

Program Overview

Monday, 21 May 2012

16:00 - 20:00 Registration
Grand Balloon1, Maneechan Resort

Tuesday, 22 May 2102

08:30 - 09:30 Registration

09:30 - 10:00 Opening Ceremony

10:00 - 10:35 **Invited Lecture 1**
Transpiration: Venue for Nutrients Delivery (A01)
Suntaree Yingjajaval

10:35 - 11:05 Coffee Break

11:05 - 11:40 **Invited Lecture 2**
Boron Nutrition in Higher Plants (A02)
Masaru Kobayashi and **Toru Matoh**

11:40 - 13:00 Lunch

Tuesday, 22 May 2012

Session I

Chair : Dr. Frank Peryea

Tree Physiology and Plant Growth

- 13:00 - 13:20 Functional Variation Among Roots in a Woody Root System (A03)
David M. Eissenstat
- 13:20 - 13:40 Nutrition Costs of Flowering in Litchi: A Comparison between 'Feizixiao' and
'Baitangying' (A04)
Shi-Ya Jiang, Huan-Yu Xu, Hui-Cong Wang, Gui-Bing Hu and
Xu-Ming Huang
- 13:40 - 14:00 The Effect of Arbuscular Mycorrhizal Fungi on the Establishment of Sour
Orange (*Citrus Aurantium*) under Different Levels of Phosphorus (A05)
Ghazi N. Al-Karaki
- 14:00 - 14:20 Effects of Foliar Fe Application on Photosynthetic Pigment Composition and
Chl Fluorescence Parameters in Field Grown Peach Leaves (A06)
Hamdi El-Jendoubi, Angeles Calatayud, Fermín Morales, **Javier Abadía** and
Anunciación Abadía
- 14:20 - 14:40 Evaluation of New Selected Rootstocks for Grapevine: Nutritional Aspects
(A07)
Duilio Porro, Stefano Pedò, Daniela Bertoldi, Osvaldo Failla and
Maurizio Zamboni
- 14:40 - 15:20 Coffee Break/ Poster Session**
- 15:20 - 15:55 **Invited Lecture 3**
Nutrient Uptake Requirements and Partitioning in Fruit trees (A08)
Massimo Tagliavini and Francesca Scandellari
- 15:55 - 16:15 Effect of Pre-harvest Calcium on Nutritional Uptake and Morphological Traits
of Papaya Seedlings (*Carica papaya* L. cv. Eksotika II) (A09)
Babak Madani, Mahmud TengkuMudaMohamed, Yahya Awang and
Jugah Kadir
- 16:15 - 16:35 Effects of Potassium Foliar Spray on Different Fruit Tree Species over 6
Years of Experiments (A10)
Ben M. Mehdi and Marchand Michel
- 18:30 - 20:30 Welcome Cocktail Reception**

Wednesday, 23 May 2012

Session II

Chair : Dr. Gerry Nielsen

Nutrient Management

- 08:30 - 09:05 **Invited Lecture 4**
Water Use, Mineral Nutrition, Tree Growth, Yield, and Fruit Quality of ‘Fuji’ and ‘Gala’ Apples under Various Irrigation Systems and Rootstocks (A11)
Esmail Fallahi, Bahar Fallahi and Bahman Shafii
- 09:05 - 09:25 Nitrogen and Potassium Citrus Tree Uptake, Fruit Removal and Seasonal Distribution in the Root Zone Under Mediterranean Climate (A12)
Abdelkader Hammami, Hafedh J. Mellouli and Mustapha Sanaa
- 09:25 - 09:45 Effects of Nitrogen, Phosphorus and Potassium on Yield and Fruit Quality of Three Navel Orange Cultivars (A13)
Hong Huang, Chengxiao Hu, Qiling Tan and Xuecheng Sun
- 09:45 - 10:05 Fertilizer Management and Sustainable Production of Fruit in Tropical Climates (A14)
Anke Kwast and Miles Harriman
- 10:05 - 10:45** **Coffee Break / Poster session**
- 10:45 - 11:20 **Invited Lecture 5**
Foliar Nutrient Uptake – of Myths and Legends (A15)
Thomas Eichert
- 11:20 - 11:40 Does It Pay to Spray? (A16)
Jon C. Frank
- 11:40 - 12:00 Nutrients Management in Kiwifruit in Shaanxi, China (A17)
Yanan Tong and Jian Wang
- 12:00 - 13:30** **Lunch**

Wednesday, 23 May 2012

Session III

Chair : Dr. Esmaeil Fallahi

Interaction and Diagnosis of Plant Nutrient Status

- 13:30 - 13:50 Development of A Nutrient-Budget Approach and Optimization of Fertilizer Management in Almond (A18)
Sebastian Saa, Saiful Muhammad and Patrick Brown
- 13:50 - 14:10 Assessment of Chemical and Biochemical Indices for Diagnosing Zinc Deficiency and Soil Associated Factors of Citrus (*Citrus sinensis* L. Osbeck) Nutrition (A19)
Vilas Patil
- 14:10 - 14:30 Influences of Different Ratio of N Supplied from Manure and Mineral Fertilizer on Nanguo Pear Growth, and Soil Nutrient Accumulation (A20)
Xiuchun Liu, Binghua Wang, Bingyu Zhang, Juncai Li, Linan Chen and Qing Chen
- 14:30 - 14:50 Kiwifruit Production - Using Nitrogen Efficiently (A21)
Linda M. Boyd, Andrew M. Barnett, Paul R. Johnstone and Warwick Catto
- 14:50 - 15:30 Coffee Break/ Poster session**
- 15:30 - 15:50 Nutrient Analysis of Plant Parts to Assess the Effect of Gypsum Application in Longkong (*Aglaia dookoo* Griff.) (A22)
Boonsong Krisornpornsan, Sayan Sdoodee and Chairat Nilnond
- 15:50 -16:10 Effect of Potassium Supply as KNO₃, K₂SO₄ or KCl on Growth and Yield of Potted Tomato Plants Grown in Saline-Neutral or Saline-Alkaline Conditions (A23)
Steven A. Oosthuyse
- 16:10 – 16:30 Response Mechanisms of Grapevine to Sustainable Strategies of Iron Chlorosis Prevention (A24)
José I. Covarrubias and **Adamo D. Rombolà**
- 16:30 - 16:50 Determination of Macro and Micro Elements of Different Pistachio Cultivars in “On” and “Off” Year Trees (A25)
Bekir E. Ak and Mine Fidan
- 17:00 - 18:00 ISHS Business Meeting**

Thursday, 24 May 2012

Mid-Symposium Technical Tour

**8:00 - 17:00 Field Tour of Tropical Fruit Orchards and Kung Krabane Bay Royal
Development Study Center (Also for Accompanying persons)**

08:00 Depart from Maneechan Resort

08:15 Arrive Mr. Somwong and Mr. Preecha Mangosteen and Salak (Snake fruit)
Orchards

10:00 Depart

10:45 Arrive Mr. Yong Durian Orchard

12:00 Lunch

13:15 Depart from Restaurant

14:00 Arrive Kung Krabane Bay Royal Development Study Center

14:30 A walk through the 1,600 m. long mangrove forest (about 2 hrs)

16:30 Depart for Hotels

19:00 - 21:30 Farewell Party

Friday, 25 May 2102

Session IV

Chair : Dr. Yongyuth Osotspa

Plant Nutrient and Fruit Quality

- 08:30 - 09:05 **Invited Lecture 6**
The Bottleneck of Ca Translocation into Fruit in Litchi (A26)
Wei Chen, Hui-Cong Wang, **Xu-Ming Huang** and Yan Fan
- 09:05 - 09:25 Mapping the Distribution of Calcium in Apple Tissue with Proton-Induced X-ray Emission – After Application of Additional Pre-harvest Foliar or Soil Calcium (A27)
Robert E. Wilsdorf, Jolanta M. Mesjasz-Przybylowicz, Wojciech J. Przybylowicz and **Elmi Lötze**
- 09:25 - 09:45 Physiological Disorders in Relation to Compositional Changes in Mango (*Mangifera indica* L. cv. ‘Chiin Hwang’) Fruit (A28)
Huey-Ling Lin, Ching-Chang Shiesh and Pei-Jen Chen
- 09:45 - 10:05 Pectin and Calcium Distribution in Cell Wall of Physiological Disorder Mangosteen Fruits (A29)
Sumitra Poovarodom and Naree Phanchindawan
- 10:05 - 10:40 Coffee Break**

Friday, 25 May 2012

Session V

Chair : Dr. Wichien Chatupote

Fruit Nutrition and Bioactive Compounds

- 10:40 - 11:15 **Invited Lecture 7**
Nutritional and Pharmaceutical Applications of Bioactive Compounds in Tropical Fruits (**A30**)
Sumitra Poovarodom, Ratiporn Haruenkit, Suchada Vearasilp, Pramroj Ruamsuke, Hanna Leontowicz, Maria Leontowicz, Jacek Namiesnik, Simon Trakhtenberg and **Shela Gorinstein**
- 11:15 - 11:35 Foliar Urea Applications Can Increase Berry Yeast-Assimilable N in Wine (*Vitis Vinifera*) Grapes (**A31**)
Gerry Neilsen, Denise Neilsen, Kirsten Hannam, Peter Millard and Andy Midwood
- 11:35 - 11:55 Effect of Nitrogen, Potassium Fertilizers and Clusters Per Vine on Yield and Anthocyanin Content in Cabernet Sauvignon Grape (**A32**)
Vason Boonterm, Anek Silapapun and **Nantakorn Boonkerd**
- 11:55 - 12:15 ISHS Award Ceremony**
- 12:15 - 13:30 Lunch**
- 13:30 - 14:10 Poster session**
- 14:10 - 14:45 **Closing Lecture:**
Assessing Risks from Climate Change and Variability in Perennial Horticultural Crops (**A33**)
Denise Neilsen, Gerry Neilsen, Alex Cannon, Bill Taylor, Ted Van der Gulik, Scott Smith and Istvan Losso
- 14:45 - 15:00 Closing Ceremony**

International and Scientific Organizing Committee

Vijay Bahadur	India
Surya P Bhattarai	Australia
Patrick Brown	USA
David Bryla	USA
R. Chithiraichelvan	India
Pedro Correia	Portugal
Esmail "Essie" Fallahi	USA
Xuming Huang	P.R. China
Huey-Ling Lin	Taiwan R.O.C.
George Wellington Melo	Brazil
Denise Neilson	Canada
Gerry Neilson	Canada
Nina Opstad	Norway
Frank Peryea	USA
Maribela Pestana	Portugal
Michelangelo Policarpo	Italy
Sumitra Poovarodom	Thailand
Adamo D. Rombolà	Italy
Carolyn Scagel	USA
Timothy Spann	USA
Massimo Tagliavini	Italy
Gabriela Teoedorescu	Romania

Editorial Committee

Sumitra Poovarodom	Thailand
Suntaree Yingjajaval	Thailand
Wichien Chatupote	Thailand

Local Advisory Committee

Ananta Dalodom	Thailand
Kitti Tirasesth	Thailand
Santhad Rojanasoonthon	Thailand
Sakchai Choochote	Thailand

Local Organizing Committee

Ammorn Insung	Thailand
Chaowalit Hongprayoon	Thailand
Narong Chomchalow	Thailand
Pramoj Ruamsuke	Thailand
Soontorn Pipitsangchan	Thailand
Sumitra Poovarodom	Thailand
Wattanachai Pongnak	Thailand
Wichien Chatupote	Thailand

Symposium Supporters

Napnutriscience Co., Ltd.
Thai Fertilizer and Agricultural Supplies Association (TFAS)
Yara (Thailand) Ltd.
Q.Yield Associates Co., Ltd.
New AG International
Padaeng Industry Public Co., Ltd.
Sonic Essential Pty. Ltd.
Alumni Association of Agricultural Technology, KMITL
Bayer Thai Co., Ltd.
Betagro Public Co., Ltd.
Horti ASIA 2012

List of Contents

Program Overview	i
List of Contents	x
Oral Presentation	1
A01 - Transpiration: Venue for Nutrients Delivery	5
A02 - Boron Nutrition in Higher Plants	6
A03 - Functional Variation Among Roots in a Woody Root System	7
A04 - Nutrition Costs of Flowering in Litchi: A Comparison between 'Feizixiao' and 'Baitangying'	8
A05 - The Effect of Arbuscular Mycorrhizal Fungi on the Establishment of Sour Orange (<i>Citrus Aurantium</i>) under Different Levels of Phosphorus	9
A06 - Effects of Foliar Fe Application on Photosynthetic Pigment Composition and Chl Fluorescence Parameters in Field Grown Peach Leaves	10
A07 - Evaluation of New Selected Rootstocks for Grapevine: Nutritional Aspects	11
A08 - Nutrient Uptake Requirements and Partitioning in Fruit trees	12
A09 - Effect of Pre-harvest Calcium on Nutritional Uptake and Morphological Traits of Papaya Seedlings (<i>Carica papaya</i> L. cv. Eksotika II)	13
A10 - Effects of Potassium Foliar Spray on Different Fruit Tree Species over 6 Years of Experiments	14
A11 - Water Use, Mineral Nutrition, Tree Growth, Yield, and Fruit Quality of 'Fuji' and 'Gala' Apples under Various Irrigation Systems and Rootstocks	17
A12 - Nitrogen and Potassium Citrus Tree Uptake, Fruit Removal and Seasonal Distribution in the Root Zone Under Mediterranean Climate	18
A13 - Effects of Nitrogen, Phosphorus and Potassium on Yield and Fruit Quality of Three Navel Orange Cultivars	19
A14 - Fertilizer Management and Sustainable Production of Fruit in Tropical Climates	20
A15 - Foliar Nutrient Uptake – of Myths and Legends	21
A16 - Does It Pay to Spray?	22
A17 - Nutrients Management in Kiwifruit in Shaanxi, China	23
A18 - Development of A Nutrient-Budget Approach and Optimization of Fertilizer Management in Almond	27
A19 - Assessment of Chemical and Biochemical Indices for Diagnosing Zinc Deficiency and Soil Associated Factors of Citrus (<i>Citrus sinensis</i> L. Osbeck) Nutrition	28
A20 - Influences of Different Ratio of N Supplied from Manure and Mineral Fertilizer on Nanguo Pear Growth, and Soil Nutrient Accumulation	29
A21 - Kiwifruit Production - Using Nitrogen Efficiently	30
A22 - Nutrient Analysis of Plant Parts to Assess the Effect of Gypsum Application in Longkong (<i>Aglaiadookkoo</i> Griff.)	31
A23 - Effect of Potassium Supply as KNO ₃ , K ₂ SO ₄ or KCl on Growth and Yield of Potted Tomato Plants Grown in Saline-Neutral or Saline-Alkaline Conditions	32
A24 - Response Mechanisms of Grapevine to Sustainable Strategies of Iron Chlorosis Prevention	33
A25 - Determination of Macro and Micro Elements of Different Pistachio Cultivars in "On" and "Off" Year Trees	34
A26 - The Bottleneck of Ca Translocation into Fruit in Litchi	37
A27 - Mapping the Distribution of Calcium in Apple Tissue with Proton-Induced X-ray Emission – After Application of Additional Pre-harvest Foliar or Soil Calcium	38

A28 - Physiological Disorders in Relation to Compositional Changes in Mango (<i>Mangifera indica</i> L. cv. 'Chiin Hwang') Fruit.....	39
A29 - Pectin and Calcium Distribution in Cell Wall of Physiological Disorder Mangosteen Fruits.....	40
A30 - Nutritional and Pharmaceutical Applications of Bioactive Compounds in Tropical Fruits.....	43
A31 - Foliar Urea Applications Can Increase Berry Yeast-Assimilable N in Wine (<i>Vitis Vinifera</i>) Grapes.....	44
A32 - Effect of Nitrogen, Potassium Fertilizers and Clusters Per Vine on Yield and Anthocyanin Content in Cabernet Sauvignon Grape.....	45
A33 - Assessing Risks from Climate Change and Variability in Perennial Horticultural Crops.....	47
Poster Presentation.....	49
P01 - Black Hailnet Effect on Vegetative Growth and Reproductive Potential of Apple Trees...	51
P02 - Transfer and Accumulation of Nitrogen (¹⁵ N) and Boron (¹⁰ B) among 'Prata-Anã' Botanical Family.....	52
P03 - Transfer and Accumulation of Boron (¹⁰ B) among 'Prata-Anã' Botanical Family.....	53
P04 - Leaf Gas Exchange of Oil Palm (<i>Elaeis guineensis</i> Jacq.) Grown in Ditch and Raised Beds.....	54
P05 - Effects of Boron Applications on Some Almond Pollen Features and Fruit Set.....	55
P06 - Cell Wall Structure of Translucent Cells of Mangosteen Fruit.....	56
P07 - Response of Red Roomy Grapevines to Foliage Spraying with Molybdenum.....	57
P08 - Improvement of Grapevine Iron Nutrition by A Bovine-Blood-Derived Compound.....	58
P09 - Effects of Fertigation Timing on Growth and Development in Strawberry cv. Korona ...	59
P10 - Nutrition and Irrigation Interactions for a Practical Solution.....	60
P11 - Influence of 6-Benzyladenine Tank-Mixed with Boron, Followed by Mid-Summer Calcium Plus Copper Sprays, on 'Gala' Apple Splitting and Firmness.....	61
P12 - Tank-Mixing Boron with 6-Benzyladenine to Enhance 'Gala' Apple Fruit Size may Promote Stem-End Splitting.....	62
P13 - Effects of Different Organic Fertilizations on Sugar Metabolism in Pear Fruit and Leaves During Fruit Development.....	63
P14 - Effects of Different Organic Fertilizers on Tree Growth, Yield, Fruit Quality and Soil Microorganism in a Pear Orchard.....	64
P15 - The Effect of Soluble and Foliar Fertilizer to Improve the Fruit Weight of Red Pitaya (<i>Hylocerus polyrhizus</i>) by Foliar Spraying.....	65
P16 - Effects of Fertigation, Water Application Frequency and Soil Amendment on Tomato Production.....	66
P17 - Comparative Effects of Controlled Release Fertilizer and Fertigation on Mineral Status of ½ Blood Orange Orchard.....	67
P18 - Influence of Fruit Load on Water Consumption, Leaf Photosynthesis and Plant Nutrient Contents of Longan Trees Grown in Sand Culture.....	68
P19 - Reduced Rates of Speedfol™ B SP as Good as Conventional Borax Applications in Satisfying the Boron Requirement of Oil Palm.....	69
P20 - Effect of Potassium Source, either as KNO ₃ or K ₂ SO ₄ , on the Vigour of Tissue Cultured Williams Banana Plants Grown in Saline-Alkaline Conditions.....	70
P21 - Effect of Spur Type, Foliar Sprays, And Differential Nitrogen Rates on Leaf Nutrient Content and Spur Leaf Area of Almond Trees.....	71
P22 - Testing the Effectiveness of Zinc Formulations Using Peach Seedlings.....	72

