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Evapotranspiration Studies on Rice in Relation to Water Use Efficiency

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ABSTRACT

STUDIES on evapotranspiration (ET) for rice were conducted in lysimeters and in the field. The daily ET varied from 3.6 to 10.9 mm/day for a spring crop, from 3.3 to 11.7 mm/day for a summer crop, and from 1.8 to 7.6 mm/day for a fall crop. The mean daily ET values were 6.5, 6.8 and 4.5 mm/day for spring, summer, and fall crops, respectively. Total ET varied from 740 to 880 mm, 610 to 840 mm, and 400 to 500 mm for spring, summer, and fall crops, respectively. The mean total ET values were 800, 740 and 450 mm for spring, summer, and fall crops, respectively. From 759 to 1150 kg with a mean of 875 kg of water was required to produce 1 kg of rough rice grain.

INTRODUCTION

Organic soils in the Everglades Agricultural Area (EAA) are subsiding at an average rate of 2.5 cm/yr. Microbial oxidation is the principle cause of subsidence. The oxidation rate can be reduced if water tables are maintained at a high level or if flooding is practiced. Previous investigations have indicated that there is a linear relation between subsidence rate and water table depth (Stephens, 1969). However, high water tables may not be compatible with efficient production of most cultivated crops that are presently grown. Previous studies have shown that rice can be grown on flooded organic soils in the Everglades (Green, 1953; Alvarez et al, 1978). Other investigations established that rice can be grown throughout the season in a flood state (Adair and Engler, 1955; Bhuiyan and Sumayao, 1978).

Production of rice in the EAA will help in reducing subsidence because this crop can be kept flooded from just after emergence until harvest. It fits well as a summer crop in the existing sugarcane-vegetable production system. However, rice also can be grown in the spring and fall seasons. In 1977, about 100 ha of rice were seeded in the EAA by one grower and 3000 ha were seeded by eight growers in 1980. Despite the increase in rice production, the information on water needs for rice crop is very scanty. Consequently, the South Florida Water Management District (SFWMD) and Institute of Food and Agricultural Sciences (IFAS), University of Florida, initiated a joint project in 1979 to study the water requirement and water use efficiency for rice production in EAA. The specific objectives of this study were:

1 to measure evapotranspiration (ET) of rice in both lysimeter and field studies;

2 to compare weekly and total ET requirements for rice production in spring, summer, and fall seasons; and

3 to compute the water use efficiency for rice production in the EAA, i.e., the amount of water required to produce 1 kg of grain.

MATERIALS AND METHODS

Experimental Site Description

A. Lysimeter Site

The system at this site consisted of two types of lysimeters, i.e. concrete lysimeters and metal drum lysimeters. The lysimeters were surrounded by St. Augustine grass *(Stenotaphrum secundatum)* in 1979. In 1980, three rows of sugarcane (Saccharum spp.), about 4.5 m wide, were grown around the lysimeter site to minimize the oasis effect. A tipping bucket type of rain gauge was installed at the site.

Concrete Lysimeters: Nine reinforced concrete tanks 183 cm by 122 cm in area and 122 cm in depth were installed at the University of Florida, Agricultural Research and Education Center (AREC) located at Belle Glade. To facilitate drainage, the tanks were installed 67 cm into the ground with about 55 cm protruding above the ground surface. The lysimeters were placed with Pahokee muck *(Lithic Medisaprist)* in layers. The soil was subjected to three wetting-drying cycles to permit any settling of the material. The bulk density of the top layer (30 cm), which was determined from four core samples in each lysimeter, was about 0.3 g/cm³. Six lysimeters were used to grow rice and the remaining three were flooded with no rice.

Lysimeter Drums: Six metal drums were used. These drum halves were 46 cm deep and 57 cm in diameter. Four drums called as lysimeter drums at ground level which were installed adjacent to the concrete lysimeters about 25 cm deep and 21 cm above ground. The other two drums called as lysimeter drums at raised level which were set on a raised platform so their top surface was at the same height as those of the concrete lysimeters. The drums were filled with Pahokee muck to approximately 18 cm below the rim. The soil was subjected to three wetting-drying cycles and the bulk density of the soil which was determined from two core samples in each drum was about 0.25 to 0.3 g/cm³. Two lysimeter drums at ground level were flooded with no rice and the remaining four were used to grow rice.

