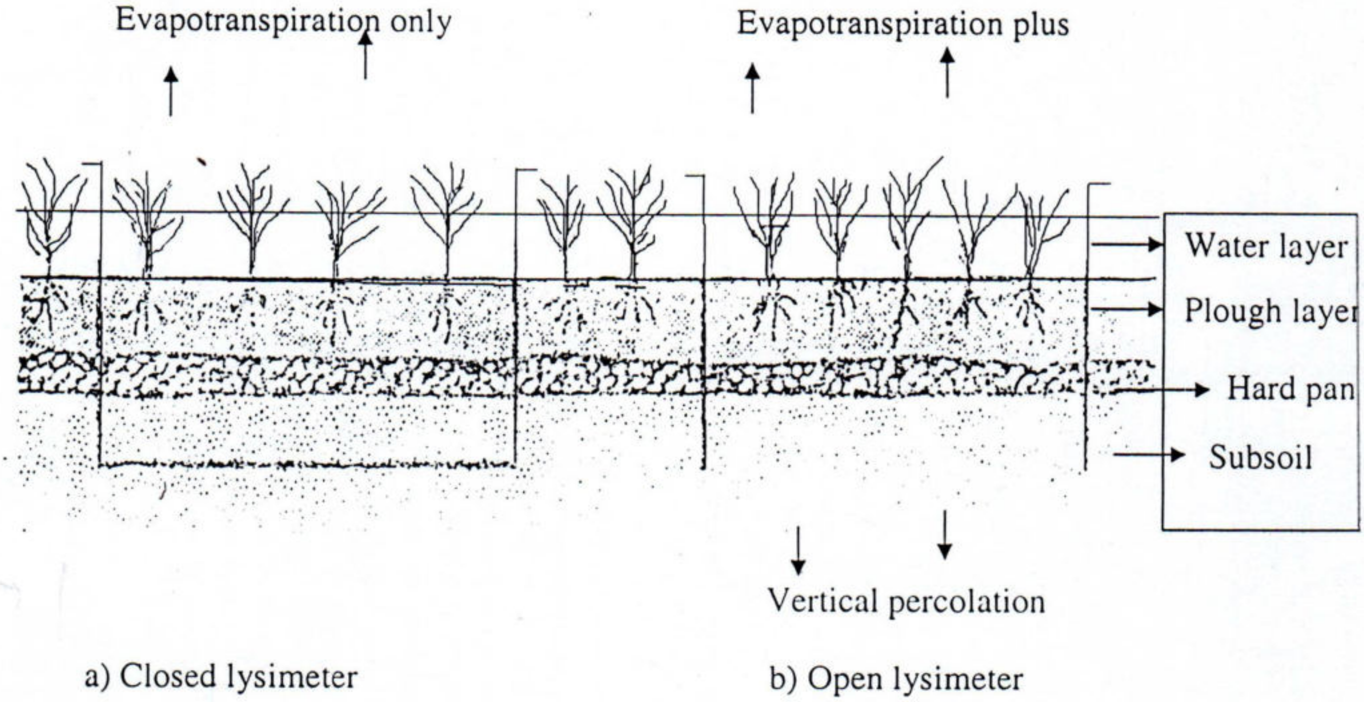
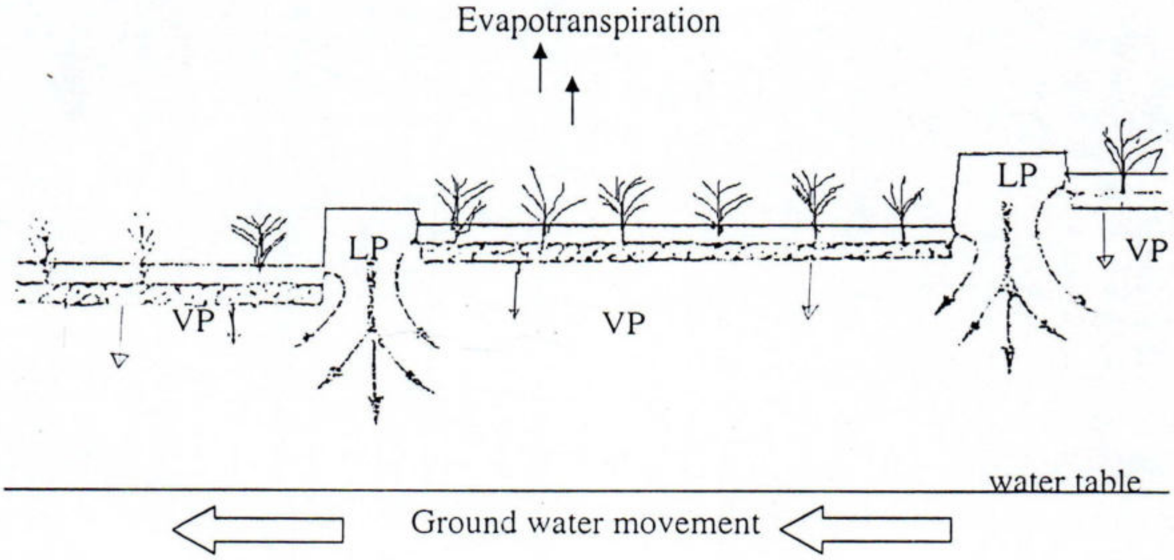


