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WATER USE EFFICIENCY OF THABUA IRRIGATION PROJECT, THAILAND

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ABSTRACT : This study was conducted at Thabua Irrigation Project which is located at the central plain of Thailand during the wet season of 1995. The main objectives of the study were to assess the water use efficiency of the irrigation system. The water use efficiency of flooded rice field (wetland paddy) was studied through the determination of seepage and percolation, evapo-transpiration and reference crop evapo-transpiration during the mid and later growth stages of rice (October– November). The average seepage and percolation and crop evapo–transpiration rate from the wetland paddy field were found to be 1.20–1.60 mm/day and 4.65-5.00 mm/day, respectively. During the study, it was observed that the average weekly water use efficiency varied from 26% to 76%. It may be mentioned here that no frequent irrigation was needed for the paddy field during the observation due to the sufficient residual water from flood and heavy rains that occurred during the wet season.

KEYWORDS : Rice (Wetland Paddy), Water Use Efficiency

INTRODUCTION

More than 75% of global rice production is harvested in irrigated rice ecosystems, which constitute 55% of total harvested area. About 25% of the total rice acreage is under rained lowland cultivation and produces 17% of global rice production (IRRI, 1993). In rainfed ecosystems, water is the major factor that determines rice production. Efficient use of water in rice-ecosystems is of crucial importance. Water use efficiency of rice fields can be determined by studying the components of water balance. In Asia, contributing 90-95% of world production, rice in irrigated and rainfed lowland environments is mostly grown under flooded conditions (Pathak and Gomej, 1991). The components that determine the water balance of puddled rice

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fields. include irrigation supply, rainfall, evaporation, transpiration, seepage and percolation.

Irrigated agriculture is dependent on adequate water supply of usable quality. It has been learnt from the past experiences that on-farm irrigation improvements depend on the system adequacy and dependability (Lazaro et al., 1979 and 1980). Naturally at the tail end of the project, water scarcity is most likely to happen which creates conflicts among farmers. The farmers are also badly affected by the poor performance of the irrigation systems, which is a result of inadequate maintenance and poor management. Therefore a project performance evaluation at farm level is needed to be conducted in terms of its objectives like water use efficiency, irrigation water quality, and equity in water delivery system at the farm level. The study on the determination of water use efficiency was conducted during the wet season of 1995 in Thabua irrigation project which is located in the Phitsanulok province, 370 km north of Bangkok at the Northern-most central plain of Thailand. Irrigation water is supplied to the project command area from Sirikit Dam. The average annual rainfall in the area varies from 800-1200 mm. The soil type of the project area is predominantly clay which is suitable for rice production.

Water use efficiency is defined as the ratio of water that is beneficially used by the crop and the total water supplied. It depends on land consolidation types, sources of irrigation water, methods of water lifting and farmer's awareness. According to Sompong. (1983), the water use efficiency is given by,

Water Use Efficiency = (Crop evapotranspiration + Deep percolation - Effective rainfall/Irrigation water applied

For upland crops, water use efficiency usually considers only ET requirements as the beneficial use of water but for low land rice, seepage and percolation can be considered a more or less inevitable consequence of keeping the soil saturated and it can therefore be counted with Etc as the water requirement for growing the crops under the given circumstances (Wickham, 1974). Percolation is the vertical movement of water beyond the root-zone to the water table while seepage is the lateral movement of sub-surface water (IRRI, 1965). Oberez (1992) found that the application efficiency at Thabua (Phitsanulok) irrigation project was 66%. The Royal Irrigation Department (RID) of Thailand determined the application efficiencies at Mae Klong and Lam Pao irrigation projects to be 43% and 63% respectively.

Odhimboo (1994) reported that the seepage and percolation vary depending on the location of measurement. Seepage and percolation around drainage bunds was found to vary from 63.7 mm/day (within 0.24 m of the bund) to 2.0 mm/day (within 0.48 to 0.72 m from bund); whereas the values for interior bunds were only 3.70 and 1.30 mm/day. The average value reported for vertical percolation was 1.20 mm/day. Ullah (1979) found that in the Lam Pao project, average percolation and seepage losses from low land paddy was 3.3 mm/day. Tawee (1985) found the average percolation of some areas of the Mae Klong Irrigation project to be 1.20 mm/day.

