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EVAPOTRANSPIRATION REQUIREMENT OF RICE AT MAPALANA IN THE WET ZONE OF SOUTHERN SRI LANKA

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Abstract : A lysimeter experiment was conducted at the Mapalana Research Farm in order to estimate the evapotranspiration (ET) demand of rice in the southern wet zone. The measured values of ET were compared with pan evaporation (EP). The impact of meteorological factors on ET and EP of rice fields were assessed by the multiple regression method. The ET rate of rice varied in the range of 2–15 mm/day. The ET/EP ratio was almost one at transplanting reaching 1.9 at heading stage. The average ET/EP ratio for the entire growth period was 1.39. It was revealed that wind is the most decisive factor governing ET and EP from rice fields.

1. Introduction

Water requirement of a vegetation is generally expressed as a function of the climate, soil and the plant. Hence, the amount of water needed by the crop varies between species, in different locations and seasons.

Rice needs more water to sustain life than most other crops owing to its semi-aquatic nature. Its evapotranspiration rate is about 3 – 4 mm/day during the initial vegetative stages and 5 – 7 mm/day during reproductive to the medium dough stages.[2,5,6] The average evapotranspiration rate in rice growing areas of Asia is about 4 – 9 mm/day.[8]

There are many reports indicating that the highest evapotranspiration rate of rice is at maximum tillering stage or at heading stage.[5,6] It is evident in many locations of South East Asia that the transpiration rate of rice increases consistantly up to the heading stage and then declines.[6] Nevertheless there are deviations from this general trend. For instance, some workers have observed the maximum rates at the tillering stage followed by an almost constant but lower rate in later stages.[4]

Research on water balance studies of rice in Sri Lanka is mostly restricted to the dry zone of the country.[1] Therefore the objective of the present research was to find the average and peak period consumption of water by rice in the Southern wet zone of the Matara District. The influence of climatological factors on evaporation and evapotranspiration from the rice field is also discussed.

2. Materials and Methods

The experiment was conducted at the University Research Farm, Mapalana, Matara District, during the Yala season (31st May–15th October) 1987.

Mapalana is located in the Agro-ecological region WL2 (Low country wet zone); the rainfall distribution of the area is typically biomodal with an annual precipitation of about 2385 mm. 864 mm of rain is received during April – August and 911 mm in October – January. This constitutes 36.2% and 38.2% of the annual rainfall respectively. The mean air temperature is fairly uniform at around 28^{o}C throughout the year. The relative humidity is usually higher in March – July and lower in January and February. The average relative humidity of the location is about 71.6%.

The predominant soils of the area are Red yellow podzolic soils with strongly mottled subsoils and low humic gley soils.

Plastic containers with closed bottoms (42 cm in height; 40 and 34 cm in diameter at the top and bottom ends) were used in the field lysimeter experiment. The containers were filled with 30 kg of soil taken from a paddy field and buried in the same field.

The soil taken for the experiment is sandy clay loam (clay 24%; silt 16%; and sand 60%), slightly acidic (pH 5.6) with 2.5% of organic matter.

The set up of the lysimeter tanks was a complete randomized block layout with 3 replications. Water losses from the lysimeters were studied under 3 levels of submergence (2.5, 5.0, 10.0 cm.).

Evapotranspiration and evaporation losses from the containers cropped with rice (variety BG 379/2) and bare soil were measured daily using a hook gauge. Three separate tanks were used to measure the evaporation from free water surface. Water level was readjusted to the required depth by adding water daily. Soil temperature of the containers were recorded daily in the morning and afternoon. Phenological observations were conducted weekly to record the growth differences of the plants.

All containers were kept weeded to avoid excess evapotranspiration losses. Basic fertilizer mixture (N:P:K: –5:15:15) was added at the rate of 250 kg/ha. A top dressing of urea was added to the containers at a rate of 23 kg/ha at tillering stage. Second top dressing was given (N:P:K –25:0:17) at the rate of 95 kg/ha at the flowering stage.

Measured evaporation and evapotranspiration data were correlated with the observed meteorological data viz. relative humidity, wind speed, air temperature and dew point temperature. The combined effect of meteorological factors on evaporation and evapotranspiration was assessed by the multiple regression method.