P23 - A Comparison of Mineral Nutrients and Photosynthesis in Jujube, Apple and Litchi Leaves.....	73
P24 - Magnesium Deficiency is Responsible for Leaf Necrosis and Early Leaf Drop in Apple Trees of cv. <i>Nicoter</i>	74
P25 - Effects of Magnesium and Manganese on SPAD Reading and Chlorophyll Contents in Interveinal Chlorotic Leaves of Jackfruit.....	75
P26 - Influence of Intensive Viticulture on Macro-Elements Content in Soils of Sub-Mediterranean Wine Growing Regions.....	76
P27 - Monitoring the Nutrient Status of Intensive Apple Orchards during the Growing Season.....	77
P28 - Application of Fertilizer Based on Soil Analysis Could Improve Yield and Quality of Grape.....	78
P29 - Use of Foliar Fertilization to Offset Effects on Navel Orange Yield of Reduced Water and Fertilizer Applied by Partial Root Zone Drying versus Conventional Irrigation.....	79
P30 - Comparison of Different Foliar-Fertilization Strategies on Yield, Fruit Size and Quality of 'Nules' Clementine Mandarin.....	80
P31 - Effects of Calcium and Boron Application on Salak Quality and Nutrient Composition.....	81
P32 - Better Fruit Quality on Apple Orchard and Sustainability of the Fertilization Through Fertigation with Balanced Nutrition.....	82
P33 - Effects of Soil pH and Aluminum Saturation on Leaf Mineral Nutrition and Incidence of Translucent Fruit Flesh Disorder of Mangosteen in East Thailand.....	83
P34 - Effects of Nitrogen on Growth, Leaf Nutrient Concentration, Flowering and Fruit Quality in Off-Season Longan.....	84
P35 - Prunus Rootstocks Influence Peach Leaf and Fruit Nutrient Content.....	85
P36 - Effect of Plastic Bagging on Growth and Nutrient Content of Mangosteen Fruit.....	86
P37 - Acidity of Passion Fruit as Affected by Potassium Fertilizer.....	87
P38 - Influence of Foliar Applied Phosphorus on Color Development and Anthocyanin Content of 'Braeburn' Apples (<i>Malus domestica</i> Borkh.).....	88
P39 - Effect of Humic Acid on Antioxidant Activities and Fruit Quality of Hot Pepper (<i>Capsicum annuum</i> L.).....	89
P40 - Effects of Glyphosate on Berry and Wine Quality: Preliminary Results.....	90
Author Index.....	91



Oral Presentation



SESSION I: Tree Physiology and Plant Growth



Transpiration: Venue for Nutrients Delivery

Suntaree Yingjajaval^{1,2,3}

¹Center for Agricultural Biotechnology, Kasetsart University, KamphaengSaen Campus, NakhonPathom 73140, Thailand; suntaree.y@ku.ac.th

²Center of Excellence on Agricultural Biotechnology (AG-BIO/PERDO-CHE), Bangkok 10900, Thailand

³Faculty of Liberal Arts and Science, Kasetsart University, KamphaengSaen, NakhonPathom 73140

The concept of soil-plant-atmosphere continuum visualizes plant as the conduit for water, solute and photo-assimilates between soil and the atmosphere. Soil as the source of water and plant nutrients is studied extensively, whereas the climatic condition as the driving force for water flow is mostly glossed over. More importantly, the control of stomates for water efflux is seen as too dynamic such that the demand side of the plant is hardly dealt with. Closing down of stomates leads to slower rate of sap flow in the xylem, lower supply of CO₂ for photosynthesis and limits the rate of translocation in the phloem systems. Without measurement of the plant under field condition, the disruption of the water flow inside the plant will go unnoticed. In the case studies of mangosteen, salak and oil palm presented, leaf gas exchange was measured concurrently with the leaf water potential gradients, the soil water status, the climatic conditions and the sap flow rate in the branch (in mangosteen). The results showed that extreme levels of radiation and vapor pressure deficit (vpd) exerted control on the rates of transpiration and water flow in the plant. Irrigation was wasteful during dry season of high vpd when transpiration was limited by the low stomatal conductance. Measurement of soil matric potential revealed several incidents of the root zone being water saturated for a long period during rainy season, coupling with low air vpd of the crown. Discontinuity of transpiration stream limits the delivery rate of plant nutrients to the leaf and the growing tissues, which leads to physiological disorders found in these plants.

Keywords: *vapor pressure deficit, sap flow, stomatal conductance, water potential, disorders*



Boron Nutrition in Higher Plants

Masaru Kobayashi and **Toru Matoh**

Laboratory of Plant Nutrition, Division of Applied Life Sciences, Graduate School of Agriculture, Kyoto University, Kyoto 606-8502, Japan; matoh@kais.kyoto-u.ac.jp

Boron (B) is an essential micronutrient for higher plants. The site to which B binds as boric acid has been identified to be a particular region of pectic polysaccharides, Rhamnogalacturonan II (RG-II). As B crosslinks two RG-II moieties, it is very likely that B plays a structural role in cell walls through binding to RG-II to building up the supramolecular cell wall structure. This finding supports the notion that B-deficient plants suffer from malformation of actively-growing cells, such as elongating roots and ripening fruits. However, it still remains unclear how B deficiency, and hence probably alterations in cell wall structure, leads to various metabolic disorders and cell death. To understand the process, we analyzed the physiological changes in suspension-cultured tobacco (*Nicotianatabacum*) BY-2 cells and *Arabidopsis thaliana* plants under B deficiency. Due to insufficient B supply, the mechanical change could be brought about by insufficient crosslinking of pectic polysaccharides at RG-II regions, as the B-RG-II complex significantly contributes to the wall tensile strength. If the cell wall becomes weaker and less resistant to turgor, then the plasma membrane would stretch. The change may lead to opening of mechano-sensitive channels and generation of signals for the altered cell wall structure. Immediate and transient increase in cytosolic Ca²⁺ concentration (Ca spike) was detected by deprivation of B in tobacco cells. Concomitantly, B deprivation immediately induces upregulation of some stress-responsive genes, such as MAP kinase enzymes in these cells. Majority of the genes were reactive-oxygen species (ROS) responsive, and the dead cells accumulated significant amount of ROS, suggesting that oxidative damage is the direct and major cause of cell death. We hypothesize that ROS are originally produced as a signal for disturbance of the cell wall structure, and build up to a toxic level unless B is resupplied and the cell wall structure is restored. This idea supports the notion that additional Ca²⁺ supply alleviates B deficiency to some extent through binding to other regions than RG-II in pectic polysaccharides. Identification of the mechanism by which cells sense the external B status will greatly contribute to our understanding of the cell wall–symplast interaction in plants.

Keywords: boron, calcium, cell walls, pectic polysaccharide, rhamnogalacturonan II



Functional Variation Among Roots in a Woody Root System

David M. Eissenstat

The Pennsylvania State University, University Park, PA, USA; dme9@psu.edu

Fruit crop mineral nutrition can be enhanced by a better understanding of the woody root systems. We discuss root variation in a woody root system using examples from fruit crops like olive, apple and grape as well as forest trees. Variation in root function can be improved by distinguishing roots of different branching orders. The roots most involved in nutrient absorption are the first- and second-order roots, using a stream-based ordering system. These roots are ephemeral and typically live less than one year in fruit crops. In contrast to higher order roots, the first- and second-order roots typically do not develop secondary growth, become colonized by mycorrhizal fungi, and have limited transport capacity. Another type of lateral root that is often not recognized is the coarse indeterminate roots often called pioneer roots. These are distinctly different from fibrous (also called feeder) roots in that pioneer roots do not become colonized by mycorrhizal fungi, have multiple hypodermal layers and quickly develop secondary vascular tissue as they become the framework of the root system. Pioneer roots also are less susceptible to soil moisture deficits than fibrous roots. For those interested in assessing root function for nutrient acquisition, it is critical to recognize the different functions of roots in a woody root system.

Keywords: *pioneer roots, root branching order, root architecture, root anatomy*



Nutrition Costs of Flowering in Litchi: A Comparison between 'Feizixiao' and 'Baitangying'

Shi-Ya Jiang, Huan-Yu Xu, Hui-Cong Wang, Gui-Bing Hu and Xu-Ming Huang

Physiological Lab for South China Fruits, College of Horticulture, South China Agricultural University, Guangzhou 510642, China; 118150215@qq.com

The study investigated panicle development, blooming pattern and fruit set in litchi (*Litchi chinensis* Sonn.) cvs. 'Feizixiao' and 'Baitangying', and compared their changes in starch and soluble sugars in shoots and leaves, and N, P, K and free amino acids in panicle and flowerlets during panicle growth and blooming. The results showed that despite significantly larger panicles produced in 'Feizixiao', final fruit set as well as fruit retention rate in the cultivar was lower than in 'Baitangying'. 'Feizixiao' had a lower pollen viability, which partially explained its lower fruit set compared to 'Baitangying'. During panicle development and especially blooming, carbohydrates in shoots and leaves declined in both cultivars, but 'Baitangying' consumed less carbohydrate reserve due to its smaller panicles. As a result, 'Baitangying' had a higher availability of carbohydrate reserve for fruit development than 'Feizixiao' after blooming. 'Feizixiao' panicle accumulated higher concentrations of N, P and K, which provided the nutritional basis for forming a larger panicle bearing a larger quantity of flowerlets. The male flowerlets of 'Feizixiao' had lower N, P and K concentrations than those of 'Baitangying', while the opposite was found in female ones. Abscising male flowerlets continued to accumulate N, P and K, which were not remobilized but lost with flower shed. Before the initiation of blooming, concentrations of total free amino acids had increased in both cultivars. Among the amino acids, Arg was by far higher than the others, suggesting anthesis of litchi had a very high demand for this amino acid. In comparison, 'Feizixiao' panicle had higher concentrations of amino acids than 'Baitangying'. The results suggest that the "nutrition cost" for the construction of panicles and blooming is by far higher in 'Feizixiao' than in 'Baitangying'. The lower fruit retention rate in 'Feizixiao' is likely related to the excessive consumption of nutrient resources by panicle and blooming, leaving less nutrition reserves for fruit set. Therefore, both pollen limitation and resource limitation contributed to the poor fruit set in 'Feizixiao'.

Keywords: litchi, panicle size, fruit set, pollen viability, carbohydrates, amino acids, minerals



The Effect of Arbuscular Mycorrhizal Fungi on the Establishment of Sour Orange (*Citrus Aurantium*) under Different Levels of Phosphorus

Ghazi N. Al-Karaki

Faculty of Agriculture, Jordan University of Science & Technology, Irbid, Jordan; gkaraki@just.edu.jo

Sour Orange (*Citrus aurantium*) is widely grown as a rootstock in all citrus-producing areas of the world. However, the low fertility of most soils in arid and semiarid areas (e.g., Jordan) is a primary constraint for good establishment of this tree. Research at Jordan University of Science and Technology (JUST) has shown that citrus trees are obligatory dependent on arbuscular mycorrhiza (AM) fungi for growth under field conditions. One year old seedlings of sour orange were obtained from a commercial nursery and inoculated or not inoculated with commercial AM inoculum, BioMycVital in a pot trial conducted at JUST plastic house. Three phosphorus fertilizer levels, high fertilizer level (2 g NPK (18:18:5 + TE) + 3.6 g KH₂PO₄/month/plant), medium fertilizer level (1 g NPK (18:18:5 + TE) + 1.8 g KH₂PO₄/month/plant), and low fertilizer level (1/3 of the medium level rate) were used as fertility treatments. Plants were irrigated with tap water. Within 10 months, the mycorrhizal inoculum stimulated growth of sour orange regardless of phosphorus level. However, best growth was obtained at low fertilizer level. Inoculation coupled with low fertilizer level increased the plant height by 73.94% and trunk diameter by 26.8% over the noninoculated plants at low fertilizer level. However, the enhancement effect of inoculation with AM decreased with increasing fertilizer level. These results indicated that sour orange should be inoculated with AM fungi at nursery stage. The results also showed that sour orange will grow better under natural conditions when effectively associated with AM fungi and less chemical fertilizer.

Keywords: JUST, AM fungi mycorrhizae, inoculum and field, citrus



Effects of Foliar Fe Application on Photosynthetic Pigment Composition and Chl Fluorescence Parameters in Field Grown Peach Leaves

Hamdi El-Jendoubi¹, Angeles Calatayud², Fermín Morales¹, **Javier Abadía¹** and Anunciación Abadía¹

¹Plant Nutrition Department, Aula Dei Experimental Station, CSIC, P.O. Box 13034, 50080 Zaragoza, Spain; jabadia@eead.csic.es

²Department of Horticulture, Instituto Valenciano de Investigaciones Agrarias (IVIA), Ctra. Moncada-Naquera km. 4.5, 46113-Moncada, Valencia, Spain

Iron (Fe) deficiency (Fe chlorosis) is a common disorder affecting fruit trees in many areas of the world, and is mainly associated with high pH, calcareous soils [1, 2]. Fruit tree Fe deficiency has economical significance, because fruit quality and yield can be severely compromised [2,3]. Therefore, the use of expensive fertilization procedures is often required [4]. The correction of iron chlorosis in fruit trees grown on calcareous soils is an old problem with no easy solution. Until rootstocks tolerant to Fe chlorosis and having favorable agronomical characteristics become gradually available, the prevention or correction of Fe chlorosis is of paramount importance to fruit growers [5]. Fe-fertilization can be done by soil-chelate applications, trunk or branch injections and foliar sprays [1]. Iron chelate supply via fertigation or soil treatments is commonly considered as the most effective methods to control Fe chlorosis under field conditions [6]. However, foliar sprays can be a cheaper, environmental-friendly alternative to soil treatments for the control of Fe chlorosis. Foliar fertilization is most effective when soil nutrient availability is low, topsoil dry, and root activity is decreased during the reproductive stage [7]. The success of treatments with Fe compounds depends on their capacity to penetrate the cuticle, travel through the apoplastic free space and cross the plasmalemma of leaf cells to reach the cytoplasm and then the chloroplast [1,8]. The scientific background for the foliar fertilizer practices is still weak [1]. In this work we evaluate the effects of an Fe-containing formulation, estimated to have the best greening effects in previous studies [9,10], on the photosynthetic pigment composition and the spatial-temporal heterogeneity of Chl fluorescence, using an imaging-PAM fluorometer. The distal half of leaves was treated with a $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ solution via dipping, first at the beginning of the trial and then 4 weeks later. Then, the re-greening of treated (distal) and untreated (proximal) leaf areas was estimated with a SPAD apparatus, on a weekly basis, during 8 weeks.

Acknowledgements. This study was supported by the Spanish Ministry of Science and Innovation (MICINN; project AGL2009-09018, co-financed with FEDER) and the Aragón Government (group A03). Authors thank Juana Martinez and Blanca Morales for help with field work and lab analysis.

- [1] Abadía et al., *Plant Physiol. Biochem.* 49 (2011) 471
- [2] El-Jendoubi et al., *Plant Physiol. Biochem.* 49 (2011) 483
- [3] Álvarez-Fernández et al., *Environmental Experimental Botany* 71 (2011) 280-286
- [4] Álvarez-Fernández et al., *Plant and Soil* 263 (2004) 5-15
- [5] Pestana et al., *Food, Agriculture & Environment* 1 (2003) 51
- [6] Lucena JJ, Eds. LL Barton and J Abadía (2006) pp 103-128
- [7] Wójcik P, *Journal of Fruit and Ornamental Plant Research* 12 (2004) 201-218
- [8] Rombolá et al., *Journal of Plant Nutrition* 23 (2000) 1751-1765
- [9] Fernández et al., *Scientia Horticulturae* 117 (2008) 241-248
- [10] Fernández et al., *Plant and Soil* 289 (2006) 239-252



Evaluation of New Selected Rootstocks for Grapevine: Nutritional Aspects

Duilio Porro¹, Stefano Pedò¹, Daniela Bertoldi¹, Osvaldo Failla², and Maurizio Zamboni³

¹Technological Transfer Center, IASMA – Edmund Mach Foundation, Via Edmund Mach 1, 38010 - S. Michele all'Adige (TN), Italy; duilio.porro@fmach.it or duilio.porro@iasma.it

²Dipartimento di Produzione Vegetale (Di.Pro.Ve.), Università di Milano, via Celoria 2, 20133 - Milano – Italy

³Istituto di Frutti-Viticultura, Università Cattolica del Sacro Cuore, via Emilia Parmense 84, 29100 - Piacenza - Italy

Available Italian rootstocks show scarce resistance to environmental as well as soil (salt, drought, and limestone) stresses. The selection of resistant rootstocks to overcome the dramatic climate-change events registered in the last recent years, is a crucial factor for the development of sustainable agricultural models (moderate irrigation and fertilization and recovery of marginal soils) and for assuring optimal maturation profiles of grapes.

Aim of trial (SERRES project n. 2010-2105) is the study of the responses of rootstock/scion combinations of four newly established rootstocks selected by Di.Pro.Ve. (M1,M2,M3,M4) for resistance to water stress, salt stress, iron chlorosis (in calcareous soils) and potassium efficiency.

In particular M1 - 106/8 [*Vitis riparia* x (*V.cordifolia*. x *V.rupestris*)] x Resseguier n°1 (*Vitis berlandieri*), and M2 - Teleki 8B (*Vitis berlandieri* x *Vitis riparia*) x 333 E.M. (*Vitis vinifera* x *Vitis berlandieri*) were selected for high resistant to iron chlorosis and to reduce vigor, M3 - R 27 (*Vitis berlandieri* x *Vitis riparia*) x Teleki 5C (*Vitis berlandieri* x *Vitis riparia*) was selected to enhance potassium efficiency, while M4 - 41B (*Vitis vinifera* x *Vitis berlandieri*) x Resseguier n°1 (*Vitis berlandieri*) was selected for high resistance to water stress and soil salinity.