Fig 1. Water losses from closed and open lysimeters



VP= vertical percolation through impermeable plough layer and hard pan

LP= lateral percolation into permeable bunds and down to groundwater table

Fig. 2. Vertical percolation through the plough layer and lateral percolation through the bunds of irrigated rice fields

CHAPTER IV

RESULT AND DISCUSSION

4.1 The Water Balance

The results of water balance studies for the experimental plot at Hajee Mohammad Danesh Science and Technology University, Dinajpur, during *Aman* season 2004 are summarized in Table 3 and illustrated in figure 6. (The simple equation (after Walker, 1994) for water balance has been used to estimate the water requirements for growing a rice crop:

Q = W+E + F + R+C

Where Q = Total water requirements

W = Wetting up and land preparation

E = Evapotranspiration from water and plants

F = Seepage and percolation

R = Surface runoff

C = Conveyance losses)

4.1.1 Wetting up and land preparation

Land preparation includes initial wetting up and saturation of the land, water needed for land preparation by puddling and an amount to establish the field water layer after transplanting the rice crop. Walker (1994) reported that the amount of water needed for land preparation varies with soil type, degree of prior drying out and cracks of the soil profile and the time taken for the clay fraction to swell. Water which is required for land preparation comprises a significant part of total requirement for rice cultivation. Kampen (1970) have shown that water requirement for land preparation varied from land to land. He summarized experimental results of water requirements for land preparation in different rice growing countries, such as Sri Lanka (300 mm), India (230-390 mm), Japan (130 mm), Malaysia (176-225 mm), Surinam (420 mm), Taiwan (120-210 mm), Thailand (300-400 mm) and Southeast Asia as a region (220-240 mm). Studies in the Ganges-Kobadak project (BRRI, 1985) in Bangladesh indicated that under researchers management conditions the average water requirement for land preparation during *Aus* and *Aman* seasons were 237 and 261mm, respectively which were less than 20% of total water requirement for the growing season. Similar studies in the following year in the same area resulted to a land preparation requirement of 284m and 215mm during Aus and *Aman* seasons, respectively (BRRI, 1986).The water requirements for land preparation in the present study was only 100 mm(Table-3) because the land was already soaked and saturated due to earlier rainfall.