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B. Field Site

Evapotranspiration studies for rice under field conditions were also conducted in a field of Pahokee muck at the AREC, at a location about 1,200 m away from the lysimeter site. The metal drums system was used to monitor the ET and grain yield in the field site. The metal drums were surrounded by about 1 ha of rice field to minimize the oasis effect. Nine metal drums (46 cm deep and 57 cm diameter) were installed in the rice fields. They were buried about 25 cm into the ground with 21 cm left above the ground surface. Surface organic soil excavated from the site was filled back into the drum. The packed soil was subjected to three wetting-drying cycles. Bulk density of the packed soil which was determined from two core samples in each drum was 0.25 to 0.3 g/cm^3. A tipping bucket type of rain gauge was installed at the field site also. Seven drums were used to grow rice and the remaining two were flooded with no rice.

Cropping System

Rice ET and grain yield studies were conducted in the concrete lysimeter and metal drums in 1979 and 1980 using the cultivar 'Lebonnet.' Two important aspects involved in the cropping system were planting methods and growth seasons.

A. Planting Methods

Two general methods of seeding and irrigating rice are practiced in the United States. One is to drill the seed in the soil; submergence follows. The other is to broadcast the seed in the water (Adair and Engler, 1955). In this study, the planting method used in the field surrounding the field drums consisted of seeding by a drill seeder at the rate of 100 kg/ha. The water table was maintained about 45 cm below the ground surface to induce germination. The field was flooded when plants had grown about 5 cm tall. Water level in the field was maintained 5 to 8 cm above the soil surface.

The planting method used in concrete lysimeters and metal drums was either transplanting or direct seeding by hand. The transplanting method is not a common practice in the United States. The reason for using the transplanting method was to study the effect of rice age on evapotranspiration during summer season. As mentioned earlier, the rice fits well in the EAA as a summer crop in the existing sugarcane-vegetable production system. However, the concrete lysimeter set up was used not only for growing rice in the summer but also used for raising winter vegetables in other seasons. Transplanting of rice was done at different dates during the summer season. One month old seedlings were transplanted at intervals of 2.5 cm within the row and 25.4 cm between the rows, and about 2.5 cm deep. The transplanting method was not used in other seasons (spring and fall). In the case of direct seeding, a spacing of 1.3 cm within the row and the same 25.4 cm between the rows was used. The seed was drilled about 2.5 cm deep and water was sprinkled to induce germination. The amount of water added was recorded. The direct seeded plots were flooded when plants had grown about 5 cm tall. The transplanted ones were flooded right after the transplanting because these plants were taken from the seeded field that was already flooded. Water level was maintained 5 to 8 cm above the soil surface.

B. Growth Seasons

As mentioned above, the main growth season for rice in the EAA is the summer. However, the rice can also be grown in spring and fall seasons if the field and water are available. Therefore, three seasons of spring, summer, and fall crops as shown in Table 1 were included in this study. A total of 12 planting combinations was undertaken during 1979 and 1980, i.e. three in spring, six in summer and three in fall. Details on number of replications and flooding periods are also listed in Table 1. The

TABLE 1. FLOODING PERIODS AND RANGE, MEAN AND STANDARD DEVIATION OF THE AVERAGE DAILY EVAPOTRANSPIRATION (ET) FOR EACH WEEK.

Season crop	Site	Year	Type of planting	Flooding period date	Flooding period period	No. of Replications	Daily ET Range	Daily ET Mean	Daily ET Std. dev.
					----day----		---------- mm/day		----------
	L.D.	1980	D.S.-G	3/28-7/7	101	2	3.6-10.9	7.2	2.4
Spring			D.S.-R	3/28-7/7	101	2	3.8-10.9	8.3	2.4
	F.D.	1980	D.S.	3/28-7/7	101	2	4.8-8.6	6.8	1.1
	C.L.	1979	T.P.	5/22-8/9	79	3	3.3-11.7	8.4	2.7
			D.S.	6/4-9/6	96	3	4.8-11.7	8.5	2.2
Summer	C.L.	1980	T.P.	7/7-9/16	71	3	4.1-10.7	7.3	2.3
	L.D.	1979	T.P.-G	7/20-10/11	83	2	4.8-10.2	8.3	1.5
			T.P.-R	7/20-10/11	83	2	4.8-11.2	8.2	1.8
	F.D.	1979	T.P.	7/20-10/11	83	2	3.3-7.9	5.8	1.3
	L.D.	1980	D.S.-G	9/2-11/17	76	2	1.8-5.3	4.3	1.2
Fall			D.S.-R	9/2-11/17	76	2	1.8-7.6	5.6	1.9
	F.D.	1980	D.S.	9/2-11/17	76	3	1.8-6.4	4.9	1.7

L.D. = Lysimeter drum
F.D. = Field drum
C.L. = Concrete lysimeter
D.S. = Direct seeded plot
T.P. = Transplanted plot
D.S.-G = Direct seeded plot with L.D. at ground level
D.S.-R = Direct seeded plot with L.D. at raised level
T.P.-G = Transplanted plot with L.D. at ground level
T.P.-R = Transplanted plot with L.D. at raised level

TABLE 2. TOTAL WATER REQUIREMENT, THE AVERAGE DAILY EVAPOTRANSPIRATION (ET) IN ENTIRE GROWTH PERIOD, AND WATER-TO-GRAIN YIELD RATIOS.