In order to suggest new genotypes useful to Italian viticulture in the light of new needs imposed by climate change, taking into account different soil climatic environments and different rootstock-scion combinations, the four new genotypes were compared with six conventional rootstocks (1103 Paulsen, S.O.4, K5BB, 140 Ruggeri, 41B and 420A) in open field conditions in five different Italian locations (Trentino, Veneto, Puglia, Sicily, and Tuscany; 3 replication for each scion/rootstock combination).

Plants of Cabernet Sauvignon grafted onto both the four different new genotypes and the six conventional rootstocks were controlled at agronomical, physiological, and nutritional levels. Data collected during the summer 2011, first year of observation, showed interesting results regarding SPAD and NDVI values recorded in leaves, as well as different K, Mg, Ca, and Fe content both in leaves and in petioles collected at veraison.

Keywords: *potassium efficiency, iron chlorosis, leaf and petiol analysis, SPAD, NDVI*



Nutrient Uptake Requirements and Partitioning in Fruit Trees

Massimo Tagliavini and Francesca Scandellari

Faculty of Science and Technology, Free University of Bolzano/Bozen, Italy; Massimo.tagliavini@unibz.it

The research on fruit trees mineral nutrition has only partially addressed the question related to the amount of nutrients annually needed by trees for their vegetative and reproductive cycle, in order to be economically viable and to minimize nutrient losses in the environment. Predicting annual amount and dynamics of the nutrient uptake, and their distribution in organs, is a fundamental step for developing rational fertilization strategies in orchards. This contribution will review literature data and research activities carried out in our laboratory to study the fluxes of macronutrients in orchard systems. Each year, tree organs increase in size and weight by primary and secondary growth, and withdraw nutrients from the soil. The cumulative amount of nutrients taken up can therefore be estimated from the nutrient content in organs accounting for the net primary production of the tree in a unit of time. Using data obtained from destructive and non-destructive samplings of trees or tree organs, we obtained a system of equations estimating tree growth from parameters easily measurable in fields for apple and citrus trees. Nutrient uptake is then estimated using a database of nutrient concentrations for each tree organ. This simple model is suitable to become a tool for growers, field advisors and administrators to recommend the amount of nutrients to be applied. To characterize the nutrient needs along the season and their internal remobilization, we used stable isotope techniques and mass balances. Data indicate that during growth each organ shows specific nutrient accumulation rates, which differ among nutrients. These results provide basic information for guiding the timing of nutrient supply, especially if fertigation techniques are adopted.



Effect of Pre-harvest Calcium on Nutritional Uptake and Morphological Traits of Papaya Seedlings (*Carica papaya* L. cv. Eksotika II)

Babak Madani^{1,3}, Mahmud TengkuMudaMohamed^{1,3}, Yahya Awang¹ and Jugah Kadir²

¹Department of Crop Science; mahmood@agri.upm.edu.my or babakmadani2009@gmail.com

²Department of Plant Protection, Faculty of Agriculture

³Institute of Tropical Agriculture (ITA)

Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

Calcium is a major plant nutrient that affects cell wall and plasma membrane formation and plays a key role in growth and biomass production in plants. It can be used to decrease fruit decay and increase firmness and storage duration. So far, little or no attention has been paid to investigate the effects of foliar application of calcium on papaya under controlled environment especially with respect to variety Eksotika II. Therefore, this study was conducted to look at the effect of different sources and concentrations of calcium on calcium uptake and growth of papaya. Papaya seedlings were established in pots and fertigated with standard nutrition solution in a net house. Four pre-harvest sprays were applied as foliar with three different sources of calcium (calcium chloride, calcium nitrate and calcium propionate) and four concentrations (0, 60, 120 and 180 mgL⁻¹). Spraying started one month after transplanting of seedlings and carried out fortnightly for two months. Ninety days after transplanting all treatments were completed. The results showed that calcium uptake by plant were not significantly affected by the different sources of calcium. However, increased calcium concentration in foliar enhanced uptake of phosphorous and calcium but, with decreased in potassium and magnesium accumulation in the tissues. In addition, with increasing concentration of calcium, seedling growth also increased. Based on the results, calcium chloride at the concentration of 180 mgL⁻¹ as foliar spray could be a suitable source of calcium for papaya in controlled environment.

Keywords: papaya, calcium sources, nutrient uptake, morphology



Effects of Potassium Foliar Spray on Different Fruit Tree Species Over 6 Years of Experiments

Ben M. Mehdi¹ and Marchand Michel²

¹Institut National Agronomique de Tunisie, 43 Av. Charles Nicole, 1082 Tunis Mahrajène, Tunisia; mehdibenmimoun@yahoo.com

²International Potash Institute, Tessenderlo Chimie, 180, rue du Centre, F-62170 Ecuire, France

Potassium is an essential mineral nutrient for the fruit growth and quality. Foliar sprays start to be used by fruit growers in addition with soil application or fertigation. Different experiments were conducted over a period of 6 years on five fruit tree species (peach, olive, pistachio, citrus and plums) in order to evaluate the effects of potassium foliar applications as the only way of fertilization on growth, yield, fruit quality and mineral status. Potassium as potassium sulfate has been applied by foliar sprays split according to the various critical stages of the fruits growth. Other treatments using fertigation or soil spread were also conducted depending on the experiments. The results showed different effects of foliar spray over the years. For yield, the effect was significant only after 5 years of experiments for olive tree but no effect was detected for pistachio after the same period. Fruit quality was generally improved for all the experiments with an increase of fruit weight and a higher solid soluble content. For foliar mineral content results show different effects depending on the experiment and fruit species. All these results are presented and discussed.

Keywords: *yield, quality, foliar mineral content, fertigation, soil spread*



SESSION II: Nutrient Management



Water Use, Mineral Nutrition, Tree Growth, Yield, and Fruit Quality of ‘Fuji’ and ‘Gala’ Apples under Various Irrigation Systems and Rootstocks

Esmaeil Fallahi, Bahar Fallahi, and Bahman Shafii

Parma Research and Extension Center, University of Idaho, 29603 U of I lane, Parma, Idaho 83660, USA; efallahi@uidaho.edu

An increasing trend in water shortage, adverse effects of excess nutrients on fruit quality and the environment and needs for high density orchards mandate the use of more efficient methods of irrigation and rootstocks. In a long-term experiment (10 years), effects of seven irrigation systems for 'Fuji' and two irrigation systems for 'Pacific Gala' on four rootstocks on growth, water use, fruit quality and mineral nutrients were studied. All drip systems used less water than full micro-sprinkler (SP). When trees were mature, each tree with SP system used about 6673 L while that with Full Drip (FD) used 4118 L per season, which was equivalent to 1010 mm and 624 mm, respectively. Thus, FD resulted in about 38 % saving in water over SP system. 'Fuji' yields and quality, particularly starch degradation pattern (SDP) and size were affected by irrigation treatments. 'Fuji' trees with FS and FD had higher K but lower Mg in leaf and fruit tissues. 'Fuji' trees with partial root drying sprinkler (PRS) had the highest leaf Fe and those with FS had the highest leaf Cu among all other treatments. Combination of FD with various levels of N fertigation revealed that application of 40 to 60 g N/tree/year resulted in optimum fruit quality and yield in 'Fuji'. 'Gala' trees on B.9 ceased its terminal growth and formed terminal buds about one month before those on other rootstocks. 'Gala' fruits from trees on G.30 and B.9 had higher SDP than those on RN-29 and Supporter 4, whereas trees on RN-29 had higher fruit weight than those on B.9 and Supporter 4. 'Gala' on B.9 had higher leaf Ca, Mg, Fe, Zn, and Mn but lower leaf K than those on other rootstocks. Gala with SP had higher leaf N, Ca, and K than those with FD.

Keywords: *irrigation efficiency, mineral nutrition*



Nitrogen and Potassium Citrus Tree Uptake, Fruit Removal and Seasonal Distribution in the Root Zone Under Mediterranean Climate

Abdelkader Hammami¹, Hafedh J. Mellouli² and Mustapha Sanaa³

¹CEDRAT-Tunisia, Soil Water & Plant Laboratory, 258 Avenue Habib BOURGUIBA 8000 Nabeul, Tunisia; cedrat.tunisie@topnet.tn

²National Agronomic Research Institute of Tunisia, Rue Hédi KARRAY 2049 Ariana, Tunisia

³National Agronomic Institute of Tunisia, 43 Avenue Charles NICOLLE Tunis, Tunisia

Optimum application of nitrogen and potassium fertilizers to citrus grove requires information's regarding existing soil N and K residues, dynamics in soil, and tree N and K requirements. However, more understanding of the fate of nutrients in the tree root zone soil matrix provides useful information to develop fertilization management practices with an adequate balanced N and K citrus needs that maximize tree uptake efficiency by minimizing losses of water soluble nutrients. The objectives of this work, was to assess the effects of nitrogen and potassium rates applied through drip irrigation system, on the citrus trees nutrient uptake, fruit nutrient removal and seasonal dynamics of fertilizer-N and K in the root zone. A field trials were conducted from 2005 to 2007 in the citrus production area located in the North East of Tunisia (El Gobba, Cap Bon); on sandy soil with 25 years old 'Clementine mandarin' trees (*C. reticulata*) on 'Sour orange' (*C. aurantium*) rootstock. Nitrogen and potassium rates from 160 to 232 kg ha⁻¹yr⁻¹ and 200 to 290 kg ha⁻¹yr⁻¹, respectively, were applied as fertigation through a drip irrigation system. Irrigation was scheduled based on soil water content monitoring by daily tensiometer readings at the root zone.

Fruit yield was positively associated with N ($r^2=0.91^{**}$) and K ($r^2=0.84^{**}$) rates, indicating that application of 192 and 200 kg ha⁻¹yr⁻¹ of N and K₂O (N:K=0.9), respectively, are required for Clementine mandarin trees to support optimal fruit yield of 43 T ha⁻¹yr⁻¹. These responses suggest that N and K tree use efficiency varied from 4.5 to 3.9 kg T⁻¹ of Clementine mandarin fresh fruit, respectively. On the other hand, tree nutrient removal indicated that both total N ($r^2=0.97^{**}$) and K ($r^2=0.98^{**}$) in fruit were positively linear correlated with fruit load, and there was also, a strong linear relation ($r^2=0.97^{**}$) between N and K in fruits, which supports the needs to maintain 1:1 ratio between the rates of N and K₂O applications. Further more, nutrient uptake efficiency (mineral fruit removal: fertilizer applied ratio) were 32.5% and 27.5% for N and K, respectively.

However, the selected fertigation management program, has contributed not only to optimize fruit yield but also to enhance tree nutrient uptake and water use efficiency by minimizing losses below tree root zone. Consequently, it should be an essential component of best management practices for Clementine mandarin under semi arid Mediterranean conditions.

Keywords: tree nutritional requirements, nutrient use efficiency, Mediterranean conditions



Effects of Nitrogen, Phosphorus and Potassium on Yield and Fruit Quality of Three Navel Orange Cultivars

Hong Huang, Chengxiao Hu, Qiling Tan, and Xuecheng Sun

College of Resources and Environment/ Micro-element Research Center, Huazhong Agricultural University, Wuhan 430070, China; hucx@mail.hzau.edu.cn

Field trials with three citrus varieties, New hall (*C. sinensis* L. cv. Newhall), Cara cara (*C. sinensis* osbeck cv. Cara cara) and Robertson (*C. sinensis* osbeck cv. Robertson), grafted on trifoliolate orange [*Poncirus trifoliata* (L.) Raf.], were carried out to determine the effects of various nitrogen, phosphorus and potassium fertilizer levels on citrus yield and fruit quality in three year. The experiment designs included 1 level of nitrogen (N 0.8 kg tree⁻¹ yr⁻¹), 3 levels of phosphorous (P1 0.2, P2 0.4 and P3 0.6 kg tree⁻¹ yr⁻¹), 3 levels of potassium (K1 0.25, K2 0.5 and K3 0.75 kg tree⁻¹ yr⁻¹) and one blank control, totally being 9 treatments with 3 replications. The recommendation rates determined by the fruit NPK uptake were 800-1333, 130-206 and 428-617 kg ha⁻¹ yr⁻¹ in New hall, 893-1489, 160-253 and 442-637 kg ha⁻¹ yr⁻¹ in Robertson, and 864-1440, 133-210 and 566-815 kg ha⁻¹ yr⁻¹ in Cara cara, respectively. The maximum yield were 85.11 (NP1K1), 101.37 (NP3K2) and 89.77 t ha⁻¹ (NP1K1) in New hall, Robertson and Cara cara, respectively. A cluster analysis of soluble solids, vitamin C and titratable acid identified that NP1K1, NP1K2 in New hall, NP2K3 and NP3K2 in Robertson, NP1K1 and NP2K1 in Cara cara, had the optimum performance. The results demonstrated that the three navel orange cultivars had the differences in the nutrient uptake with fruit (N, P and K), yield and fruit quality, and the NPK recommendation rations were consistent with the effects of NPK on yield and fruit quality. The recommendation NPK rates can be determined by the fruit nutrient uptake and the yield. The optimum rations of N:P:K are 1:0.16:0.54, 1:0.18:0.49 and 1:0.15:0.66 in New hall, Robertson and Cara cara, respectively.

Keywords: citrus, NPK, fertilization, fruit nutrient uptake



Fertilizer Management and Sustainable Production of Fruit in Tropical Climates

Anke Kwast¹ and Miles Harriman²

¹Research Institute Hanninghof, Yara International ASA, P.O.Box 2464, Solli N-0202, Oslo, Norway; anke.kwast@yara.com

²Yara (Thailand) Ltd, Sukhumvit Rd., Klongton, Klongtoey, Bangkok 10110, Thailand; miles.harriman@yara.com

Fertilizer management can improve productivity and sustainability of fruit production by supplying required nutrients and improving soil fertility.

This paper presents the effect of different N-forms on soil acidity. Nitrate based N fertilizer are recommended for acid soils, as they do not need to be nitrified to nitrate, the preferred N form of most crops and they are non-acidifying. Applying urea or ammonium based N fertilizer leads to pronounced ammonium nutrition, due to inhibited nitrification at low soil pH, also observed in incubation trials with 8 Thai soils. Ammonium uptake by plant roots leads to a further acidification of the rhizosphere, with all the related problems e.g. aluminum toxicity. This research has a relevance to Thailand because acidic soils are common.

Data from a fertigation trial of citrus growing on acid soils in Brazil on behalf of Yara, compares calcium nitrate with ammonium nitrate fertilization. During the first three years no differences were observed, but during the following 4 years a consistent yield increase of 12 to 40 % was found with calcium nitrate as compared to ammonium nitrate. The two N fertilizers were compared at increasing application rates, and the resulting dose-rate response curve shows enhanced yield potential of calcium nitrate. Even though lime was applied frequently according to best practice, it has not prevented the acidification of the root zone caused by ammonium nitrate, and the pH falls to pH 3 at high N rates. While calcium nitrate remained rather pH-neutral. The long term negative effects of root zone acidification in fruit trees and the problems associated with rectifying root zone pH using powdered limestone are discussed.

The advantage of calcium nitrate in acid soils can be explained by the non-acidifying effect, by the increase of calcium concentration down to 60 cm soil depth, which has ameliorative effects on aluminum toxicity and by the improving the Ca status crops.



Foliar Nutrient Uptake – of Myths and Legends

Thomas Eichert

University of Bonn, Institute of Crop Science and Resource Conservation (INRES), Dept. of Plant Nutrition, Karlrobert-Kreiten-Str. 13, D 53115 Bonn, Germany; t.eichert@uni-bonn.de

Foliar fertilization is a common practice to quickly correct nutrient deficiencies, especially under conditions of limited soil nutrient availability. For a long time it has been a matter of debate how nutrients enter the leaves. It was assumed that uptake is restricted to the cuticle, while stomata were supposed to be impermeable to foliar-applied solutes. It was suggested that uptake occurs through “ectodesmata”, a concept that was later disproved but still persists in current textbooks and review articles. The recent model assumes that polar solutes, such as nutrient salts, enter the cuticle through hydrophilic polar pores. Early estimations suggested that the pores are so small (diameter: 1 nm) that they exclude large molecules, such as sucrose or iron chelates, from foliar uptake.

We present evidence indicating that some of these conceptions have to be revised. We found that solute uptake through stomata is in fact possible (Eichert and Burkhardt 2001) and that the stomatal penetration pathway can be as important as the cuticular pathway (Eichert and Goldbach 2008). Experiments using N compounds or nm-particles showed that the stomatal pathway enables penetration of substances as large as 40 nm (Eichert and Goldbach 2008, Eichert et al. 2008). Estimations of pore sizes in cuticles of stomata-free, intact leaves yielded diameters of 4-5 nm (Eichert and Goldbach 2008).

These results are in accordance with observations in the field that large molecules (e.g., Fe-chelates) can penetrate stomata-free upper leaf surfaces and that uptake rates of mineral nutrients are frequently larger through the stomata-bearing lower leaf surface than through the upper surface. These findings call for the broadening of our conception of foliar uptake. The current, revised model (Eichert and Fernández 2012) thus takes into account that both the cuticle and stomata may contribute significantly to foliar penetration.

Eichert T, Burkhardt J (2001) Quantification of stomatal uptake of ionic solutes using a new model system. *Journal of Experimental Botany* 52: 771-781.

Eichert T, Fernández V (2012) Uptake and Release of Mineral Elements by Leaves and Other Aerial Plant Parts. In: Marschner's *Mineral Nutrition of Higher Plants*, 3rd edition, Academic Press, pp. 71-84

Eichert T, Goldbach HE (2008) Equivalent pore radii of hydrophilic foliar uptake routes in stomatous and astomatous leaf surfaces – further evidence for a stomatal pathway. *Physiologia Plantarum* 132: 491–502.

Eichert T, Kurtz A., Steiner U., Goldbach HE (2008) Size exclusion limits and lateral heterogeneity of the stomatal foliar uptake pathway for aqueous solutes and water-suspended nanoparticles. *Physiologia Plantarum* 134: 151–160.



Does It Pay To Spray?

