Tree and Forestry Science and Biotechnology

Abbreviation: Tree For. Sci. Biotech.
Print: ISSN 1752-3753
Frequency and Peer status: Biannual, Peer reviewed

Scope and target readership: *Tree and Forestry Science and Biotechnology* will provide a complete analysis and understanding of all aspects of tree science and biotechnology.

Tree and Forestry Science and Biotechnology primarily wishes to examine:
1) *In vitro* propagation (micropropagation, somatic embryogenesis, tissue culture, bioreactor system production);
2) Mycorrhizal symbioses (and effects on plant physiology, productivity, reproduction and disease resistance);
3) Cultural practices (greenhouse production, hydroponics, aeroponics, organic farming);
4) Physiology, genetics, molecular biology, structural botany (integrated, pure and applied);
5) Pathology;
6) Production of secondary metabolites, organic and inorganic biochemistry, and phytochemistry;
7) Storage of valuable genetic material (low temperature storage or cryopreservation);
8) Novel techniques for analysis (genetic, biochemical, biophysical);
9) Forest management, economics and regulation (including solutions to deforestation);
10) Forestry policy as that which benefits society, the economy, and maintains genetic diversity.

For publication in *Tree and Forestry Science and Biotechnology* the research must provide a highly significant new contribution to our understanding of tree and forestry species and must generally be supported by a combination of either: physiological, biochemical, genetic or molecular analyses. All areas of study are welcome and the experimental approaches used can be wide-ranging. Results that simply provide a description without an integrated multi-disciplinary approach will generally not be considered.

Global Science Books, Ltd.
Editorial Office
Miki cho Post Office, Kagawa ken, Kita gun
Miki cho, Ikenobe 3011-2, P.O. Box 7
761-0799, Japan

Head Office: Isleworth, United Kingdom
Accounting: Lagos, Portugal

GSB homepage: www.globalsciencebooks.info
Journals web-page: http://www.globalsciencebooks.info/Journals/GSBJournals.html
TFSB web-page: http://www.globalsciencebooks.info/Journals/TFSB.html
GSB Japan web-page: http://www17.plala.or.jp/gsbjapan

Guest Editors

Dr. Paula Tennant

Dr. Noureddine Benkeblia

University of the West Indies, Jamaica

In co-operation with

University of the West Indies, Jamaica

UWI
Life Sciences

Cover photos: Top, left: Tangelo fruits grown nearby La Tendida, Venezuela; Top, right: Symptoms of (treated) gummosis in orange (Fermin *et al*., pp 152-163). Electron transport rate measured with a pulse-modulated imaging system for analysing the chlorophyll fluorescence kinetic (Zude and Kläring, pp 139-151).

Disclaimers: All comments, conclusions, opinions, and recommendations are those of the author(s), and do not necessarily reflect the views of the publisher, or the Editor(s). GSB does not specifically endorse any product mentioned in any manuscript, and accepts product descriptions and details to be an integral part of the scientific content.

Printed in Japan on acid-free paper.
Published: June, 2009.

The Guest Editors

Dr. Paula Tennant is a research plant pathologist working with virus diseases of fruit crops at the University of the West Indies, Mona, Jamaica. She received a BSc degree in Botany from the University of the West Indies and her PhD in Plant Pathology at Cornell University. Post doctoral experience working with *Papaya ringspot virus* and the efficacy of pathogen-derived resistance for the control of the virus in Jamaica was at Cornell University and the Biotechnology Centre, University of the West Indies, Mona. These efforts and close collaboration with the Jamaica Agricultural Development Foundation (JADF) have led to the establishment of the appropriate regulatory structures to oversee the use and importation of agricultural biotechnology products in Jamaica and the development of a bio-engineered agricultural product of the Caribbean. She joined the Staff in the Department of Life Sciences in 2001, continuing work with papaya and more recently initiating work on the characterization of *Citrus tristeza virus* isolates and citrus viroids in Jamaica. In 2001, Dr. Tennant received the Young Agriculturist Award from the Inter-American Institute for Cooperation on Agriculture (IICA) for her work on papaya. She co-teaches a graduate course, Plant Diseases and their control, and undergraduate courses in Molecular Biology, Virology and Plant Biotechnology at the University of the West Indies, Mona.

