AUTOMATED MEASUREMENT OF CONTAINER TEMPERATURE AND MOISTURE FOR IMPROVEMENT OF IRRIGATION SCHEDULING IN NURSERIES

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Introduction

The availability of water for agriculture has become an important issue, especially due to the continuing drought. Without adequate water, agriculture and especially the green industry can not survive as water is one of the most critical inputs for nursery plants. Some type of improvement in monitoring of water use by nursery crops is needed. The goal of this project was to develop automated procedures that can determine changes in container temperature and moisture. This information can then be used for the development of improved irritation scheduling systems that can reduce the total amount of water required for irrigation of nursery crops.

Materials and Methods

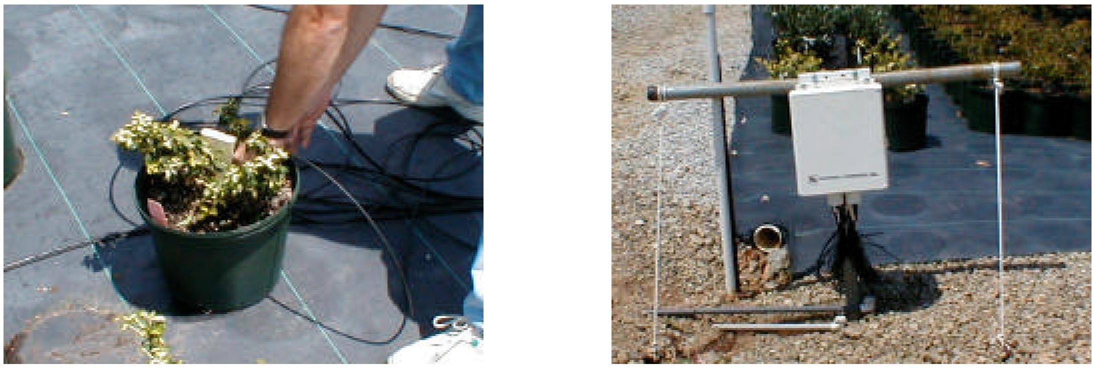
The experiment was conducted at the Center for Applied Nursery Research (CANR), located in Dearing, Georgia. The first experiment was started in May, 2002. 15 soil temperature probes and 15 soil moisture probes were installed in three different sizes of containers, including 3, 5 and 7 gallon containers. The 3 gallon containers were planted with *Eunymous* "Blondie", the 5 gallon containers were planted with *Buddleia* Seedling #7 and the 7 gallon containers were planted with *Philadelphus lemoinei* (Figure 1).

3 Gallon Containers — 5 Gallon Containers — 7 Gallon Containers

Figure 1 – First Experiment conducted during the summer and fall Season, 2002.

The soil temperature and soil moisture probes were connected to an automated data logger (Figure 2), which recorded the container conditions every 15 minutes. In addition, daily averages and extremes, including maximum and minimum values, were calculated at midnight. This information was stored in an automated weather station, located at

CANR, and was retrieved daily via a dedicated telephone line and modem by a computer located at the College of Agricultural and Environmental Science-Griffin Campus.



(a) (b)

Figure 2 – (a) Installation of the Soil Moisture and Soil Temperature Probe and (b) Data logger.

Actual data collection did not start until August 20 due to malfunctioning of the equipment. Hence, the data analysis of this report covers the period August 20, 2002 through November 3, 2002.

Preliminary Results

Four of the five plants in the 3 gallon containers did not survive the experiment. The plants grown in the 5 gallon containers developed vigorously, while the plants grown in the 7 gallon containers showed poor development (Figure 3).

3 Gallon Containers 5 Gallon Containers 7 Gallon Containers

Figure 3 – Conditions of the plants at the end of the summer/fall season experiment.

Extreme soil temperatures as high as 50^{o}C were observed in the three gallon containers, whereas the 5 and 7 gallon containers showed maximum temperatures that were at least 5 degrees less for the same day. The temporal variation of the daily average temperature for the 3, 5 and 7 gallon containers was very similar and showed the same trend (Figure 4). The highest average temperatures were found in the 3 gallon containers and the lowest average temperatures were found in the 5 gallon containers.