3. Results and Discussion

The evapotranspiration demand of transplanted rice varied from 2–15 mm/day (Figure 1). The total evapotranspiration demand for the season was 515, 513, 549 mm. for 2.5, 5.0 and 10.0 cm. submergence levels respectively. This consumption was for the entire growth period excluding the first two weeks in the nursery and the last two weeks prior to harvest. Evapotranspiration rate increased with the increasing depth of submergence. However, the evapotranspiration rates at different levels of submergence appear to be not significant.

In the first, 20 days of growth, evapotranspiration rate was slightly higher compared to the evaporation from bare soil or free water surface (Figure 1). The evapotranspiration gradually increased after 20 days from transplanting, which is probably associated with the growth and development of the assimilatory surface.

Evapotranspiration had a highly significant relationship ($r = 0.93$) with evaporation during the initial stages (up to 30 days from transplanting) and also in the later stages, ($r = 0.89$) (ie. after 80–105 days from transplanting) However, in the middle of the growing season (30–80 days from transplanting)the correlation between evaporation and evapotranspiration was low ($r = 0.35$). This may be due to the high transpiration rate coinciding with larger leaf area.

The ET/EP ratio was almost 01 at transplanting, reaching 1.9 between 40 – 50 days from transplanting (Figure 2). The average ET/EP ratio for the entire period of growth was 1.39.

Rice had two maxima of evapotranspiration in the tillering and heading stages (Figure 1). According to Kung et al. and Grist,[3,4] the rice crop is in great need of water during the maximum tiller number stage and in the heading stage. Nevertheless in most of the experiments the rate of evapotranspiration observed at heading was much greater than the rate at maximum tillering stage.[6] As reported in Thailand[4] rice may have higher peak rate at tillering stage.

The differences of peak rates at tillering and heading phases may be associated with the morphological characteristics of the variety, such as medium to high tillering capacity accompanied with thick erect leaves and lodging resistance. The peak demand of water on the 6th and 7th weeks may