4.1.2 Evapotranspiration

Water is lost from the rice field by evapotranspiration from the soil and water surface by transpiration from the rice plants and various processes of infiltration or percolation into and through the rice field. It is generally believed that evapotranspiration and infiltration or vertical percolation together accounts for most of the water used in the rice field. In the present study during the crop growing period, the monthly total evaporation were 116 mm, 107 mm, 109 mm and 104 mm in the month of August, September, October and November, respectively, and the monthly total rainfall were 128 mm, 254 mm and 370 mm during August, September and October respectively. In the present study the highest evaporation (116 mm) was observed in August and the lowest (104 mm) was in November. Saleh and Fatema (1988) found actual ET estimating from pan evaporation ranges from 3.59-4.68 mm/day during dry season and 3.05-4.54 mm/day in wet season. So, the evaporation is near about same as estimated by them. The highest rainfall (370 mm) was recorded in October and there was no rainfall in November. Walker (1994) found that the mean daily evapotranspiration rate as measured by the closed lysimeters was 5.7mm/day and the evapotranspiration plus the vertical percolation from the open lysimeters was 7.3mm/day, giving a mean vertical percolation rate of 1.6mm/day.

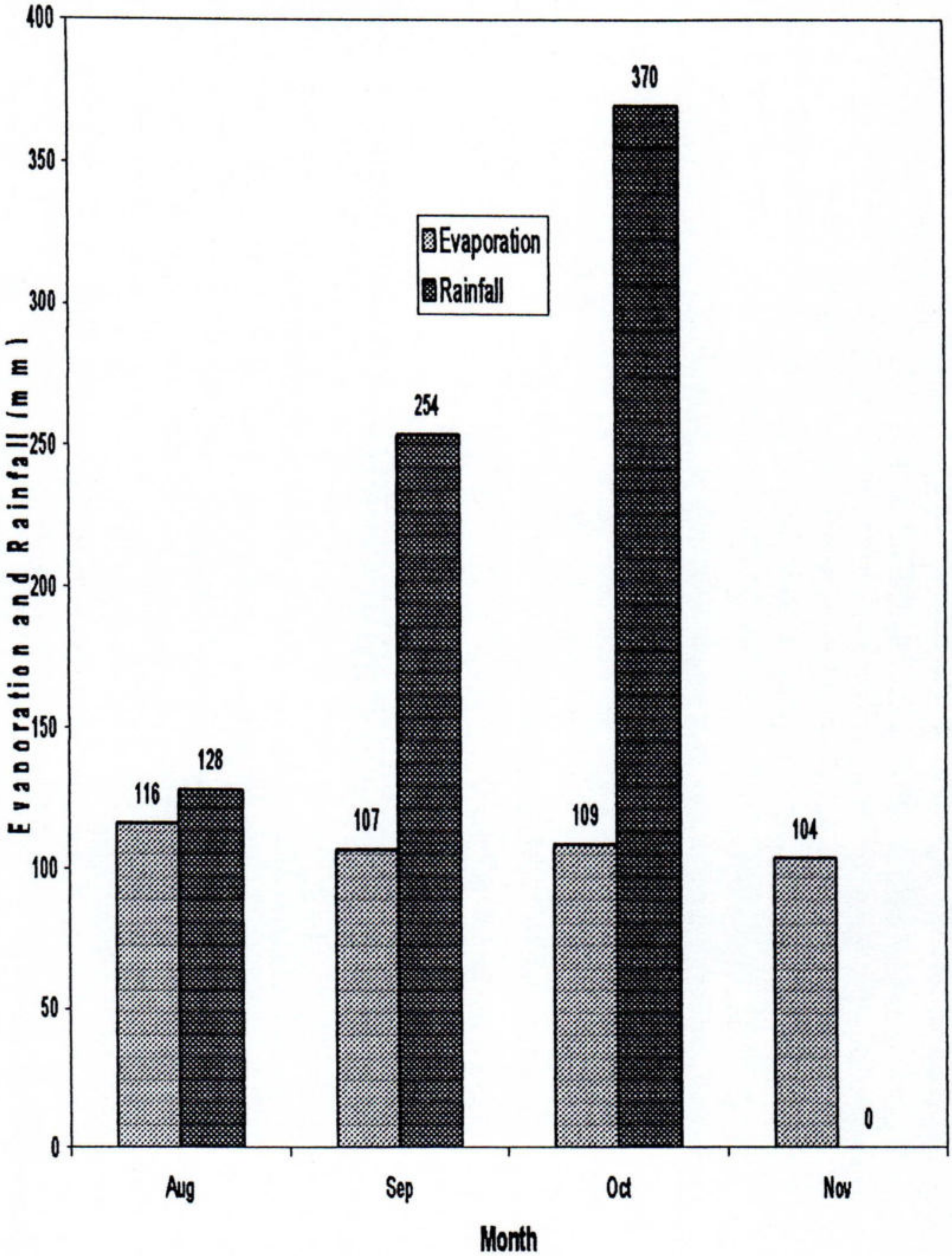


Fig 3. Monthly total evaporation and rainfall during T. *Aman* season 2004.

