

Irrigation Scheduling: An Overview of the Potential to Integrate Modeling and Sensing Techniques in a Windows-based Environment

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Significance to Industry: We describe a flexible system for the visual interpretation of spatially explicit irrigation data within a pc windows based Graphical User Interface (GUI). This will allow us to better estimate plant water use and more precisely manage day-to-day irrigation scheduling for nursery operations on a wide scale. The goal is to provide an intuitive user interface to manipulate and organize environmental and soil moisture data for automatic input into a decision support tool. This user-friendly access to process-based plant transpiration models will be an effective way to increase their application beyond the research community. The GUI will allow access to this powerful decision support system through a user-friendly computer interface, without any reduction in information precision of the irrigation scheduling model.

Nature of Work: Although mechanistic or process-based approaches to irrigation scheduling are powerful tools that can be used to provide insights into nursery water use dynamics, they are often written in arcane computer code, involve complex mathematical equations, and lack a user-friendly GUI that operates inside a pc windowing environment. The aforementioned limitations prevent most irrigation models from being used by more than a handful of researchers, let alone beyond the research community. For the purpose of the application of process-based irrigation management, we have developed a GUI that standardizes model/interface coupling and simplifies end user operation. The original objective of this work was to couple a tree process-based transpiration model to a generic GUI. In so doing, we expanded on the concept by including a wireless node network to relay environmental and soil moisture data directly to a base station for direct model input. We discuss our system and the potential application of an automated irrigation system that calculates plant water consumption from species and genotype-specific plant physiological responses. To accomplish accurate water use predictions, our model simulates transpiration in complex canopies using detailed information on leaf area, leaf distribution, and physiology. The application of physiological equations, where calculations are done on volumetric sub volumes of the tree crown and then summed and/or averaged for individual crown layers or whole crowns, generates irrigation estimates by using plant water use as an indicator of irrigation requirements.

Results and Discussion: Precise water application, based on actual plant water use, could have at least a ten (1) to twenty-fold (2) reduction in current nursery water application rates. Although water restrictions are becoming more common, recent advances in the ability to automatically collect and disseminate data in the field could offset the finite water resources by allowing growers to increase their water use efficiency. Wireless sensor networks, such as the system developed at Carnegie Mellon University (3) are particularly well suited to the needs of data collection in horticultural environments. When placed in the field, the nodes automatically find each other to create a wireless network. Collected data is then automatically relayed to a central point, from which it can be made available as model input. The ability to collect data in this manner has already been demonstrated in a production nursery setting; however, integration of all aspects (data collection, model coupling, and user output) is currently under development. Figure 1 below illustrates how the environmental and physiological data can be automatically integrated into the species-specific transpiration model. Model estimates of water use and plant water requirements are output and used to both make irrigation decisions (command executed by a sensor node) and visualize model updates via the GUI. Figure 2 illustrates a schematic diagram of the environmental sensors connected to the wireless network and coupled to the model used for simulations (captured computer screen model output in the GUI is the right side of Fig. 2). Within each time step, the model adjusts transpiration based on interactions between environmental, soil moisture, and plant physiological response. For example, the substrate moisture deficit calculation is as described in Bauerle et al. (1). The updated substrate moisture is carried into the next time step for input into the substrate moisture deficit subroutine. The calculated moisture deficit value is one of the input values required to calculate the amount of stomatal conductance regulation and hence, interacts with other equations to derive whole plant water use. Overall, the GUI provides a user friendly interface to a behind the scenes system. In this configuration, whole tree estimates can be rapidly visualized for either computerized or human based irrigation decision management.

Literature Cited:

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Figure 1. Environmental and physiological data is automatically integrated into the species-specific transpiration model. Model estimates of water use and plant water requirements are output and used to both make irrigation decisions (command executed by a sensor node) and model updates.

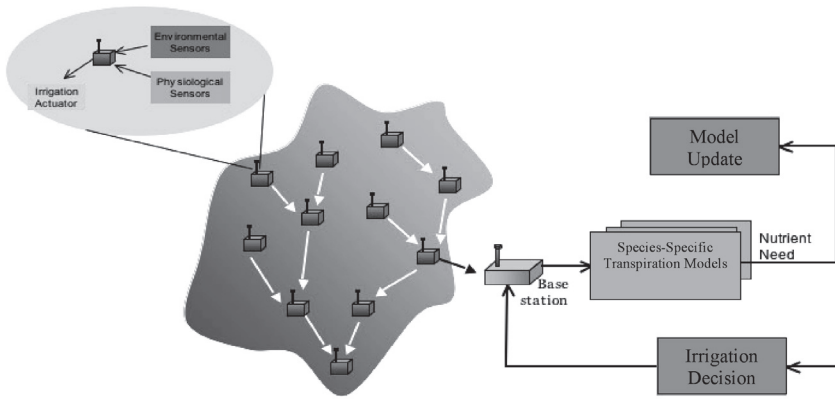


Figure 2. Schematic diagram of the environmental sensors connected to the wireless network and coupled to the canopy model used for simulations (captured computer screen model output in Graphical User Interface for Crop Simulators is the right side of Fig. 2). Within each time step, the model adjusts transpiration based on stomatal conductance regulation. The substrate moisture deficit calculation is as described in Bauerle et al. (1). The updated substrate moisture is carried into the next time step for interaction with substrate subroutines.