Jon Carl Frank

International Ag Labs, P.O. Box 788, Fiarmont, MN , USA; Jon.Frank@aglabs.com

Foliar feeding plants is not new. Foliar feeding plants with soluble calcium can be valuable if the plant translocates the calcium from the leaf to the developing fruit. Adequate calcium in the fruit is responsible for cell wall integrity, fruit size, shelf life, and flavor. It also appears to strongly increase the volume of yield.

Foliar feeding has been long recognized for its contribution toward fruit quality. One neglected area of research has been the cost of foliar feeding and the return on investment (ROI). A corollary question involves frequency of foliar feeding. More specifically a dramatic increase in frequency.

To answer these questions a mature block of Bing cherries in the Yakima Valley of Washington State was selected. A foliar program was applied 3 days a week skipping Sunday. Each foliar spray consisted of a mix composed of a calcium foliar spray with an analysis of 5-16-4-5Ca, a liquid seaweed blend, and dissolved dextrose. Other trace minerals were added to the foliar solution in small quantities if shown deficient by a plant tissue test. Foliar spraying started at blossom drop and continued till harvest. This 7 week window represented approximately 21 foliar applications.

The result was an outstanding yield of medium-sized cherries. Did this frequent rate of foliar nutrition give a positive ROI? Without a doubt! The owner was extremely pleased to harvest 10 tons to the acre.

Keywords: *foliar nutrition, foliar feeding calcium, frequency of foliar spraying, return on investment*



Nutrients Management in Kiwifruit in Shaanxi, China

Yanan Tong and Jian Wang

Northwest A&F University, Resource and Environment Collage, 712100, Yangling, Shaanxi, P.R. of China; tongyanan@nwsuaf.edu.cn

Total Kiwifruit tree planted area in China was 70,000 ha and the yield was 850,000 t in 2010, 43,000 ha of which planted in Shaanxi province with the yield of 600,000 t, the yield was 60% of whole China production and 1/3 of the world, respectively. Three trees were selected for sampling in six different stages. Sampling began on March 28 (sprouting and foliage growing), May 18 (young fruit), July 9 (fruit expansion), September 8 (fruit maturity), November 6 (defoliation) and on January 11 next year (dormancy). Samples of fruit, leaves, new tops, branches, trunks, and roots were collected separately each time. Nitrogen (N), Phosphorus (P) and Potassium (K), concentration and accumulation in kiwifruit trees showed that fall accumulated NPK were used to meet demand during the new leaves and branches come out in Spring next year. When kiwifruit production was 40 t/ha, the total NPK absorption were 216.7 kg/ha, 36.9 kg/ha and 169 kg/ha, respectively. Of which, NPK distribution of kiwifruit tree during harvesting period were 52%, 48% and 62% in fruits, 19%, 17% and 23% in leaves, 22%, 19% and 12% in stem and 7%, 16% and 3% in root, respectively. The nutrients accumulation of fruits and leaves, removed from orchards after harvested in fall, which provided a basis for fertilization recommendation next year. The consuming nutrients of NPK per 100kg kiwifruits were 0.54 kg/ha, 0.092 kg/ha and 0.42 kg/ha, respectively.

Keywords: *kiwifruit, N, P, K, fertilizer efficiency, yield, quality*



SESSION III: Interaction and Diagnosis of Plant Nutrition Status



Development of A Nutrient-Budget Approach and Optimization of Fertilizer Management in Almond

Sebastian Saa, Saiful Muhammad and Patrick Brown

Department of Plant Sciences, University of California, Davis. MS#2, One Shields Avenue, Davis CA, USA; ssaa@ucdavis.edu

Optimal nutrition is essential to maintain the competitiveness of orchard crops. In the following we will report on results of a series of large integrated field studies conducted in Almond from 2008- 2012. These studies have been used to develop and test new approaches to the use of tissue sampling and interpretation, whole orchard nutrient budget analysis, quantification of nutrient demand and nutrient losses and development of novel integrated management practices. One of these projects principal goals was the systematic reexamination of both current leaf-sampling protocols and the application and interpretation of established critical values. A second principal goal of this project was to determine the response of almond to different nutrient application rates, seasonal timings, and fertilizer sources; a third objective was the development of a phenology and yield-based nutrient demand model and a final objective was to quantify nutrient losses from the system.

A reanalysis of the use of leaf sampling and critical values suggests that, in Almond, leaf samples can be collected at any time following full leaf expansion and that algorithms can be used to interpret nutrient concentrations with respect to a previously established critical value even if that standard was established at a different sampling date. Measurements of field nutrient variability at multiple sites has been used to establish robust field sampling strategies while multi site yield and nutrient analysis has been used to establish crop demand curves and patterns of nutrient uptake throughout the season. In Almond 80% of the total N and 70% of the total K is accumulated in fruit by mid-June, one month prior to harvest. Yield and N concentration determine N demand which varies from 54 – 70 lb N in fruit for every 1000 lb kernel yield. Leaf tissue N concentration correlates with fruit N concentration and can be used to refine total crop nutrient uptake. Mean fruit K removal is 80 lb for 1000 lb kernel yield but is not sensitive to differences in tissue K concentration. In these trials in which N application and movement in the soil is carefully controlled a long term nitrogen use efficiency (NUE) calculated as N applied/N removed in crop of 75% has been achieved demonstrating that perennial systems can attain remarkably good nitrogen use efficiencies when carefully managed.

Keywords: *almond, foliar analysis, nutrient budget, critical value*



Assessment of Chemical and Biochemical Indices for Diagnosing Zinc Deficiency and Soil Associated Factors of Citrus (*Citrus sinensis* L. Osbeck) Nutrition

Vilas Patil

Department of Soil Science and Agril. Chemistry, Marathwada Agricultural University, Parbhani 431402, Maharashtra, India; vilas_22902@yahoo.co.in

A three phase research programme was planned to assess the chemical and biochemical indices for diagnosing Zn deficiency and soil associated factors of citrus nutrition in Marathwada region of Maharashtra state of India. In the first phase a survey of sweet orange orchards was carried out to evaluate the nutritional status and to find out constraints in fruit production. In the second phase a pot culture experiment was conducted to evaluate the critical concentration of zinc in soil and leaf. Similarly biochemical indices the CAA (Carbonic Anhydrase Activity) and chlorophyll were also studied. While in third phase, another pot culture experiment was conducted to find out the effect of lime, organic manure and zinc on growth of sweet orange seedlings. The results of three phase research programme revealed that sweet orange orchards (*Citrus sinensis* L. Osbeck) of the region are grown on variety of soils (Entisol, Inceptisol and Vertisol) without considering its suitability. Similarly, inclusion of intercrops is adopted without testing compatibility. Soil analysis of orchard soils showed calcareous in nature and clay in texture. Deficiencies of N and Zn are wide spread followed by P. Leaf analysis confirmed wide spread deficiency of N and Zn followed by P. In addition it showed deficiency of K and Mn. Biochemical indices viz. CAA and chlorophyll content of sweet orange leaf found to be sensitive and reliable index in diagnosing zinc deficiency. Sweet orange orchards established on Inceptisols performing better than the orchards established on other soil types. Improvement in sweet orange seedling was recorded with high zinc soils supplied with 5 mg Zn, marginal zinc status soils with 10 mg Zn and low zinc status soils with 15 mg Zn kg⁻¹. Reduction in sweet orange growth was noticed with 15 to 20 per cent CaCO₃ level. It was further concluded that detrimental effect of high CaCO₃ content (up to 20 per cent) on growth can be alleviated to some extent by applying double or triple (10 to 15 g organic manure kg⁻¹) the recommended dose of organic manure. Organic manure in combination with zinc performed best in improving growth, uptake of zinc, CAA, chlorophyll and dry matter production of sweet orange seedlings. Critical concentration under varied level of CaCO₃ and organic matter content of soil for sweet orange varied from 1.04 to 1.17 mg kg⁻¹, while critical zinc concentration varied from 28.80 to 36.40 mg kg⁻¹. The variations in critical concentration of zinc in soil and sweet orange leaf are attributed to the variability of CaCO₃ and organic matter in soil.



Influences of Different Ratio of N Supplied from Manure and Mineral Fertilizer on Nanguo Pear Growth, and Soil Nutrient Accumulation

Xiuchun Liu^{1,2}, Binghua Wang², Bingyu Zhang², Juncai Li², Linan Chen² and **Qing Chen¹**

¹College of Resources and Environmental Sciences, China Agricultural University, Beijing, 100193, China; qchen@cau.edu.cn

²Liaoning Institute of Pomology, Yingkou, 115009, China

A three-year field trial was conducted in Liaoning, northeast of China, in order to compare the effects of different ratio of N supplied from manure and mineral fertilizer on yield and quality of 15-year Nanguo pear and soil nutrient accumulation from 2009 to 2011. The pear grafting on *Pyrus ussuriensis* was planted with the spacing of 4 m × 5 m in brown soil. Five treatments were employed with an ordered complete block design, including (1) 100% of N supplied from mineral fertilizer (I10); (2) 60% of N from mineral fertilizer + 40% of N from manure (I6O4); (3) 40% of N from mineral fertilizer + 60% of N from manure (I4O6); (4) 100% of N supplied from manure (O10); (5) No N application (CK). All treatments were applied with 0.4 kg N, 0.2 kg P₂O₅, and 0.4 kg K₂O per tree each year, which split into 40% of total nutrient after blooming, and 60% in the mid of September with chicken manure, urea, DAP potassium sulfate. P and K from mineral fertilizers were based on the input from manure in each treatment. It was found that higher fruit yield was monitored in the treatments of I6O4 (54.4 kg FW/tree/year) and I4O6 (56.2 kg FW/tree/year) in 2009 and 2010. Fertilization practices improved leaf calcium content in 2010. Leaf K content in I10 treatment significantly increased due to high proportion of K₂SO₄ application in 2011. Manure applied promoted total fruit soluble sugar content in 2010. Meanwhile, manure treatment (O10) increased the accumulation of organic matter (21.4 g/kg) and total N (1.18g/kg) in the surface soil layer. Soil exchangeable K and Olsen P contents in the I4O6 and I6O4 treatments were higher than those in other treatments. It was suggested that the combining effect of manure and mineral fertilization is important to maintain soil fertility and improve fruit production.

Keywords: Nanguo pear, manure, mineral fertilizer, nitrogen, yield, fruit quality, soil fertility



Kiwifruit Production - Using Nitrogen Efficiently

Linda M. Boyd¹, Andrew M. Barnett¹, Paul R. Johnstone¹ and Warwick Catto²

¹The New Zealand Institute for Plant & Food Research Limited, Private Bag 92 169, Auckland 1142, New Zealand; Linda.boyd@plantandfood.co.nz

²Ballance Agri-Nutrients Limited, PO Box 12 503, Tauranga, New Zealand

New Zealand is geographically isolated from many of the key markets for its kiwifruit. To retain a competitive edge, the industry needs to produce high-quality fruit whilst minimising production costs. In the market, high quality means uniform size, acceptable taste and good storage potential. Consumer acceptability has been linked to fruit dry matter concentration (DMC; dry weight as a percentage of fresh weight). To encourage production of high-quality fruit, New Zealand kiwifruit growers receive financial incentives to produce fruit within a certain size range and with DMC. The grower needs to consistently produce high yields of high DM fruit, whilst optimising canopy management to minimise labour costs. Nitrogen can affect fruit size, DMC and storage potential and canopy vigour, therefore optimising nitrogen management is an important part of production of high-quality kiwifruit. In this paper we discuss how amount, timing and mode of N input can influence source-sink relationships within the vine, and how we are tailoring N input to orchards with different soil types and orchard management practices.

Keywords: *Actinidia, taste, storage quality, vine vigour, nitrogen mineralisation*



Nutrient Analysis of Plant Parts to Assess the Effect of Gypsum Application in Longkong (*Aglaia dookkoo* Griff.)

Boonsong Krisornpornsan¹, Sayan Sdoodee² and Chairat Nilnond³

¹Department of Technology and Industry, Faculty of Science and Technology, Prince of Songkla, Pattani, 94000, Thailand; Kboonson@bunga.pn.psu.ac.th

²Department of Plant Science, Faculty of Natural Resource, Prince of Songkla, Songkhla, 90112, Thailand

³Department of Earth Science, Faculty of Natural Resource, Prince of Songkla, Songkhla, 90112, Thailand

Longkong belongs to the Meliaceae family and originates from the south of Thailand. It is an economically important plant in the peninsula of Thailand, widely distributed from the south through the east, north and central. The soil orders in southern Thailand are mainly ultisols with low fertility and calcium content. Impacts of gypsum in soil improvement have been investigated in southern Thailand and the results are very positive. However, its influence in longkong has not yet been clarified. Therefore, a field-trial experiment was established in Kanchanadit district, Surat Thani province. The objective of this study was to assess the effect of gypsum application on macronutrient (N, P, K, Ca and Mg) concentration in longkong plant parts. The experiment was conducted with two treatments consisting of control and 400g gypsum application per square meter. Concentrations of N, P, K, Ca and Mg were measured in roots, stems, leaves and fruit clusters. According to the amount of total nutrient concentration of the longkong tree, it was found that the tree under gypsum treatment had less Mg concentration, but greater P and K concentrations than that in the control treatment. Concentrations of N and Ca were not significantly different. The result also showed that the gypsum application increased P and K but decreased Mg in the plant parts. However, N and Ca tended to decrease under gypsum application. Concentrations of N and Ca were highest in leaf ($17.99 \pm 1.58 \text{ g kg}^{-1}$ and $6.84 \pm 0.90 \text{ g kg}^{-1}$, respectively), while the highest of P was in root ($5.31 \pm 1.16 \text{ g kg}^{-1}$). The highest K and Mg concentrations were in the rind of longkong fruit ($24.64 \pm 2.11 \text{ g kg}^{-1}$ and $2.52 \pm 0.51 \text{ g kg}^{-1}$, respectively).

Keywords: nutrient, plant parts, gypsum, longkong, *Aglaia dookkoo*



Effect of Potassium Supply as KNO_3 , K_2SO_4 or KCl on Growth and Yield of Potted Tomato Plants Grown in Saline-Neutral or Saline-Alkaline Conditions

Steve A. Oosthuysen

HortResearch SA, P.O. Box 3849, Tzaneen 0850, South Africa; hortres@pixie.co.za

High pH-saline conditions typically occur in desert environments where the soils have a high content of calcium carbonate, sodium carbonate and sodium chloride, and the water is rich in bicarbonates of Ca and Na and contains an appreciable quantity of NaCl. Tomato plants have a high K requirement. If K is not accumulated sufficiently, growth and yield are reduced. It is known that abundance of soil NO_3^- depresses chloride (Cl^-) uptake through competitive inhibition, and growth and yield in tomato are adversely affected by Cl^- . Tomato roots, as do the roots of most crops, naturally have a high affinity NO_3^- . Cl^- uptake at the expense of NO_3^- uptake may result in reduced K assimilation, and give rise to reduced health, yield and quality in tomato. NO_3^- is known to generally promote the uptake of the cationic plant nutrients namely K, Ca, Mg, Cu, Fe, Mn, and Zn. NO_3^- rich as opposed to sulfate (SO_4^{2-}) rich fertigation solutions are less prone to result in root-zone salinity build up, since NO_3^- fertilizers comprise nutrient ions that are mainly taken up as compared to SO_4^{2-} fertilizers where uptake of SO_4^{2-} as opposed to NO_3^- is substantially less.

Tomato plants were grown in pots comprising 80:20 (v/v) river sand/calcium carbonate or river sand. Equal fertigation programs were provided in terms of elemental supply of N, P, K, Ca, Mg, Cu, Fe, Mn, Zn, B and Mo. The exclusion of KNO_3 and inclusion of K_2SO_4 or KCl in supplying K, gave rise to a formulation containing a greater quantity of NH_4^+ -N relative to NO_3^- -N. NH_4^+ uptake is known to depress the uptake of K and the other cationic plant nutrients. Moreover, the fertigation solution also contained a greater quantity of SO_4^{2-} , which if not assimilated effectively increases soil solution salinity. The aim was to show the benefit, in fertigating, of using KNO_3 as opposed to K_2SO_4 or KCl as the K source in tomato plants grown in saline-alkaline conditions, or just saline conditions for comparative reasons. Growth, fruit number or plant yield was greater in the plants grown in calcium carbonate/river sand. In terms to K source, growth, fruit number or plant yield was greatest in the plants fertigated with the solution made-up with KNO_3 . A difference in performance relating to fertigation with the solution made-up with KCl or K_2SO_4 was not apparent.



Response Mechanisms of Grapevine to Sustainable Strategies of Iron Chlorosis Prevention

José I. Covarrubias and Adamo D. Rombolà

Department of Fruit Tree and Woody Plant Science, University of Bologna, Viale G. Fanin 46, 40127 Bologna (BO), Italy; adamo.rombola@unibo.it

The prevention/cure of Fe chlorosis with Fe chelates is a very widespread agronomical practice in vineyards and orchards, nevertheless it implies high costs and potential environmental and health risks. Such consequences strongly suggest the need of adopting alternative strategies for managing Fe nutrition according to soil and plant parameters. Recently it has been shown that intercropping with graminaceous species, due to their abilities of solubilizing soil Fe through phytosiderophores secretion, effectively prevent Fe chlorosis in fruit tree crops. In addition, it is known that high nitrate concentrations in the rhizosphere can induce Fe-deficiency chlorosis. The aim of this work was to study physiological and biochemical response mechanisms of grapevine to sustainable strategies of Fe chlorosis prevention, based on ammonium management and intercropping with graminaceous species. A pot experiment was conducted in 2010-2011 seasons growing vines of cv Cabernet Sauvignon grafted on the Fe-chlorosis susceptible genotype *Vitis riparia* in 33-L pots filled with calcareous soil. Treatments were the following: 1) Control (bare soil); 2) Soil-applied Fe-EDDHA; 3) Leaf-applied Fe-EDTA; 4) Intercropping with *Festuca rubra* (Fe-efficient graminaceous species); 5) Soil-applied N-NH₄⁺; and 6) N-NH₄⁺ plus a nitrification inhibitor (DMPP). Results indicate the potential for efficiently preventing grapevine Fe chlorosis by maintaining limited concentrations of ammonium in the rhizosphere and intercropping with Fe-efficient grasses. The presence of *Festuca rubra* reduced markedly plant growth. In the second vegetative season, Fe-deficient control vines showed the lowest leaf chlorophyll levels, the highest root citrate concentration (along with Fe-EDTA foliarly-treated plants) and PEPC activity. Vines fertilized with ammonium (with and without nitrification inhibitor) and co-cultivated with *Festuca rubra* displayed levels of root organic acids and activities of the Fe-deficiency induced enzyme PEPC, similar to values recorded in Fe-EDDHA-fed plants.