Dr. Noureddine Benkeblia is a scientist involved in postharvest plant biochemistry and physiology, including preservation technologies for horticultural crops. His work is mainly devoted to the metabolism of the carbohydrate, fructooligosaccharides (FOS), during plant development and storage periods. A few years ago, he introduced the new concept of system biology – Metabolomics – to investigate the mechanisms of biosynthesis and accumulation of FOS in Liliaceous plants. Dr. Benkeblia first received his BSc, MSc and Doctorate (PhD) from INA (Algeria), and Doctor in Agriculture (PhD) from Kagoshima University (Japan). After few years teaching in Algeria, he joined INRA, Avignon (France) as a Postdoctoral Scientist from 2001. From 2002 to 2008, he worked as a Visiting Professor in the University of Rakuno Gakuen, Ebetsu (Japan) and also as a Research Associate in Hokkaido University from 2005 to 2007. Dr. Benkeblia joined the Staff in the Department of Life Sciences University of the West Indies, Mona, Jamaica in 2008, continuing his work on the physiology, the biochemistry and metabolomic of fructan-containing plants in Jamaica. He also works on the postharvest physiology and biochemistry of local fruits such as ackee and sorrel. Dr. N. Benkeblia is teaching plant physiology, horticulture and postharvest management of crops.

SPECIAL ISSUE: CONTENTS

Tree and Forestry Science and Biotechnology

SPECIAL ISSUES: CITRUS II (Guest Editors: Paula Tennant, Noureddine Benkeblia (University of the West Indies, Jamaica)) ~ March, 2009

Special Issue 1

Farhat Abbas, Ali Fares (USA) Best Management Practices in Citrus Cultivation (pp 1-11)

ABSTRACT

Invited Review: There are growing concerns about the environmental impact of intensive agricultural production including citrus cultivation on our natural resources, i.e., water resources. In addition to enhancing citrus tree growth, fruit yield, and quality of citrus orchards, the properly adopted citrus best management practices (BMPs) should help protecting our environment. Thus, the goals of citrus BMPs are to integrate different approaches to optimize irrigation water and minimize surface- and sub-surface transport of nutrients and pesticides, and control citrus related pests, weeds, and disease attack. This article reviews the major citrus BMPs including: i) citrus irrigation management, ii) citrus nutrient management, and iii) citrus pests, weeds, and disease control. Environmental impact of citrus cultivation on our water resources, if the recommended BMPs are not properly adopted, are also discussed. The information presented in this article should help scientists, professionals, and citrus growers adopt the recommended BMPs for sustainable citrus cultivation.

Ali Fares (USA) Citrus Irrigation Scheduling (pp 12-21)

ABSTRACT

Invited Review: As the major water user, irrigated agriculture is expected to make substantial changes to optimize its water use. Ample research findings in the literature show that an efficient irrigation scheduling reduces production cost, improves crop yield, limits erosion and sediment loading, and enhances environmental quality. A successful irrigation water management program optimizes water availability, while ensuring the best crop yield and quality at the lowest cost to the producer. Irrigation scheduling is generally meant to calculate the exact amount and timing of irrigation to be applied to the field based on the crop irrigation water requirements. This review manuscript discusses the following sections: i) soil and its major physical properties that influence irrigation scheduling, ii) measurement of some of soil physical properties iii) rainfall characteristics (amount, intensity and distribution) and their effect on irrigation scheduling, iv) citrus crop properties that influence water uptake (root system and crop growth stages and parameters, crop water uptake across the growing season), v) irrigation techniques used in citrus, vi) different citrus irrigation scheduling techniques, and vii) an outlook of future research in citrus irrigation scheduling.