Season crop	Site	Year	Type of planting	Growth period date	Growth period period	No. of Replications	ET Flooding	ET Growth period Total	ET Growth period Ave	Water-to-grain yields ratios
					-- day --		------- mm	---	mm/day --	---- kg/kg ---
Spring	L.D.	1980	D.S.-G	3/6-7/7	123	2	740	776	6.3	828
			D.S.-R	3/6-7/7	123	2	843	880	7.2	889
	F.D.	1980	D.S.	3/6-7/7	123	2	699	736	6.0	784
Summer	C.L.	1979	T.P.	4/22-8/9	109	3	897	796	7.3	746
			D.S.	5/20-9/6	109	3	809	838	7.7	744
		1980	T.P.	6/7-9/16	101	3	538	616	6.1	993
	L.D.	1979	T.P.-G	6/20-10/11	113	2	695	813	7.2	N.D.
			T.P.-R	6/20-10/11	113	2	657	774	6.8	N.D.
	F.D.	1979	T.P.	6/20-10/11	113	2	493	610	5.4	N.D.
Fall	L.D.	1980	D.S.-G	8/10-11/17	99	2	344	396	4.0	N.D.
			D.S.-R	8/10-11/17	99	2	451	502	5.1	N.D.
	F.D.	1980	D.S.	8/10-11/17	99	3	398	449	4.5	1147

The variables of L.D., F.D., C.L., D.S., T.P., D.S.-G, D.S.-R, T.P.-G, and T.P.-R are as defined in Table 1.
N.D. = No data.

growth periods are listed in Table 2. As Table 2 shows, the spring crop was planted on March 6, 1980 and harvested on July 7, whereas fall crop was planted on August 10, 1980 and harvested on November 17. However, the planting dates for summer crop varied from the end of April to the middle of June in accordance with the end of winter crop season and the availability of fallow sugarcane field. The details of the growth season are listed in Table 2.

Sampling Programs

Water loss in each concrete lysimeter and metal drums, and rainfall data were monitored at 8:00 a.m. daily except on weekends and holidays. When heavy rainfall occurred, measurements were also made over the weekend.

Grain in each concrete lysimeter and metal drum was hand harvested, and was air-dried for several days.

Oasis Effect Consideration

The lysimeters were located at a site with environmental conditions different from those of the field, and experiments at the lysimeter and field sites were not conducted simultaneously. To adjust for these differences, an intermediate parameter such as standard pan evaporation (i.e., Standard Class A National Weather Bureau Evaporation Pan) was used to establish a conversion factor. It needs to be noted that there could be a poor correlation between the calculated ET and the measured pan evaporation in some areas as indicated by Brown et al. (1978). However, Shih et al (1981) found that the measured pan evaporation is a quite applicable method for estimating the basinwide ET in south Florida. Therefore, the standard pan evaporation data taken at AREC was used in this study. The relationships used were:

$$a = SPE/PEL \quad [1]$$

$$b = SPE/PEF \quad [2]$$

where

SPE = standard pan evaporation

PEL = evaporation from uncropped drums in the lysimeter site

PEF = evaporation from uncropped drums in the field site

a,b = coefficients

The values of a and b were estimated from the experimental data gathered from both lysimeter and field sites and the weather station. The conversion factor (A) is:

$$A = a/b \quad [3]$$

If the A value equals 1, there is no location effect. This A value was used to normalize the ET data collected at the lysimeter site in relation to the ET observed in the field.

Evapotranspiration for Different Periods

Evapotranspiration estimates for rice production were based on two time intervals: (a) weekly and (b) the entire growth period. The weekly periods extended from Fridays through Thursdays.

The total ET for the entire growing season was estimated by two methods. For the direct seeded crops, the ET includes the irrigation water before flooding (ETDSI) and the water used after flooding (ETDSF). Therefore, the total ET for a direct seeded crop (ETDS) can be expressed as:

$$ETDS = ETDSI + ETDSF \quad [4]$$

For the transplanted crop, the ET before transplanting was estimated for a period of one month using a ratio (R) between ET obtained from the first month of the direct seeded crop (ETDST) and the same period of standard pan evaporation data (SPET), i.e.

$$R = ETDST/SPET \quad [5]$$

The ET before transplanting (ETTPB) was estimated by a relationship:

$$ETTPB = R \cdot (SPEBT) \quad [6]$$

where SPEBT is the standard pan evaporation during the month preceding the transplanting date. In this study, both transplanting and direct seeding were done on the same day. Thus, the SPEBT is for one month preceding the SPET.

