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Estimating Daily Water Use for Potted Chrysanthemum Using Pan Evaporation and Plant Height

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Abstract. **Daily water use for potted *Chrysanthemum* X*morifolium* Ramat. 'Spirit' was estimated from pan evaporation and plant height data collected over 2 seasons using 3 different growing environments (glass greenhouse, saranhouse, and outside—no structure). Regression equations derived using pan evaporation and plant height were not significantly improved with the inclusion of plant width as an additional variable to estimate water use.**

Evapotranspiration (ET) for a given crop depends on factors such as plant species, environment, stage of growth (plant cover), spacing, and water availability (5, 8, 13). Any method for estimating ET must either define or take these factors into account to be effective. Common estimating methods for ET include water balance techniques (including the use of lysimeters), micrometeorological methods, and the use of empirical equations (1, 4, 6, 9, 11, 13). Energy requirements for greenhouse-grown tomatoes were used to estimate ET requirements (11) and utilized micrometeorological parameters and size (height) characteristics of the crop. Many tedious measurements were required, but this study showed promising results for predicting ET.

One commonly used and widely accepted environmental parameter which tends to integrate environmental conditions into one measurement is pan evaporation (13). It is a simple measurement to take; however, to be effective in describing the environment of the crop it is used for, it must be placed in the same environment as the crop to take into account any changes in microclimatic conditions that may occur. Guttormsen (7) described the relationship between pan evaporation measurements and transpiration of greenhouse-grown tomatoes and concluded that this relationship changed during the growth cycle as the plants grew. He concluded also that the evaporation pan was an adequate instrument to use to describe this relationship.

The use of leaf area to describe growth stage (plant coverage) conditions would be most desirable since it directly estimates the potential transpiring surface of the crop (3). Acquiring the leaf area data is time-consuming, however, and generally is destructive to the plants. The use of nondestructive plant height and width measurements to describe the plant canopy also can be used. Although there is little evidence that plant height influences ET for crops grown in the field, greenhouse and isolated lysimeter studies have shown a direct relationship between ET and plant height (5).

One objective of this study was to measure daily water use (or ET) of potted chrysanthemums grown under differing evaporative demand conditions, and to determine the relationship of this quantity to plant height, plant width, and the pan evaporation of the growing environment when simultaneously measured. These parameters were chosen because of potential physiological significance and simplicity for measurement. Using a statistical approach, a significant relationship would result in a regression equation to estimate water use based on the measured parameters. Establishing this method of estimating daily water use was the main objective of the study.

Collection of the data occurred in 2 seasons, from Sept.–Nov. 1981 (fall), and from Mar.–Apr. 1982 (spring). For the fall season, 'Spirit' chrysanthemum plants were transplanted into 15-cm plastic pots (4 plants per pot) and grown as non-disbudded pot mums. The growth regulator butanedioic acid mono-(2,2-dimethylhydrazide) (daminozide) was used to control plant heights to within 30–40 cm final height (2). A 5:3:1:1 ratio by volume of Canadian peat, horticultural grade vermiculite, builders' sand, and perlite, respectively, was used as the potting medium. This mix was amended with 7 kg/m^3 Osmocote 14N–6.1P–11.6K, 6 kg/m^3 dolomite, 3 kg/m^3 single superphosphate, 3 kg/m^3 hydrated lime, and 1.1 kg/m^3 Perk (minor element mixture) resulting in a pot mixture pH of 6.5.

A glass greenhouse structure was used for the fall season. A method was used to measure water use of individual pots (12) which utilized the capillary mat irrigation system (10). A 24-hr period for water-use determination was used daily for sets of 6 pots removed from the mat and spaced on 40-cm centers, a recommended spacing (2) used commonly in commercial operations. Measurements of plant height and width were made immediately prior to the 24-hr period. The assumption for this procedure was that the change in weight of each pot during the 24-hr period off the mat was due only to water leaving the pot by evapotranspiration. In essence, the pots were treated as short-term weighing lysimeters. Precautions were taken to ensure that no water stress occurred during the time period the pots were off the mat by providing each pot with a covered, shallow pan water reservoir. Since the reservoirs were covered, changes in their water quantities were due to plant water uptake, and were included in water use estimates for each pot. The water level in each reservoir was <1 cm. Since several sets of pots were used, and each pot was removed weekly from the mat, no problem with roots growing into the mat and subsequent root damage due to removal was experienced.

Evaporative demand was measured simultaneously during the process described above using a Belfort Evaporation Recorder Model 6075. This instrument uses a 250 cm^2 evaporation pan and a 24-hr clock to record evaporation amount and rate continuously. This instrument was located fully exposed near the plants used in the study to ensure proper measurement of the evaporative demand of the growing environment.

