



CONTENTS

Susan D. Day, P. Eric Wiseman, Sarah B. Dickinson, and J. Roger Harris

**Tree Root Ecology in the Urban Environment and Implications for a Sustainable Rhizosphere ..... 193**

**Abstract.** This review examines current understandings of how the belowground characteristics of urban settings affect tree roots as well as how tree roots contribute to biogeochemical processes in this belowground environment. Soil characteristics common to the urban environment include soil compaction and other physical impediments to root exploration, elevated pH, altered temperature and moisture patterns, and the presence of contaminants. These conditions may alter the growth dynamics, morphology, and physiology of roots. At the same time, roots have a profound effect on the soil environment, with trees directing 40%–73% of assimilated carbon below ground. Urban rhizosphere ecology is a topic of renewed interest for research not only because of its critical role in the urban ecosystem, but also because of its role in global environmental issues. In addition to its obvious contribution to aboveground growth, root exploration of the soil environment can influence environmental sustainability through root contributions to soil structure and drainage. Root influence is further mediated by the intimate role of roots in soil biological activity and thus carbon storage and nutrient cycling. Current advances and implications for emerging research are discussed.

**Key Words.** Heavy Metals; Road Salt; Root Periodicity; Soil Compaction; Soil Structure; Urban Hydrology; Urban Infrastructure.

David R. Smitley, Joseph J. Docola, and David L. Cox

**Multiple-year Protection of Ash Trees from Emerald Ash Borer with a Single Trunk Injection of Emamectin Benzoate, and Single-year Protection with an Imidacloprid Basal Drench ..... 206**

**Abstract.** Green ash (*Fraxinus pennsylvanica* Marsh.) street trees ranging in size from 25 to 45 cm dbh were trunk injected with emamectin benzoate at rates of 0.10–0.60 g ai/2.54 cm dbh at three Michigan, U.S., locations in 2005 or 2006. Tree health was monitored by annual canopy thinning and dieback ratings for up to four years after a single treatment. Branch samples were collected in the autumn and the bark removed to count emerald ash borer larvae for most treatments over the same period of time. A single trunk injection treatment of emamectin benzoate at the 0.1, 0.2, or 0.4 g ai rate gave 100% control of emerald ash borer larvae in 98 of 99 treated trees for 2–3 years. Canopy ratings for treated trees remained similar for 2–4 years following trunk injection, while >50% of the control trees died during the same period of time. Ash trees that received a combination of an imidacloprid trunk injection and an imidacloprid basal drench or an annual imidacloprid basal drench had similar canopy ratings, but more larvae were found in branches from trees receiving the annual basal drench.

**Key Words.** *Agrilus planipennis*; Ash; Emerald Ash Borer; Emamectin Benzoate; *Fraxinus*; Trunk Injection.

Glynn C. Percival and Kelly Noviss

**Penconazole Induced Heat Tolerance in Scots Pine (*Pinus sylvestris*) and Evergreen Oak (*Quercus ilex*) ..... 212**

**Abstract.** The ability of penconazole, a triazole fungicide derivative, to protect against and ameliorate heat stress was studied in evergreen oak (*Quercus ilex*) and Scots pine (*Pinus sylvestris*). Under laboratory conditions, heat damage to the leaf photosynthetic system based on the stability of the chlorophyll a/b light-harvesting complex within photosystem II (chlorophyll fluorescence  $F_o$  responses) and leaf photochemical efficiency (chlorophyll fluorescence  $F_v/F_m$  emissions) of detached leaves was constantly less in penconazole treated trees. In both species, greatest protection of the leaf photosynthetic system to heat induced disorders was achieved by application of penconazole at a concentration of 30 g per liter of water compared to penconazole applied at a concentration of 0.15 or 0.45 g per liter of water. Subjecting containerized trees of both species to 10 minutes at 50°C significantly reduced tree vitality with respect to chlorophyll fluorescence  $F_o$  and  $F_v/F_m$  emissions, total foliar chlorophylls, leaf photosynthetic rates ( $P_n$ ) and significantly increased damage to cellular membrane integrity as manifest by higher leaf electrolyte leakage and visual leaf necrosis between stressed and non-heat stressed well-watered trees. The influence of penconazole applied immediately after heat stress on the pattern of recovery over the following twelve weeks demonstrated penconazole treated trees were the most capable of recovery. With respect to chlorophyll fluorescence  $F_o$  and leaf electrolyte leakage values recovery rates of heat damaged trees treated with penconazole ranged from 20%–50% higher than non-triazole treated control trees. In all cases non-penconazole treated control trees had the least capacity for recovery. Regardless of species, height, leaf area, root, shoot, and total plant dry

weight were, in virtually all instances, greater than non-penconazole treated controls. The tactical use of the triazole derivative penconazole as an ameliorant against heat damage and recovery from heat stress in Scots pine and evergreen oak would be of benefit to improve tree recovery rates and growth. From a practical point of view penconazole at 30 g a.i. per liter of water is suggested based on the results of this study.