The ET after transplanting (ETTPA) was recorded from the day the plant was transplanted. The total ET for transplanted crop (ETTP) was obtained as:

$$ETTP = ETTPB + ETTPA \quad [7]$$

Water and Yield Relations

The water-to-grain yield ratio is defined as the amount of water required to produce 1 kg of grain. The value was computed using the ET and grain yield data.

RESULTS AND DISCUSSION

Oasis Effect Estimation

Weekly free water surface evaporation and rainfall data for both sites and different growing periods were analyzed. Application of the evaporation data to the methods defined in equations [1] and [2] gave values of factor A as defined in equation [3]. The A values for the summer crop were 0.68 in 1979 and 0.78 in 1980. The higher ratio for A in 1980 implied that the location effect in 1980 was smaller than that in 1979. This was probably due to reduction of the location effect by growing sugarcane around the lysimeter site in 1980. This improvement could account for about 10 percent of oasis effect as compared with the natural field condition.

The A values for spring and fall crops in 1980 were calculated as 0.81 and 0.82, respectively. The values were slightly higher than that in summer crop.

Those computed A values were used to normalize the ET data gathered at the lysimeter site in relation to the ET observed in the field. The ET data of lysimeter site represent the normalized result hereafter. In other words, the ET data in both lysimeter and field site is referenced to a similar basis of environmental condition.

Weekly Evapotranspiration

The weekly ET data of the lysimeter site, and the field site data for different growing seasons were calculated as an average of daily ET in each week (ADW). The weekly ET was limited to the flooded period. Data before flooding will be discussed later. The standard pan evaporation data for the same period was also calculated as an average of daily evaporation in each week and the results are shown in Fig. 1 for the years 1979 and 1980.

The ADW values for spring crop, summer crop in concrete lysimeters, for summer crops in lysimeter and field drums, and fall crops are plotted in Figs. 2, 3, 4 and 5, respectively. Some observations can be made from those figures.

The ADW values in the spring crop increased steadily up to 10 weeks after flooding, and then leveled off for three to four weeks. The ET declined in the last two weeks before harvest (Fig. 2). The data shown in lysimeter drums and field drums have a similar pattern of ET. In this study, the direct seeded crops stayed in vegetative stage about 65-70, 55-60, and 45-50 days after planting in spring, summer, and fall seasons, respectively, and then entered the reproductive state (panicle differentiation stage). The crops were ready to be harvested about 55-60 days after panicle differentiation had occurred. Weekly ET for the spring crop generally increased with time until it reached a maximum and then declined. This

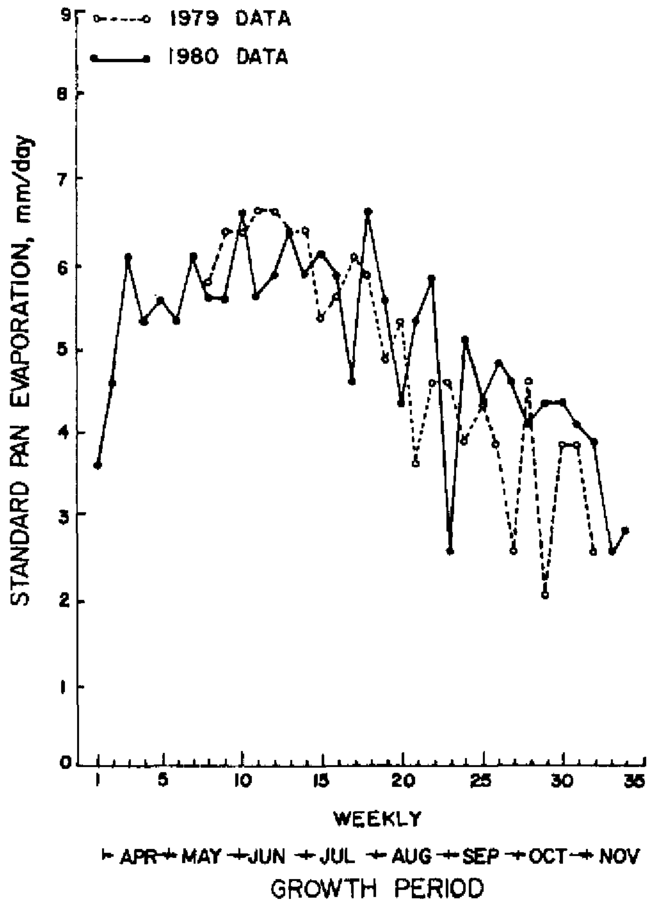

FIG. 1 The average daily standard pan evaporation for each week in relation to time.