Keywords: *Fe-deficiency, intercropping, ammonium, organic acids, phosphoenolpyruvate carboxylase*



Determination of Macro and Micro Elements of Different Pistachio Cultivars in “On” and “Off” Year Trees

Bekir E. Ak and Mine Fidan

University of Harran, Faculty of Agriculture, Department of Horticulture, 63000 Sanliurfa-Turkey;
beak@harran.edu.tr

This study was conducted to search plant nutrition content of different parts of pistachio cultivars in 2003-2004 vegetation period. This research was carried on 35 year old, fruitful or unfruitful (showing alternate bearing) Kırmızı, Siirt and Ohadi pistachio cultivars which are grafted on *P. vera* rootstock at the Ceylanpınar State Farm.

The results of the analysis of leaf samples taken from fruitful or unfruitful trees as follow; nitrogen (N), phosphorous (P), calcium (Ca) contents were not sufficient, potassium (K), magnesium (Mg), iron (Fe) and copper (Cu) contents of the samples were sufficient. Also it was determined that zinc (Zn) level is good enough in fruitful pistachio trees, but insufficient in unfruitful trees. Plants could not utilize the elements in the soil because of high level of Ca, low water content and high temperature.

Keywords: pistachio, fertilization, mineral elements, element concentration



SESSION IV: Plant Nutrient and Fruit Quality



The Bottleneck of Ca Translocation into Fruit in Litchi

Wei Chen¹, Hui-Cong Wang¹, **Xu-Ming Huang¹**, Yan Fan²

¹Physiological Lab for South China Fruits, College of Horticulture, South China Agricultural University, Guangzhou 510642, China; Huangxm@scau.edu.cn

²Dongguan Agricultural Research Center, Dongguan 523002, Guangdong, China

Ca availability in pericarp is related to fruit cracking resistance in litchi. Our study showed that fruit pedicle had a by far higher Ca concentration than the pericarp, indicating that there was a bottleneck in Ca translocation into fruit at the fruit end of the pedicle. We tried to explore the mechanism that creates the bottleneck for calcium transport by examining the pathways of calcium translocation into fruit. Ca concentration was found to be higher in the phloem than in the xylem in trunk, large branch, shoot, peduncle and pedicle, and Ca in phloem tissue was higher in more matured organs, i.e. trunk>large branch>shoot>peduncle>pedicle. X-ray mapping of calcium in the pedicle revealed that the element was chiefly distributed in phloem close to the cambium. The results indicated the possibility that Ca translocation to fruit is chiefly through phloem pathway, i.e. symplast pathway. Transfusion of LaCl₃ (1 mg/ml), blocker of Ca channels that transport Ca from apoplast to symplast, into fruit pedicle resulted in significant reduction in Ca concentration in the pericarp and inhibited fruit growth and coloration. During fruit maturation, fruit Ca uptake was completely inhibited by LaCl₃ treatment. The results proved that Ca translocation into fruit is depended on Ca channels. It is likely that prior to translocation into fruit, Ca in pedicle is moved from apoplast to symplast and that this cross-membrane movement of Ca is rate-limiting and creates the bottleneck effect in Ca translocation into fruit.

Keywords: calcium, translocation into fruit, Ca channels, pedicle, litchi



Mapping the Distribution of Calcium in Apple Tissue with Proton-Induced X-ray Emission – After Application of Additional Pre-harvest Foliar or Soil Calcium

Robert E. Wilsdorf¹, Jolanta M. Mesjasz-Przybylowicz², Wojciech J. Przybylowicz^{2,3} and **Elmi Lötze**¹

¹Department of Horticultural Science, Stellenbosch University, Private Bag XI, Matieland, 7602 South Africa; elotze@sun.ac.za

²Materials Research Department, iThemba LABS for Accelerator Based Sciences, Somerset West 7129, South Africa

³on leave from the Faculty of Physics & Applied Computer Science, AGH University of Science and Technology, 30 Mickiewicza Av., 30-059 Kraków, Poland

The development of calcium (Ca) deficiencies in the apple fruit are ascribed to a lack in accumulation of Ca in specific areas of the fruit. Localized deficiencies therefore commonly occur in spite of sufficient levels of total fruit Ca. A trial was conducted during two consecutive seasons (2008/9 and 2009/10) to evaluate the contribution of either foliar or soil-applied Ca on the localization of Ca in “Braeburn” apple fruit. Ca ($\text{Ca}(\text{NO}_3)_2$) was applied either in the form of soil pellets (Tropicote™) at fruit set or after harvest, or as a series of weekly foliar applications (Calflo™) between 21 and 70 days after full bloom (dafb). Additional treatments consisting of combinations of these were also applied. Elemental Ca mapping across the radius of the fruit was achieved via the use of micro-PIXE (particle induced X-ray emission). In all treatments, Ca was concentrated in the skin and core of the fruit, with the lowest values occurring in the outer cortex. At 80 dafb, Ca was highly associated with vascular bundles in an otherwise homogenous cortex. Fruit set Ca soil applications consistently resulted in fruit with less Ca at 80 dafb compared to the other treatments. The prevalence of vascular bundles mostly determined the average Ca concentrations in the core, inner and outer cortex regions and emphasizes the importance of the functionality of vascular bundles throughout the season. Foliar Ca altered the distribution of Ca in the fruit and resulted in a significant increase in Ca in the outer cortex relative to the core.

Keywords: *elemental mapping, PIXE, X-ray microanalysis, Ca deficiency, bitter pit, Malus domestica*



Physiological Disorders in Relation to Compositional Changes in Mango (*Mangifera indica* L. cv. ‘Chiin Hwang’) Fruit

Huey-Ling Lin, Ching-Chang Shiesh and Pei-Jen Chen

Department of Horticulture, National Chung-Hsing University, 250 Kuo-Kwang Road, Taichung 402, Taiwan, R. O. C.; hllin@dragon.nchu.edu.tw

Five physiological disorder symptoms of ‘Chiin Hwang’ (*Mangifera indica* L. cv. ‘Chiin Hwang’) mangoes, soft nose, jelly seed, lumpy tissue, pitting necrosis and scorch, were investigated and their alcohol dehydrogenase (ADH), peroxidase (POD), ethanol, acetaldehyde, starch and mineral elements contents were analyzed in relation to their disorder. The results showed that the fruit infected with jelly seed had the highest ADH activity, and those with lumpy tissue, pitting necrosis, scorch, soft nose and jelly seed displayed relatively higher levels of ethanol and acetaldehyde. Lumpy tissue fruit topped the rest with a starch concentration of 18.46%, and pitting necrosis fell far behind all the others in Ca content, which was only 0.008%. These data along with others indicate that fruit with different disorder symptoms have differing enzyme activities and also differ in chemical composition. Lumpy tissue, jelly seed and soft nose may result from an uneven ripening speed during fruition, hampering the regular process of turning starch into soluble sugars and initiating an anaerobic respiration pathway detrimental to healthy fruit growth. Fruit with scorch or pitting necrosis suffer from browning that cannot be solely attributed to the action of peroxidase. Pitting necrosis fruit have a low calcium concentration and high peroxidase activity, perhaps because the calcium deficiency induces cell breakdown.

Keywords: *alcohol dehydrogenase, calcium, Mangifera indica* L. cv. ‘Chiin Hwang’, *peroxidase, softnose*



Pectin and Calcium Distribution in Cell Wall of Physiological Disorder Mangosteen Fruits

Sumitra Poovarodom and Naree Phanchindawan

Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand; kpsumitr@kmitl.ac.th

The two most important physiological disorders of mangosteen fruit are translucent flesh (TFD) and gamboges (GD), with the combined TFD and GD being the most severe. Both symptoms appear only inside the fruit and impossible to detect from the outside. Previous researches showed that calcium (Ca) application significantly reduced these symptoms. However, Ca concentration in the disorder flesh was found to be higher than in the normal flesh. To elucidate this dilemma, cell wall materials from flesh of normal, TFD and TFD+GD fruits were extracted in 6 sequential step, i.e. with water (free pectin), 0.05M CDTA (cleave ionically bound pectin), 0.05M Na₂CO₃ (cleave ester linkage) at 4°C and then at 20°C, 1M KOH and 4M KOH. Pectin and Ca associated with each fraction were analyzed. Ca in tissue of flesh from the same fruit was also determined in separated samples. In all fruit types, the first 4 extracting steps yielded around 90% of pectin. Total pectin as well as the alcohol insoluble solid (AIS) was significantly higher in TFD and TFD+GD than in the normal fruit. The proportion of CDTA soluble fractions was relatively constant in all fruit samples. However, the normal flesh has a higher proportion of water soluble fraction accompanied by a marked reduction in Na₂CO₃ soluble pectin. The 4°C Na₂CO₃- soluble fraction of 25.9% in normal fruit were much lower than the 40.3% in TFD and 42.2% of total pectin in TFD+GD. The results suggested that the water soluble fraction in normal fruit has been solubilized from the Na₂CO₃- soluble fraction of the cell wall.

The total concentrations of Ca in the flesh (tissue Ca) and cell wall Ca, although not significantly different, were slightly higher in TFD and TFD+GD than in the normal fruits. The proportion of cell wall Ca to total tissue Ca of the flesh was 63-65%, the majority of which is associated with pectin. The water and CDTA-soluble fractions yielded up to 85-89% of the total wall Ca in all fruit samples. In normal fruit, 25% of wall Ca was water soluble and 43% was CDTA-soluble. In comparison, in TFD and TFD+GD fruit, only 7.4-8.8% of wall Ca were in water soluble form, the rest of which were associated with ionically bound pectins. The higher proportion of both the ionically bound and the ester linkage pectins may be the cause of the firm and crisp texture of translucent flesh.

Keywords: *Garcinia mangostana L., translucent flesh disorder, gamboges*



SESSION V: Fruit Nutrition and Bioactive Compounds



Nutritional and Pharmaceutical Applications of Bioactive Compounds in Tropical Fruits

Sumitra Poovarodom¹, Ratiporn Haruenkit¹, Suchada Vearasilp², Pramroj Ruamsuke³, Hanna Leontowicz⁴, Maria Leontowicz⁴, Jacek Namiesnik⁵, Simon Trakhtenberg⁶ and **Shela Gorinstein**⁷

¹King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

²Faculty of Agriculture/Postharvest Technology Research Institute/Postharvest Technology Innovation Center, Chiang Mai University, Chiang Mai 50200, Thailand

³Faculty of Agricultural Technology, Rambhai Barni Rajabhat University, Chanthaburi 22000, Thailand

⁴Department of Physiological Sciences, Faculty of Veterinary Medicine, Warsaw University of Life Sciences (SGGW), Warsaw, Poland

⁵Department of Analytical Chemistry, Chemical Faculty, Gdańsk University of Technology, 80 952 Gdańsk, Poland

⁶Kaplan Medical Center, Rehovot 76100, Israel

⁷The Institute for Drug Research, School of Pharmacy, The Hebrew University, Hadassah Medical School, Jerusalem 91120, Israel; gorin@cc.huji.ac.il

The main objective of this study was to investigate the physicochemical and nutritional characteristics of selected exotic fruits from Chanthaburi and the influence of their physiologically active compounds on human health, through our investigations *in vitro* and *in vivo* and scientifically proven information. Various analytical methods were applied for the detection of biologically active metabolites derived from exotic fruits (polyphenols, flavonoids, flavanols, tannins, ascorbic acid, anthocyanins, minerals, and fibers) and antioxidant radical scavenging assays (DPPH, FRAP, CUPRAC, and ABTS). The correlation between the polyphenols and other bioactive compounds, and their antioxidant activities was reported for studied fruit extracts. Organic matter and mineral composition of the soil, where the investigated fruits grown, was investigated as well. During the last two decades our international scientific group investigated *in vitro* the physicochemical and nutritional characteristics of some cultivars of durian at various stages of ripening, mangosteen and new cultivars of snake fruit in comparison with avocado, kiwifruit and mango, and *in vivo* their influence on laboratory animals and humans (1-3). Diets containing high cholesterol levels led to atherosclerosis damage in the livers and hearts of rats. Supplementation of diets with exotic fruits positively affects plasma lipid profile, antioxidant activity and histological examination of aorta in rats fed cholesterol containing diets. The interaction between drugs and serum albumin plays an important role in the distribution and metabolism of drugs. The properties of polyphenol extracts of exotic fruits showed the ability to quench serum albumin by forming the complexes similar with the ones between proteins and pure flavonoids such as catechin and quercetin, by Fourier transform infrared (FT-IR), ultraviolet spectroscopy, two and three-dimensional fluorimetry (2D-FL) and (3D-FL). In conclusion, it is necessary to promote a consumption of exotic fruits (a rich source of natural antioxidants) as a supplement to everyday human diet.

Keywords: antioxidant, bioactive compound, flavonoid, lipid profile, diet supplementation

References

1. Poovarodom et al., Intern. J. Food Sci. Technol. 45 (2010) 921–929.
2. Leontowicz, et al., Europ. J. Integ. Med., 3 (2011) e169–e181.
3. Gorinstein, et al., Food Res. Intern. 44 (2011) 2222–2232.



Foliar Urea Applications Can Increase Berry Yeast-Assimilable N in Wine (*Vitis Vinifera*) Grapes

Gerry Neilsen¹, Denise Neilsen¹, Kirsten Hannam¹, Peter Millard², and Andy Midwood²

¹Research Scientists, Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, B.C., Canada V0H 1Z0.; Gerry.Neilsen@agr.gc.ca

²The James Hutton Institute, Craigiebuckler, Scotland, AB15 8QH, Scotland

Wine grapes (*V. vinifera*) in western North America commonly have deficient yeast-assimilable N concentrations (YANC) necessitating the addition of diammonium phosphate fertilizer to the must. This situation has stimulated research on strategies associated with late season N fertilization to alleviate this condition. Commencing in 2009, seven different vineyards with historically low YANC at commercial harvest were located in southern, British Columbia. In 2010, five different N treatments were applied around veraison in a randomized, complete block design using six-replicate, five vine plots. Treatments included: (1) a control which was the standard commercial vineyard N regime (approx 40-50 kg N ha⁻¹, applied at late dormancy); three additional (2) 1 %; and (3) 2% (w/v) urea sprays applied around veraison; (4) the same amount of urea-N applied to the soil at the same times directly beneath drip emitters and (5) a combination treatment involving application of half the N as a foliar spray and half as a soil application at the same times. Treatments had minimal effects on fruit yield and berry quality. YANC were however significantly affected by treatments. The most effective treatment was the 3x2% urea spray which had the highest YANC at all sites with values exceeding the 3x 1% spray treatment at five of seven sites. Maximum concentrations were much closer to a desired 140 mg/L optimum value but did not exceed this concentration. Vines receiving only soil N applications had low YANC, exceeding the control treatments in only three of seven vineyards. The combination soil/foliar treatment consistently increased YANC relative to the control but was effective as the high concentration foliar urea in only one vineyard. Results will also be shown from 2011 when N¹⁵ labelled urea was applied to the foliar and soil treatments and 'N-serve', an efficiency enhanced soil N product was applied.

Keywords: fruit quality, N¹⁵ tracer, stuck fermentation, vigour, yield



Effect of Nitrogen, Potassium Fertilizers and Clusters Per Vine on Yield and Anthocyanin Content in Cabernet Sauvignon Grape

Vason Boonterm¹, Anek Silapapun¹ and Nantakorn Boonkerd²

¹Crop Intregation Business C.P. Group, Bangkok, Thailand

²School of Biotechnology, Institute of Agricultural Technology, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand; nantakon@sut.ac.th

The experiment was carried out in a humid subtropical climate located in the south of China, in Xichang, Sichuan province, (27°N, 102 °E, and 1650 m above mean sea level) during the 2005 and 2006 seasons. Eight years old, irrigated Cabernet Sauvignon vine were planted at Xichang Chia Tai Wine & Spirits Co., Ltd. Vine plants were spaced 1.25 m between 2 vines and rows were 2.0 m apart and oriented approximately north/south. Vines were trained to vertical shoot positioned training system (VSP), and were bilaterally cordon-trained, spur-pruned, and shoots were vertically positioned upright. Vines were irrigated by drip irrigation system. The 3 different levels of N-K were 0-0, 100-20, and 200-60 g/plant and the 3 different levels of clusters per vine were 10, 20, and 30 clusters. Treatments were applied to 1 vine plot, each replicated 6 times in a split plot, in which the main plots were clusters per vine. Shoot lengths were maintained at 15 nodes by shoot trimming. It was found that the yield of grapes in year 2005 was higher than 2006. Increasing the rate of N-K in both years did not increase yield, but increased number of clusters enhanced yields in both years. Color and phenolic compounds in the berries were higher in year 2006 than 2005. At the 0-0 and 100-20 levels of N-K, the phenolic compounds in the grape were lower than other treatments. It was also found that the Cabernet Sauvignon berry contained more malvidin than other anthocyanins. Wine quality (color and balance of acidity, tannins, and alcohol) which made from this grape berries was higher with higher grape quality, as indicated by color and phenolic compounds in the berries.

Keywords: *pruning, trimming, irrigation*



Assessing Risks from Climate Change and Variability in Perennial Horticultural Crops

Denise Neilsen¹, Gerry Neilsen¹, Alex Cannon², Bill Taylor³, Ted Van der Gulik⁴, Scott Smith¹ and Istvan Losso¹

¹Pacific Agri-Food Research Centre, Summerland B.C., V0H 1Z0, Canada; Denise.Neilsen@agr.gc.ca

²Pacific Climate Impacts Consortium, University of Victoria, Victoria, B.C., V8W 3A4, Canada

³Environment Canada, Pacific and Yukon Region, Vancouver, B.C., V63 3S5, Canada

⁴BC Ministry of Agriculture, Abbotsford, B.C., V3G 2E, Canada

Potential effects of climate change on agriculture have been better documented for agronomic than for horticultural crops (IPCC, 2007). Yet, perennial horticultural crops must withstand year-round climate related biotic and abiotic stresses and often require high economic outlay for establishment rendering producers vulnerable to failure. Previously, research focused on assessing the effects of changing temperatures and precipitation on a large scale – continental or even global, more recently the emphasis has changed to examining effects at the regional scale, which is more appropriate for both producers and regional planning.

