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Application of a Simplified Evapotranspiration Model for Predicting Irrigation Requirements of Peach[1]

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Abstract. **A 2-year study was made of 2 methods of scheduling irrigation of peach (*Prunus persica* (L.) Batsch cv. Harken/Siberian C). In each year, irrigation schedules necessary to prevent the available soil moisture (ASM) from falling below 50% level in the top 30 cm were essentially the same, whether determined from direct measurement of soil moisture or predicted from a simplified Priestley and Taylor evapotranspiration model.**

There is a growing interest in scheduling irrigation by using direct or indirect measurements of crop evapotranspiration in place of soil moisture measurements (1, 2). Direct measurement of crop evapotranspiration can be obtained with use of lysimeters (2) and can be closely estimated by use of a standard Class A evaporation pan (1). Crop evapotranspiration can also be estimated indirectly by climatological data (1, 2). Recently Priestley and Taylor (4) have developed a reliable model to estimate daily potential evapotranspiration. However, this model requires data on net radiation which are not usually available from most weather stations. Accordingly, a simplified Priestley and Taylor model which utilizes daily sunshine duration instead of net radiation was developed for estimating daily potential evapotranspiration, the details of which will be published elsewhere. Here, we report the use of this model for predicting irrigation requirements of peach and compare it to irrigation schedules obtained by measurement of soil moisture.

Irrigation requirements based on climatological data were developed using the generalized equation which has been successfully used for corn (3):

$$SM_d = SM_{d-1} - ET_c + P_e + I - D$$

where SM_d and SM_{d-1} are the soil moisture in the 30 cm layer (mm) on day d and d–1 respectively; ET_c is crop evapotranspiration (mm); P_e is effective rainfall (mm); I is irrigation (mm); and D is drainage below the root zone (mm). In initiating the program, one estimates or measures SM_{d-1}; thereafter, the SM_{d-1} term is always the previous day's computed soil moisture.

Crop evapotranspiration (ET_c) was estimated from the product of potential evapotranspiration (ET_p) and a crop coefficient (K_c) appropriate for peach (1). The crop coefficients (K_c) we used were 0.82 in May, 0.87 from June to July 15, and 0.90 from July 16 to August to account for the increase in foliage cover (1). The daily potential evapotranspiration (ET_p) was calculated with a simplified equation originally developed by Priestly and Taylor (4):

$$ET_p = 1.26\,(0.48 + 0.01\,T_a)[(0.114 + 0.365\tfrac{n}{N})R_a - 0.039]$$

where ET_p is potential evapotranspiration (mm); T_a is the mean air temperature for daily estimates calculated from $T_a = (T_a\,\max + T_a\,\min)/2$; N is maximum possible hours of bright sunshine (hours); and R_a is downward solar radiation for the same latitude outside of the atmosphere (mm/day). Values for R_a and N at different latitudes and months are available from published tables (1). The actual

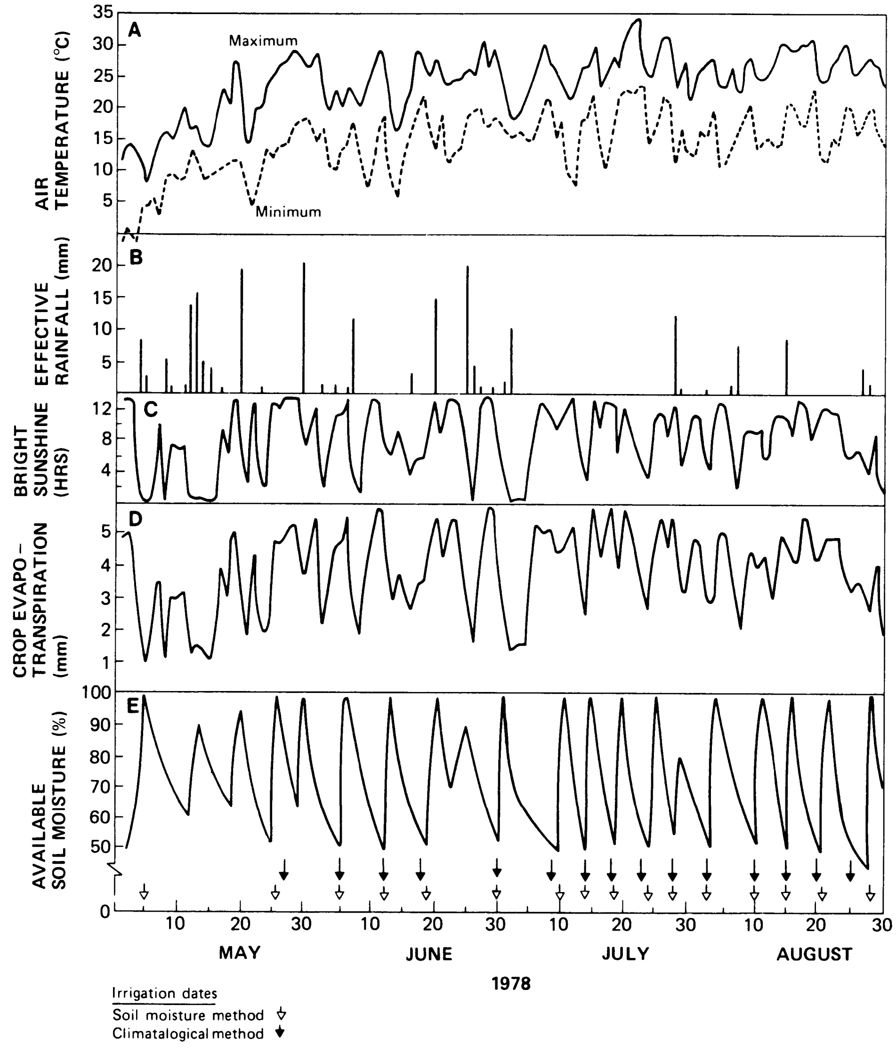

Fig. 1. Daily records of climatic data used for scheduling irrigation from May to August, 1978: (A) air temperature, (B) effective rainfall and (C) bright sunshine. Also shown are (D) crop evapotranspiration estimated from the product of potential evapotranspiration and a crop coefficient and (E) available soil moisture obtained from neutron moisture probe. The actual irrigation dates based on soil moisture measurement (⇩) and predicted dates based on climatological method (⬇) are also included.