Boonsang (1988) studied the Mae Klong (Thailand) irrigation project's performance and found that the water use efficiencies at farm and project levels were 31.9% and 30%, respectively. In the present study, the water use efficiency was studied in two service units (one service unit covers nearly 20-25 ha). Since rice is the principal crop in Thailand during the wet season, the water use efficiency (WUE) was studied for this crop only.

MATERIALS AND METHODS

The water use efficiency at the low-land rice field was determined in two service units (C-102) and C-188), each coxcring an area of about 10-12 hectares, at one irrigation cycle basis by the following the formulae developed by Sompong Boonpraser (1983)

Water Use Efficiency = (Crop ET + DP - ER)/ Irrigation Water Supplied

Where, ET = Evapo-transpiraton

DP = Deep Percolation

ER = Effective Rainfall

Each of the components of water use efficiency was determined directly at the field level.

DETERMINATION OF ET

Two blocks of the project command area were selected for the direct measurement of crop ET. Two lysimeter tanks, one open bottomed and the other one closed bottomed were placed within rice blocks. The readings of the lysimeters were taken in every morning during the months of October and November, the critical periods for wetland paddy. The difference of reding between two successive days gave the amount of crop evapotranspiration for the previous day. The quantity of rainfall was incorporated during calculation. The ET was also computed from the reference Crop ET. Finally the measured ET was compared with the computed ET.

MEASUREMENT OF RAINFALL AND EVAPORATION

Rainfall was recorded from the automatic rain gauge installed at the field office of the project. For the measurement of evaporation, a class-A pan was installed near the rain gauge. The readings for both were taken in every morning

DETERMINATION OF REFERENCE CROP EVAPOTRANSPIRA-TION (ET_O)

ETo was computed by pan-evaporation method with observed pan evaporation data by using the following relationship

$$ET_o = K_p * E_{pan}$$

Where, K_p = Pan - coefficient
E_{pan} = Mean monthly pan evaporation in mm
ET_o = Reference Crop evapo-transpiration in mm

The pan co-efficient has been provided by FAO-24 (1977) based on different levels of mean monthly relative humidity, surrounding vegetation cover of evaporation pan and 24 hours wind speed. It was also computed by Penman - Monteith method from the meteorological data collected from the nearest station from the study area.

DETERMINATION OF CROP - COEFFICIENT (K_C)

The values of K_c for wetland paddy at the different growth stages for the study area were taken from the research report "Consumptive Use of Water in Wetland Paddy Fields" during 1979-80, published by Royal Irrigation Department of Thailand.

DETERMINATION OF DEEP PERCOLATION (DP)

Percolation was measured by closed and open bottomed double tank lysimeter in the wet paddy fields. The readings for both were taken at 24-hour intervals. The difference between two successive readings of the open bottomed tank gave the sum of ET and DP. So, percolation was found out by subtracting ET from the total (ET+DP).

DETERMINATION OF EFFECTIVE RAINFALL (ER)

The determination of effective rainfall in low-land paddy field was done according to Sarnsomboon (1965). According to this estimate, rainfall up to 200 mm/month can be fully utilized in case of rice cultivation and rainfall over 200mm/month is partly effective. Table 1 provides the estimates of effective rainfall from Sarsom boon (1965).

Table 1. Effective Rainfall for Rice

Total Monthly Rainfall (P_m) mm	Effective Rainfall (mm)
$P_m \leq 200$	100%
$200 \leq Pm \leq 250$	94%
$250 \leq Pm \leq 300$	90%
$300 \leq Pm \leq 350$	83%
$350 \leq Pm \leq 400$	79%
$400 \leq Pm \leq 450$	71%
$450 \leq Pm \leq 500$	65%

Source : Sarsomboon (1965)
Note : P_m = Monthly precipitation

RESULTS AND DISCUSSION

Measurement of Evaporation and Rainfall

Evaporation data measured with a class-A pan during the study period at the Thabua irrigation project, are presented in the Table 2. The average monthly evaporation values were 4.56, 4.69 and 4.60 mm/day during the months of September, October and November, respectively. Rainfall data measured by an automatic rain gauge at the station during the study period are shown in Table 3. According to the past records during 1986-1995, the highest rainfall (1267-40 mm) was recorded in 1995. The annual rainfall trends during the last ten years and monthly variation of rainfall (1986-1995) at the project area are shown in Table 4 and Fig. 1, respectively.

