BMPToolbox.org - Interactive Simulation Tools for Managing Water and Nutrients in Container Nurseries

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Significance to the Industry Interactive, web-based simulation tools are available to help growers and grower-advisors evaluate and quantify effects that management practices might have on water and nutrient use efficiency when producing ornamental plants in containers. Production simulations are based on historical weather data so that outcomes can be evaluated over a number of years. In addition to tools which help make strategic decisions regarding best management practices, a real-time tool offers day-to-day irrigation recommendations based upon estimated plant demand.

Nature of Work A team of researchers developed a plant growth model for simulating production of woody ornamental plants in small (trade #1-3) containers with sprinkler irrigation (1). CCROP (Container Crop Resource Optimization Program) mathematically describes critical biophysical processes (e.g. plant growth and development, evapotranspiration, nutrient release from controlled-release fertilizers, plant nutrient uptake, leaching, etc.) and how these processes interact with environmental conditions imposed by weather and management practices. Web-based tools (www.bmptoolbox.org) were developed to 1) provide a user-friendly means for selecting input management practices, 2) run CCROP simulations, and 3) view outcomes both graphically and in tabular form. Historical weather data is obtained from the Florida Automated Weather Network (FAWN; http://fawn.ifas.ufl.edu). Use of the BMPtoolbox.org website is free-of-charge but users must login to an account. Simulations can be stored under the account, which we have found useful for extension educational programs. In the following section we will briefly describe the four tools currently available (Table 1) and provide examples of how they might be used in management practice decision-making.

Grower Tool This tool is designed to evaluate a single set of management practices. Unlike the other tools, graphical output includes daily time-plots which can be useful for evaluating changes that occur during the season (e.g. spacing, irrigation, plant growth, fertilizer release). For example, the Grower Tool could be used by a grower in Quincy, FL who wants to make some general plans for scheduling labor associated with pruning, spacing, irrigation demand, and fertility for a March 1 planting of a fast-growing woody ornamental in trade #3 containers. Liner transplants are started container-to-container in a triangular arrangement and then spaced one container diameter apart when recommended by model. With this option, containers are spaced when leaf area

index (LAI=leaf area/ground area) reaches three at which time light becomes limiting. We select model-recommended irrigation which is based upon resupplying water lost through evapotranspiration (ET-based) and apply a 12-14 month CRF fertilizer (18% N; 15% controlled-release N) at 3 lb N/ yd^3 (99 g/container). A finish plant height of 30 inches is selected.

After submitting these Grower Tool inputs, daily time-plots can be viewed to get some insight into scheduling questions. The user can view the mean response to multiple years of weather data or select individual years to see how responses might change year-to-year (Fig 1). Selecting plant height from the plant response drop down menu shows that plants would typically be pruned 9-10 weeks after planting. Selecting leaf area index from same menu shows that plants might need spacing approximately 16 weeks after planting. Selecting mean irrigation from water-response menu shows how irrigation requirement changes during production from 0.1-0.2 inches at the beginning of the season to a maximum of 0.5-0.7 in the summer followed by a gradual decrease during the fall. From the same menu you might be interested to see patterns of drainage, N leaching, and runoff that were projected to occur during each year's simulation and how rain is closely linked to significant leaching events. For total irrigation demand, select summary to see that an average of 57 inches of water was required. To see if N or water was limiting, select N sufficiency or water sufficiency from plant-response menu in daily time-plots. For this example, N and water sufficiency (0 = severe deficiency; 1 = no deficiency, optimal growth) were 1 throughout the season indicating that the 3 lb N/yd^3 rate and ET-based irrigation met plant requirements. Repeating the example but changing fertilizer rate to 1.5 lb N/yd^3 and irrigation rate to 0.5 inch/day results in N and water deficiencies developing in the second half of the growing period.

