Water Management

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Section Editor

Assessment of Bottled and Tap Water from Middle Tennessee Counties Dominated by Nursery Crop Production

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Significance to Industry: Nursery crop production activities can be labor intensive because it involves both field and greenhouse operations. The intensity is exacerbated when workers have to work in summer months when outside temperature averages 80-85 degrees Fahrenheit. Under these conditions workers are encouraged to drink plenty of water. This either could be bottled water or tap water. Fresh water is a finite and precious resource essential for sustaining life and health. However, with population growth coupled with rapid urbanization, changing lifestyles and economic development, concerns over drinking water quality and availability is becoming very important. As a result, consumers are demanding and paying premium prices for clean drinking water. It is not uncommon for consumers to pay three dollars for a 20 oz (591 ml) of bottled water. Certainly, many factors account for U.S. consumers' enthusiasm for bottled water. Central among these factors include portability, safety, convenience, value and healthfulness. Bottled water's versatility makes it suitable for consumption at any time of the day as well as any circumstances. United States residents drink more bottled water annually than any other beverage, other than carbonated soft drinks (International Bottled Water Association, 2011). Bottled water wide acceptability is related to the convenience and taste it provides (Glecik, 2006) along with the belief that it is purer than tap water; this perception by consumers makes it a healthy alternative to tap water (Ahmad and Bajahlan, 2007).

Nature of Work: Six counties from middle Tennessee were chosen for the collection of the tap water samples. These counties were chosen because they represent urban, urbanizing and rural counties. Secondary to these reasons, they were chosen because of their accessibility from our campus and the rural counties have an abundant of field nursery production operations. Therefore, among the chosen six counties Davidson County (pop. 648,295) is urbanized while Williamson County (pop. 192,911)) and Rutherford County (pop. 274,454) are considered urbanizing. Coffee County (pop. 53,222) and Warren County (pop. 39,839) were the rural counties according to U.S. Census Bureau (2012). Twelve different brands of bottled water containing spring and purified water types were purchased randomly from supermarket in Middle Tennessee. (Note that the names of the bottled water were not listed in this publication for obvious reasons, however if interested please contact via e-mail address in the manuscript). All analytical chemicals used were of reagent grade and were purchased from Fisher

Scientific (Suwanee GA, USA) and Hach (Loveland, CO, USA). The deionized water used throughout the experiment had less than 1µg/L organics and a resistivity of 18.3 m Ω/cm at room temperature. A stock solution (100ppm) of mixed standards containing a suite of elements were obtained from SPEX Certiprep, Inc (Metuchen, NJ. USA). Another stock solution (1000 ppm) of metal ions standards were purchased through Fisher Scientific. A Varian Vista-Pro Inductively Coupled Plasma-optical emission Spectrometer (ICP-OES) was used to measure the metal ions (major, minor and trace) content of the water samples. The ICP-OES was calibrated by preparing calibration standard solutions from the stock standard solutions and an internal standard (scandium) was used as part of the quality assurance. Standard reference material (SRM 1643e) was used to check the accuracy and precision of the analytical method. The Standard reference material (SRM 1643e: trace elements in natural water) was purchased from National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA. The water samples were transported to the laboratory for analyses. The tap water samples and the bottled water samples did not contain particulates hence they were not filtered prior to analyses. The elements determined by ICP-OES are depicted in Table 1. Additionnaly, the physico-chemical parameters of the water samples (pH, conductivity, total dissolved solid and turbidity) were also determined according to Hovis et al, 2012.