Measurement of Deep percolation

Deep percolation in the wetland paddy field at the Thabua irrigation project was monitored by lysimeters in two selected blocks or service units, mentioned earlier during the months of October and November.

Table 2. Observed Pan Evaporation at Thabua station during the Wet Season 1995

Date	Months		
	September	October	November
1		0.30	0.50
2			0.39
3		0.20	0.45
4		0.35	0.26
5		0.28	0.30
6		0.26	0.40
7		0.34	0.30
8		0.25	0.35
9		0.40	0.38
10		0.45	0.37
11		0.40	0.40
12	0.31	0.38	0.42
13	0.39	0.41	0.46
14	0.46	0.34	0.39
15	0.43	0.30	0.40
16	0.41	0.45	0.41
17	0.49	0.26	0.43
18	0.5	0.56	0.45
19	0.38	0.42	0.37
20	0.46	0.46	0.39
21	0.5	0.41	0.45
22	0.52	0.50	0.43
23	0.5	0.30	0.49
24	0.49	0.60	0.52
25	0.45	0.40	0.53
26	0.44	0.40	0.56
27	0.47	0.40	0.50
28	0.5	0.30	0.48
29	0.48	0.30	0.47
30	0.51	0.35	0.42
31	0.42	0.40	

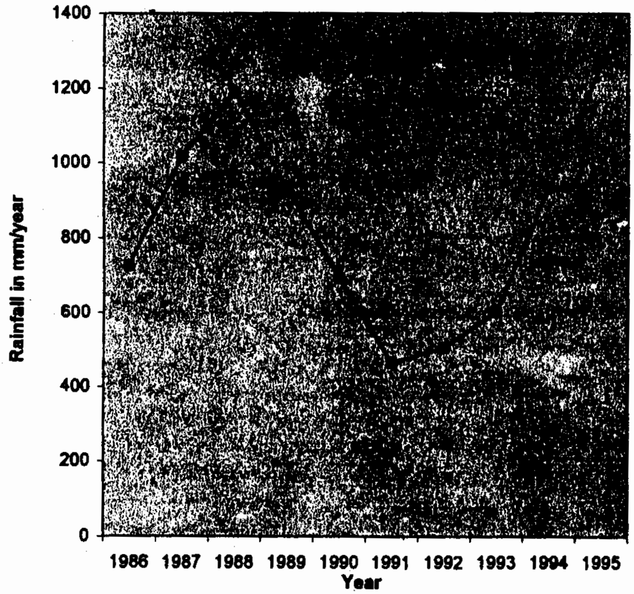

Fig 1. Variation of annual rainfall for Thabua rainfall station.

The results were presented in the Tables 5, 6, 7 and 8. The daily average deep percolation rates for canal C-102 were 1.59 and 1.30 mm during the months of October and November, respectively. For canal C-188, the values were 1.2 and 1.60 mm/day, respectively. It was almost similar to the percolation rate of 1.20 mm/day at Mae Klong irrigation project Tawee, (1985) with similar soil texture. It may be mentioned here that due to severe flood during the wet season of 1995, it was possible to monitor deep percolation in the above two months only.

Table 3. Recorded Rainfall (in mm) during the Wet Season 1995

Unit : mm/month

Date	Months								
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							20.0		
2			40.00	1.00					
3			7.00		4.10	30.10			
4	4.10			39.70		6.40			
5							1.70		
6		90.70		5.10			25.60		
7				11.20			3.00	28.00	
8		2.90		4.80	5.60		4.00		
9				2.70	7.90	31.60	1.50		
10			2.30	3.80	5.20				
11		100.10	15.90		10.40	1.00			
12					10.60	13.50			
13			0.50	11.90	15.40	26.10			
14					18.60	11.70			
15			0.60		2.80	37.30			
16				16.10					
17			77.30	5.40					
18		13.00		62.60	18.90				
19		12.70			2.80				
20		93.0					43.50		
21					30.00		11.50		
22				6,50	1.30	6.10			
23					38.60	53.10			
24				68.60					
25				17.50					
26				6.40	10.20				
27			4.90		25.20				
28						3.90			
29			1.00						
30				26.30		26.10			
31				7.40					
Total	4.10	212.30	147.5	297.00	214.60	248.6	110.8	28.00	