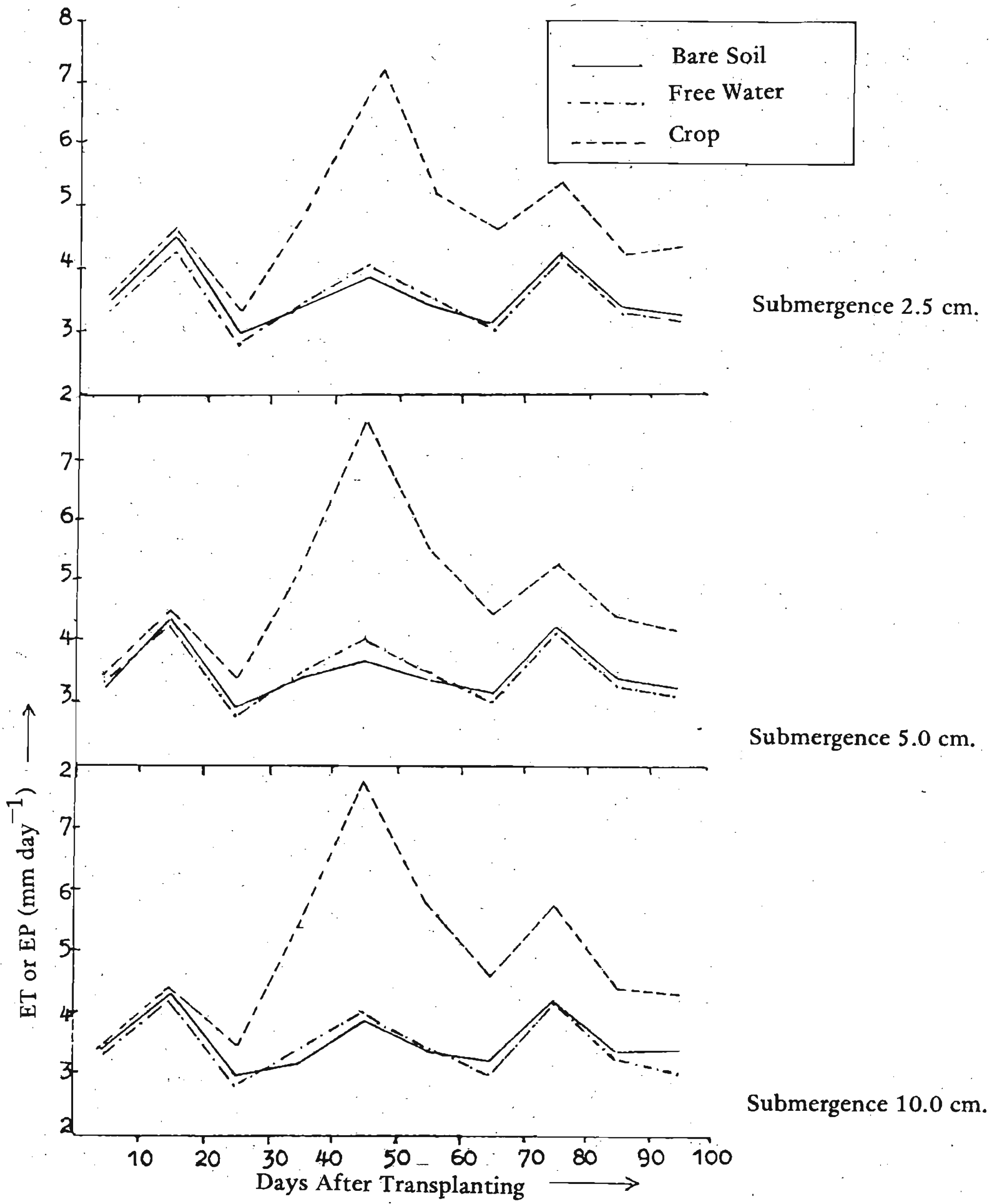

Figure 1. Water losses from the free water surface, bare soil and the cropped soil at various levels of submergence.

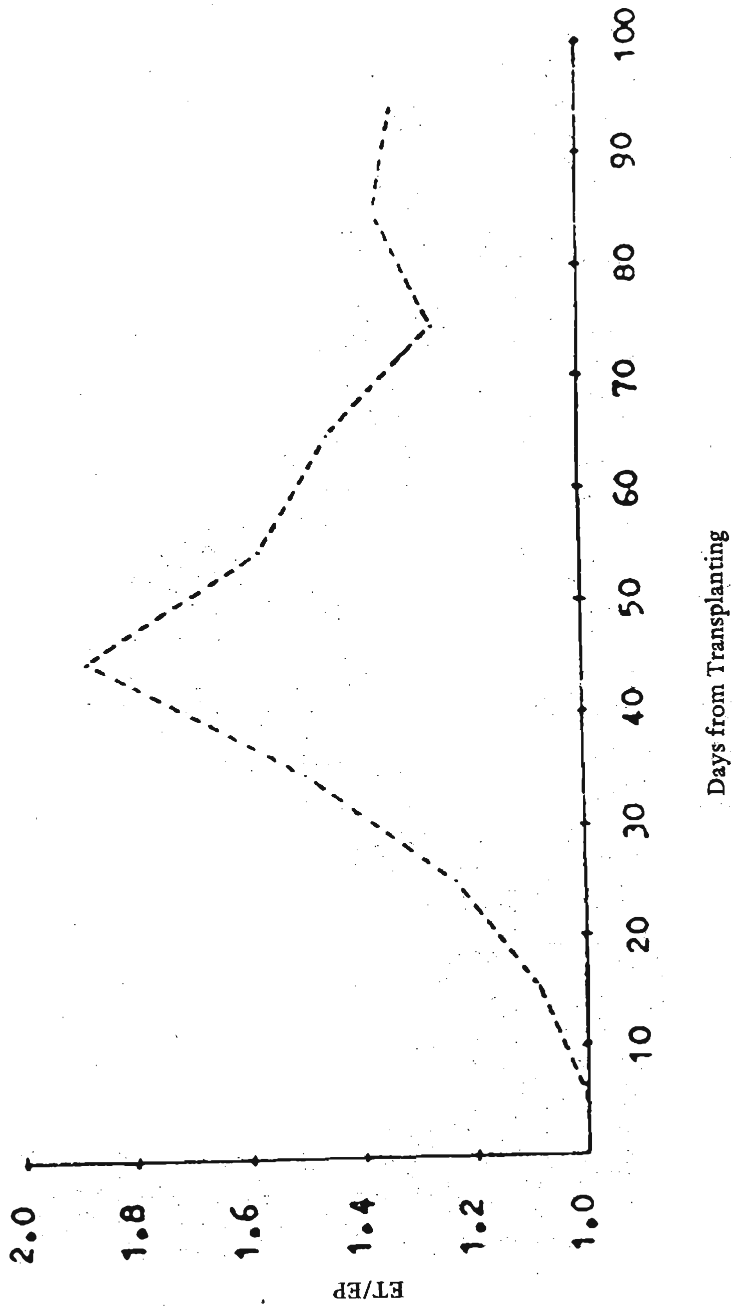

Figure 2. Evapotranspiration to Evaporation Ratios of Paddy

be associated with the existing meteorological conditions (high wind speed and temperature) and development of tillers and rapid increase in leaf area after the 2nd application of fertilizer late in the 4th week.