Comparison Tools These tools help conduct virtual experiments by comparing several levels of a given factor (e.g. plant date, location, fertilizer rate, irrigation) keeping all other selected management practices the same. As an example, a company wanting to compare production at two of their nursery locations, one in Marianna (North Florida) and one in Homestead (South Florida) could run the Location Comparison Tool. If you select the two locations and submit the same input management practices as the Grower Tool example above, expected outcomes can be viewed graphically (Fig. 2). Simulated crop time was 1 month shorter for Homestead than for Marianna when planted in March and 3 months shorter in October. Simulated differences in crop time had implications relative to estimated irrigation pumping costs and N leaching. Interestingly, high runoff N was projected for the March planting in Homestead. Rainfall results reveal that this was likely due to summer rains in Homestead (40 inches for March planting but only 15 inches for October planting). Based solely on this information, the nursery might opt to plant a fall crop in Homestead location and a spring crop in Marianna to improve crop production efficiency.

Real-time Irrigation Tool This tool provides a daily irrigation recommendation based upon applying enough water to bring the simulated water deficit back to container

capacity. Weather is updated from FAWN weather stations at 2 a.m. each morning so that the tool can use the past day's weather to estimate the substrate water deficit that needs to be replenished with irrigation. The tool allows the user to adjust (calibrate) simulated plant growth if different from actual as well as enter important events such spacing and pruning. An example of a real-time irrigation output is given in Fig. 3 for a trade #3 woody ornamental planted 60 days earlier. The irrigation recommendation is based on 100% irrigation uniformity so growers will need to adjust irrigation rates according to actual irrigation uniformity measured in the field.

Technical Tool Geared for a more technical user, this tool allows a wider range of inputs to be changed. For example, a user wanting to evaluate the effect of a substrate's volumetric water-holding capacity (default value of 25% is used for other tools) may vary this input parameter incrementally and observe simulated effects on irrigation and runoff.

In summary, we described how CCROP provides growers and grower advisers with an interactive means to quantify effects of management practices on many aspects of container crop production. Comparative values may be just as important as absolute values as was demonstrated in the Location Comparison Tool example. While additional tools will be added and current tools likely modified, we hope the use of simulation tools will provide a fresh perspective on how management practices and the environment might interact in container nurseries.

Literature Cited

1. Million, J.B., J.T. Ritchie, T.H. Yeager, C.A. Larsen, C.D. Warner and J.P. Albano. 2011. CCROP - Simulation model for container-grown nursery plant production. Scientia Horticulturae 130(4):874-886.

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Table 1. Description of currently available tools for running CCROP simulations (www.bmptoolbox.org) to evaluate effects of management practices on plant growth and water and nutrient use during production of ornamental plants in trade #1 and #3 containers.

BMPToolbox	Purpose	Output
Grower Tool	Detailed simulation of one set of management practices	Daily time-plots and season totals
Comparison Tools	Run virtual experiments by comparing several levels of a factor (e.g. fertilizer, irrigation, location, planting date)	Season totals
Real-time Irrigation Tool	Tracks day-to-day progress of a crop in real-time providing a daily irrigation recommendation	Daily irrigation recommendation and daily time-plots
Technical Tool	For technical user, allows user to change all input variables	Daily time-plots including cumulative curves (metric units)