Table 4. Rainfall Records at Thabua Irrigation Project during 1986-1995

Unit : mm

Serial No.	Year	Total Rainfal	No. of rainy day	Month of highest Rainfall	Amount of the highest Rainfall
1	1986	724.80	73	July	161.65
2	1987	1016.00	94	September	161.60
3	1988	1188.90	88	October	283.90
4	1989	930.01	90	September	202.80
5	1990	693.30	88	September	177.70
6	1991	465.50	70	September	255.50
7	1992	506.10	64	August	243.90
8	1993	604.20	47	September	281.80
9	1994	935.70	57	August	257.80
10	1995	1267.40	71	July	297.00

Computation of Reference Crop Evapotranspiration (ETo)

Crop evapotranspiration was computed by Pan-Evaporation method with observed pan evaporation data. The monthly average ETo was calculated to be 4.45, 4.65 and 4.76 mm/day for the months September, October and November, respectively (shown in the Table 9). It was also computed by Penman-Monteith method with the available meteorological data for the study area. In this case, the monthly ETo were found to be relatively lower than Pan-evaporation method and the values were 3.2, 3.1 and 3.2 mm/day for the above months (presented in the Table-10.)

Table 5. Observed Deep Percolation for Wet Land Paddy in the Study Area

Month : **October**

Date	Tank Reading cm				ET	ET & DP	DP	Rainfall
	Open Bottom		Closed Bottom		in cm	in cm	Reading	in cm
	Initial	Reset	Initial	Reset	(4)*-(4)	(1)*-(1)	in cm	
	(1)	(2)	(3)	(4)	(5)	(6)	(6)-(7)	
1	18.00		18.50		0.49	0.62	0.13	2.00
2		19.38		20.01	0.46	0.58	0.11	
3	18.80		19.55		0.54	0.59	0.14	
4	18.21		19.01		0.48	0.63	0.15	
5	17.59		18.53		0.50	0.64	0.14	0.17
6	17.12		18.20		0.49	0.64	0.15	2.56
7		19.04		20.27	0.45	0.64	0.16	0.30
8	18.70		20.12		0.51	0.59	0.12	0.40
9	18.52		20.01		0.47	0.61	0.14	0.15
10	18.06		19.69		0.48	0.63	0.15	
11	17.43		19.21		0.46	0.60	0.14	
12	16.83		18.75		0.47	0.63	0.16	0.63
13	16.83		18.75		0.45	0.60	0.15	
14	16.23		18.30		0.50	0.65	0.15	
15	15.59		17.80		0.48	0.65	0.13	
16	14.98		17.33		0.51	0.63	0.12	
17	14.35		16.82		0.49	0.62	0.15	
18	13.74		16.33		0.44	0.60	0.16	
19	13.14		15.89		0.45	0.62	0.17	4.35
20		16.87		19.79	0.49	0.64	0.15	1.15
21		17.38		20.45	0.50	0.62	0.12	
22	16.77		19.95		0.42	0.65	0.13	
23	16.12		19.53		0.44	0.58	0.15	
24	16.54		19.01		0.47	0.58	0.11	
25	14.96		18.54		0.45	0.57	0.12	
26	14.40		18.09		0.45	0.59	0.14	
27	13.81		17.64		0.48	0.62	0.14	
28	13.19		17.16		0.50	0.64	0.15	
29	12.55		16.66		0.45	0.60	0.15	
30	11.95		16.21		0.45	0.57	0.12	
31	11.38		15.76					

Note : (4)* & (1) = Previous Days Reading
(4) & (1) = Following Days Reading

Daily Average DP=1.49mm
Daily average ETcrop = 4.7 mm

Measurement of Crop Evapotranspiration (ETcrop)

The Daily ETcrop for the wetland paddy was also measured for the above selective blocks of the project with the lysimeters. The average ETcrop was recorded 4.70 and 4.80 mm/day during October and November respectively for the canal C-102. The same was observed 4.65 and 5.0 mm/day for the canal C-188 during the studied period (presented in the tables 5, 6, 7 and 8). The measured ET crop was compared with the computed crop evapotranspiration by pan-evaporation and Penman-Monteith method. The computed ETcrop was found to be somewhat lower.