Evaporation of water from the bare soil and free water surface in lysimeters were similar. The evaporation from the bare soil was maximum when the level of submergence was 10.0 cm. (Figure 1). The evaporation from the free water surface and bare soil had a correlation of 0.95, 0.94 and 0.91 for the respective submergence levels of 2.5, 5.0 and 10.0 cm.

The recorded values of the class A pan evaporation by the meteorological station were high compared to the evaporation from the free water surface, of the lysimeters (Figure 3). This may be due to the high humidity in the paddy fields. The correlation between measured values of class A pan evaporation and the evaporation from lysimeter tanks were high (r = 0.92), the regression equation for these two variables could be given as,
EW= 0.808 EP + 0.317
(EW = Evaporation from rice fields mm/day,
EP = Pan evaporation mm/day).

The effect of different meteorological factors such as air temperature; dew point temperature; wind speed and relative humidity on evaporation and evapotranspiration is indicated by the correlation coefficients (Table 1).

Table 1. Possible correlations of meteorological factors on evaporation and evapotranspiration.

Meteorological factor	Pan evaporation (EP) (mm/day)	Evapotranspiration (ET) rate of rice (mm/day)
Air temperature (X2) C	0.5513*	0.3959*
Dew point temperature (X3) C	0.1805	0.4565*
Wind speed (X4) m/s	0.8547*	0.6879*
Relative humidity % (X5)	0.2272	0.1322

It is apparent that wind is highly correlated with pan evaporation and the evapotranspiration rate of the rice fields. The correlation between air temperature and pan evaporation is also significant.

The analysis of variance of meteorological factors on evaporation (EP) and evapotranspiration (ET) as regressions are given in the Tables 2(a) and