Results and Discussion: The levels of aluminum (Al), copper (Cu) and iron (Fe) in the tap water in all the counties were relatively consistent and were below US-EPA (2013) allowable limits. The same is true with all the bottled water tested, they were also below US-EPA allowable limits. Phosphorus (P) concentration in the tap water samples ranged from 0.01 ppm (Coffee County, a rural county) to 0.28 ppm (Davidson County, an urban county). The slightly high phosphorus content in water samples collected from Davidson County could be attributed to the phosphorus rich limestone found in the area. Phosphorus in the bottled water samples ranged from 0.00 ppm to 0.015ppm. Water hardiness is an important water quality feature and it is affected by the concentration of calcium (Ca) and magnesium (Mg) in water, which in many instances is influenced by surrounding soil and rocks. The concentration of calcium in the tap water samples ranged from 27 ppm in Williamson County to 51 ppm in both Coffee and Cannon counties. Middle Tennessee has an abundance of limestone rock, which may explain the relatively high concentrations of calcium in the counties sampled. The bottled water samples had a calcium concentration ranging from 0.002 ppm to 76 ppm. Water is generally classified as soft when it contains 0 to 60 ppm of calcium carbonate; moderately hard if it contains 61 to 120 ppm of calcium carbonate and hard if it contains 121 to 180 ppm (USGS Office of Water Quality, 2012). Based on our findings all the water samples were considered soft except for one brand of the bottled water that was moderately hard. While the concentration of heavy metals in both the tap water and bottled water were below US-EPA allowable limits; statistically our data showed that tap water collected from urban to urbanizing counties had significantly higher percentage of heavy metals than that of rural counties areas (Figures 1, 2). The reasons could be attributed to urban sprawl and associated greater number of industries than in the rural counties. However, the concentrations of inorganic and metal ions found in the two types of drinking water sources were relatively similar. Suggesting that, there is no different in the chemical constituents of tap water and bottled water analyzed. Certainly, many factors account for consumers' enthusiasm for bottled water. Central among these factors include portability, safety, convenience and healthfulness. Bottled water's versatility makes it suitable for consumption at any time of day as well as any circumstances.

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Table 1. Elements determined in tap water and bottled water, 2013.

Type	Elements	Instrument used
Macro elements	Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus (P), Silicon (Si), Chloride (Cl^-) and Fluoride (F^-)	Inductively Coupled Plasma-optical emission spectrometer (ICP-OES) but for Fluoride and Chloride Ion Selective Electrodes were used.
Trace elements	Lithium (Li), Boron (B), Aluminum (Al), Titanium (Ti), Vanadium(V), Chromium (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni) Copper (Cu), Zinc (Zn)	ICP-OES
Heavy metals	Arsenic (As), Cadmium (Cd), Mercury (Hg), Lead (Pb), Molybdenum(Mo)	ICP- OES