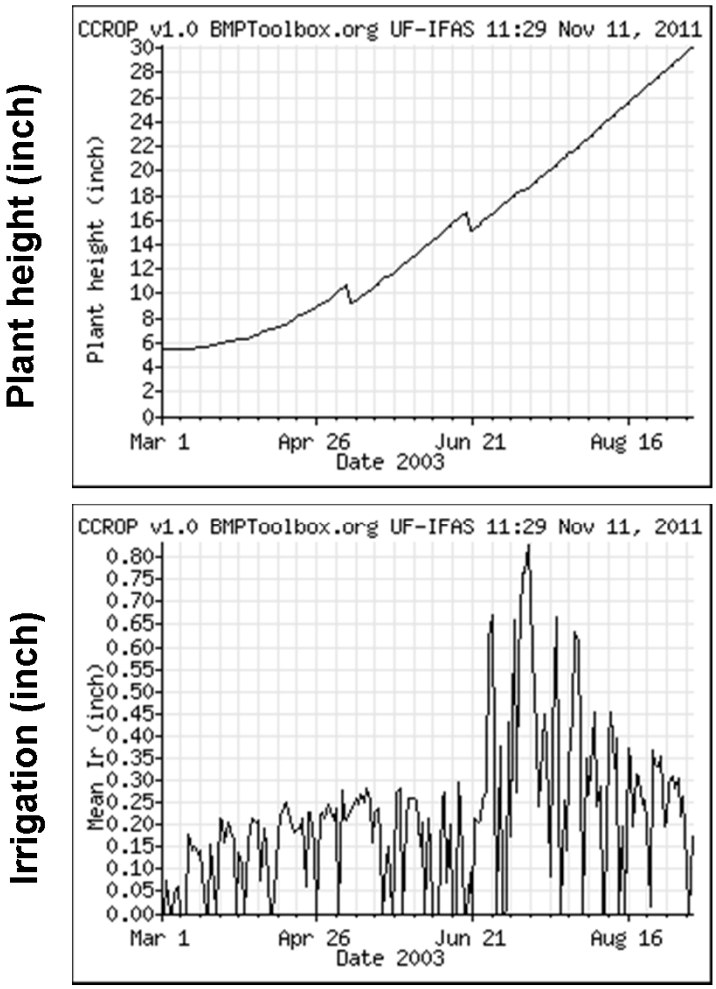

Fig. 1. Example outcomes from using Grower Tool to simulate production of a woody, ornamental plant planted in trade #3 containers and grown in Quincy, Florida. Results from only one year (2003) out the nine years of simulated plantings (2003-2011) are shown.