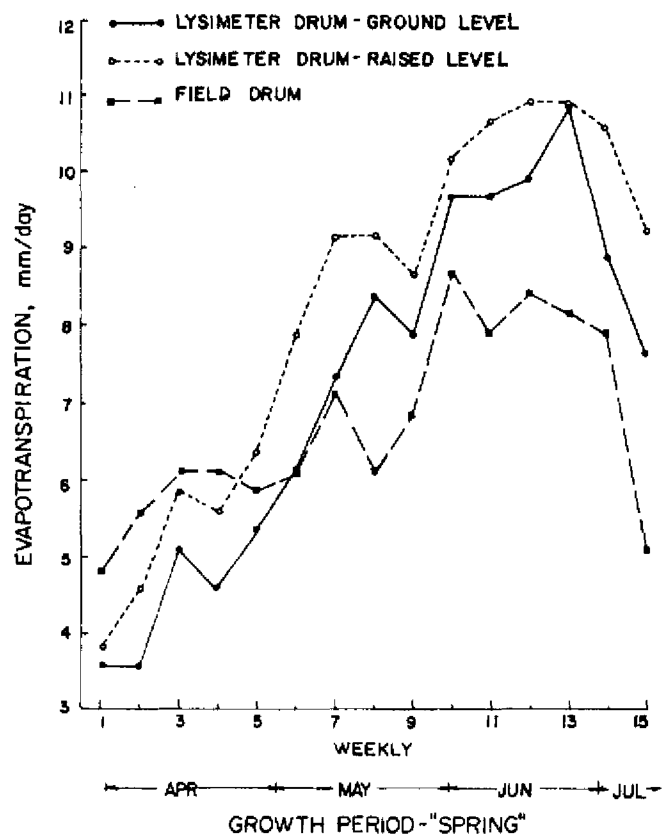

FIG. 2 The average daily evapotranspiration each week for spring direct seeding crop in both lysimeter and field drums in 1980.

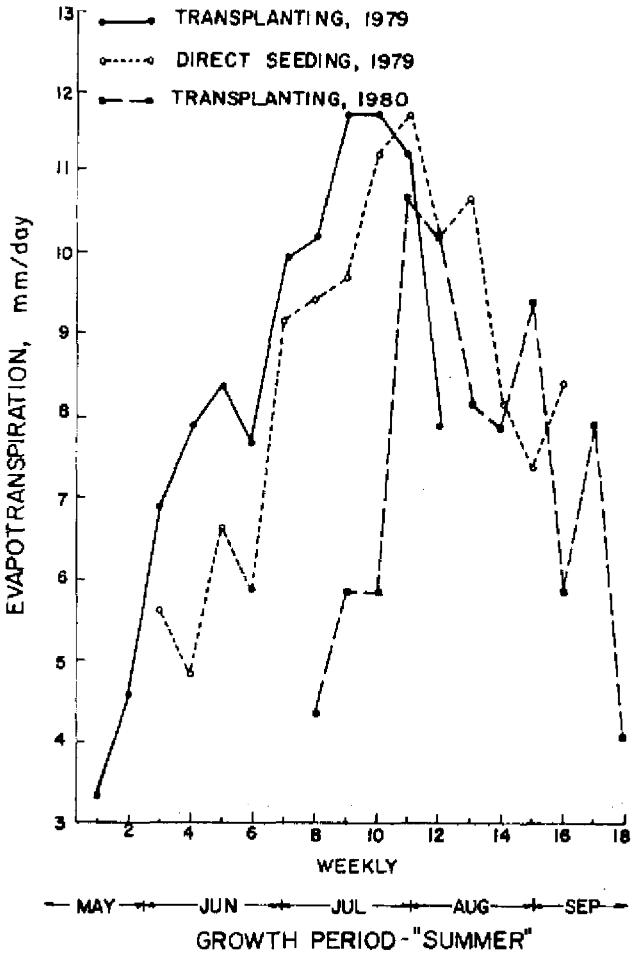

FIG. 3 The average daily evapotranspiration each week for summer crop in concrete lysimeter.