**Key Words.** Chlorophylls; Chlorophyll Fluorescence; Electrolyte Leakage; Fungicides; Growth Inhibitor; Physiogenic Stress; Stress Enzymes.

A.D. Ali and Shawn C. Bernick

### **Effects of Paclobutrazol on Royal Palm (*Roystonea regia*) Trunk and Height Growth..... 221**

**Abstract.** Paclobutrazol is a plant growth regulator which reduces cell elongation and growth. It is commonly used in reducing the growth of herbaceous plants and woody dicots. It has also shown activity against young palms, such as oil and date palms. The effects of basal drench treatments applied annually or as a single application on mature Royal palms (*Roystonea regia*) were studied over a three-year period. No significant effects were noted on lateral trunk growth. Paclobutrazol treatments resulted in slower vertical growth than in palms not receiving a treatment. However, even at 36 MAT, the average reduction in vertical growth (approx. 50 cm) was still not horticulturally significant relative to the overall palm height of approximately 7 m. Royal palms may attain heights up to 24 m when mature. It is recommended that they not be planted within 7 m of utility lines especially considering regulating their vertical growth is not a practical option.

**Key Words.** Growth; Growth Regulators; Height Control; Paclobutrazol; Royal Palm; *Roystonea regia*.

John Ball and Shane Vosberg

### **A Survey of United States Tree Care Companies: Part I - Safety Training and Fatal Accidents .... 224**

**Abstract.** Tree work has a high accident rate compared to many other occupations. News accounts of recent accidents can be easily accessed through the internet, though this may not provide a true picture of the number and types of accidents occurring. U.S. government bureaus and agencies have produced reports citing the number and circumstances of fatal accidents in the profession. The government's information is obtained from many sources and may not accurately identify types or frequency of these accidents. A survey of the accidents and safety training among tree care companies was conducted using a mail questionnaire based on the Tailored Design Method. The company managers responding to the survey overwhelming identified having trained field workers as very important yet only about two-thirds of their companies conducted any training. The training most often conducted was on aerial lifts, chain saws, and chipper, which was provided by company employees in a field setting. Driver's training was not part of a formal safety program for most of the companies. Aerial rescue was practiced by about one-fourth of the surveyed companies. The most common fatal accidents involved contact with an electrical conductor followed by being struck by a falling limb. The relative number of fatal accidents by event or exposure in this survey was similar to that identified by two federal government reports on fatal accident in the field.

**Key Words.** Arboricultural Accidents; Arboricultural Accident Survey; Safety Training; Tailored Design Method; Tree Care Industry Accidents.

E. Gregory McPherson

### **Selecting Reference Cities for i-Tree Streets..... 230**

**Abstract.** The i-Tree Streets (formerly STRATUM) computer program quantifies municipal forest structure, function, and value using tree growth and geographic data from sixteen U.S. reference cities, one for each of sixteen climate zones. Selecting the reference city that best matches a subject city is problematic when the subject city is outside the U.S., lays on the border between two climate zones, has a different climate, or tree species composition because of differences in elevation, urban morphology, and environmental quality. A systematic process for selecting the best match is described and illustrated for Lisbon, Portugal. Selection criteria are tree species composition, heating and cooling degree days, and annual precipitation. Raw and difference values for each criterion are normalized to range from 0 to 10 using linear interpolation. The coefficient for each criterion is weighted to reflect its relative importance. The Root Mean Square Error (RMSE) is calculated and the reference city with the lowest value is the best match for the subject city. The state of California's reference cities of Modesto (RMSE = 2.41) and Claremont (2.71) proved to be the best match for Lisbon when coefficients were unequally weighted.

**Key Words.** Benefit-Cost Analysis; i-Tree Streets; Municipal Forests; Street Tree Inventory; Urban Forest Valuation.