Gradual climate change is expected to affect the geographic range of crops, pests and diseases. However, the suitability of specific location for crops will be determined by the frequency of extreme events (e.g. droughts, low and high temperatures) and variability in growing conditions, both of which are expected to increase in response to global warming. Assessing the risks associated with climate change, variability and extreme events requires both the development of models for horticultural production systems that are responsive to climate variables at an appropriate temporal and spatial scale and also knowledge of the threshold conditions which limit crop success. Examples of approaches to assessing the effects of climate change on crop suitability, pests and diseases and water resources and to the development of tools to assist adaptation will be discussed. Building resilience may lie in careful assessment of crop suitability or designing new crops and management practices to withstand climate extremes. Equally important is communicating this knowledge to producers, planners and policy makers. This is particularly the case with respect to the preservation of land and water resources which will be required in the future to meet global food requirements.



Poster Presentation



Black Hailnet Effect on Vegetative Growth and Reproductive Potential of Apple Trees

Gitta M. Kocsisne¹, Laszlo Kocsis¹, Dick van Maurik², Zoltan Szabo³, Jozsef Nyeki³ and Miklos Soltesz⁴

¹University of Pannonia, Georgikon Faculty, Deak F. u. 16., 8360, Keszthely, Zala, Hungary; kmgitta@hotmail.com

²Almakuti Bt., Zalaszanto, 103.

³University of Debrecen, Institute For Extension and Development, 4032 Debrecen, Böszörményi u. 138., Hungary

⁴College of Kecskemét, Faculty of Horticulture, 6000 Kecskemét, Erdei F. u. 1/3., Hungary

Frequency of the hailstorms increased in the vegetation period in the last ten years in Hungary. These condition are forcing producers to protect their orchards. Nowadays they start to use hailnet above the trees against the hail in our country.

In this study the effect of the hailnet on the apple tree vegetative growth (the size of the canopy, circumferences of the trunk) and the reproductive potential (reproductive bud development) were investigated to determine the potential of apple production under hailnet in the western part of Hungary.

Six apple cultivars – Fuji, Gala Galaxy, Golden Reinders, Idared, Braeburn, Jonagored- were compared under netted and non- netted conditions over a three-year period.

Every year the hailnet was fixed above the apple trees after the blooming period when the bees finished their work. So the fertility did not depend on the hailnet effect.

The size, the weight, the firmness, the total soluble solids were measured. Fruit colouration was determined during harvest time. Significant differences were obtained in the total soluble solids and the colouration of the fruits between the different conditions.

Keywords: *extreme climatic conditions, fruit quality, plant growth*



Transfer and Accumulation of Nitrogen (¹⁵N) and Boron (¹⁰B) among 'Prata-Anã' Botanical Family

Maria G.V. Rodrigues¹, Antônio E. Boaretto², **William Natale**³, Rodrigo M. Boaretto⁴ and Dilermando D. Pacheco⁵

¹Empresa de Pesquisa Agropecuária de Minas Gerais, scholarship of FAPEMIG, Nova Porteirinha, MG, Brazil; magevr@epamig.br

²Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Piracicaba, SP, Brazil; a.e.boaretto@cena.usp.br

³Universidade Estadual de São Paulo, Campus de Jaboticabal, Departamento de Solos e Adubos, Jaboticabal, SP, Brazil; natale@fcav.unesp.br

⁴Instituto Agronômico, Cordeirópolis, SP, Brasil; boaretto@iac.sp.gov.br

⁵Instituto Federal Norte de Minas Gerais, Januária, MG, Brazil; ddpacheco.agro@gmail.com

In theory, the nutrients can be provided for banana plants by the desuckering process, through drilling made by a 'lurdinha' cut off, due to the fact that nutrients may be absorbed and distributed to the linked plants. In order to evaluate this hypothesis, it was applied 10 g of urea and 3 g of boric acid individually per each botanical family, enriched with ¹⁵N e ¹⁰B, respectively, applied in the desuckering drill to the unwanted shoot. The experiment was performed in two banana crop fields of 'Prata-anã' variety, well-irrigated (A1), and less-irrigated (A2). One month after the enriched fertilizer application isotopically, the families were collected and split into parts. Soil samples under the mother plant and shoot (treatment) rhizome were also collected. In the laboratory, the samples were prepared and analyzed by a mass spectrophotometer to determine the ¹⁵N e ¹⁰B percentage and total N and B percentage. The amount of N and B percentage was determined for all plant parts (%N_{ppf}, %B_{ppf}) and soil sample (%N_{spf}, %B_{spf}). It was observed that more than 60% of N and more than 50% of B was recovered in the fertilized banana plants. The N_{ppf} and B_{ppf} were detected, which indicates that both nutrients were absorbed and distributed through the botanical family. As ¹⁵N and ¹⁰B were recovered for all the family plants and also in the soil, below the mother plant rhizome, it was concluded that N and B, applied directly to rhizome, via desuckering drilling, had translocated through xylem, following transpiratory flow, and partly lost to soil.

Keywords: isotopic technique, nutrient distribution, mineral nutrition, *Musa sp.*



Transfer and Accumulation of Boron (¹⁰B) among 'Prata-Anã' Botanical Family

Antônio E. Boaretto¹, Maria G.V. Rodrigues², William Natale³, Rodrigo M. Boaretto⁴, Dilermando D. Pacheco⁵

¹Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Piracicaba, SP, Brazil; a.e.boaretto@cena.usp.br

²Empresa de Pesquisa Agropecuária de Minas Gerais, scholarship of FAPEMIG, Nova Porteirinha, MG, Brazil; magevr@epamig.br

³Universidade Estadual de São Paulo, Campus de Jaboticabal, Departamento de Solos e Adubos, Jaboticabal, SP, Brazil; natale@fcav.unesp.br

⁴Instituto Agrônomo, Cordeirópolis, SP, Brasil; boaretto@iac.sp.gov.br

⁵Instituto Federal Norte de Minas Gerais, Januária, MG, Brazil; ddpacheco.agro@gmail.com

As the banana plant pseudostem is a compacted leaf sheaths, the nutrients can be provided through them and whenever provided, theoretically, will be provided into all the linked plants. In order to evaluate this case, the isotopic methodology was used in an irrigated 'Prata-anã' variety experiment, northern State of Minas Gerais, Brazil. Three treatments were evaluated resulting from the injection of 10 mL of boric acid solution enriched with ¹⁰B (30%) isotope, in the pseudostem of three development stages: T1) seedlings at first true leaf emission (leaf with length: width ratio typical of the cultivar); T2) seedlings at eighth true leaf emission; T3) shoots at preflowering. One month after fertilizer application, the plants were removed and split into various parts. Soil samples under rhizome of the mother plants and fertilized ones were also collected. In the laboratory, the samples were prepared and analyzed by a mass spectrophotometer to determine the total ¹⁰B and B percentages. The boron percentages were determined for all plant parts (%B_{ppf.}) and soil sample (%B_{spf.}). The result of ¹⁰B recovered from all botanical family of the three treatments and in the two soil samples, concluding that B injected in the seedlings pseudostem with one or eight true leaves and also the plant during bunch emission, translocate via xylem, following the transpiratory flow, and partly lost to soil.

Keywords: isotopes, micronutrient, nutrients distribution, *Musa sp.*



Leaf Gas Exchange of Oil Palm (*Elaeis guineensis* Jacq.) Grown in Ditch and Raised Beds

Pornchai Paiboon^{1,2}, Pannee Chuennakorn^{1,2} and Suntaree Yingjajaval^{1,2,3}

¹Center for Agricultural Biotechnology, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand; ecopsyio@yahoo.com

²Center of Excellence on Agricultural Biotechnology (AG-BIO/PERDO-CHE), Bangkok 10900, Thailand

³Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen, Nakhon Pathom 73140, Thailand

Thailand Central Plain is river flood plain. Farmers constructed surrounded earth dike and ditches with raised-beds in their plots. Oil palm is being grown in such reshaped land in the Rangsit area (N14° 16.77', E100° 52.73') which is located farther north from the recommended latitude ($\pm 10^\circ$) for commercial oil palm plantation. This study examines the limiting factors on the leaf gas exchange rates of oil palm. The soil matric potential showed that the root activity was limited to 30 cm with the deeper soil saturated with water penetrated from the ditch. Oil palm experienced high air vapor pressure deficit (vpd_{air}) during the dry season and low vpd_{air} coupling with saturated condition of entire root zone for up to 4 months during the raining season. The leaf net photosynthesis (A) and transpiration (E) started when there was sunlight (8 am) and rose quickly (10 am) to the highest levels of $A = 21.3 \mu\text{molCO}_2 \text{ m}^{-2} \text{ s}^{-1}$, $E = 11.7 \text{ mmolH}_2\text{O m}^{-2} \text{ s}^{-1}$ and the stomatal conductance (g_s) = $535 \text{ mmolH}_2\text{O m}^{-2} \text{ s}^{-1}$. The total water potential dropped to a minimum of -1500 kPa and the turgor potential decreased from 1700 kPa to almost zero. Evidently the rate of root water uptake did not match the transpiration demand. Around noon, stronger radiation increased leaf to air vpd (vpd_{leaf}). The threshold vpd_{leaf} at 2.5 kPa signified the closure induction of the stomates which caused drastic decreases in A, E and g_s and leaf water potentials recovered. Substantial rates of leaf gas exchange lasted for a period of only 3 hours in the morning.

We conclude that vpd is the controlling parameter on the gas exchange through the opening mechanism of stomates. Nevertheless, as the oil palm biomass was still small, the leaf assimilation rate was sufficient to produce high yield of up to 35 ton ha^{-1} .

Keywords: leaf gas exchange, stomatal conductance, vapor pressure deficit, water potential



Effects of Boron Applications on Some Almond Pollen Features and Fruit Set

Ibrahim Bolat, Mehmet Kizildemir, and **Bekir E. Ak**

University of Harran, Faculty of Agriculture, Department of Horticulture, 63000 Sanliurfa-Turkey; beak@harran.edu.tr

This study was carried out to determine the effects of boron application on leaf boron contents, some pollen features, at Nonpareil and Drake cultivars and open - self - artificial pollinated fruit set was determined at Nonpareil almond cultivar in Sanliurfa ecological and in low boron content soil conditions. The applied doses were at 0 (control), 250 ppm, 500 ppm and 750 ppm during 2004-2006 years. Spraying of boron were applied end of Autumn and bud swelling time in Spring. Applications were made significantly higher leaf boron content than control. Pollen viability and germination rates were increased with related to boron dose in generally. Boron applications more effective in Drake cultivar than Nonpareil for pollen viability. Different boron levels increased the rate of fruit set in cross-pollinated combination, although, boron application was found less effective for fruit set rate in open pollinated almond trees. Boron application does not effective for self pollinated trees. Boron applications in self-pollinated almond trees delayed early fruit drop for one week.

Keywords: *almond, boron, foliar fertilization, fruit set*



Cell Wall Structure of Translucent Cells of Mangosteen Fruit

Yupadee Paopun^{1,2,3}, Patcharee Umrung^{1,2,3}, Piyanan Thanomchat^{1,2,3} and Sumitra Poovarodom^{1,2,4}

¹Center for Agricultural Biotechnology, Kasetsart University, KamphaengSaen Campus, NakhonPathom 73140, Thailand; rdiydp@ku.ac.th

²Center of Excellence on Agricultural Biotechnology (AG-BIO/PERDO-CHE), Bangkok 10900, Thailand

³Scientific Equipment and Research Division, Kasetsart University Research and Development Institute, Bangkok, 10900, Thailand

⁴Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand

Mangosteen fruit (*Garcinia mangostana*, family Clusiaceae (Guttiferae)) is parthenocarpic and its flesh is aril type with mostly only one large seed. It is common incidence that the flesh enveloped the seed will appear translucent having firm and crisp texture. The cause of the translucent flesh disorder is speculated to be related to Ca/B deficiency as supply does not match the demand for a short period of time during fruit development. The nature of the cell structure is still not understood.

This study investigates the abnormality of the cell wall of the translucent cells using the optical and the transmission electron microscopes. The aril flesh composes of parenchyma cells. There are four distinct differences between the normal and the translucent parenchyma cells. In translucent flesh, cells are swollen and the middle lamella and cell wall are thicker. In some cells, there appears separating space between cell wall matrix and the middle lamella and in others, the middle lamella showed disintegration. The cell wall matrix is also less dense compared to normal parenchyma cell. In summary, the cell walls of the translucent flesh have lost their integrity.

Keywords: mangosteen, cell wall, middle lamella, translucent flesh

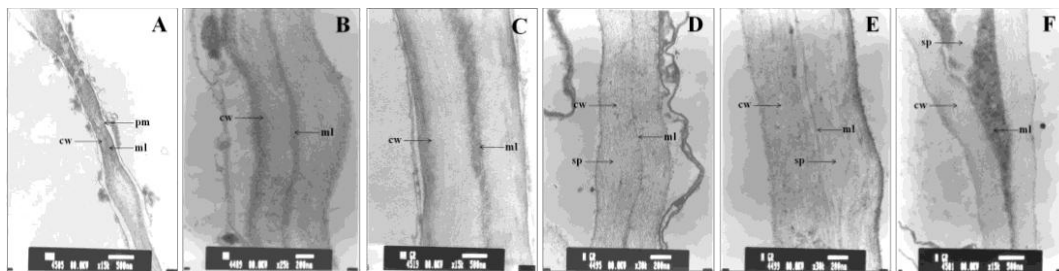


Fig1. Transmission electron microscopy images of aril parenchyma cell of mangosteen fruit. (A and B) cell walls and middle lamella of normal parenchyma cell, (C) translucent cells were swollen, the middle lamella and the cell wall were thicker than normal cell, (D and E) space separating cell wall and middle lamella in translucent cell, (F) disintegration of the middle lamella of translucent cell [cw=cell wall, ml=middle lamella, pm=plasmodesma, sp=space].



Response of Red Roomy Grapevines to Foliage Spraying with Molybdenum

Gamal EL-Dawwy

Soil Sci. Dept., Fac. of Agric., Minia Univ., EL-Minia, Egypt; eldawwy2000@yahoo.com

The effect of six concentrations of molybdenum 0.0, 10, 20, 40, 80, and 160 ppm on growth, leaf chemical composition and productivity of Red Roomy grapevines was studied.

The results showed that raising molybdenum concentrations increased leaf area and its content of N and P, yield, weights of cluster and berries, berry dimensions, total soluble solids and total sugars, while reduced shot and cracked berries and total acidity. Molybdenum had no effect on the leaf content of K, total chlorophyll and the number of cluster.

The best results were obtained by foliage spraying of Red Roomy grapevines with molybdenum at 40 ppm twice at the beginning of vegetative growth (2nd week of April) and again at one month after fruit set (1st week of July).



Improvement of Grapevine Iron Nutrition by A Bovine-Blood-Derived Compound

Paola Tessarin¹, Emanuele Ingrosso¹, Aparecida C. Boliani², **Adamo D. Rombolà**¹

¹Department of Fruit Tree and Woody Plant Science, University of Bologna, Viale G. Fanin 46, 40127 Bologna, Italy; adamo.rombola@unibo.it

²Departamento de Fitotecnia, Tecnologia de Alimentos e Sócio-economia, Faculdade de Engenharia, Universidade Estadual Paulista, 15385-000 Ilha Solteira, Brazil

Iron (Fe) is essential for chlorophyll formation and plant growth. Iron deficiency chlorosis is a major nutritional disorder in several fruit trees cultivated in calcareous and alkaline soils, reducing fruit yield and quality and causing heavy economic losses to growers. Since Fe chelates, the most widespread fertilizers used for preventing or curing Fe deficiency, pose risks of environmental pollutions, the development of sustainable agronomic alternatives represents a priority for the fruit industry. In this work, we investigated the effectiveness of a fluid bovine blood-derived product (BB; 0,125% Fe) for preventing Fe deficiency in grapevine plants. During the vegetative season 2011 potted plants of the following graft combinations: Sangiovese/SO4, Cabernet Sauvignon/SO4 and 140 R, 140 R/Cabernet Sauvignon, Vitis riparia/Cabernet Sauvignon were grown on calcareous soil. Plants were submitted to the succeeding soil treatments: 1) Control; 2) Fe-EDDHA (Fe 6%); 3) Bovine-Blood (5 g/l); 4) Bovine-Blood (20 g/l). During the experiment leaf chlorophyll content was recorded. With the exception of Cabernet Sauvignon/SO4 plants, Fe-EDDHA increased leaf chlorophyll content. Bovine-blood at low concentration displayed similar or higher effectiveness than Fe-EDDHA. Enhancing BB concentration resulted in higher leaf chlorophyll content only in some graft combinations. Data highlight the efficiency of the Fe blood-compound in the sustainable prevention of grapevine Fe deficiency.

Keywords: *Fe-deficiency, Fe chlorosis, sustainability, viticulture, graft combinations*



Effects of Fertigation Timing on Growth and Development in Strawberry cv. Korona

Nina Opstad, Anita Sønsteby, Hans G. Espelien and Unni M. Roos

Arable Crops Division, Norwegian Institute for Agricultural and Environmental Research, NO-2849 Kapp, Norway; nina.opstad@bioforsk.no

Increased focus on targeted fertilization to specific processes in the plant has questioned the purpose of the common practice with spring fertilization. The following pot trials were designed to increase the knowledge on effects of fertilizer timing in small overwintered plants (Trial 1) and runner plants (Trial 2) potted in 2 L pots in June and fertigated with a complete nutrient solution until late September or early October. At defined developmental stages, the electric conductivity (EC) of the nutrient solution was increased with extra calcium nitrate for a period of three weeks, in addition to two treatments with continuously high or low EC. Vegetative and generative traits were recorded during the trial and after a destructive harvest, and demonstrated clear effects of fertilizer timing. In trial 1, a high EC early in the season resulted in the highest leaf area and DW of petioles, while the continuous high fertigation rate induced the highest number of runners and leaves. When the increase in EC was delayed until July, vegetative growth was less stimulated by the same fertilizer rate. High EC during plant establishment or flower differentiation tended to give the highest yield and quantity of berries >30 mm the subsequent season, but the variation between plants was considerable. In trial two, the most apparent effects were found in runner plants propagated in compost, which were phenotypically very different from the other treatments.