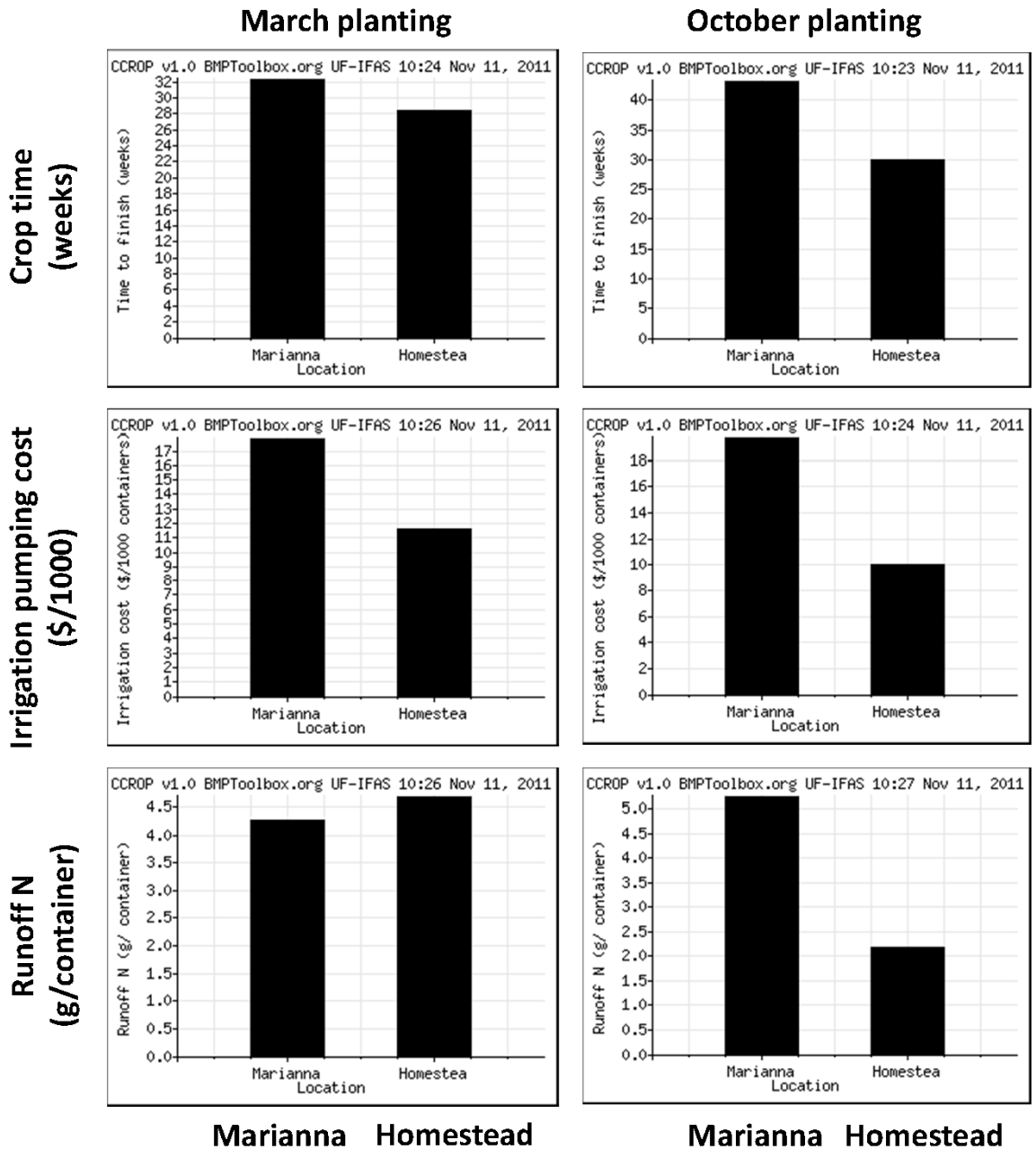

Fig. 2. Outcomes from using the Location Comparison Tool to simulate production of a fast-growing, woody ornamental plant in trade #3 containers at two locations, Marianna (North Florida) and Homestead (South Florida) and for two planting dates (March and October).

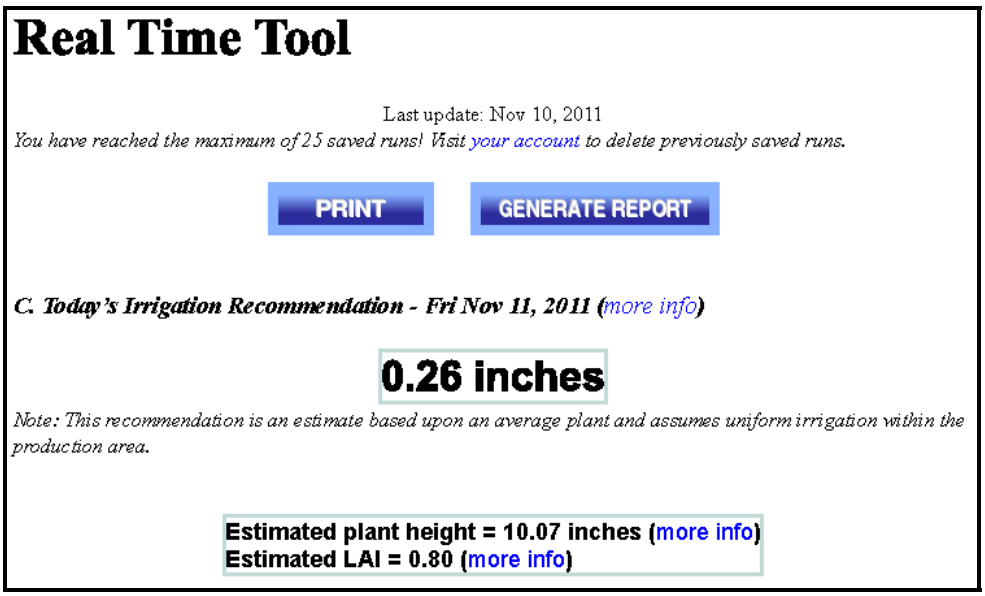

Fig. 3. The Real-Time Irrigation Tool provides a daily irrigation recommendation based on the amount of water required to replenish simulated water deficit in container substrate from the past day's evapotranspiration.