Table 6. Observed Deep Percolation for Wet Land Paddy in the Study Area

Month : **November**

Date	Tank Reading cm				ET	ET & DP	DP	Rainfall
	Open Bottom		Closed Bottom		in cm	in cm	Reading	in com
	Initial (1)	Reset (2)	Initial (3)	Reset (4)	(4)*-(4) (5)	(1)*-(1) (6)	in cm (6)-(7)	
1	22.00		21.00		0.50	0.61	0.11	
2	21.39		20.50		0.49	0.61	0.12	
3	20.78		20.01		0.51	0.62	0.11	
4	20.17		19.50		0.49	0.60	0.12	
5	19.57		19.01		0.47	0.59	0.12	
6	18.98		18.55		0.49	0.63	0.14	
7	18.35		18.01		0.50	0.62	0.13	2.80
8		20.53		20.36	0.48	0.61	0.11	
9	19.92		19.88		0.46	0.60	0.14	
10	19.33		19.42		0.44	0.57	0.13	
11	18.76		18.98		0.45	0.59	0.14	
12	18.17		18.53		0.47	0.48	0.10	
13	17.69		18.01		0.47	0.58	0.11	
14	17.11		17.55		0.47	0.59	0.12	
15	16.53		17.01		0.49	0.62	0.14	
16	15.90		16.53		0.48	0.59	0.11	
17	15.25		16.05		0.52	0.65	0.13	
18	14.60		15.53		0.48	0.63	0.15	
19	13.97		15.05		0.47	0.59	0.12	
20	13.38		14.58		0.47	0.58	0.12	
21	12.80		14.12		0.48	0.61	0.13	
22	12.19		13.63		0.41	0.56	0.15	
23	11.63		13.22		0.44	0.57	0.13	
24	11.06		12.78		0.45	0.59	0.14	
25	10.47		12.33					

Note : (4)* & (1) = Previous Days Reading
(4) & (1) = Following Days Reading

Daily Average DP = 1.3 mm
Daily average ETcrop = 4.8 mm

Water Use Efficiency during the Wet Season

There was sufficient storage of water in the paddy fields due to the residual floodwater and heavy rainfall during the wet season. So, farmers of the project area did not irrigate their fields at a regular interval. Therefore, it was not possible to calculate the weekly water use efficiencies during the entire study-period. The weekly water use efficiencies varied from 22% to 93% for the canal C-102 and 30% to 59% for the canal C-188 (Presented in the Table 11).

Table 7. Observed Deep Percolation for WetLand Paddy in the Study Area

Canal : **C-188** Month : **October**

Date	Tank Reading cm				ET	ET & DP	DP	Rainfall
	Open Bottom		Closed Bottom		in cm	in cm	Reading	in com
	Initial	Reset	Initial	Reset	(4)*-(4)	(1)*-(1)	in cm	
	(1)	(2)	(3)	(4)	(5)	(6)	(6)-(7)	
1	18.50		16.50		0.40	0.52	0.12	2.00
2		19.98	18.10		0.40	0.52	0.12	
3	19.46		17.65		0.45	0.58	0.13	
4	18.88		17.25		0.40	0.50	0.10	
5	18.38		16.75		0.50	0.59	0.09	0.17
6	17.96		16.45		0.48	0.59	0.11	2.56
7		19.93			0.50	0.64	0.14	0.30
8	19.59		18.36		0.45	0.59	0.14	0.40
9	19.40		18.35		0.41	0.51	0.10	0.15
10	19.04		18.06		0.45	0.55	0.10	
11	18.51		17.61		0.44	0.57	0.13	
12	17.94		17.17		0.47	0.48	0.11	
13	17.46		16.70		0.50	0.64	0.14	
14	16.82		16.20		0.49	0.64	0.15	
15	16.19		15.71		0.48	0.62	0.14	
16	15.56		15.23		0.42	0.53	0.11	
17	15.03		14.83		0.40	0.52	0.13	
18	14.51		14.43		0.43	0.57	0.14	
19	13.94		14.00		0.45	0.58	0.13	
20	13.36		13.55		0.48	0.59	0.12	4.35
21		17.12		17.43	0.50	0.64	0.14	1.15
22		17.63		18.10	0.49	0.62	0.13	
23	17.01		17.61		0.47	0.61	0.14	
24	16.40		17.14		0.49	0.61	0.12	
25	15.79		16.65		0.50	0.62	0.12	
26	15.17		16.20		0.45	0.60	0.15	
27	14.57		15.75		0.47	0.57	0.10	
28	14.00		15.29		0.44	0.54	0.10	
29	13.46		14.85		0.44	0.56	0.12	
30	12.90.		14.41		0.49	0.65	0.16	
31	12.25		13.92					