Ali Fares, Farhat Abbas, Sanjit K. Deb, Siva Paramasivam (USA) Citrus Chemigation (pp 22-31)

ABSTRACT

Invited Review: Advances in microirrigation techniques have facilitated greater adoption of chemigation in citrus production. Citrus chemigation is the application of liquid chemicals, i.e., fertilizers, pesticides, and/or herbicides to citrus groves through irrigation systems. This article reviews citrus chemigation; it discusses chemigation management, chemigation system components, and chemigation efficiency under citrus production systems. Pressurized irrigation systems, e.g., overhead sprinklers, microsprinklers, and/or drip systems have successfully been used to carry out citrus chemigation. Through chemigation practices, citrus growers have been able to control the timing and the amount of chemical application to their groves. Selection of suitable irrigation system, use of efficient injection devices, and compatibility of chemicals are crucial for an efficient chemigation operation. Combined use of incompatible chemicals could form insoluble compounds and/or precipitates that may clog the chemigation system.

Anoop Kumar Srivastava (India) Integrated Nutrient Management: Concept and Application in Citrus (pp 32-58)

ABSTRACT

Invited Review: Multiple nutrient deficiencies are common in citrus orchards the world over. Integrated nutrient management (INM), a concept that involves the combined use of chemical fertilizers, microbial inoculation and organic manures, has shown much better promise than any of the other strategies of fertilization in citrus. INM-based fertilization has a definite edge over

conventional fertilization since the former advocates treatment once or twice to inflict changes in the physico-chemical and microbial environment, while the latter is effective only when practiced 3-4 times synchronizing with phenological growth stages and often 15-20 times using fertigation or even much better technicalities involved with sensor-based variable rate application using site-specific fertilization. Dual function microbes e.g. *Trichoderma harzianum*/*viride*, *Pseudomonas fluorescens*, *Bacillus polymyxa*, arbuscular mycorrhizae, etc. both having growth-promoting ability as well as strong antagonistic effect against soil-borne pathogens loaded to manure as substrate coupled with 75% of RDF (recommended doses of fertilizers) are equally effective to combat multiple nutrient deficiencies on both alkaline calcareous and acidic non-calcareous soils, irrespective of cultivar type and climate.

Ram Mohan Uckoo, Juan M. Enciso, Irama Wesselman, Kim Jones, Shad D. Nelson (USA) Impact of Compost Application on Citrus Production under Drip and Microjet Spray Irrigation Systems (pp 59-65)

ABSTRACT

Original Research Paper: Texas is the third largest citrus producing state in the USA, after Florida and California. The majority of citrus in the Lower Rio Grande Valley (LRGV) of south Texas is grown under flood irrigation. Due to rapid urban development, periodic droughts and dependence upon irrigation water flows along the Rio Grande River, the semi arid conditions of South Texas commonly results in rapid decline in irrigation water supplies. Perennial crops in the LRGV, like citrus, have an annual evapotranspiration demand that far exceeds annual precipitation in this semi-arid climate. Due to limited water supplies, alternative irrigation and cultural practices are being sought to increase the irrigation use efficiency, enhance plant growth and sustain citrus crop production. A field experiment was conducted from 2003 to 2006 at the Texas A&M University-Kingsville, Citrus Center located in Weslaco, Texas. In this study, 20 year old Rio Red grapefruit trees (*Citrus paradisi* Macf.) received compost and non-compost treatments and were compared using drip and micro-jet spray irrigation systems. The objectives of this study were to evaluate whether annual compost and fertilization application would positively impact citrus root development, growth, and crop production under low-flow irrigation systems, drip and microjet spray. After one year of compost application, a trend of higher crop production was observed in three consecutive harvest years in composted trees compared to non-composted trees under both irrigation systems. Root density was found to be higher under composted than non-composted tree canopies, and a more uniform root growth proliferation was observed under microjet spray than drip irrigated systems. Furthermore, soil moisture sensing equipment continually showed higher soil moisture content under composted vs non-composted trees, suggesting that annual compost application under low water use systems may be ideal for improving water conservation in citrus production for south Texas.