Data collected in the fall were analyzed using stepwise multiple regression. The postulated regression model was:

$$\text{WATER} = f(\text{HT, WT, EVAP}) \quad \text{[Eq. 1]}$$

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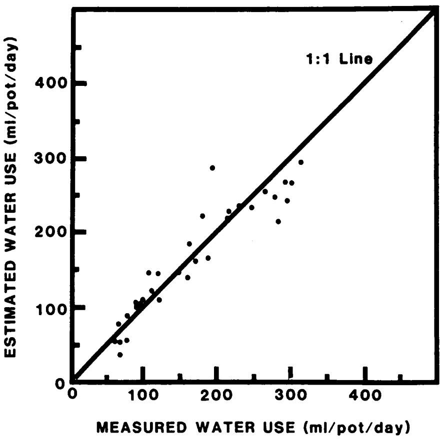

Fig. 1. Estimated water use for potted chrysanthemums using Eq. 2 vs. measured water use from fall data.

where WATER = total water use (ml); HT = plant height (cm); WT = plant width (cm); and EVAP = pan evaporation (mm H_2O). The resultant regression equation with the highest F-test significance ($P < 1\%$) and coefficient of determination ($R^2 = 0.87$) was:

$$\text{WATER} = 238.636 + 7.881\ (\text{HT}) + 127.472\ (\text{EVAP}) \quad \text{[Eq. 2]}$$

The addition of WT in the regression equation did not significantly improve R^2. Fig. 1 illustrates the comparison of water use amounts estimated using Eq. 2 vs. actual measured amounts.

Since data were collected for the fall season in only one growing environment, a limited range in evaporative demand (0.8–2.0 mm day^{-1}) was experienced. To widen this range, data were collected in the spring season for plants growing in 3 different growing environments: 1) a glass greenhouse as in the fall season, 2) a saran shadehouse structure, and 3) full sunlight, with no structure. These environments represent the range of conditions in which chrysanthemums are grown commercially. Experimental setup and data collection procedures were the same as those for the fall season, except that no growth regulator was used on the plants grown outside since light conditions were such that desired final plant heights could be achieved naturally. Each growing site utilized the capillary mat system and had an evaporation recorder located with the plants.

Wide ranges in magnitude of the measured parameters resulted because data were collected for the entire growth cycle of the pot mums and in 3 different growing environments. These ranges were: 12–39 cm for HT, 26–56 cm for WT, 0.8–5.9 mm/day for EVAP, and 58–1266 ml day^{-1} for WATER. Applicability of the derived relationships is valid only within these ranges.

Data collected for both seasons were grouped and subjected to regression analyses as in the fall test. The combined final equation which includes only those parameters which significantly improved the equation was:

$$\text{WATER} = 456.723 + 15.194\ (\text{HT}) + 146.082\ (\text{EVAP}) \quad \text{[Eq. 3]}$$

with an $R^2 = 0.85$ at $P < 1\%$. As was the case in the fall season, the addition of WT in the regression equation did not improve the equation significantly. This combined equation differed from the equation developed from the fall season in intercept magnitude and variable coefficients because a much wider range of evaporative demand was experienced. It is important to note the consistency of HT and EVAP being the most significant factors included in the models from both the fall and spring data.

The individual relationships of each factor included in the final equation (EVAP and HT) to WATER were significant although R^2 for equations containing each alone were not that high (0.59 for EVAP and 0.31 for HT). However, the importance of including both factors in the regression equation is illustrated by the improved fit of Eq. 3 ($R^2 = 0.85$). The relationship of water use estimated using Eq. 3 vs. measured water use is shown in Fig. 2. Data points resulting from the various locations are separated to illustrate applicability to differing growing environments.

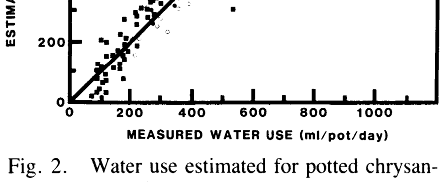

Fig. 2. Water use estimated for potted chrysanthemums using Eq. 3 vs. measured water use from combined fall and spring data for 3 growing environments.

The strong relationship exhibited between the pan evaporation-plant height combination and water use indicates a possible means by which daily water requirements for potted chrysanthemums can be estimated. Application of the use of this method would mean that, on a daily basis, irrigation water would be applied to pots to maintain a no-water-stress condition by replenishing that water used by the plant during the preceding 24-hr period (or for however long evaporative demand was measured).

The derived regression equation estimated water requirements for potted chrysanthemums grown under the defined crop management conditions. Research is continuing to determine the effects of cultural variables, such as growth regulators, cultivars, and other crop management schemes, on the use of pan evaporation and plant height as estimators of water use of potted chrysanthemums.

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