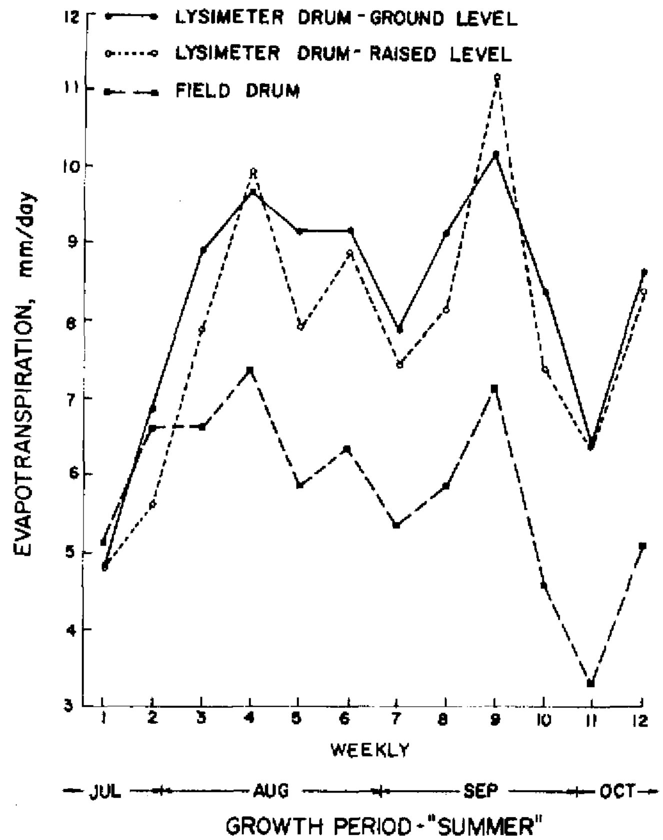

FIG. 4 The average daily evapotranspiration each week for summer transplanting crop in both lysimeter and field drums in 1979.

suggested that the ET was low during the vegetative stage, and then increased as the reproductive stage approached and remained high during flowering and fruiting stages. Flowering and fruiting periods require more water as reported by Yoshida (1979). Matsushima (1962) also observed that the rice crop is most sensitive to water stress from 20 days before heading to 10 days after heading. Hiler et al (1970) reported the susceptibility of a rice crop to water shortage during the reproductive and ripening phases period was about two times of that during the vegetative phase. The results of this study also showed that the ET during these critical stages was relatively larger than that in the vegetative stage.

The ADW values for the summer crop in concrete lysimeters as shown in Fig. 3, also followed a similar pattern as shown in Fig. 2 for the spring crop. The ADW values for the summer crop in the drum systems as shown in Fig. 4 were slightly different from others. This could be due to the climatic factors influencing the ET because the high ET period of the crop coincided with the low SPE period as shown in Fig. 1. Thus, the maximum water requirement might have leveled off.

The range, mean, and standard deviation of the ADW for spring, summer, and fall crops are given in Table 1. The ranges of ADW values ranged from 3.6 to 10.9 mm/day, 3.3 to 11.7 mm/day, and 1.8 to 7.6 mm/day for spring, summer, and fall crops, respectively. The mean values of ADW ranged from 6.8 to 8.3 mm/day, 5.8 to 8.5 mm/day, and 4.3 to 5.6 mm/day for the spring, summer, and fall crops, respectively. The devia-

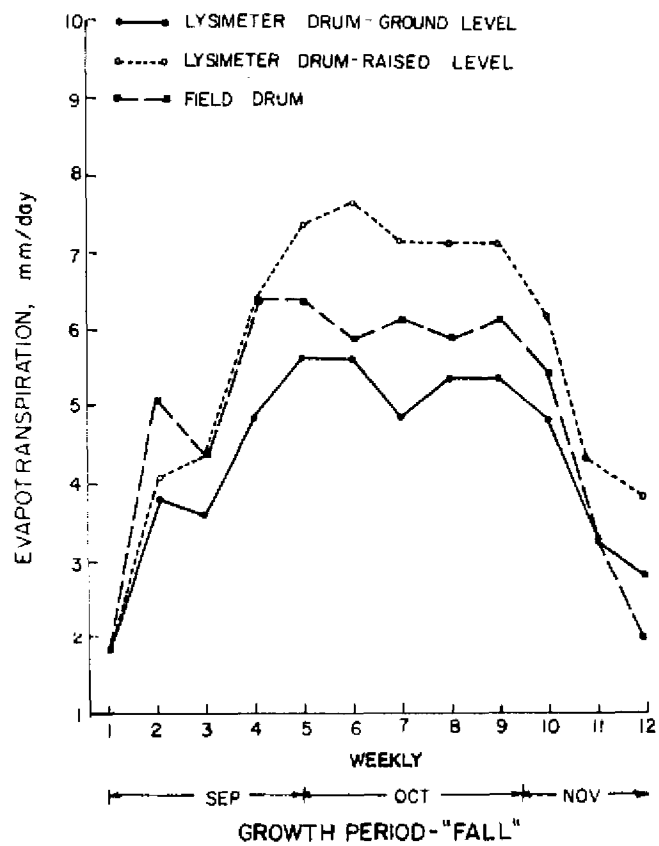

FIG. 5 The average daily evapotranspiration each week for fall direct seeding crop in both lysimeter and field drums in 1980.

tions of ranges and means for the summer crops are slightly larger than those in the spring crops. But, the deviations in the fall crops are much smaller than those in two other seasons. The standard deviations for ADW varied from 1.1 to 2.7 mm/day and were not much different among the three crop seasons.