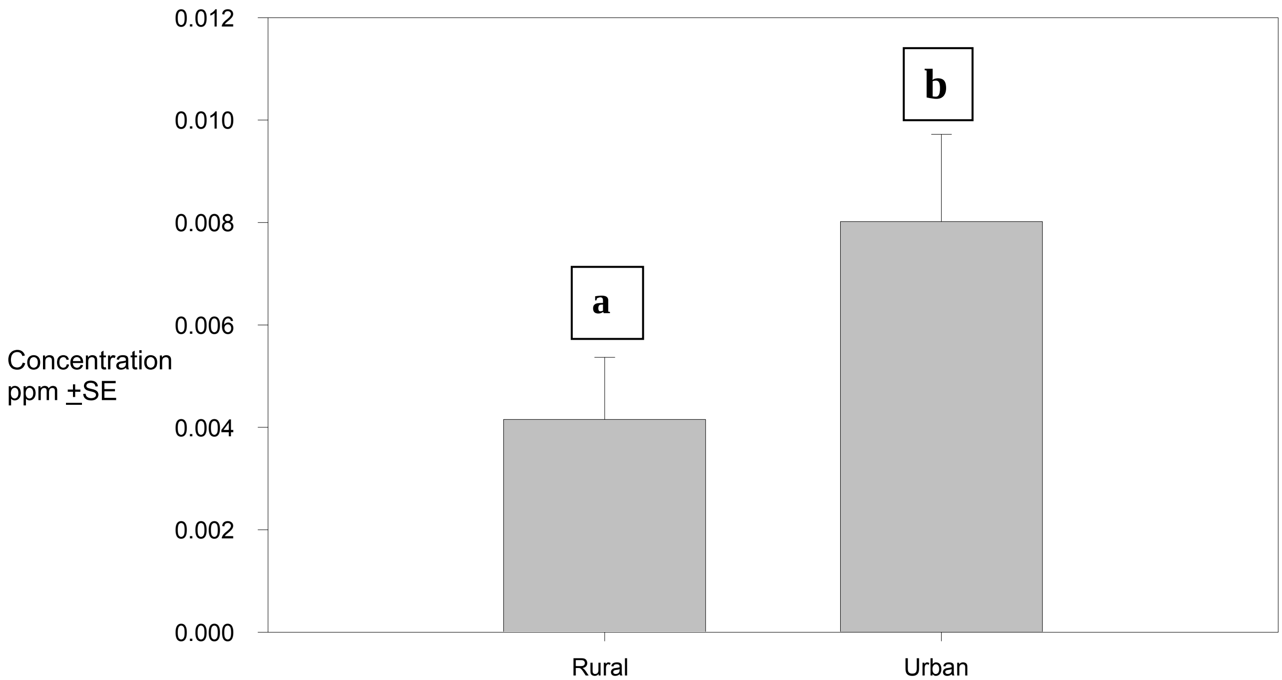

Figure 1. Mean + SE heavy metal residues in parts per million (ppm) for urban counties (Williamson, Davidson, Rutherford) and rural counties (Coffee, Canon, Warren). Bars with different letters were significantly different (χ^2 = 4.31; df=1; P < 0.038) (Wilcoxon Rank Sum Test) (SAS 2003).

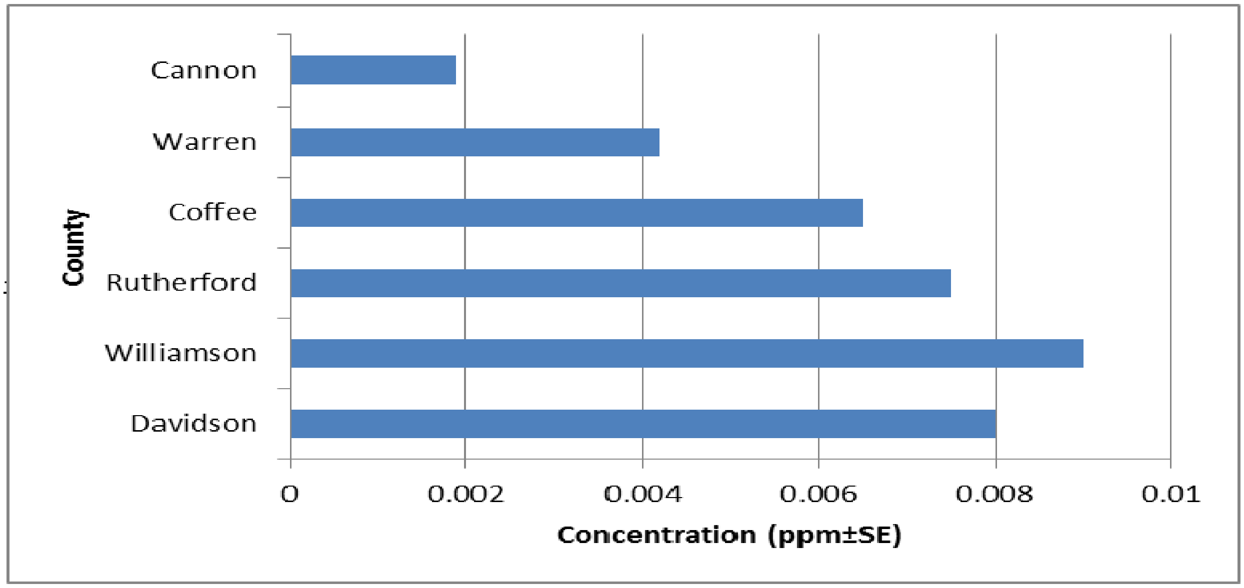

Figure 2. Mean ± SE heavy metal residues in parts per million (ppm) in different counties. The rural counties (Coffee, Warren, and Cannon) had lower concentrations than the urban counties when data were pooled ($P < 0.05$). The figure suggests that as we move from urban county such as Davidson to rural counties such as Canon the concentration of heavy metals tends to decrease.