Hong Li (Canada) Citrus Tree Abiotic and Biotic Stress and Implication of Simulation and Modeling Tools in Tree Management (pp 66-78)

ABSTRACT

Invited Review: Plant abiotic and biotic stress is related to unfavorable and environmental constraints. As a warm climate tree fruit crop, citrus (*Citrus sinensis* (L.) Osb.) is adapted to a wide variety of soil types and growth conditions. However, when waterlogging, soil acidity and root weevil infestation occur simultaneously, citrus roots can be injured from anaerobic disturbance, oxygen deprivation and root injury, which can lead to tree decline. Multi-year spatial overlay patterns of plants, insects and soils may yield management insights for reducing plant biotic and abiotic stresses. This paper attempts to summarize abiotic and biotic stress of citrus trees associated with soil anaerobe, soil waterlogging, environmental acidity and *Diaprepes abbreviatus* root weevil infestation, and to give an overview of the development of new biological tools such as greenhouse simulation and model prediction tools for integrated fruit production of citrus. Greenhouse simulation studies and a series of multi-year studies at citrus orchard scale have been conducted across center and southern counties in Florida. The results showed that citrus tree decline was correlated with anaerobe and high soil Fe concentrations ($P < 0.05$), and citrus tree biotic and abiotic stress is directly reflected by low leaf stomatal conductance, flooding root damage, weevil larval root feeding injury, and anaerobic-related soil redox potential. Citrus rootstock roots were injured up to three weeks of submergence and flooded-roots were more susceptible to *Diaprepes* root weevil feeding than non-flooded roots. Time series analysis reveals that root adult weevil population outbreaks were associated with warm air temperatures across a period of three years ($r = 0.49$, $P < 0.0067$), suggesting that warming conditions would contribute to more tree biotic stress. Greenhouse simulation tools and time series forecast models have the implication in reducing biotic and abiotic stress of citrus trees.

Bruna De Felice (Italy) Transposable Sequences in Citrus Genome: Role of Mobile Elements in the Adaptation to Stressful

Environments (pp 79-86)

ABSTRACT

Invited Review: Mobile DNAs make up a large proportion of the nuclear plant genome. They can rearrange genomes and other individual gene structure and regulation through a number of activities, such as transposition, insertion, excision, chromosome breakage, and ectopic recombination. Ty-like retrotransposons, a widespread class of transposable elements in the plant kingdom, have been found in the *Citrus* genome. The aim of this review is to illustrate the evolutionary relationships of Ty-like elements in *Citrus* species, as well as the genomic organization of these sequences in *Citrus* genome and their transcriptional activity. Wounding, salt and cell cultured stress produce transcriptional activation of several Ty-like elements in *C. limon.* Therefore, transcriptional activation under stress conditions of transposon sequences opens the possibility that these mobile elements have given more genetic variability to *Citrus* plants, thus facilitating adaptation to a range of stressful habitats.

Antonio Roberto Pereira, Nilson Augusto Villa Nova (Brazil) Transpiration of Irrigated Tahiti Acid Lime Trees with Different Canopy Leaf Areas, Reference Evapotranspiration and Water Balance for Precision Irrigation Schemes (pp 87-91)

ABSTRACT

Original Research Paper: Regardless of the canopy leaf area, daily normalized transpiration (per unit leaf area) of irrigated Tahiti acid lime trees were equivalent to the normalized reference evapotranspiration (per unit of grass leaf area). Normalized transpiration represented about 1/3 of the reference evapotranspiration (ETo) during the growing season. Such coefficient represents the inverse of the leaf area of a hypothetical reference surface. Tree phenology disturbed substantially the relationship during the physiological rest of autumn/winter when photoperiod was short and the minimum temperature was below 15°C. Normalized transpiration was nearly constant ($\approx$ 0.4 L m^{-2} leaf d^{-1}) and independent of ETo during the rest period. However, once the tree was physiologically prepared to bloom (late winter/early spring) minimum temperature was not a limiting factor to the transpiration. A large canopy leaf area (99 m^2) played a major role in drastically reducing the normalized transpiration during summer days with high atmospheric demand (minimum relative humidity below 50%; maximum vapor pressure deficit above 2 kPa). During such days transpiration was reduced by 30 to 40% indicating that the shallow root system was not able to uptake soil water fast enough to supply the large transpiration surface under high demand. Conversely, a small tree (3 m^2 of leaf area) did not show any transpiration restriction. This is an indication that a pruning or topping program would reduce the growth of the transpiring area to keep a potential transpiration rate. An individualized soil water balance approach for precision irrigation schemes is presented.