The average volumetric soil moisture in the 3 and 7 gallon containers varied between 22 to 35%, while the volumetric soil water content was extremely low in the 5 gallon containers, reaching values as low as 6% and as high as 16% (Figure 4). The largest plants were found in the 5 gallon containers (figure 5). Consequently those plants had higher water uptake rates, which was the cause for the difference in water content between these three container sizes. The trend for the volumetric soil water content was very similar for the 3 and 7 gallon containers, but different for the 5 gallon containers (Figure 4). While in the 3 and 7 gallon containers the average daily soil moisture content increased over time, it decreased in the 5 gallon containers. The same trend was also found when soil moisture was analyzed on a relative basis (Figure 5).

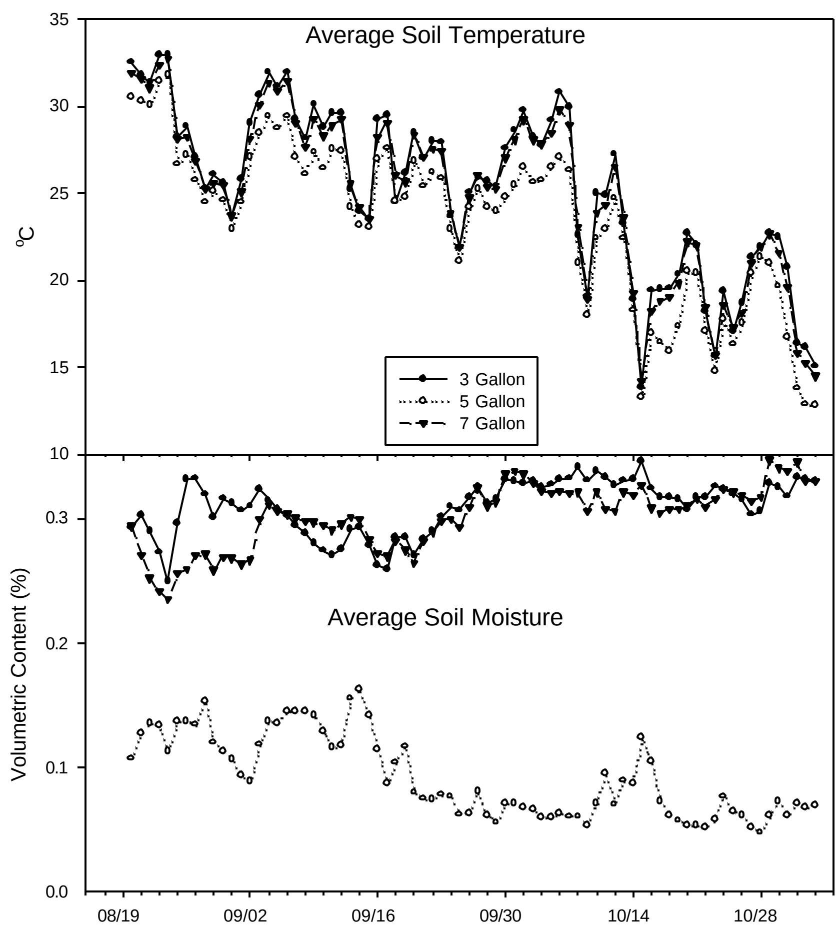


Figure 4 – Temporal variation of the Soil Temperature and Soil Moisture Averages.

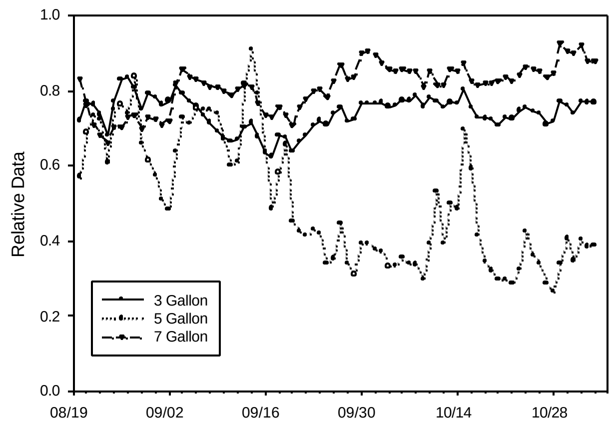


Figure 5 – Temporal Variation of the Relative Soil Moisture Content.

