Resource Management Tool for Container Production

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Significance to the Industry. The management tool described in this paper allows the industry to objectively evaluate the effects that management practices can have on plant growth, water usage, and runoff. As such it provides a tool which can help make decisions regarding BMP implementation which are based upon local weather information and grower practices. Currently, the tool is limited to simulating production of a fast-growing shrub in a #1 container. Future research is aimed at expanding its usefulness to species with different growth characteristics and at validating its accuracy for simulating growth in larger containers.

Nature of Work. Decisions regarding the management of container crops are largely based upon grower knowledge and experience. Models which simulate crop growth can provide a scientifically-based tool for objectively evaluating the effects that critical management practices can have on crop production and resource utilization (1). For any given set of management inputs imposed by the grower, weather is the primary factor which affects crop production, nutrient and water requirements, and runoff. By running what-if experiments using historical weather data, a simulation tool can be used to select practices which would likely result in an acceptable product while maximizing the efficient use of resources such as water, fertilizer, space, and labor. This paper describes a model that has been developed to simulate the production of overhead-irrigated #1 sweet viburnum [*Viburnum odoratissimum* (L.) Ker-Gawl.] and gives an example of how this tool can be used to evaluate a best management practice (BMP) tailored to your nursery.

Crop simulation models are computer programs which use equations to describe plant growth. For our model, these equations are physically-based, meaning the equations in the model describe known physiological processes (e.g. transpiration, evaporation, photosynthesis, light interception, radiation use efficiency, etc). Our equations are based on a daily time period so that the rates of these physiological processes are integrated over a 24-hour day rather than by the hour or minute. A daily time frame has implications for real-time decision-making such as irrigation scheduling.

The heart of the model is the simulation of leaf area growth and development. Leaf area development (i.e. leaf appearance rate) determines the 'photosynthetic sink' or potential for biomass growth and is controlled primarily by temperature. The leaf canopy intercepts incoming solar radiation and therefore determines the 'photosynthetic source' available for new leaf area growth and biomass accumulation. Depending upon the weather and stage of growth, growth can either be sink-limited or source-limited. Leaf area also affects substrate temperature by intercepting solar radiation that would otherwise impinge upon container walls and substrate surfaces. Furthermore, leaf area affects the amount of overhead irrigation water that is captured by the container. Leaf area is directly related to the amount of evapotranspiration that occurs and biomass accumulation is directly related to the amount of nutrients required. Therefore, simulating leaf area growth and development plays an integral role in estimating water and nutrient requirements during production. If these resources are not available, equations are in place to provide negative feedback.

Runoff in the nursery is a result of both container drainage and un-intercepted irrigation and rain. Container substrate has a finite capacity to store water. If irrigation and rain exceed this capacity then drainage occurs. Plant spacing and leaf area affect the amounts of un-intercepted irrigation and rainfall that fall between the containers. The model estimates daily runoff based upon daily rain and irrigation inputs and loss through evapotranspiration. Nitrogen in runoff is a function of the pool of soluble N in the substrate. The pool of soluble substrate N is estimated using equations that predict N release from controlled-release fertilizer (CRF) and N removal from plant uptake and container drainage. By simulating runoff volume and N content, management practices can be selected which minimize these losses while maintaining acceptable growth.

The following inputs are needed to run the model:

• location (i.e. daily weather – min and max air temperatures, solar radiation and rain)
• transplant size, plant date, container size
• container spacing and move schedule
• harvest date or harvest size
• substrate volume, substrate water contents at container capacity and at wilting point
• irrigation schedule (fixed rate, ET-based, or input file), auto rain cutoff
• fertilizer grade, longevity rating and application rate, N conc. of irrigation water
• pruning schedule and degree of pruning

The following outputs are generated by the model:

• finish date or size, root and shoot biomass, leaf area, leaf area index, plant size
• irrigation amount, irrigation capture, substrate water content, water sufficiency
• evapotranspiration, drainage, runoff amount
• actual and optimum root and shoot N concentration
• N demand, N supply, N uptake, and N sufficiency
• N release from CRF, substrate N, drainage N, runoff N, irrigation N

Outputs include daily and season totals and can be expressed on a per-container basis for efficiency analyses or expressed on an area basis for runoff and nutrient management evaluations. Also, simple statistics (e.g. mean, median, max, min, standard deviation) can be generated to describe responses when the simulation is run using multiple years of weather data.