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Effect of Container Spacing and Plant Species on Water Use

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Index words evapotranspiration, container plant irrigation

Significance to the Industry Water conservation continues to be an important challenge for the nursery industry. Our research indicates the distance between container-grown plants should be minimized during production as plant water use increases significantly when plants are placed at wide spacing. The importance of spacing is substantiated by the finding that the increase in water use due to spacing was generally larger than the differences in water use between the species evaluated.

Nature of Work Irrigation amounts applied to container-grown nursery plants are rarely based on scientific research. One irrigation Best Management Practice (BMP) is to group plants by irrigation need. Emphasis has traditionally been to group by plant species or genera. However, recent research has indicated that placing similar-sized plants at different spacings can greatly affect water use (1) leading one to question whether plants should be grouped not only by species or genera but also considering plant spacing, plant size, or other criteria. The objective of this research was to compare the relative effect of plant species and plant spacing by measuring the evapotranspiration (ET) rate of six plant species at two different spacings in a production nursery environment.

At Saunders Brothers Nursery in Piney River, Virginia, 19 uniform and marketable-sized plants for each of six species (Table 1) in trade 3-gallon containers (approximately 10 liter volume) were positioned in an offset spacing pattern (hexagonal) either non-spaced or at wide spacing (Table 1). The non-spaced arrangement allowed plant species to be compared under full canopy coverage of the production area. The ET of both non-spaced and spaced plants was determined by weighing seven interior plants in the morning following irrigation and drainage and again at dusk. Container ETc (cm) was calculated by dividing grams or cm^3 of water lost from the container plant by the top area of the container (cm^2). Results for Aug. 2, 2013 are presented in Figure 1. The minimum and maximum temperatures on this day were, 63 and 84 F, respectively, and average solar radiation was 323 W/m^2.

Results and Discussion ETc for non-spaced plants ranged from 0.81 cm for *Rhododendron* to 1.27 cm for *Berberis*. The ETc for spaced plants ranged from 1.27 cm for *Gardenia* to 1.64 cm for *Berberis*. ETc of *Berberis* greatly exceeded the ETc of the other plants and this may be because *Berberis* plants were 2 to 4 inches wider than other plants. Excluding *Berberis*, ETc for all non-spaced plants was within one standard deviation of the mean (Figure 1) and the difference in ETc for the remaining five genera was 0.18 cm for the non-spaced plants and 0.26 cm for spaced plants. The increase in ETc for spaced plants vs non-spaced plants ranged from 28% for *Gardenia* to 84% for *Spiraea*.

While additional testing with a large number of species is needed to make definitive conclusions about differences in water use for different species, these data indicate that under similar environmental conditions differences in water use between plant species may be less important than differences in plant spacing. These data and data from a previous study (1) indicate that widely-spaced plants can use considerably more water than non-spaced plants. In the research reported here, spaced plants used an average of 52% more water than non-spaced plants on the same day. Growing plants with minimal distances between containers that result in quality plants should be a BMP for conserving water. Likewise, grouping plants by plant size and spacing may be as important as grouping plants by species.

Literature Cited

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Acknowledgement

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Table 1. Plants and spacing for trade #3 containers used for evapotranspiration (ET) evaluation at Saunders Brothers Nursery in Piney River, Virginia on Aug. 2, 2013.