A functional relationship between soil moisture and soil temperature was found when both variables were analyzed for specific daily period. Average conditions during the period from midnight to 08:00 AM appeared to be better for the 3 and 7 gallon containers, while no good correlation between soil moisture and soil temperature was found for the 5 gallon containers. The initial results also showed a significant variation in soil moisture when the soil temperature reached 20°C (Figure 6).

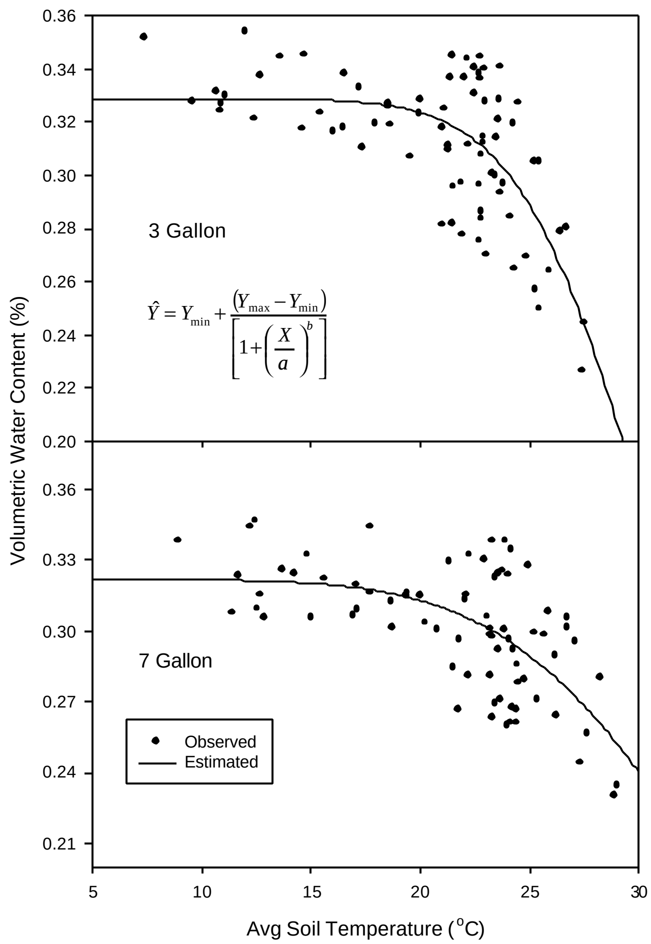


Figure 6 – Average soil moisture content as a function of average soil temperature. Averages are calculated for the period form midnight (00:00 AM) to 08:00 AM.

There was also a high correlation between potential evapotranspiration (ET) and soil temperature. Initial results showed an exponential relationship between potential evapotranspiration and soil temperature for the 3, 5 and 7 gallon containers. The best relations were found when the maximum and average soil temperatures for each treatment were used (Figure 7).

These initial results are very promising, especially because the temporal variation of the soil temperature was more predictable than soil moisture. Moreover, air temperature and soil temperature are closely related, allowing the introduction of empirical parameters based on this relationship to determine estimated ET_{crop} (Figure 8).

The advantage of this relationship is that it is relatively easy and simple to measure the temperature of the air. This would only for the development of a practical method to estimate crop water needs using only one climatic variable. After this correction, we can recalculate the Et as a function of the corrected air temperature (Figure 9).