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Table 1. Comparison of methods of scheduling irrigation to prevent available soil moisture from falling below 50% in a peach orchard in 1979.

Methods of scheduling irrigation	Date June	 July	 August
Soil moisture method (actual dates)	6, 14, 19, 25	13, 17, 23, 30	8, 14, 29
Climatological method (predicted dates)	3, 11, 15, 19, 25	12, 17, 20, 24, 30	8, 15, 30

number of hours of bright sunshine per day (n) was obtained from weather data at Harrow, using the Campbell Stokes sunshine recorder.

Effective rainfall (P_e) was the portion of total rainfall available for plant use. The runoff from irrigated sandy soil is minimal. For light precipitation (P), effective rainfall (P_e) can be calculated as suggested by Kanemasu et al. (3):

$$P_e = (P/25.4)^{0.75} \times 25.4, \quad \text{if } P \geq 25.4 \text{ mm}$$
$$P_e = P, \quad \text{if } P < 25.4 \text{ mm}$$

The maximum daily soil moisture ($SM_{f.c.}$) was set to the field capacity. In this study, $SM_{f.c.}$ and $SM_{1/2f.c.}$ were 52.5 and 36.0 mm respectively. If daily soil moisture (SM_d) exceeded field capacity (52.5 mm), then drainage (D) was calculated from $D = SM_d - SM_{f.c.}$. If daily soil moisture (SM_d) was less than 50% ASM (36.0 mm), then irrigation (I) was required. The amount of water required was calculated from $I = SM_{f.c.} - SM_d$.

Climatological data for the 1978 and 1979 growing seasons were obtained from the weather station at the Harrow Research Station and soil moisture data were obtained from an experimental peach orchard 4.8 km southeast of the weather station. The soil type was Fox sand which had the following characteristics: the field capacity in the top 30 cm was 17.5% on a volume basis and the permanent wilting point was 6.53%. Soil moisture was measured with a Nuclear Chicago neutron subsurface probe (no. 4810) and scaler (no. 5920). Routine moisture measurements were made at the 20 cm depth using 12 different sites in the orchard. Irrigation schedules to prevent the available soil moisture from falling below the 50% level, were based on the average of these 12 sites. When the soil moisture content reached the predetermined level equivalent to 50% ASM irrigation was applied to restore the soil to field capacity.

The actual irrigation schedule used in 1978 based on direct soil moisture measurement agreed very closely with the predicted schedule based on the simplified Priestly and Taylor model (Fig. 1E). The parameters used for predicting irrigation requirements in 1978 are shown in Fig. 1 A to D. These comparisons were repeated in 1979 and again very good agreement was obtained (Table 1).

The prediction method for scheduling irrigation described here was preferable to soil moisture method because of its greater simplicity and adaptability for use with computers or electronic calculators.

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Leaf Anatomy and Water Stress of Aseptically Cultured 'Pixy' Plum Grown under Different Environments[1]

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Abstract. **This study examined the leaf anatomy and water stress of *Prunus insititia* L. cv. Pixy grown in aseptic culture before and after transfer to the greenhouse and grown in a layerage bed in the field. The depth of palisade cells was significantly less in aseptically cultured plantlets than in greenhouse transfererred plants, and less in greenhouse transferred than in field-grown plants. Percent mesophyll air space was greater in plantlet than in plant leaves. Upper or lower leaf epidermal cell length of plantlets of field grown plants was not significantly different. Stomatal frequency for plantlet leaves was significantly less about 150 stomata per mm^2) than that of plant leaves (300 stomata per mm^2). Excised plantlet leaves lost greater than 50% of total leaf water content within 30 min; excised greenhouse leaves lost 50% after 90 minutes.**

Plantlets when transferred from aseptic culture to the greenhouse may become water stressed and continued growth or survival may be decreased (9). The purpose of this study was to contrast the leaf anatomy and water stress of 'Pixy' plum plants grown in aseptic culture before and after transfer to the greenhouse with those propagated from a layerage bed in the field.

Leaf anatomy is influenced by light and moisture (2). Leaves developing at high light intensities have more and larger palisade cells than those in shade (2). Leaves developing under low soil moisture have smaller intercellular spaces and higher stomatal frequencies than those grown with ample moisture (2, 6, 10). Plants grown at high relative humidity have poorly developed epicuticular waxes (9) and higher transpiration rates in dry air than do dry-air plants (8).

In the summer of 1979, 'Pixy' plum plantlets were aseptically cultured by Cheng's (1) method. One half of the rooted plantlets were transferred to peat:perlite (1:1 by volume), fertilized weekly with 473 ppm N, 456 ppm P, and 868 ppm K, and grown in a greenhouse at 27°C and normal day length for 3 weeks. Field plants were grown in layering beds at Oregon Rootstocks, Inc., in Gervais, Oregon.

Leaves were collected from the third to fifth node of aseptically-cultured plantlets. Leaves initiated and matured in the greenhouse were collected from transferred plants. Fully expanded leaves were collected from field grown plants. Samples were fixed in formalin-aceto-al-

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