So, we can say that the ET rate of rice is not same at different places. The prediction of ET rate measured by different methods and equations is controversial and conflicting. These differences may occur due to the differences of weather and climate of different places.

The total evaporation during the growing season was 436 mm and the total rainfall was 752 mm. Although the total rainfall was higher than the total evaporation during the growing season but irrigation water was required because the rainfall was not evenly distributed throughout the season. Sometimes there was excess rainfall than the crop demand and major part of it was lost as direct runoff from the field. Sometimes there was less rainfall than the crop demand. Therefore, irrigation was required during the drought period.

The observation of evaporation and rainfall revealed that in the study area the evaporative demand gradually decreases from August to November during T. *Aman* season. The rainfall was not sufficient for rice cultivation and unevenly distributed throughout the growing season.

Evapotranspiration Loss in the T. *Aman* Season of 2004

The results of field experiments averaged for each month are summarized in Table 1.

Table 1: Measurement of Evapotranspiration (mm/day) from rice field using lysimetric study, during T. *Aman* season 2004.

Treatment	**Month**				**Average**
	Aug	Sep	Oct	Nov	
T1R1	4.45	4.28	3.99	3.33	
T1R2	3.81	4.16	4.28	4.44	
T1R3	4.10	4.16	4.04	4.28	
T1R4	4.82	4.28	4.44	4.28	
Mean	4.30	4.22	4.19	4.08	4.20
T2R1	5.08	3.99	3.99	4.66	
T2R2	5.03	4.44	4.44	4.28	
T2R3	4.02	4.44	4.35	3.84	
T2R4	3.93	4.66	4.32	4.16	
Mean	4.52	4.38	4.28	4.24	4.36