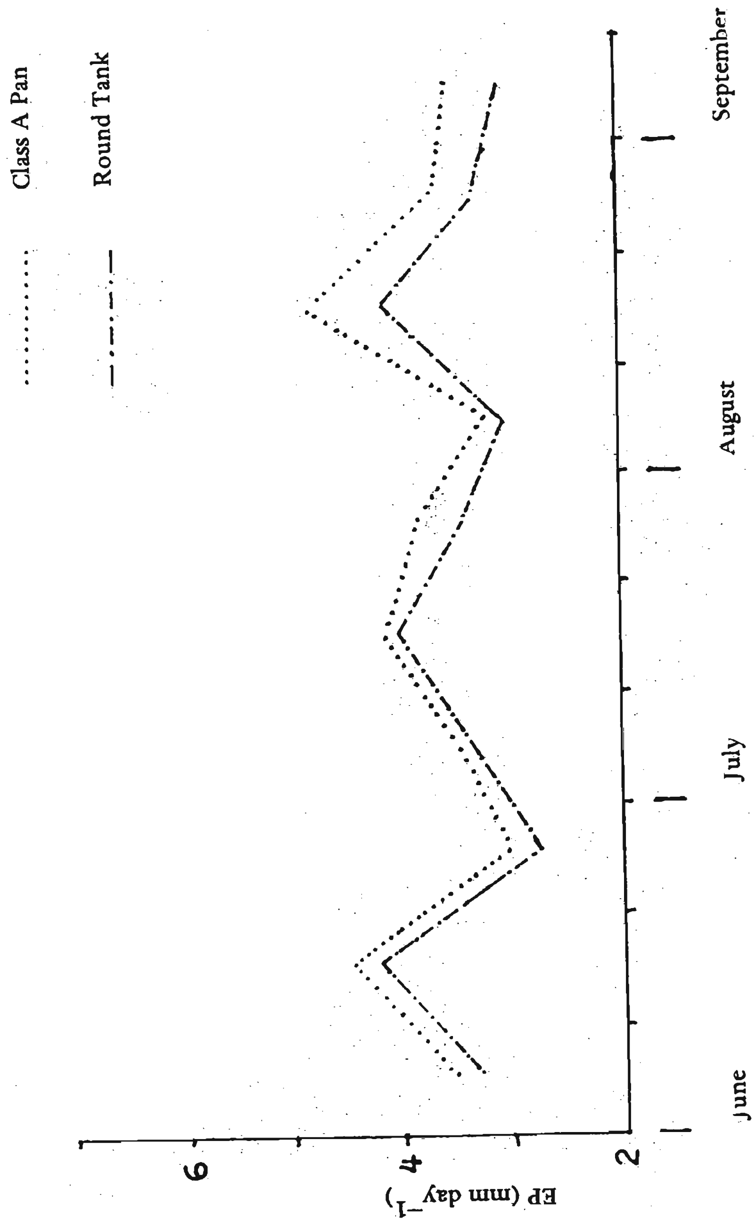

Figure 3. 10 Day Averages of Evaporation from the Class A Pan and the Lysimeters

2 (b). It is clear that the impact of wind wind on evaporation or evapotranspiration is highly significant whether or not air temperature, relative humidity or dew point temperature have an effect on it. Thus it was revealed that wind is the most decisive factor governing pan evaporation and evapotranspiration from rice fields.

Table 2 (a). Analysis of variance of the different meteorological factors over the evaporation.

Source of variance	S.S.	D.F.	M.S.	F. Value
Regression of X2 X3 X4 X5	59.129	4	14.782	31.7*
X3 X4 X5 ignoring X2	58.577	3	19.526	41.7*
X4 X5 ignoring X2 X3	58.537	2	29.268	63.75*
X4 ignoring X2 X3 X5	58.528	1	58.528	130.15*
X5 ignoring X2 X3 X4	4.135	1	4.135	2.012
X3 ignoring X2 X4 X5	2.609	1	2.609	1.016
X2 ignoring X3 X4 X5	24.350	1	24.350	20.96*
X2 assuming X3 X4 X5	0.5527	1	0.5527	1.185
X3 assuming X4 X5 ignoring X2	0.04	1	0.04	0.08
Effect of X5 when X4	0.0082	1	0.0082	0.017
Effect of X4 when X5 in the model	54.4	1	54.4	116.6*
Error	20.984	45	0.466	–
Total	80.113	49		

X2 – air temperature C^{O}

X3 – dew point t^{O}

X4 – wind speed m/s

X5 – relative humidity %

Table 2 (b). Analysis of variance of the different meteorological factors over the evapotranspiration.

Source of variance	S.S.	D.F.	M.S.	F. value
Regression of X2 X3 X4 X5	167.478	4	41.869	15.877*
X2 X3 X5 ignoring X4	96.796	3	32.265	7.838*
X3 X4 X5 ignoring X2	167.409	3	55.803	21.619*
X2 X4 X5 ignoring X3	136.017	3	45.339	13.892*
X2 X3 X4 ignoring X5	167.382	3	55.79	21.61*
X4 X5 ignoring X2 X3	135.961	2	67.981	21.274*
X2 X3 ignoring X4 X5	95.53	2	47.768	11.778*
X5 ignoring X2 X3 X4	4.99	1	4.99	0.854*
X2 X5 ignoring X3 X4	45.384	2	22.692	4.43*
X3 X4 ignoring X2 X5	167.478	2	83.739	33.094*
X4 ignoring X2 X3 X5	135.401	1	135.401	43.114*
X2 ignoring X3 X4 X5	44.839	1	44.839	8.919*
X3 ignoring X2 X4 X5	59.625	1	59.625	12.635*
X2 assuming X3 X4 X5	0.069	1	0.069	0.026
X5 assuming X2 X3 X4	0.096	1	0.096	0.048
X3 assuming X2 X4 X5	31.461	1	31.461	11.93*
X4 assuming X2 X3 X5	70.68	1	70.68	26.803*
Effect of X3 when X4 in the model	32.077	1	32.077	2.63
Effect of X4 when X3 in the model	107.853	1	107.853	40.89*
Error	118.668	45	2.637	—
Total	286.146	49		

The regression lines for evaporation (EP) and evapotranspiration (ET) when wind speed (X4) is included to the regression models would be,

EP = 1.4676 + 0.7734 X4 and
ET = 2.4857 X4 – 2.9853
(EP and ET; (mm/day), X4; (m/s) respectively.

These regression lines would be a useful tool in estimating Evaporation (EP), and Evapotranspiration (ET), from the rice fields at Mapalana.

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