Also in the second trial, the early of applications and the high fertilizer rate stimulated vegetative growth. Leaf area was high in all treatments except when applied very late (September) and with a continuous low rate. Increasing fertigation during crown development, which is prior to the flower differentiation period (beginning late August in 'Korona' at the site of the trial), resulted in the same number of crowns as fertigation during flower differentiation. By the time of the destructive harvest of the plants in mid-October, both treatments had 3.0 crowns per plant. An extra treatment with composted cow dung, combined with a low EC of the nutrient solution gave the highest number of runners, the fewest crowns and the biggest leaves. The results and suggestions for further research are discussed.

Keywords: *compost, fertigation, Fragaria x ananassa, precision fertilization*



Nutrition and Irrigation Interactions for a Practical Solution

Penelope Measham¹, Alistair Gracie¹, Sally Bound² and Stephen Wilson¹

¹Tasmanian Institute of Agricultural Research, School of Agricultural Science, University of Tasmania, Private Bag 54, Hobart, Tasmania, 7001, Australia; penelope.measham@utas.edu.au

²Tasmanian Institute of Agricultural Research, 13 St Johns Avenue, New Town, Tasmania, 7008, Australia

Fruit cracking in sweet cherries is an economically significant problem for growers world-wide, and is associated with late season rainfall. Building resilience into fruit from an early stage in order to withstand rapid excess water entry without cracking is important.

Recent findings from a Tasmanian Institute of Agricultural Research project have broadened the understanding of the fruit cracking phenomenon. It was discovered during the 2010/2011 growing season that higher volumes of irrigation resulted in increased resilience to rain-induced cracking in the sweet cherry variety 'Sylvia'. Reduced volumes (deficit) of irrigation increased susceptibility to cracking. The assumption that cuticular integrity was maintained under higher irrigation due to lower diurnal variations in fruit size (therefore increasing resilience) was supported by monitoring fruit growth with sensors during the rapid expansion phase of growth. Fruit from trees under reduced irrigation showed high fluctuations.

However, given the structural role of calcium in plant cells, and that calcium is xylem mobile, the higher volumes of irrigation may have favoured the uptake and incorporation of calcium into fruit cells, and thus enabled fruit to better withstand rapid uptake of water through the vascular system. The trial is being repeated in the 2011/12 growing season, with calcium levels in fruit monitored at each fruit growth stage and at harvest. In addition, fruit mechanical properties will be assessed at harvest (January 2012). This should provide information about building resilience to cracking in sweet cherry fruit and highlight the importance of both nutrition and irrigation in managing risk, and the application of that knowledge to provide solutions to a very real dilemma.

The findings will be important for the development of future cherry fruit cracking management strategies, which may need to be considered early in fruit growth, rather than later in the season when cracking occurs.

Keywords : *cherry, cracking, irrigation, calcium*



Influence of 6-Benzyladenine Tank-Mixed with Boron, Followed by Mid-Summer Calcium Plus Copper Sprays, on ‘Gala’ Apple Splitting and Firmness

Frank J. Peryea¹ and Gerry H. Neilsen²

¹Tree Fruit Research and Extension Center, Washington State University, Wenatchee, Washington, USA; fjperyea@wsu.edu

²Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, Summerland, British Columbia, Canada

Fruits of ‘Gala’ apple (*Malus ×domestica* Borkh.) are prone to splitting and softening, which may be exacerbated by practices used to enhance fruit size. In 2007, we evaluated two practices believed by some growers to be effective – tank-mixing boron (B) with the plant bioregulator 6-benzyladenine (6-BA) to further promote the beneficial effect of the 6-BA on fruit size, and applying mid-summer calcium (Ca) plus copper (Cu) sprays to reduce splitting and enhance firmness of the presumably larger fruit. The experimental trees were hand-thinned to commercial standard to reduce the effect of crop load on fruiting responses. The 6-BA, with or without added B, failed to influence fruit mass, red color, starch index, firmness, or splitting incidence. Following up the 6-BA + B treatments with six mid-summer Ca plus Cu sprays produced no beneficial effects on the fruit but did substantially increase fruit Cu concentration and unwashed leaf tissue concentrations of component elements (Ca, Cu, P, S, Zn, Mn) of the Ca plus Cu spray. With one exception, detergent- plus acid-washing of the leaves lowered the concentrations of these elements to background levels, suggesting that they were present as non-phytoactive spray residues on the leaf surfaces. Only Cu remained elevated in the washed leaves. The Ca in the applied Ca product (an organically complexed CaO) did not appear to be phytoavailable. The results of the current study indicate that tank-mixing B with 6-BA applied for fruit sizing and applying mid-summer Ca plus Cu sprays do not improve ‘Gala’ fruit quality.

Keywords: *Malus ×domestica*, mineral nutrition, fruit quality, cracking, bioregulator



Tank-Mixing Boron with 6-Benzyladenine to Enhance ‘Gala’ Apple Fruit Size may Promote Stem-End Splitting

Frank J. Peryea and Gerry H. Neilsen

¹Tree Fruit Research and Extension Center, Washington State University, Wenatchee, Washington, USA; fperyea@wsu.edu

²Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, Summerland, British Columbia, Canada

Because ‘Gala’ apple fruit (*Malus ×domestica* Borkh.) are naturally small, there is considerable commercial effort made to increase their size. The plant bioregulator 6-benzyladenine (6-BA) often is applied for the express purpose of enhancing ‘Gala’ apple fruit size. ‘Gala’ apples also are prone to a physiological disorder known as stem-end splitting (SES), manifest as longitudinal and radical cracking of the fruit originating at the stem end. Although the 6-BA label recommends against tank-mixing other substances with the product, many growers believe that adding boron (B) enhances the activity of 6-BA. This practice simultaneously provides B for nutritional purposes, which is recommended to be applied annually under Washington State (USA) conditions. In 2004 and 2005, we conducted field research examining the effect of adding various formulations of B to 6-BA sprays made to increase fruit size. The 6-BA sprays had little effect on average fruit mass but tended change the distribution of fruit size within the total fruit population. Rather than shifting the fruit size population curve to larger fruit, it reduced kurtosis, with the increase in the proportion of large fruits being offset by a complementary increase in the proportion of small fruits. Adding B did not appreciably alter fruit size grouping frequencies compared to 6-BA alone. The B-containing sprays had no effect on mid-summer leaf B but did increase at-harvest fruit B. There was a tendency for the B-containing spray treatments to increase the incidence of SES in both years. There was a significant linear relationship between SES and fruit B, suggesting that SES may be exacerbated by small increases in fruit B within the concentration range normally considered optimal for preventing B deficiency symptoms and avoiding B toxicity problems. It is possible that SES in ‘Gala’ apple is particularly sensitive to B excess, suggesting that B fertilization recommendations should be cultivar-specific.

Keywords: *Malus ×domestica*, mineral nutrition, fruit quality, cracking, bioregulator



Effects of Different Organic Fertilizations on Sugar Metabolism in Pear Fruit and Leaves During Fruit Development

Xiao-hui Song, Kai-Xie, **Caixia-Dong** and Yangchun-Xu

College of Resources and Environmental Sciences, Nanjing Agricultural University, Nanjing 210095, China; cxdong@njau.edu.cn

The influence of different organic fertilizations on the sugar metabolism in pear fruit and leaves was studied on “*Huangguan*” pear during fruit development. The different organic fertilizations were as follows: (1) Unfertilized, as control (CK); (2) Conventional fertilization, applied as local custom, only using chemical fertilizers (CV); (3) Bio-organic fertilizer inoculated *bacillus polymyxa* (BOF); (4) Chicken manure (CM); (5) Organic-inorganic compound fertilizer (CF). This experiment was conducted in the consecutive year of 2009-2011. The results showed that single weight of fruit was increased in a varying degree by organic fertilizations, especially by BOF. Compared to CK, the levels of total sugar contents in fruit were significantly increased by organic fertilizations during fruit development. To the sugar components, fructose, sorbitol and sucrose were enhanced by organic fertilizations by 7-9%, 12-20% and 30-40% in the mature fruit, respectively. During the fruit development, fructose, sorbitol and glucose concentrations first showed an increasing trend and then declined until maturation, except sucrose, which was in a consistent increase throughout the development. On the whole, these sugars in leaves all decreased from the early stage, coming to the minimum level at maturation. The activity of NAD⁺-dependent sorbitol dehydrogenase (NAD-SDH) in leaves was significantly increased while that of sorbitol-6-phosphate dehydrogenase (S6PDH) was significantly decreased in a contrary way with the growth of fruit, yet fruit NAD-SDH activity first showed a rapid increase and then declined until maturation, peaking at 70DAB. BOF treatment led to the higher activities of leaf S6PDH and NAD-SDH than that of CK throughout the fruit development, except NAD-SDH at the mature stage. In addition, it resulted in the corresponding higher contents of fructose, sucrose and sorbitol in BOF. Therefore, it could be concluded that the application of bio-organic fertilizer in pear orchard might be beneficial for the improvement of fruit quality.

Keywords: *pyrus*, bio-organic fertilizer, sucrose, fructose



Effects of Different Organic Fertilizers on Tree Growth, Yield, Fruit Quality and Soil Microorganism in a Pear Orchard

Xiao-hui Song, Kai Xie, **Caixia Dong** and Yangchun Xu

College of Resources and Environmental Sciences, Nanjing Agricultural University, Nanjing 210095, China; cxdong@njau.edu.cn

The aim of this work was to investigate the response of tree growth, fruit yield, quality and soil microorganism to different organic fertilizers applied in a pear orchard with 5 fertilizer managements. The treatments of organic fertilizers used were: (1) Unfertilized control (CK); (2) Conventional fertilization including only chemical fertilizers (CV); (3) Bio-organic fertilizer inoculated *bacillus polymyxa* (BOF); (4) Chicken manure (CM); (5) Organic-inorganic compound fertilizer (CF), which were arranged in a complete randomized block design with three replications. The results showed that in general, new shoot length, leaf area, hundred leaves weight, single fruit weight and photosynthetic activity were increased by the application of BOF in comparison with CK, while leaf chlorophyll content was not significantly influenced. As a result, the fruit yield at mature stage in BOF treatment was significantly higher than other treatments. Significantly higher sugars but lower organic acid contents were obtained by the application of BOF and CF as compared with CK or CV. At the same time, organic fertilization led to higher amounts of soil bacteria, fungi and actinomycetes than CK or CV, especially BOF treatment. Taken together, BOF application played a vital role both in tree growth and in fruit taste and quality improvement.

Keywords: *pyrus, organic fertilization, yield, fruit, soil microbial*



The Effect of Soluble and Foliar Fertilizer to Improve the Fruit Weight of Red Pitaya (*Hylocerus polyrhizus*) by Foliar Spraying

Kek Hoe Then

Felda Agricultural Services Sdn. Bhd., Malaysia; kh.then@felda.net.my

Red pitaya (*Hylocerus polyrhizus*) is a new fruit crop in Malaysia. It has high demand from domestic market due to its high nutrition value and attractive appearance. The market price of red pitaya is based on the bigger fruit size, the fruit weight more than 450 g is categories as Grade A which deserved higher price. A study was conducted to improve the fruit size and quality of red pitaya by foliar spraying. Four types of foliar fertilizers and soluble fertilizers, such as Box-Fruit® (1% v/v), Box-MBF® (1% v/v), potassium nitrate (1% w/w) and mono-potassium phosphate (1% w/w) were used in this study. The fertilizers were sprayed to the branches at weekly interval and the yield performance was recorded after three months of treatment. About fourteen batches of fruits were harvested during this study. The result showed both soluble and foliar fertilizers treated plants was no significant different in yield and total fruits produced as compared to untreated plants, except the Box-MBF® treated plants showed lower yield and fruits numbers as compared to untreated plants. Box-Fruit® treated plants were able to produce bigger fruit at average 342.0 g as compared to untreated plants which only produced average of 279.9 g per fruit. Meanwhile, potassium nitrate treated plants showed slightly increased in average fruit size at 295.3 g but no significant different with untreated plants. Both Box-Fruit® and potassium nitrate fertilizer that contain high level of potassium nutrient were able to improve the fruit quality of red pitaya by produced 22.1% and 16.2% of fruits as Grade A as compared to untreated plants which only 10.4%.

Keywords: *Hylocerus polyrhizus*, potassium fertilizer, foliar spray, fruit weight, grade



Effects of Fertigation, Water Application Frequency and Soil Amendment on Tomato Production

Sumitra Chanthai¹, Nantakorn Boonkerd², Thitiporn Machikowa¹ and **Sodchol Wonprasaid¹**

¹School of Crop Production Technology, Institute of Agricultural Technology, Suranaree University of Technology, NakhonRatchasima 30000, Thailand; sodchol@sut.ac.th

²School of Biotechnology, Institute of Agricultural Technology, Suranaree University of Technology, NakhonRatchasima 30000, Thailand

Hot and dry conditions in the Northeast lead to high plant water requirement. To meet the plant water requirement, high amount of water has to be applied. However, most soils in the Northeast are sandy textures with low water holding capacity (WHC). When the amount of applied water is greater than the soil WHC, there will be water and nutrient loss due to leaching. Under these conditions, low amount of water (less than soil WHC) has to be frequently applied which may lead to higher labor cost and water loss from irrigation system. Soil organic amendments can improve soil structure which directly and indirectly increases the soil WHC and may reduce the frequency of water application. The experiment was conducted at Suranaree University of Technology, NakhonRatchasima, Thailand, in 2011 with the objective of evaluating the effects of fertigation, water application frequency and soil amendment on tomato yield, nutrient and water use efficiency. The treatments included three water application frequencies (1. at cumulative crop evapotranspiration (ET_c) = 15 mm, 2. ET_c=25mm and 3. ET_c = 35 mm); two fertilized methods (fertigation and soil application); and two soil amendments (with and without soil amendment). The results indicated that fertigation produced greater tomato yield and nutrient use efficiency than soil application regardless of water application frequency and soil amendment. Without soil amendment, water application at ET_c 15 mm had significantly greater tomato yield and water use efficiency than those of at ET_c 25 and 35 mm. With soil amendment, the effect of water application frequency on tomato yield was small. All water application frequencies produced similar high tomato yield. It can be concluded that soil amendment could reduce the frequency of water application without any effect on tomato yield.

Keywords: *crop evapotranspiration (ET_c), water holding capacity (WHC), plant water requirement, sandy soil*



Comparative Effects of Controlled Release Fertilizer and Fertigation on Mineral Status of 1/2 Blood Orange Orchard

Farah Rim and **Ben M. Mehdi**

Institut National Agronomique de Tunisie, 43 Av. Charles Nicole, 1082 Tunis Mahrajène, Tunisia; mehdibenmimoun@yahoo.com

This study was conducted to compare a controlled release fertilizer to fertigation for leaf mineral status and soil mineral status of 11 years old bearing “1/2 blood orange” trees (*Citrus sinensis Swingle*). On one plot the trees received an application of controlled release fertilizer in two times: before the start of spring growth in March (17N-12P-18K +2Mg) and in July with another formulation of the controlled release fertilizer (13N-5P-27K +2Mg). On a second plot, the trees were fertigated with the same quantity of nutrients as the first plot with ordinary fertilizers but distributed throughout the growing season.

SPAD units were significantly higher with controlled release fertilizer than fertigation. For leaf mineral content, only leaf K was affected by fertilizer source. At the end of the season, soil mineral content also seems to be not affected by fertilizer source excepted for potassium.

Keywords: *citrus, SPAD, nitrogen, phosphorus, potassium*



Influence of Fruit Load on Water Consumption, Leaf Photosynthesis and Plant Nutrient Contents of Longan Trees Grown in Sand Culture

Chiti Sritontip, Yuttana Khaosumain and Sunti Changjeraja

Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, 52000, Thailand; Chiti@rmutl.ac.th

The effects of fruit load levels on water consumption, photosynthesis characteristics and leaf nutrient concentrations of 3-year-old grafted longan trees cv. “Daw” were investigated during February to September 2008. The longan trees were grown in lysimeter tanks with a capacity 100 liters container filled with sand and irrigated with Hoagland nutrient solution. The CRD experimental design comprised of 4 treatments i.e. 1) high fruit load, 2) medium fruit load, 3) low fruit load and 4) no fruit. The result showed that water consumption of all treatments was similar. However, all fruit load treatments had higher chlorophyll fluorescence, CO₂ exchange rate, transpiration rate and stomata conductance rate than no fruit treatment. The high fruit load treatment had the highest number of fruit per panicle, fruit weight per panicle, total yield and total leaf non structural carbohydrate (TNC). Nevertheless, longan trees with high fruit load had significantly lower fruit weight, fruit size and aril thickness. Leaf K, Ca and Mg contents were lowest in high fruit load treatment but all treatments had no effect on leaf N and P contents.

Keywords: *longan, crop load, lysimeter, CO₂ exchange rate*



Reduced Rates of Speedfol™ B SP as good as Conventional Borax Applications in Satisfying the Boron Requirement of Oil Palm

Steve Oosthuysen and Bert Desmet

Hortresearch SA, P.O. Box 384, Tzaneen 0850, Tzaneen, South Africa; hortres@pixie.co.za
CharleeSQM, 31 Soi Soi 138 (meesak), Lat Phrao Rd, Bang Kapi, Bangkok 10240, Thailand

The results of two randomized experiments (Split Plot Designs) carried out by Makin Group, Indonesia, and P.T. J.A. Wattie, Indonesia, clearly showed that reduced rates of **Speedfol™ B SP** (17% B; 55% B₂O₃) were as effective in increasing leaf boron concentration in oil palm as was conventional Borax (15% B; 48% B₂O₃) rates. In the Makin research, 100 g of Borax applied per plant was compared with 88 or 53 g of **Speedfol™ B SP** applied per palm. This trial was carried out on five-year-old oil palms in a commercial plantation. At 53 g per plant, **Speedfol™ B SP** was either added in dry-powder form, or added in 10 l of water. Dry **Speedfol™ B SP** applied at 88 g or 53 g per palm was as effective in affecting leaf B as was Borax applied at 100 g per palm, treatment differences here being small in relative terms and statistically non-significant (B₀, B₁ and B₂). However, 53 g of **Speedfol™ B SP** applied in water resulted in reduced leaf B concentration. Leaf boron bore no apparent relation to the time delay in taking leaf samples, leaf samples having been taken 2, 6, 10 and 12 weeks after application. In the experiment carried out by P.T. J.A. Wattie, using three-year-old palms growing in peat soils, reduced product rates were applied per palm. 50 g of dry Borax was applied, whereas 40 or 30 g of dry **Speedfol™ B SP** was applied. Furthermore, 30 g per palm was additionally applied in 5 l of water around the main stem. 40 or 30 g of **Speedfol™ B SP** was as effective as 50 g of Borax in influencing leaf boron concentration; differences between the means being relatively small and statistically non-significant. A reduction relating to wet application was not noted in this experiment. The result of these studies clearly indicates that reduced rates of **Speedfol™ B SP**, as opposed to conventionally used Borax, can be applied to meet the boron requirement of commercially grown oil palm plants. Reductions of as much as 47 percent were as effective in influencing frond boron concentration. **Speedfol™ B SP** as a crystalline product has additional benefits over Borax in that it is more soluble in water, contains a directly root-utilizable form of boron, and can be conveniently used as a blending ingredient in the fertilizers generally used in oil palm.