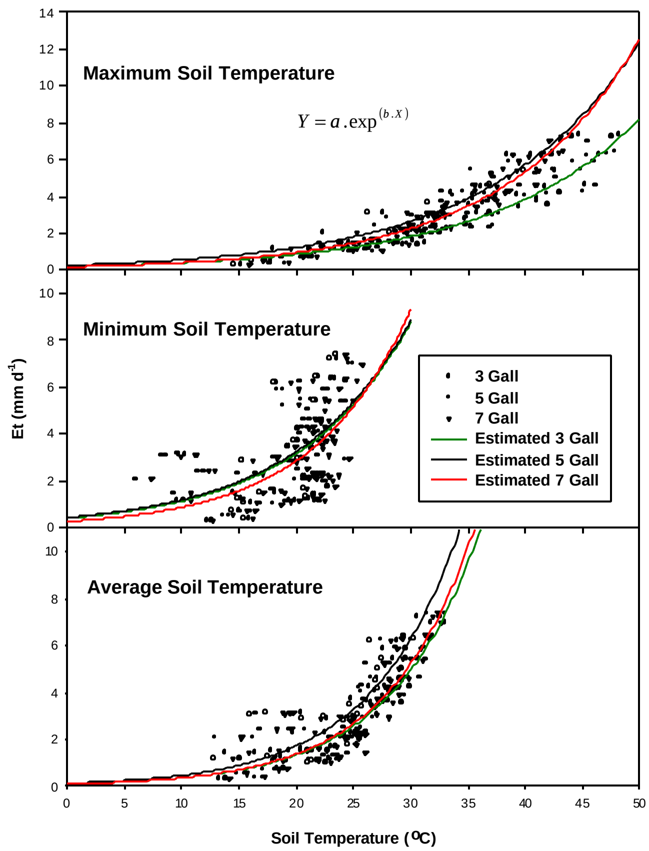


Figure 7 – Potential Evapotranspiration as a function of soil temperature.

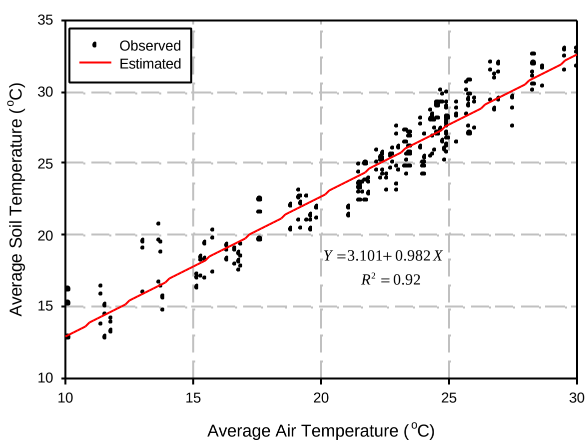


Figure 8 – The functional relationship between soil and air temperature.

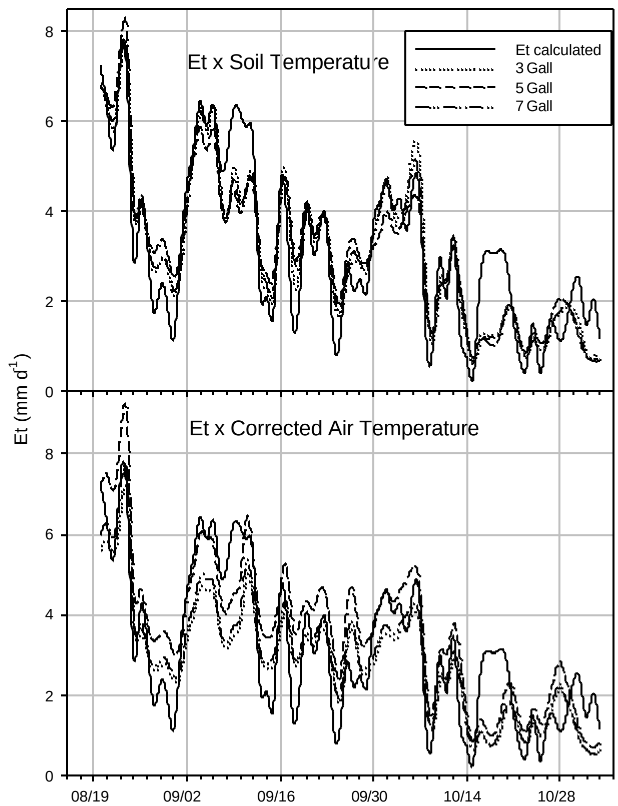


Figure 9 – Temporal variation of calculated Et and Et based on air and soil temperature.