Note : (4)* & (1) = Previous Days Reading — Daily Average DP = 1.2mm

(4) & (1) = Following Days Reading — Daily average ETcrop = 4.65 mm

Table 8. Observed Deep Percolation for Wetland Paddy in the Study Area

Canal : **C-188** Month : **November**

Date	Tank Reading cm				ET	ET & DP	DP	Rainfall
	Open Bottom		Closed Bottom		in cm	in cm	Reading	in com
	Initial (1)	Reset (2)	Initial (3)	Reset (4)	(4)*-(4) (5)	(1)*-(1) (6)	in cm (6)-(7)	
1								
2	13.70		17.00		0.55	0.70	0.20	
3	13.00		16.45		0.45	0.70	0.15	
4	12.40		16.04		0.40	0.60	0.15	
5	11.90		16.60		0.40	0.50	0.10	
6	11.35		16.20		0.45	0.55	0.15	
7	11.10		16.10		0.40	0.60	0.15	2.80
8		13.30		18.50	0.40	0.50	0.10	
9	12.80		18.10		0.35	0.60	0.15	
10	12.20		17.75		0.35	0.50	0.20	
11	11.70		17.40		0.35	0.50	0.15	
12	11.20		17.05		0.40	0.50	0.15	
13	10.70		16.65		0.50	0.60	0.20	
14	10.10		16.15		0.50	0.70	0.20	
15	9.40		15.65		0.40	0.60	0.10	
16	8.80		15.25		0.46	0.62	0.12	
17		16.00		21.99	0.47	0.59	0.12	
18	15.41		21.52		0.44	0.57	0.13	
19	14.84		21.08		0.47	0.63	0.16	
20	14.21		20.61		0.43	0.54	0.11	
21	13.67		20.18		0.45	0.58	0.13	
22	13.09		19.73		0.48	0.64	0.16	
23	12.45		19.25		0.50	0.65	0.15	
24	11.80		18.75		0.50	0.66	0.16	
25	11.14		18.25					

Note : (4)* & (1) = Previous Days Reading Daily average ETcrop=5 mm

(4) & (1) = Following Days Reading Daily Average DP = 1.6 mm

7.2 cm of water was applied as irrigation on November 17, 1995

Table 9. Computation of Reference crop Evapotranspiration (Eto) by Pan Evaporation Method

Week after planting	8th	9th	10th	11th	12th	13th	14th	15th	16th
Pan Evap. (mm/day	4.70	4.90	4.60	4.80	4.60	4.50	4.80	4.60	4.40
Pan Co-efficient	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Eto (mm/day)	3.76	3.92	3.68	3.84	3.68	3.60	3.84	3.68	3.52
Crop CO-effi. (Kc)	1.16	1.16	1.16	1.25	1.30	1.32	1.32	1.32	1.24
Etcrop (mm/day)	4.36	4.55	4.27	4.80	4.78	4.75	5.07	4.86	4.36

Table 10. Comparison of Computed Etcrop with Measured Etcrop

Week after planting	8th	9th	10th	11th	12th	13th	14th	15th	16th
Computed Etcrop by Pan Evaporation	4.36	4.55	4.27	4.80	4.78	4.75	5.07	4.86	4.36
Computed Etcrop by Penman-Monteith	4.03	4.12	4.80	4.09	3.96	3.81	3.72	3.65	3.58
Measured Etcrop		4.80	4.78	4.78	4.58	4.85	5.47	5.40	4.57

Table 11. Water Use Efficiency of Thabua Irrigation Projcet during the Wet Season