Juana Maria Delgado Saborit (UK) Effects of Air Pollution on Citrus Trees (pp 92-104)

ABSTRACT

Invited Review: Agricultural crops can be injured when exposed to concentrations of various air pollutants. Injury ranges from visible markings on the foliage, to reduced growth and yield, to premature death of the plant. The development and severity of the injury depends not only on the concentration of the particular pollutant, but also on a number of other factors. These include the length of exposure to the pollutant, the plant species as well as the environmental factors conducive to a build-up of the pollutant. Effects on vegetation vary and can appear just after short periods of exposure to high concentrations of air pollutants resulting in acute effects, or chronic effects after long exposure periods to low concentrations. This review describes documented effects of air pollutants, such as ozone, fluoride, sulfur dioxide, acidic precipitation and other pollutants on citrus trees, describes the mechanisms of injury and damage of the air pollutants to the plant, discusses the suitability of using dose vs. exposure to define the air pollutant uptake and analyses the past trends and future research needs in the field of effects of air pollutants on citrus trees.

Qiang-Sheng Wu (China), Yoseph Levy (Israel), Ying-Ning Zou (China) Arbuscular Mycorrhizae and Water Relations in Citrus (pp 105-112)

ABSTRACT

Invited Mini-Review: Citrus is one of the most important commercial fruit crops throughout the world, including China. However, it is grown in regions that are frequently subjected to water deficiency, which restricts the yield and quality of the crop. Citrus has very few and short root hairs and is highly dependent on arbuscular mycorrhizae, since the mutualistic symbiosis replaces some of the root hairs' functions. In this review, we describe arbuscular mycorrhizal symbiosis, mycorrhizal dependency of

citrus, and the effect of drought stress on mycorrhizal development in citrus plants. We also describe advances in understanding how arbuscular mycorrhizal symbiosis improves water relations in citrus. These mechanisms include the direct water uptake and transport via external hyphae, the indirect effect of improved phosphorus nutrition, the improvement of osmotic adjustment and reactive oxygen metabolism, and the effect of glomalin produced by arbuscular mycorrhizae.

Xujun Ye (China/Japan), Kenshi Sakai, Akira Sasao, Shin-ichi Asada (Japan) Integrating Field Experiments with Modeling to Investigate the Dynamics of Alternate Bearing in Citrus (pp 113-119)

ABSTRACT

Original Research Paper: The management of alternate bearing has become an important issue in fruit production. The potential benefits of applying various alternate bearing control measures on alternate bearing crops can only be realized when yield information on individual trees of particular crops is obtained. This study investigates the dynamics of alternate bearing in citrus via an integrative use of field experiments and numerical simulation models. Fruit yield data on 48 individual trees in an experimental citrus orchard were recorded over a period of 4 consecutive years (from 2002 to 2005). An aerial image was used to measure the canopy size of individual trees. Models were developed based on different combinations of three variables: the time series yield data, the canopy size and the derived yield density. The models were examined in terms of their potentials to predict fruit yield on individual trees. Results indicated that alternate bearing in citrus behaves more significantly in terms of yield density rather than total fruit yield on individual trees. The model based on canopy size and yield achieved the best prediction performance among the developed models, showing that a simple combination of the canopy size and the total yield for individual trees in one year can provide sufficient information for the yield attainability in the following year. This study demonstrates that the integrative use of field experiments and modeling approach has considerable promise in predicting citrus yield on individual trees. Yield estimates obtained by the proposed method would provide valuable information for planning harvest schedules and developing programs for site- and tree-specific application of variable rate technology (VRT) in citrus management.

Juana Fernández-López, Luis Aleson-Carbonell, Esther Sendra, Estrella Sayas-Barberá, José Angel Pérez-Alvarez (Spain) Dietary Polyphenols as Functional Ingredients: Relevance to Citrus Fruits (pp 120-126)

ABSTRACT

Invited Mini-Review: Numerous studies have demonstrated the biologically significant roles played by dietary polyphenols, such as antioxidants, antimicrobials, anticarcinogens or antimutagens, leading to their recognition as potential functional ingredients or food additives. This paper presents a revision of works published in recent years on the topic and looks at possible future trends in the sector. We also provide additional information on other biological effects of phenolics, with special attention to phenolics in citrus fruits, which could be of interest for the formulation of functional foods.