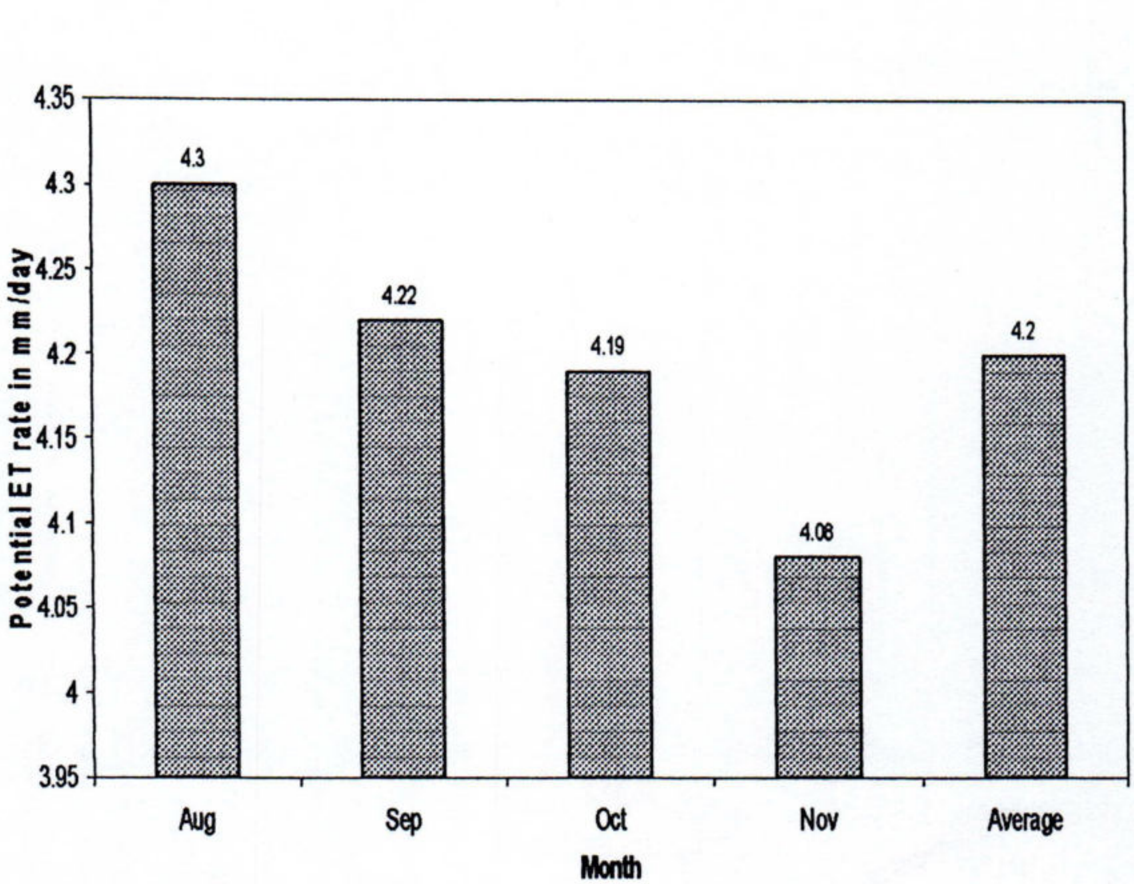


Fig 4. Evapotranspiration rate in different months during T. *Aman* season, 2004 (Treatment T_1)

The mean daily evapotranspiration (ET) rates as measured by the closed bottom lysimeters were 4.30 mm/day, 4.22 mm/day, 4.19 mm/day and 4.08 mm/day during the month of August, September, October and November respectively for the treatment T_2. The average of the mean ET rate for the same treatment was found to be 4.20 mm/day (Fig. 4).