Total Evapotranspiration

The total ET of the direct seeded crop (ETDS) was estimated based on the method defined in equation [4]. The amount of ETDS was obtained from the water used in irrigation before flooding. The value of ETDSF was obtained from the weekly ET data. The ETTPB was computed based on the method defined in equation [6], and the ETTPA was obtained from the weekly ET data. The ETTP was then computed based on the method defined in equation [7]. The values of ETDSF, ETDS, ETTPB and ETTP are listed in Table 2 for the three seasons' crop.

The average daily ET varied from 6.0 to 7.2 mm/day, 5.4 to 7.7 mm/day, and 4.0 to 5.1 mm/day for the spring, summer, and fall crops, respectively. The range of average daily ET for the spring crop was slightly smaller than that in the summer. But, the value for the fall crop was smaller than that from the other two seasons.

The total ET for three seasons varied from 400 mm for the fall crop to 880 mm for the spring crop. The total ET for different seasons varied from 740 to 880 mm, 610 to 840 mm, and 400 to 500 mm for the spring, summer, and fall crops, respectively. The average daily ET values were 6.5, 6.8 and 4.5 mm/day for spring, summer, and fall crops, respectively. The average total ET values were 800, 740, and 450 mm for spring, summer and fall crops, respectively. Although the average daily ET is slightly smaller in the spring crop than that in summer crop, the average total ET in spring crop is greater than that in summer crop. This could be because the spring crop had about 10 percent longer growth period than the summer crop. The total ET for the fall crop was reduced by about 35 percent as compared with the summer crop even though the two crops had a similar length of growth period.

The total ET values for spring and summer crops with 4-month growth period obtained in these studies are very close to those reported by others for similar growth periods. For instance, Bagadion et al (1978) from Philippines indicated that the total ET for rice crop with 4-month growth period was 813 mm. However, the ET value for a 5-month rice crop should be higher than these values. For example, Jones et al (1978) indicated that from 838 to 1143 mm of water was required to produce rice crop with 5-month growth period in southern states. Similarly, Miller et al (1980) reported that from 914 to 1016 mm of water was required for a 5-month rice crop in Sacramento Valley Area, CA with interspersed fields of fallow or stubble land. They also indicated that the ET would be 10 to 20 percent higher in areas of comparatively low humidity with considerable fallow or stubble land. Besides the growth period difference, the humidity in the Everglades is very high (the average relative humidity is about 80 percent) during the summer and the days are shorter than in the Sacramento Valley. Also during the wet summer season in the EAA, increased cloudiness would reduce the solar radiation. These factors would also lead to somewhat lower total ET values in Florida. The total ET for rice production in other states is slightly higher than that in this study. The average daily ET in Philippines was reported to be about 7 to 8 mm/day (Reyes, 1973). Furthermore, Wickham and Sen (1978) also reported that the range of rice ET varied from 3 to 11 mm/day. Those results appear to be in good agreement with our data.

Water-to-Grain Yield Relation

After air drying the grain contained about 11 to 12 percent of water by weight, which is proper for milling operations (Snyder, 1980). The grain yield in this study is referred to the rough rice grain with 12 percent of water by weight. The water-to-yield ratios are also listed in Table 2. The average water required to produce 1 kg of grain yield varied from 746 to 1143 kg. This value is very close to the water-to-sugar yield ratio for sugarcane in Florida (from 884 to 1115 kg) as reported Shih and Gascho (1980).

Appendix I. Notation

The following symbols are used in this paper:

a	= a ratio between SPE and PEL
A	= a conversion factor used to normalize the ET data gathered at lysimeter site in relation to the ET data observed in field site
ADW	= an average of daily evapotranspiration in each week
b	= a ratio between SPE and PEF
C.L.	= concrete lysimeter
D.S.	= direct seeded plot
D.S.-G	= D.S. with L.D. at ground level
D.S.-R	= D.S. with L.D. at raised level
ET	= evapotranspiration
ETDS	= total ET for direct seeded crop
ETDSF	= water used by direct seeded crop after flooding
ETDSI	= irrigation water for direct seeded crop before flooding
ETDST	= ET for the first month of the direct seeded crop
ETTP	= total ET for transplanted crop
ETTPA	= ET for transplanted crop after transplanting
ETTPB	= ET for transplanted crop before transplanting
F.D.	= field drum
L.D.	= lysimeter drum
PEF	= evaporation from uncropped drums in the field site
PEL	= evaporation from uncropped drums in the lysimeter site
R	= a ratio between ETDST and SPET
SPE	= standard pan evaporation
SPEBT	= SPE during the month preceding the transplanting date
SPET	= SPE for the same period of first month of the direct seeded crop
T.P.	= transplanted plot
T.P.-G	= T.P. with L.D. at ground level
T.P.-R	= T.P. with L.D. at raised level

