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A Simple Method to Measure On-farm Pan Evaporation for Scheduling Irrigation

Eric Simonne¹,
Harry A. Mills¹, and
Doyle A. Smittle²

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Summary. Measurements of daily, 3-day, and 6-day cumulative pan evaporation using a #2 wash tub or a modified steel drum and a ruler provided an accurate, easy, and inexpensive way to schedule irrigation. Pan factors for these containers, which were covered with a 5-cm-mesh wire under humid climatic conditions, were 1.0 and 1.1, respectively.

Class A pan evaporation (E_p) can be used to estimate evapotranspiration (ET) because water evaporation from a shallow pan and plant transpiration are affected similarly by climatic conditions (Doty et al., 1982; Stanhill, 1962); however, E_p must be adjusted with a crop factor

(CF), computed as $CF = ET/E_p$, for scheduling irrigations. The U.S. Weather Bureau class A pan (1.2 m in diameter, 0.3 m deep) is exposed fully to sunlight and wind, and the vegetation surrounding the pan is lower than the top of the pan. Water levels in a class A pan are recorded 24 h apart with a hook gauge. Daily E_p is computed as the difference between two consecutive measurements (Jensen and Middleton, 1970). In the field, class A pans are often covered with a 5-cm-mesh wire to exclude animals. The presence of this type of screen on a class A pan reduced evaporation by $\approx 10\%$ (Campbell and Phene, 1976). However, evaporation from a class A pan covered with a similar screen was highly correlated with potential evapotranspiration (Howell et al., 1983) and could be used to schedule irrigation (Campbell and Phene, 1976).

While evaporative pans have been used to schedule irrigation for several horticultural crops (Byers and Moore, 1987; Smittle et al., 1990), a class A pan and hook gauge have not been adopted for on-farm use because of their cost (about \$500). Less-expensive containers and simpler measuring devices could substitute for a U.S. Weather Bureau pan and hook gauge. However, the ratio pan factor (PF) of evaporation from the class A to the substitute pan (E_{ps}) must be determined for each container ($PF = E_p/E_{ps}$) and varies with climatic conditions (Westesen and Hanson, 1981). Then, E_p can be computed from evaporation data using other containers as $E_p = PF \times E_{ps}$. Although containers other than class A pan have been used to estimate ET (Tjosvold and Schulbach, 1991), their pan factors have not been determined.

We determined pan factors for a #2 wash tub and a modified 200-liter steel drum under humid weather conditions in the southeastern United States. We also established whether the expected error in cumulative E_p measurements would affect the timing of irrigations for irrigation models based on cumulative E_p (Smittle et al., 1990).

The four containers were a standard class A pan, a #2 wash tub (48-cm bottom i.d., 54.5-cm top i.d., and 27-cm deep), and a #2 wash tub with an inverted cone (29-cm long, 10-cm top diameter, and 3-cm bottom diameter) to compensate the slope of the side, and a 56.5-cm-diameter steel drum cut to the height of 28 cm. The steel drum was painted with aluminum paint to reduce radiant heating. The containers were placed at the Univ. of Georgia Coastal Plain Experiment Station, Tifton, on a 20-cm-high horizontal wooden frame adjacent to a weather station from 4 Apr. to 30 May 1991. The addition of 1 ml of sodium hypochlorite solution (5.25%) per liter of water prevented algal growth. The tubs and the steel drum were covered with 5-cm-mesh wire to ensure that all water losses were due to evaporation. A plastic tube (30-cm long and 8-cm i.d.) installed vertically in the center of each container maintained vertical and immobile a plastic ruler. The water level in each container was recorded with a hook gauge and with the rulers at 0800 HR each day. The hook gauge was placed on top of the plastic pipe for the measurements. Rainfall was recorded and daily pan evaporation was computed according to the U.S. Weather Bureau method. Water levels were maintained between 20 and 25 cm in all the pans and also were recorded after adding or removing water. Since E_p is used as a cumulative value in most irrigation programs, cumulative E_p was computed by adding three and six consecutive daily E_p . Data were analyzed by regression analysis (SAS Institute, 1988). Pan factors were computed as the ratio of evaporation from the class A pan to evaporation from the substitute pan.

The pan factors for the tub, the tub with a cone, and the steel drum were 1.04, 1.05, and 1.08, respectively, when measured with a hook gauge, and 1.08, 1.08, and 1.10, respectively, when measured with a ruler. During the 56-day sampling period,

¹Department of Horticulture, University of Georgia, Athens, GA 30602.

²Department of Horticulture, Coastal Plain Experiment Station, Tifton, GA 31793.

Table 1. Correlation coefficients (R) and confidence intervals (95% CI) for the expected mean error of the relationships between reference pan evaporation and evaporation from selected containers measured with a hook or a ruler for daily, 3-day, and 6-day cumulative evaporations.

Container	Daily		3-day		6-day	
	R ²	95% CI	R ²	95% CI	R ²	95% CI
<i>Measurement with a hook gauge</i>						
#2 wash tub	0.91	0.3 ± 0.6	0.99	0.1 ± 1.0	0.99	0.1 ± 1.0
#2 wash tub with cone	0.91	0.3 ± 0.7	0.98	0.3 ± 1.3	0.99	0.3 ± 1.3
Steel drum	0.91	0.3 ± 0.7	0.98	0.3 ± 1.3	0.99	0.3 ± 1.3
<i>Measurement with a ruler</i>						
#2 wash tub	0.93	0.1 ± 0.6	0.98	0.1 ± 1.0	0.99	0.1 ± 1.0
#2 wash tub with cone	0.89	0.2 ± 0.8	0.97	0.1 ± 1.4	0.99	0.1 ± 1.4
Steel drum	0.91	0.2 ± 0.7	0.98	0.1 ± 1.4	0.99	0.1 ± 1.4

Reference pan evaporation from a class A pan measured with a hook gauge.

$\mu \pm t(0.05/2; df) \times [MSE/(df + 1)]^{1/2}$.

evaporation from the class A pan ranged from 0.3 to 7.4 mmžday⁻¹ and averaged 4.2 mmžday⁻¹. Paired *t* tests showed that only *E_p* from the steel drum, measured with a hook gauge or a ruler, was significantly different (*P* < 0.05) from reference *E_p*. Moreover, the differences in average daily *E_p* between the class A pan and the other containers ranged between 0.2 to 0.4 mm for both methods. These results show that a pan factor of 1.0 could be used for either the tub or the tub with a cone when either a hook gauge or a ruler were used, because water level measurements could be determined only to 1 mm with the ruler and 0.03 mm with the hook gauge. These findings agree with a similar test under semiarid conditions (Sims and Jackson, 1971).

A close relationship among the methods and the containers also was observed when *E_p* was cumulated for 3 or 6 days (Table I). Cumulated 3- and

6-day mean errors with both methods ranged from 0.1 to 0.3 mm. A positive error shows that *E_{px}* overestimates *E_p*, whereas a negative *E_{px}* underestimates *E_p*. Confidence intervals for the mean error showed a 0.95 probability that daily, 3-day, and 6-day cumulated error will be less than the average daily *E_p*. The largest expected error was 2.8 mm. An error of this magnitude would not influence irrigation frequency because *E_p* during the spring averages 4.2 mmžday⁻¹, and the decision to start irrigation is made only once a day.

This suggests that these containers could be used for scheduling irrigation from evaporation data in humid areas. Therefore, a #2 wash tub or a drum covered with wire with water depth measurements by a fixed ruler effectively provide an easy, quick, and inexpensive record of on-farm pan evaporation for scheduling irrigation using a pan factor of 1.0 or 1.1, respectively.

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