New approach to estimate the additional water requirements in sprinkler irrigation: A predictive model

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Summary

A regression model was developed from ET rates measured over sprinkler irrigated cotton by an ECV/energy balance technique. Rates from several trials were nondimensionalised and averaged to remove variation caused by cloud, time of day and experimental factors. Prior to irrigation the nondimensional ET followed a linear relationship. After commencing irrigation the rate of ET quickly jumped to a significantly higher value and stabilized to follow a linear relationship until conclusion of the irrigation. The ET decreased over the post irrigation drying period, following an exponential decay until again reaching a steady value. The model allows estimation of the additional water requirements in sprinkler irrigation to be estimated for other times and locations.

Introduction

Regression analysis is a popular data analysis and synthesis method widely used in agronomic and irrigation studies; and has been used in the development of empirical equations for predicting various evaporation and evapotranspiration characteristics using more routinely measured climatic variables as inputs (Kovor & Nandagiri 2007). However, no literature has been found reporting the use of this technique in sprinkler irrigation to estimate the additional evaporation that occurs due to a wet canopy. Recently, Uddin *et al.* (2011) showed that the additional evaporation due to the wet canopy under sprinkler irrigation can be estimated using the eddy covariance (ECV) technique. They also indicated that a regression model can be developed from these ECV measurements and it would be an important tool to predict the additional evaporation in sprinkler irrigation on the basis of local climatic data. Hence, the objective of this study is to develop a regression model to estimate the additional water requirements in sprinkler irrigation using local meteorological data irrespective of time and place.

Methods and Materials

The study was conducted at the Agricultural Experimental Station situated at the University of Southern Queensland, Toowoomba, Australia. The actual ET (ET_{ecadj}) was measured over an irrigated mature cotton crop using eddy covariance (ECV). To remove the effects of climatic factors and random errors and to allow averaging of the data trials conducted over several days, the measurements of actual ET were nondimensionalised by reference ET i.e. ET_{ecadj}/ET_{ref}. The reference ET was calculated on the basis of meteorological data measured at the study site using a four-component net radiometer and temperature and relative humidity probes placed at outside of irrigated plot. Using the nondimensionalised values of actual ET for the different phases of irrigation, pre, during and post irrigation, regression equations were obtained to fit the data. Various mathematical regression equations were investigated including the simple linear, quadratic, exponential, power and logarithmic to obtain the best fitting equations. The statistical parameters of χ^2, root mean square error (RMSE) and modelling efficiency (EF) were used as the criteria to select the best equation to account for variation in each curve.

Results & Discussion

Figure 1 shows five distinct phases of ET in sprinkler irrigation which includes:

i. a period of more or less constant value of nondimensional ET prior to irrigation where a linear relationship applies – this is the dry canopy evaporation rate,

ii. a period of rapid increase of ET just after starting irrigation as the canopy is wetted,

iii. a more or less stable ET during irrigation where the intercepted water evaporated from the wet canopy is continuously replaced by the irrigation spray,

iv. a period of declining rate of ET post irrigation (drying) for about 1 hour as the residual intercepted water is evaporated, which follows an exponential decay curve, and

v. a more or less constant rate of nondimensional ET equivalent to the pre irrigation value.

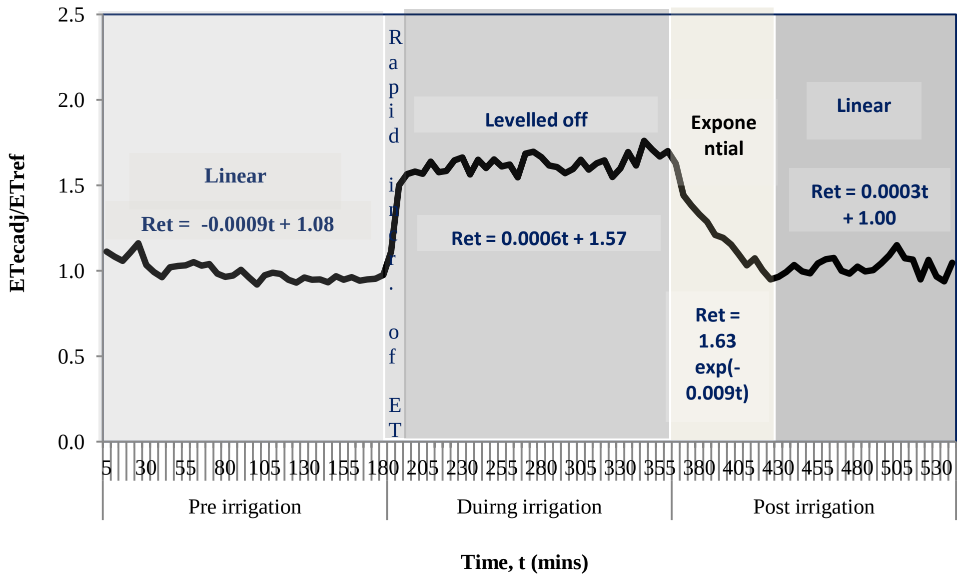

Figure 1: Schematic representation of the different phases of irrigation in terms of dimensionless ET

The regression equations obtained from this analysis, as shown in figure 1, for the respective phases can be used to estimate the additional evaporation during sprinkler irrigation. This is an indication of the additional water that needs to be applied in each irrigation to satisfy the evaporation losses.

References

Kovoor, G.M. and Nandagiri, L. (2007). Developing regression models for predicting pan evaporation from climatic data — A comparison of multiple least-squares, principal components, and partial least-squares approaches. *Journal of irrigation and drainage engineering, 133*(5), 444-454.

Uddin, J., Smith, R., Nigel, H., and Joseph, F. (2011). Eddy covariance measurements of the total evaporation during sprinkler irrigation-Preliminary results. *Conference Proceedings*, *Society for Engineering in Agriculture (SEAg),* Gold Coast, Australia, 28-30 September, 2011.