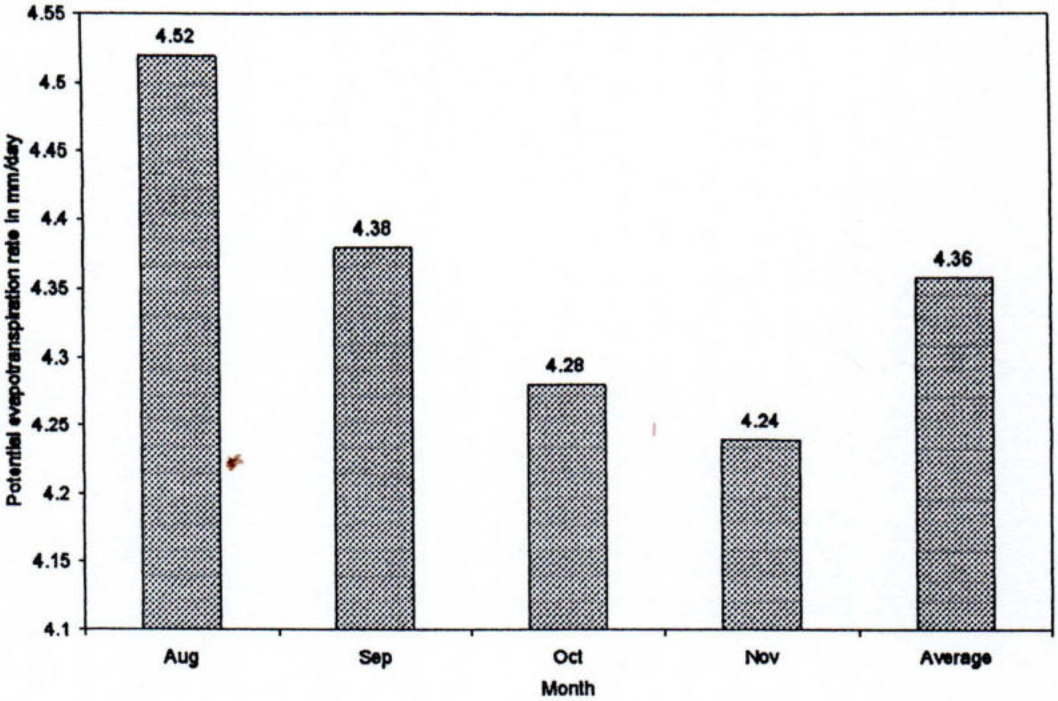


Fig. 5. Evapotranspiration rate in different months during *T Aman* season, 2004 (Treatment T_2).

Evapotranspiration and seepage-percolation together accounts for most of the water used in the rice fields. The mean daily evapotranspiration (ET) rates as measured by the closed bottom lysimeters were 4.30 mm/day, 4.22 mm/day, 4.19 mm/day and 4.08 mm/day during the month of August, September, October and November, respectively for the treatment T_1. The average of the mean ET rate for the same treatment was found to be 4.20 mm/day. The total ET requirement was 414 mm during the growing period based on monthly ET rate. It may be mentioned here that the ET and seepage percolation rate was considered up to 15 days before harvest. Because irrigation supply was stopped before 15 days of harvest as the crop was matured at that time and no irrigation was required.

Similarly, the mean ET rates for the treatment T_2 were 4.52 mm/day, 4.38 mm/day, 4.28 mm/day and 4.24 mm/day during the above four months respectively, giving the average of the mean evapotranspiration of 4.36 mm/day. For both the treatments the ET rates gradually decreased from August to November. This may be due to lower evaporative demand from August to November.

4.1.3 Seepage and percolation

In rice fields under traditional cultivation method, the top soil is saturated and puddled during land preparation to breakdown its structure; this is done deliberately to reduce its permeability. Below this soft and relatively impermeable upper layer (usually 15 to 20 cm thick), repeated ploughing and transplanting create a much harder layer at depth (10cm thick) which is termed as hard pan. It is extremely hard and water loses due to infiltration through it are reduced to as minimum. A horizontal loss sideways in to the bunds or field boundary is called seepage. The sloping-scale gauge installed in the rice fields recorded a combined evapotranspiration, seepage and vertical percolation losses from the rice fields. The sloping gauges in rice fields recorded a mean seepage and percolation losses of 5.42 mm/day, 6.82 mm/day, 6.64 mm/day and 5.19 mm/day (Table 2) during the month of

August, September, October and November, respectively for the treatment T_1 and that for treatment T_2 were 6.38 mm/day, 5.49 mm/day, 6.15 mm/day and 6.47 mm/day during the above months respectively. The average of the mean seepage-percolation rate was 6.02 mm/day for T_1 and 6.12 mm/day for T_2. The variation from month to month is slight and comparable. There was no significant difference in S and P rate between the two treatments. Wickham and Tadase (1976) found that the S & P rates were 6 mm/day for clay loam soil and for sandy loam soil it was 13 mm/day. Ghani (1987) found the average S & P rates were 8.6 mm/day for clay loam in selected locations of GK project. So, we found that the S & P rates vary due to the texture and type of soil.

The results of T. *Aman* seasonal field experiments during 2004 show that on average, the ET rate is 4.28 mm/day and the S and P rate is 6.07 mm/day. These two values demonstrated that 41% of the applied water was needed for ET and the rest 59% is lost from the field as seepage and percolation.