Ricky W. K. Wong (China) The Pharmacological Actions of Grapefruit Extracts: Naringin and Naringinin (pp 127-138)

ABSTRACT

Invited Mini-Review: The grapefruit extract components, naringin and its aglycone naringinin, are commonly used health supplements; they exert a variety of pharmacological actions. This article attempts to review their pharmacokinetics, pharmacological actions and their uses in various managements, including effect on cardiovascular system; effect on skeletal system; effect on smooth muscle; effect on gastric intestinal system; effect on endocrine system; effect against tumour; protection against toxins in chemotherapy drugs and the environment; antioxidant effect; drug interactions; antiinflammatory effect and the newly discovered osteogenic and antibacterial actions.

Manuela Zude, Hans-Peter Kläring (Germany) Two Case Studies of Precision Horticulture Approaches in Citrus Production (pp 139-151)

ABSTRACT

Invited Review: In the age of information technology, process-oriented data analysis is the focus of emerging science and is predicted to form the basis for economic growth. The general consensus is that, especially in agronomy, new innovative approaches are needed for a future process management. Because citrus is economically a very important fruit crop worldwide, two case studies of *in-situ* analysis of plant and fruit with prominent importance in the citrus production are reviewed targeting

site-specific production measures. In the first approach, the review provides a background of the measurable plant response to oxygen shortage in the root zone by means of non-destructive methods and gives an outlook of the applications in citrus. In a second case study the quality analysis of citrus fruit at the tree level is discussed. The feasibility of the spatio-temporally resolved data recording in the harvest management is pointed out.

Gustavo Fermin, Armando Briceño, Francisca Ely, Luis Cedeño, Yani Aranguren, Carle Valecillos (Venezuela) Citrus Cultivation in Venezuela (pp 152-163)

ABSTRACT

Invited Review: This short review focuses on a few aspects related to the citrus industry that have received attention in Venezuela. From a well, culturally speaking, established citrus industry, consistent efforts have been made to study the main pests and pathogens that cause diseases and economic losses in citrus orchards across Venezuela. Despite the knowledge gathered from almost a century of phytopathological studies, however, very few advances have been attained in the improvement of citrus germplasm in Venezuela. In the same way, postharvest management of the produce has not shown a successful history of accomplishments. The marginal increase of production and yield in recent times that seems to be decelerating the tendency of the last fifteen years to accumulate losses, however, have yet to demonstrate that the industry is experiencing a renewal of its cultural practices and an increase in financial and technological inputs. Increases in the consumption of fruits have also been recorded in the last few years, but consumption has not yet reached the recommended levels set by international standards. The citrus industry in Venezuela has still much to do, despite being one of the most important in the country, to contribute to food security and to offer the producers an attractive source of personal and professional satisfaction as well as financial reward.

Ganesh C. Bora (USA) Economics of Variable Rate Nitrogen Application in Florida Citrus Grove (pp 164-168)

ABSTRACT

Invited Mini-Review: Precision farming is a management system to optimize input and maximize benefits. Variable rate technology (VRT) of inputs is an important component of precision agriculture that results in the reduction of inputs. This not only provides economic benefits to the farmers along with reductions in agrochemicals and fertilizer application, but also has positive environmental impact. Citrus growers in Florida are willing to adapt VRT fertilization, if they are aware of the economic benefits. This study attempted to estimate the economic benefit of VRT fertilization by accounting the savings of amount of fertilizer. There is a potential of 40% savings of urea which corresponds to US$138/ha/year. Although the initial investment for a VRT spreader is high, to the tune of twenty nine thousand dollars, its use for 558 ha of citrus grove would pay for it considering even 15% reduction in amount of urea applied. Assuming a 40% reduction in urea and about 40% adaptation rate VRT fertilization, there is a potential of savings of 8.3 million kg of urea and US$10.7 million per year in Florida. This would also marginalize the gap between demand and supply; reduce nitrate leaching and fertilizer uptake efficiency.