	Container spacing (inches within, between rows)	
Plants evaluated	Non-spaced	Spaced
Berberis thunbergii f. atropurpurea 'Rose Glow'	11, 9.5	19, 17
Gardenia jasminoides 'Frostproof'	11, 9.5	15, 14
Hydrangea paniculata Pinky Winky™	11, 9.5	17, 17
Rhododendron spp. 'Girard's Crimson'	11, 9.5	16, 18
Spiraea japonica 'Tracy' Double Play® Big Bang	11, 9.5	18, 17
Weigela florida Wine & Roses®	11, 9.5	15, 17

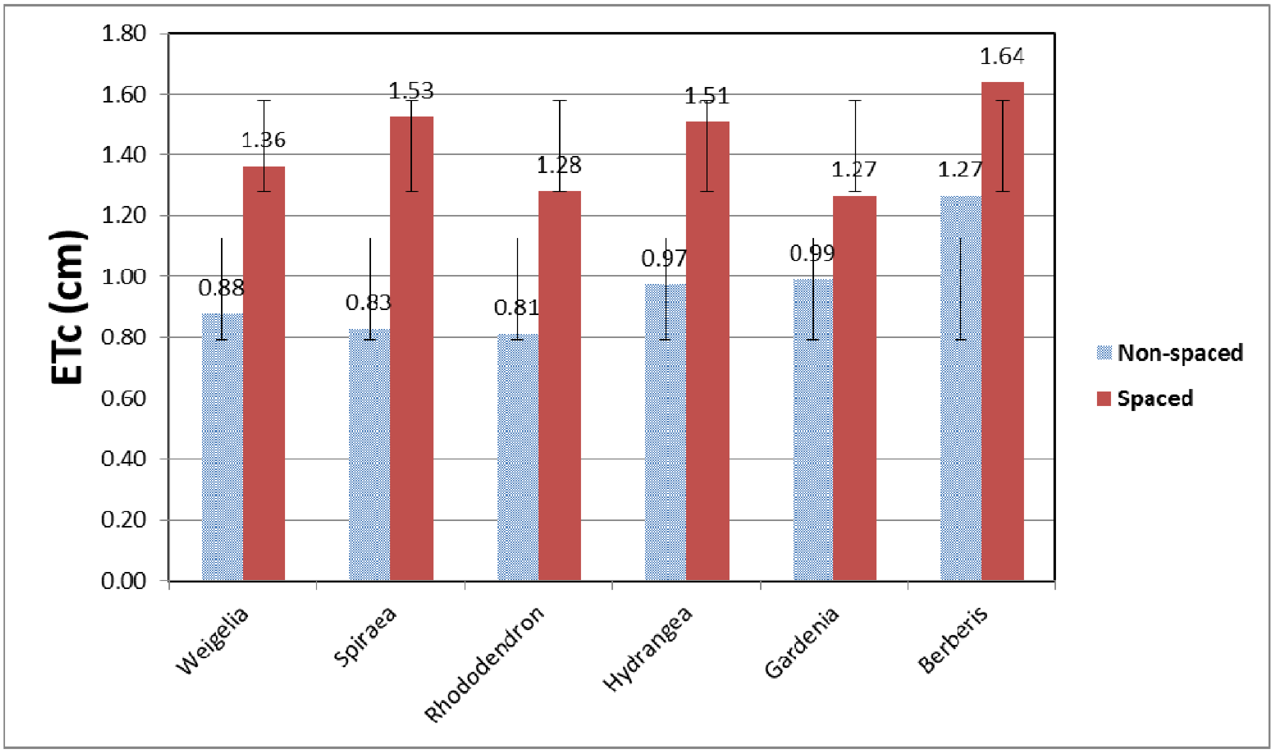

Figure 1. Effect of spacing and container plant on evapotranspiration (ETc) measured on Aug. 2, 2013 at Saunders Brothers Nursery in Piney River, Virginia. Bars represent one standard deviation from the mean (n=7) value of each of two spacing groups.