A web-based interface is being developed which allows the user to select critical management factors, run the simulation and view the output in graphical or tabular form. Currently, the tool has two basic versions – a grower-friendly version and a technical version. The technical version, which is in metric units, allows the user to change essentially any input in the model. The grower version, which is in English units, has fewer input options but is easier to use. With the grower version, the user has the option of comparing two or more levels of a factor keeping all other inputs the same. For example, there are comparison tools to evaluate different fertilizer rates, different irrigation schedules, and different plant dates. By running "what if" scenarios or comparisons, the grower achieves knowledge of the best practices to implement with minimal environmental impacts. For example, a 30-yr simulation comparing 1, 2, and 3 lb of N per cubic yard for a March planting in central Florida showed that by decreasing the fertilizer rate from 3 to 2 lb N per cubic yard N loss was reduced >50% (0.6 vs. 1.3 g N/container) without sacrificing growth (Fig. 1).

Crop simulation models help producers make decisions with little investment costs and enhance decisions where directed experimentation is lacking. Decisions from simulations are based on the best science available for the range of inputs encountered in production. Decision support systems that use models to evaluate input variables will be very important in the future as input costs escalate. With these tools, producers will be able to choose BMPs which maximize environmental benefits and minimize input costs.

Literature Cited

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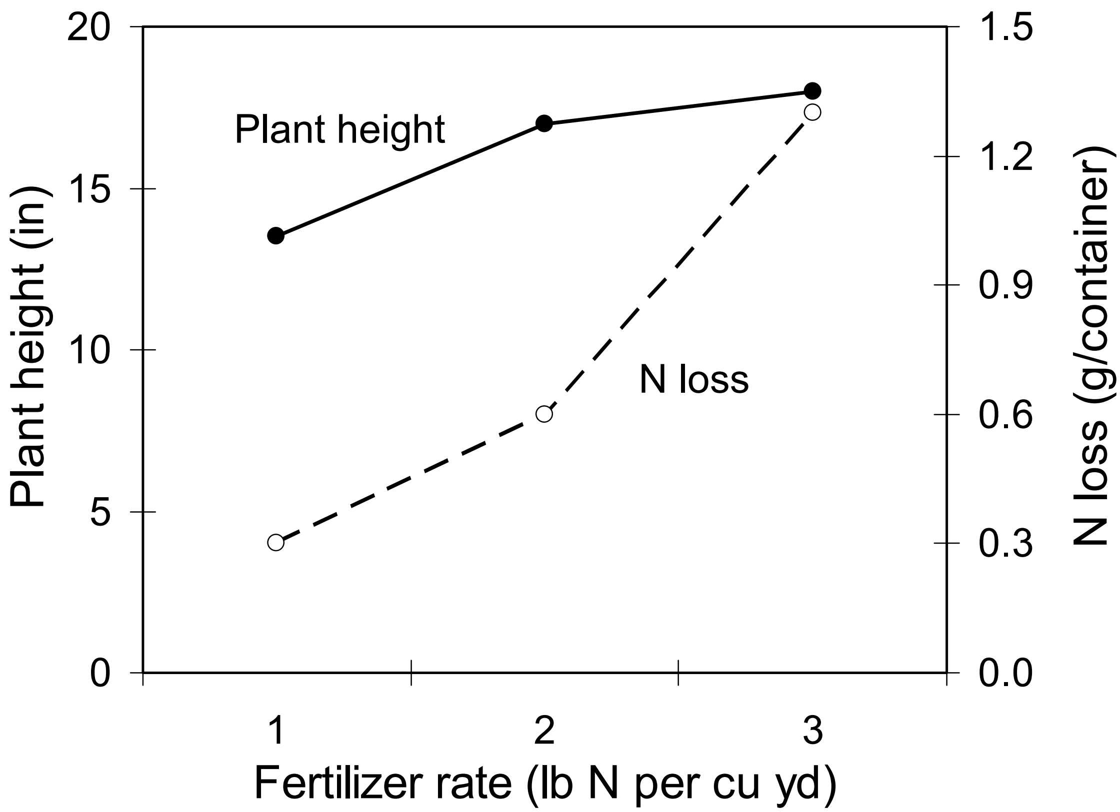

Fig. 1. Average growth and fertilizer N loss during the simulated production of #1 sweet viburnum fertilized with three different controlled-release fertilizer rates. Simulations were based on 30 years of historical weather for central Florida, a March 1 plant date, overhead irrigation rate of 0.5 inch/day, and a 20-week growing period.