Table 2: Measurement of Seepage and Percolation (mm/day) from rice field using lysimetric study, during T. *Aman* season 2004.

Treatment	Month				Average
	Aug	Sep	Oct	Nov	
T1R1	5.19	6.67	7.83	6.0	
T1R2	5.07	6.66	5.71	4.44	
T1R3	5.97	6.31	6.71	5.0	
T1R4	5.46	7.66	6.31	5.33	
Mean	5.42	6.82	6.64	5.19	6.02
T2R1	6.59	4.33	6.56	7.38	
T2R2	7.35	5.55	6.19	6.24	
T2R3	6.12	6.04	5.95	6.16	
T2R4	5.44	6.02	5.89	6.08	
Mean	6.38	5.49	6.15	6.47	6.12

4.1.4 Surface runoff

Generally surface runoff does not occur during dry season. But it has to be accepted in periods of heavy rainfall. In times of water scarcity, this runoff should be minimized. Higher bunds increase rainfall conservation within fields. Generally surface runoff occurs during T. *Aman* season due to heavy rainfall. In the present study out of 752 mm of rainfall during the growing period about 526 mm was found to be effective and the rest 226 mm was lost as surface runoff. The effective rainfall was considered as 70% (Rashid, 2004) of total rainfall during T. *Aman* season..

4.1.5 Conveyance losses

In conveying the irrigation water from the water source to rice fields, a part of it evaporation from the water surface of canals and by infiltration through the wetted perimeter. Evaporation from the canal surface is usually negligible when expressed as a percentage of flow volume but infiltration losses can be considerable. Conveyance losses can be reduced by lining the canals. In the present study conveyance loss was negligible and was not considered in the estimation as the source of water was very close to the experimental plot.

Table 3: Water balance (mm) for the experimental plot at Hajee Mohammad Danesh Science and Technology University, Dinajpur, during T. *Aman* season 2004.

Month	Rainfall	Potential irrigation requirement	Actual irrigation supply	Evapo-transpiration	Surface runoff	Seepage & percolation
August	128	311*	315	133	38	168
September	254	155	156	127	77	205
October	370	77	80	130	111	206
November	00	55	65	24	00	31
Total	**752**	**598**	**616**	**414**	**226**	**610**

- Including 100 mm of water required for land preparation.