Location : **C-102**

Week after planting	Irrigation Water Applied, mm	Effective Rainfall mm/week	D P mm/week	Etcrop mm/week	Weekly WUE (%)
9	60.00	30.30	9.52	33.75	21.75
10	0.00	7.10	10.15	32.40	na
11	0.00	55.00	10.13	33.55	na
12	45.00	0.00	8.85	32.05	90.88
13	0.00	28.00	9.20	33.95	na
14	0.00	0.00	8.70	38.35	na
15	50.00	0.00	8.45	37.80	92.5
16	0.00	0.00	9.40	32.00	na

Location : **C-102**

Week after planting	Irrigation Water Applied, mm	Effective Rainfall mm/week	Dp mm/week	Etcrop mm/week	Weekly WUE (%)
9	0.00	30.30	8.05	31.25	na
10	0.00	7.10	8.55	32.10	na
11	48.00	55.00	9.00	31.55	30.10
12	0.00	0.00	8.80	28.35	na
13	49.60	28.00	8.54	32.50	26.29
14	0.00	0.00	9.50	30.50	na
15	72.00	0.00	10.30	32.40	59.30
16	0.00	0.00	10.00	33.10	na

*na=not applicable

CONCLUSIONS & RECOMMENDATIONS

Deep percolation rate observed from the study varied from 1.3 to 1.6 mm/day which is almost similar to the reported percolation rate of 1.20 mm/day at Mae klong irrigation project of similar soil texture Tawee (1985). Due to the heavy textured soil in the study area, the seepage and percolation rates were comparatively lower.

The average weekly water use efficiency was found to be 51% which is comparatively higher than the previous results reported by Sompong (1983). Due to the sufficient storage of water in the paddy fields from the residual floodwater and heavy rainfalls during the wet season, farmers did not irrigate their fields at a regular interval during the study period. Due to this reason, the water use efficiency was higher.

The ET_{crop} for paddy fields, which was measured directly by lysimeter tanks, varied from 4.30 to 5.0 mm/day depending upon the crop growth stages. This was comparable with the results found from various literatures and research reports for wetland paddy. The measured ET_{crop} was closer to the values computed by Pan-evaporation method but it was higher than those calculated by Penman-Monteith method.

The water use efficiency of the project can be increased by the regulation of proper irrigation scheduling at the farm level by RID staff. The extension workers may train farmers optimum water use in paddy field.

Because of the abnormal climatic situation in the wet season, the water use efficiency should be studied further under normal situation for fruitful recommendations. The water use efficiency should be studied further in more representative areas during the wet as well as the dry season to have the overall WUE of Thabua irrigation project.

REFERENCES

BOONSANG (1988), "Evaluation of Dry Season Irrigation Performance in Mae Klong Irrigation Project", M. Engg. Thesis, AIT, Bangkok Thailand.

DOORENBOS, J. and Pruiti, W.O. (1977), Guidelines for Predicting Crop Water Requirements, FAO Irrigation and Drainage Paper, Vol. 24, Rome, Itally.

Irri , (1993.) Rice Research in a time of change. IRRI's Medium- Term Plan for 1994-1998. International Rice Research Institute, Los Banos, Philippines, pp-79.

Oberez, A. T. (1992), "Performance Evaluation of Thabua Irrigation Systems, Phitsanulok, Thailand", M. Engg. Thesis, AIT, Bangkok, Thailand.

Odhiambo, O. (1994), "Modeling Water Balance Components in Relation to Field Lay Out in Low Land Paddy Fields", Ph. D. Dissertation, AIT, Bangkok, Thailand.

Pathak, M.D and Çomej, K.A. (1991), Rice Production trends in selected Asian Countries. IRRI Research papers-147, International Rice Research Institute, Losbanos, Phillippines.

Sarnsomboon , N. S. (1965), Handbook for Irrigated Agriculture (in Thai Rongruang Press, Bangkok, Thailnd.

Ullah, M.E. (1979), "Irrigation Efficiency Evaluation of Lam Pao Project", M. Engg. Thesis, AIT, Bangkok, Thailand.

WICKHAM, T. (1974), "Water Management in the Humid Tropic on Farm Level Analysis." Ph. D Thesis, Graduate School, Cornel University, U.S.A.