The initial analysis did not show any correlation between evapotranspiration and soil moisture. While volumetric soil water content showed a similar trend in both the 3 and 7 gallon containers with average values varying around 30%, the 5 gallon containers values were isolated between 5 and 15% (Figure 10).

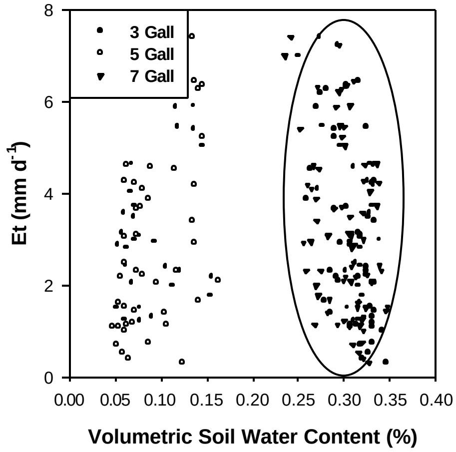


Figure 10 – Relationship between Soil Moisture and Evapotranspiration

Winter Season Experiment

A similar experiment will be conducted during the fall and winter seasons of 2002/2003. The main goal of this experiment will be to evaluate the impact of different irrigation regimes applied during the winter growing season. In addition, different plant species will be used compared to those that were used for the summer/fall experiment.

Due to the differences in soil water content that were found between the 3 and 7 gallon containers and the 5 gallon containers, the irrigation system was evaluated. The spatial water distribution of the sprinkler irrigation system seemed adequate (Figure 11). The small differences found in terms of irrigation depth could be due to various factors, such as measurement procedures and wind direction. Therefore, the spatial distribution of the experiment can be considered adequate.

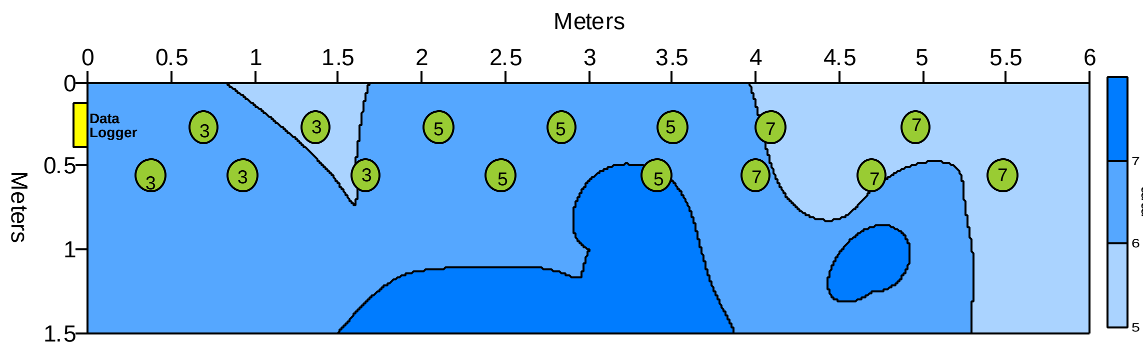


Figure 11 – Spatial water distribution of the sprinkler irrigation system. The position of the containers is depicted with the green circle.

The winter experiment season was started in November 19, 2002. The 3 gallon containers were planted with *Ilex chinensis* “Bufordi”, Dwarf Burford, the 5 gallon containers were planted with *Cuppres ocyparis* “Leylandi” and the 7 gallon containers were planted with *Ilex* x “Ruby Sceptor” (Figure 12).

3 Gallon 5 Gallon 7 Gallon

Figure 12 – Second Experiment conducted during the fall and winter season, 2002/2003.