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Evapotranspiration Studies on Rice in Relation to Water Use Efficiency

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ABSTRACT

STUDIES on evapotranspiration (ET) for rice were conducted in lysimeters and in the field. The daily ET varied from 3.6 to 10.9 mm/day for a spring crop, from 3.3 to 11.7 mm/day for a summer crop, and from 1.8 to 7.6 mm/day for a fall crop. The mean daily ET values were 6.5, 6.8 and 4.5 mm/day for spring, summer, and fall crops, respectively. Total ET varied from 740 to 880 mm, 610 to 840 mm, and 400 to 500 mm for spring, summer, and fall crops, respectively. The mean total ET values were 800, 740 and 450 mm for spring, summer, and fall crops, respectively. From 759 to 1150 kg with a mean of 875 kg of water was required to produce 1 kg of rough rice grain.

INTRODUCTION

Organic soils in the Everglades Agricultural Area (EAA) are subsiding at an average rate of 2.5 cm/yr. Microbial oxidation is the principle cause of subsidence. The oxidation rate can be reduced if water tables are maintained at a high level or if flooding is practiced. Previous investigations have indicated that there is a linear relation between subsidence rate and water table depth (Stephens, 1969). However, high water tables may not be compatible with efficient production of most cultivated crops that are presently grown. Previous studies have shown that rice can be grown on flooded organic soils in the Everglades (Green, 1953; Alvarez et al, 1978). Other investigations established that rice can be grown throughout the season in a flood state (Adair and Engler, 1955; Bhuiyan and Sumayao, 1978).

Production of rice in the EAA will help in reducing subsidence because this crop can be kept flooded from just after emergence until harvest. It fits well as a summer crop in the existing sugarcane-vegetable production system. However, rice also can be grown in the spring and fall seasons. In 1977, about 100 ha of rice were seeded in the EAA by one grower and 3000 ha were seeded by eight growers in 1980. Despite the increase in rice production, the information on water needs for rice crop is very scanty. Consequently, the South Florida Water Management District (SFWMD) and Institute of Food and Agricultural Sciences (IFAS), University of Florida, initiated a joint project in 1979 to study the water requirement and water use efficiency for rice production in EAA. The specific objectives of this study were:

1 to measure evapotranspiration (ET) of rice in both lysimeter and field studies;

2 to compare weekly and total ET requirements for rice production in spring, summer, and fall seasons; and

3 to compute the water use efficiency for rice production in the EAA, i.e., the amount of water required to produce 1 kg of grain.

MATERIALS AND METHODS

Experimental Site Description

A. Lysimeter Site

The system at this site consisted of two types of lysimeters, i.e. concrete lysimeters and metal drum lysimeters. The lysimeters were surrounded by St. Augustine grass *(Stenotaphrum secundatum)* in 1979. In 1980, three rows of sugarcane (Saccharum spp.), about 4.5 m wide, were grown around the lysimeter site to minimize the oasis effect. A tipping bucket type of rain gauge was installed at the site.

Concrete Lysimeters: Nine reinforced concrete tanks 183 cm by 122 cm in area and 122 cm in depth were installed at the University of Florida, Agricultural Research and Education Center (AREC) located at Belle Glade. To facilitate drainage, the tanks were installed 67 cm into the ground with about 55 cm protruding above the ground surface. The lysimeters were placed with Pahokee muck *(Lithic Medisaprist)* in layers. The soil was subjected to three wetting-drying cycles to permit any settling of the material. The bulk density of the top layer (30 cm), which was determined from four core samples in each lysimeter, was about 0.3 g/cm^3. Six lysimeters were used to grow rice and the remaining three were flooded with no rice.

Lysimeter Drums: Six metal drums were used. These drum halves were 46 cm deep and 57 cm in diameter. Four drums called as lysimeter drums at ground level which were installed adjacent to the concrete lysimeters about 25 cm deep and 21 cm above ground. The other two drums called as lysimeter drums at raised level which were set on a raised platform so their top surface was at the same height as those of the concrete lysimeters. The drums were filled with Pahokee muck to approximately 18 cm below the rim. The soil was subjected to three wetting-drying cycles and the bulk density of the soil which was determined from two core samples in each drum was about 0.25 to 0.3 g/cm^3. Two lysimeter drums at ground level were flooded with no rice and the remaining four were used to grow rice.

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