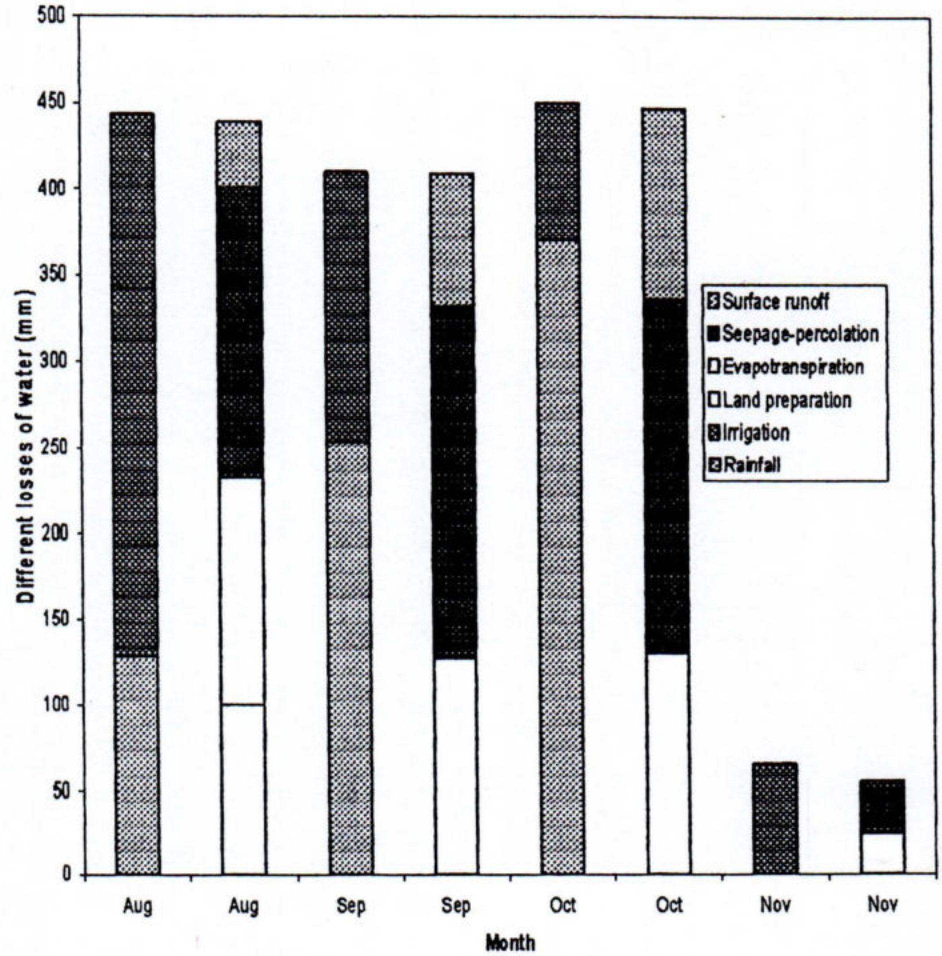


Fig 6: Water balance of irrigated rice field in T. *Aman* season.

This study indicated that 30% of the total supplied water in rice field was used by the rice plants as ET and the rest 70% was lost through seepage-percolation, surface drainage and other unaccounted processes.

Although two irrigation treatments were followed in the study but no significant difference in water requirements and seepage percolation rates were found between the two treatments due to rainfall. There was 752 mm of rainfall during the growing period which hampered to maintain treatment T_2 (irrigation after 3 days of disappearing of standing water). Therefore, it can be concluded that this treatment is not applicable for T. *Aman* season. Water saving techniques, like shallow application of irrigation water may be practiced in T. *Aman* season which may lead to efficient utilization of irrigation water through minimizing excessive losses of seepage and percolation.

CHAPTER V

SUMMARY AND CONCLUSION

A piece of research work was conducted at the Agronomy Field Laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur from July to November'2004 with a view to study the water balance of irrigated T. *Aman* rice. The experiment consisted two treatments viz. continuous standing water (1-7cm) and irrigation (5-7cm) after three days of disappearing of standing water. The experiment was laid out in Randomly Complete Block Design (RCBD) with four replications. The unit plot size was 20 m^2 (4mx5m). Strong levees were constructed around each plot. Applied irrigation water measured with V–Notches. Two types of lysimeters were used viz. open bottom lysimeter and closed bottom lysimeter to measure the ET and S &P. A rain gauge was also used to measure the rainfall. The rates were calculated each day and the effective readings were averaged for each month and expressed in mm/day. Irrigation supply was before stopped 15 days of harvesting, as the crop was mature and irrigation was not required at that time.

This study indicated that 30% of the total supplied water in rice field was used by the rice plants and the rest 70% was lost through seepage-percolation, surface drainage and other unaccounted processes.

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APPENDIX

Appendix. 1. Weather data of the experimental site during the period from July to December 2004

Month	**Air Temperature (^{0}C)			* Rainfall (mm) Minimum	**Relative Humidity (%)	*Sunshine (hrs)
July	31.72	26.54	29.13	-----	85.58	3.57
August	31.64	26.32	28.98	128	88.35	4.37
September	30.54	25.43	27.99	254	89.93	3.45
October	31.62	23.86	27.74	370	86.10	3.31
November	29.70	19.09	24.40	00	82.37	6.63
December	26.71	13.43	20.07	00	77.00	7.93

* Monthly total
**Monthly Average
Source: Weather yeard, Wheat Research Center, BARI, Nasipur, Dinajpur