Effect of Potassium Source, either as KNO_3 or K_2SO_4 , on the Vigour of Tissue Cultured Williams Banana Plants Grown in Saline-Alkaline Conditions

Steven A. Oosthuysen

HortResearch SA. P.O. Box 3849 Tzaneen, 0850, South Africa; hortres@pixie.co.za

The aim was to demonstrate the growth benefit, in fertigation, of using KNO_3 as opposed to K_2SO_4 as the potassium source in the situation of banana grown in saline and high pH conditions. Such conditions typically occur in desert environments where the soils have a relatively high content of calcium carbonate, sodium carbonate and sodium chloride, and the water is rich in bicarbonates of calcium and sodium, and contain an appreciable quantity of sodium chloride. A pot trial was carried out. Tissue cultured Williams banana plantlets were used. Fertigation was carried at two nutrient rates. After several weeks of fertigation, the number of leaves on each plant and plant fresh weight were recorded as well as plant fresh weight. Dry weight was also recorded. A benefit in growth in terms of fresh weight to KNO_3 's inclusion was found when fertigation was carried out at the elevated salt rate. The inclusion of K_2SO_4 depressed growth both in terms of fresh weight and dry matter accumulation when fertigating at the elevated rate. Differences were not apparent regarding fertigation ingredients following fertigation at a reduced nutrient rate. The banana plants may have tolerated the saline condition difference and been able to take up nutrients adequately irrespective of the fertigation solution makeup when reduced concentrations were experienced. When the elevated concentrations were experienced, KNO_3 's inclusion clearly gave rise to enhanced growth. Conversely, K_2SO_4 's inclusion gave rise to depressed growth both in terms of fresh weight and dry weight accumulation when elevated nutrient concentrations were experienced. The fertigation solution differences did not affect leaf emergence rate. The use of the elevated nutrient concentration solutions may have given rise to a slight reduction in medium pH with time.



Effect of Spur Type, Foliar Sprays, And Differential Nitrogen Rates on Leaf Nutrient Content and Spur Leaf Area of Almond Trees

Sebastian Saa¹, Saiful Muhammad², Sebastian Castro³, Patrick Brown⁴

¹Department of Plant Sciences, University of California Davis. MS#2, One Shields Avenue, Davis CA, USA; ssaa@ucdavis.edu

²Department of Plant Sciences, University of California Davis, MS#2, One Shields Avenue, Davis CA, USA; smuhammad@ucdavis.edu

³Department of Plant Sciences, University of California Davis, MS#2, One Shields Avenue, Davis CA USA; secastro@gmail.com

⁴Department of Plant Sciences, University of California Davis. MS#2, One Shields Avenue, Davis CA USA; phbrown@ucdavis.edu

Spurs serve as the fundamental bearing units in almond. Mature almond trees bear a high percentage of fruit on these short shoots, with only a small percentage (fewer than 15%) of fruit born laterally on long 1-year-old shoots (Heerema *et al.* 2008). As a result, maintenance of the total number of living spurs per tree and ensuring their productivity is extremely important. This study evaluated the effect of fruit presence in leaf nitrogen content and the effect of foliar sprays and different nitrogen treatments on spur leaf area.

One hundred forty four commercial almond trees receiving differential rates of nitrogen for three prior years (140, 224, 392 kg/ha) were selected. In each tree 33 spurs were selected (a total of 4,752) and divided in three different categories (non-fruiting spurs (NF); one-fruiting spurs (F1); two-fruiting spurs (F2)). Differential soil nitrogen and foliar nutrients were then applied and the effects on leaf nutrient concentrations and spur leaf area were determined. Leaf nitrogen concentrations declined as season progressed and were negatively correlated with whole tree nutrient accumulation in fruit. Leaf nitrogen concentration was significantly decreased by the number of fruits on the spur and there was a marked reduction in spur leaf area. Soil N and multi element foliar applications significantly increased spur leaf area however these effects did not fully compensate for the reduction due to fruit presence. Results suggest that spurs act as semi-autonomous units on the almond tree and that soil N application can reduce fruit induced loss of spur leaf area. Foliar applications only enhanced leaf area when applied to low N trees.

Keywords: spur, leaf area, nitrogen, almonds, foliar sprays



Testing the Effectiveness of Zinc Formulations Using Peach Seedlings

R. Scott Johnson¹ and Patrick H. Brown²

¹Kearney Agricultural Center (KAC) 9240 Riverbend Road Parlier, CA 93648 (559) 646-6547, USA; sjohnson@uckac.edu

²Department of Plant Sciences, UC Davis. MS#2, One Shields Avenue, Davis CA, USA; phbrown@ucdavis.edu

It is difficult to compare the effectiveness of different zinc formulations because of low uptake percentages, high variability of zinc content in the plant before application and generally low mobility. We have developed a method that is consistent and effective, and demonstrates dramatic differences among formulations. It involves Nemaguard peach seedlings grown in washed sand and fertilized with 10% Hoagland solution minus zinc. Once the seedlings are about 30 to 40 cm in height, they begin to show typical zinc deficiency symptoms of narrow, pointed, chlorotic leaves at the shoot tip. Plants are then sprayed with different zinc formulations and fertilizer strength is increased to 40% Hoagland solution to help promote vigorous growth and stimulate lateral shoots. Generally after 20 to 30 days there are distinct differences among treatments. The biggest effect tends to be on lateral shoot growth in both length and especially leaf area. There is also an increase in individual leaf area on the primary shoot and in zinc concentration of the new growth. The degree of increase demonstrates the relative effectiveness of the material. Using this method, we conducted four separate experiments testing a total of 12 different zinc formulations. By completion of the 4th experiment we came to the conclusion that effectiveness of zinc formulations was related to solubility and size of the accompanying anion. Our hypothesis is: the more soluble the material and the smaller the accompanying anion (lower molecular weight), the more effective the formulation.

Keywords: *Zinc, foliar sprays, peach trees, shoot growth, leaf area*



A Comparison of Mineral Nutrients and Photosynthesis in Jujube, Apple and Litchi Leaves

Xinyu Fu, Lingyao Zhou, Huicong Wang and Xuming Huang

College of Horticulture, South China Agricultural University, Guangzhou 510642, China; Leni616@gmail.com

The changes in accumulation of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) and boron (B) were determined in developing leaves of jujube (*Zizyphus mauritiana* Lam.), apple (*Malus domestica* Borkh. Cv. 'Anna') and litchi (*Litchi chinensis* Sonn. cv. 'Baili') over one growing season in the same orchard. Additionally, net photosynthetic rate (Pn) in the developing leaves of the three species was compared in relation to mineral nutrients. Concentration of N and P on dry mass basis generally declined, whereas that of Ca and Fe increased during leaf development in the three species, with no marked changes detected in Mg and Cu. K decreased in jujube and litchi, but increased in apple. For Mn, obvious increase was found in jujube and litchi, and variable changes in apple. Zn tended to accumulate in developing litchi leaves. B was high in young leaves of apple, but subsequently increased as leaves getting matured. Net photosynthetic rate (Pn) increased with leaf development. In jujube, Pn in top expanding leaves increased to mature leaf level within 3 days, and in apple it took about a week, while in litchi, Pn increased slowly. Pn in mature leaves of jujube was the highest ($15.39\mu\text{mol m}^{-2} \text{s}^{-1}$), apple the second ($11.95\mu\text{mol m}^{-2} \text{s}^{-1}$) and litchi the lowest ($7.20\mu\text{mol m}^{-2} \text{s}^{-1}$). Except for B and Ca, the other mineral elements (N, P, K, Mg, Mn, Cu, Zn and Fe) were not low in litchi leaves with the lowest Pn, suggesting the low Pn in litchi was not due to the lack of these elements. It seemed that litchi had a poorer ability in uptake of B and Ca than the other two fruit species.



Magnesium Deficiency is Responsible for Leaf Necrosis and Early Leaf Drop in Apple Trees of cv. *Nicoter*

Damino Zanutelli¹, Walter Guerra², Martin Rechenmacher¹, Anna Cassar², Reinhold Stainer¹ and **Massimo Tagliavini**¹

¹Faculty of Science and Technology, Free University of Bolzano/Bozen, Italy;
Massimo.tagliavini@unibz.it

²Research Center for Agriculture and Forestry, Laimburg, Italy

Apple cultivar “Nicoter” has been recently released as a cross between “BreaburnHillwell” and “Gala Must”. The consumers have shown to appreciate the quality of its fruits, which are commercialized under the brand Kanzi ®, through a so called “Club” system. In Italy, as well as in other Countries, young (less than 5 years) plantings of this cultivar often show leaf necrosis in summer as well as early drop of basal and median leaves, a phenomenon that may depress tree productivity well as fruit quality. We have investigated the role of magnesium (Mg) in this syndrome through two approaches: 1) magnesium (and in one orchard also manganese - Mn) salts have been sprayed in contrasting periods of the season to the tree canopy in two orchards located in South Tyrol (Italy) where trees of cv. Nicoter had previously showed leaf necrosis symptoms; 2) we studied the dynamics of accumulation of major mineral nutrients in the bourse shoots of trees and their partitioning among old leaves, young leaves, stems and fruits. The experiments were carried out in 2008 and 2009. Differently from the Mn sprays, the Mg sprays to the canopy have severely reduced the number of leaves affected by necrosis as well as the degree of severity of the symptoms, also enhancing the Mg concentration of leaves. Unsprayed, control trees often had leaf Mg concentration below 0.15%, while leaves with severe necrosis symptoms had an average Mg concentration of 0.08%. Although with different intensities, Mg, as well as calcium, nitrogen and potassium accumulated in the bourse shoot from fruit set to fruit maturity period. Magnesium content in old leaves, differently from that of other nutrients, significantly decreased in summer, suggesting a net flux of Mg from these leaves to other sinks like fruits and new leaves. We conclude that temporary Mg deficiency of old leaves is responsible for leaf necrosis and early leaf drop in trees of cultivar Nicoter. Leaf spray of Mg salt are effective in reducing the symptom intensity



Effects of Magnesium and Manganese on SPAD Reading and Chlorophyll Contents in Interveinal Chlorotic Leaves of Jackfruit

Kanapol Jutamanee and Supanun Ngennoy

Department of Botany, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand;
kanapol.j@ku.ac.th

The present study aims to evaluate the changing of greenness in interveinal chlorotic jackfruit leaves using SPAD-502 chlorophyll meter after sprayed with magnesium and manganese nutrient solutions. Linear regression models fitted the relationships of SPAD values to leaf chlorophyll contents using the data obtained from all treatments. Foliar application of manganese solution significantly increased the leaf SPAD values only at the age of 3 weeks old. There was no significant difference of leaf SPAD values in all treatments during the age of 5 to 15 weeks old. Strong linear correlations are obtained between SPAD values and chlorophyll contents. For total chlorophyll: $R^2 = 0.8006$, for chlorophyll a: $R^2 = 0.7506$ and for chlorophyll b: $R^2 = 0.6491$. Thus, the SPAD -502 was a good tool to evaluate chlorophyll contents of jackfruit leaf.

Keywords: *Arthocarpus heterophyllua Lam., interveinal chlorosis, chlorophyll contents*



Influence of Intensive Viticulture on Macro-Elements Content in Soils of Sub-Mediterranean Wine Growing Regions

Denis Rusjan¹, Mojca Mavrič-Štrukelj² and Tjaša Jug²

¹University of Ljubljana, Biotechnical Faculty, Agronomy Department, Jamnikarjeva 101, SI-1000 Ljubljana, Slovenia; denis.rusjan@bf.uni-lj.si

²Chamber of Agriculture and Forestry of Slovenia, Nova Gorica Institute for Agriculture and Forestry, Pri hrastu 18, 5000 Nova Gorica, Slovenia

In intensive agriculture the pesticides and fertilizers are the main source of elements and metals pollution. This may be critical, because of the fact that soil purifies slowly and partially, and pollutants tend to accumulate. This study was conducted to inventory the macroelements content (K, P and Mg), content of organic matter and pH in/of the soils of sub-Mediterranean wine growing regions in Slovenia. More than 550 soils sampling and five forests sites were selected to account the differences in elements content. Digested and diluted samples were analyzed with Agilent 4500 series ICP-MS instrument. The soil sites differed in soil type and durance of intensive viticulture production. In general, the pH of soils showed values from neutral (6.8-7.2) to slight acidulous (5.6-6.7) and less than 30% of vineyards have optimal availability of organic matter. The durance of intensive production increases the content of K, P and Mg, especially in vineyards on typed of soil named flysch. The statistically highest contents of K ($60.7 \pm 12.5 \text{ mg } 100\text{g}^{-1}$) and of P ($45.4 \pm 8.8 \text{ mg } 100\text{g}^{-1}$) were determined in vineyards older than 20 years, although some excessive content were also determined in younger vineyards. Mg showed higher variation in contents, especially in vineyards with alluvial soil type. The study confirmed that the main pollutant in the region is the intensive viticulture practice, especially the use of fertilizers.

Keywords: *potassium, phosphorus, magnesium, pH, organic matter, pollution, agriculture, vineyard, metal*



Monitoring the Nutrient Status of Intensive Apple Orchards during the Growing Season

Bruce Scott

E E Muir & Sons, 18 Raymond Road, Laverton North, Victoria, Australia;
bscott@eem.com.au

Intensive apple orchards in Australia are heavily fertilised in the first two years after planting, with the aim of developing a tree size and structure that is capable of producing high yields and quality in the third year and beyond. Orchards have been developed at densities of approximately 3000 trees/ha and yields in the third year have been up to 50-60 t/ha. Plant sap analysis and soil solution analysis are used to monitor the nutrient status of the orchards and the results help orchardists and agronomists to assess their fertiliser strategies. The rapid turnaround times of the sap and solution samples in the laboratory allow for quick responses in adjusting, or adding to, the fertiliser program. Follow-up samples can help to assess the impact of specific inputs. Plant sap analysis and soil solution analysis within the growing season provide significant advantages in comparison to standard dry matter plant samples and soil analysis. The use of plant sap analysis and soil solution analysis is helping apple orchardists and agronomists to develop best management practices in regard to fertiliser use, including the choices of fertiliser materials, the rates of applications, the timings of applications and the methods of applications.

Keywords: *sap, soil, fertiliser*



Application of Fertilizer Based on Soil Analysis Could Improve Yield and Quality of Grape

Prapusuk Srivara¹, Rungrod Ratsamee¹, Patcharporn Sripunya¹, Surachai Tangjaitrong¹, Suratin Jaidee² and **Nantakorn Boonkerd**²

¹ Silverlake Vineyard, Na Jomtien, Pattaya, Chonburi, 20250, Thailand

² Institute of Agricultural Technology, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand; nantakon@sut.ac.th

Fruit crops are considered high value crops. As a result, most farmers apply high rate of fertilizers, resulting in high amount of nutrient accumulation in soil. Grape is one of the high value crops which farmers apply high rate of chemical fertilizers. The most popular fertilizer formulas used are 15-15-15 and 8-24-24 (N-P₂O₅-K₂O) and are repeated annually. Besides chemical fertilizers organic fertilizers (compost and manure) are also applied at high rate resulting in high accumulation of P and K. From our study by collecting and analyzing soil in vineyards which have been cultivated for over 3 years, we found that available P and K varied from 200-800 ppm P and 400-1500 ppm K, respectively. The highest P and K were found in vineyard of table grape. With this practice and in combination with heavy doses of pesticides, most vineyards of table grape do not last for more than 4 years. To solve this problem we used soil analysis as a guide for fertilizer application. Since N element is not accumulated in soil, it could be applied through fertigation according to the requirement by vine. P and K were applied in soil based on soil analysis. If available P in soil was lower than 20 ppm it was applied to keep the estimated amount at 20-50 ppm. For K, it was applied to meet 50-70 ppm in soil when the K concentration is below 50 ppm. Results obtained from this study were very satisfactory. Growth of vine and berry yield was increased while fertilizer cost was greatly reduced.

Keywords: *vineyard, cultivation*



Use of Foliar Fertilization to Offset Effects on Navel Orange Yield of Reduced Water and Fertilizer Applied by Partial Root Zone Drying versus Conventional Irrigation

Ben A. Faber¹ and Carol J. Lovatt²

¹University of California Cooperative Extension, Ventura County, 669 County Square Dr., #100, Ventura, CA 93003-5401, USA; bafaber@ucdavis.edu

²Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124, USA

With increasing costs and reduced availability of quality irrigation water and the possibility that California growers might have to produce citrus with 30% less water, our research goal was to meet the challenge of California's water shortage crisis by demonstrating that yield of commercially valuable large navel orange fruit can be sustained despite irrigating citrus trees with 25% or 50% less water. The efficacy of using partial root zone drying (PRD) to reduce the amount of water and irrigation-applied fertilizer used to produce navel oranges, combined with foliar fertilization to sustain the yield of commercially valuable large-size fruit and, thus, increase grower net income was tested. Specific objectives were: (1) to reduce annual water use in a commercial navel orange orchard by alternately wetting and drying the root zone on two sides of the tree (PRD) at irrigation rates 25% and 50% less than the well-watered control under conventional irrigation (CI); (2) to compare PRD treatments with CI at 25% and 50% less water (CI-RR) than the well-watered control; (3) to determine the effect of supplementing PRD and CI-RR treatments with foliar fertilization (especially N and K to ensure adequate nutrition to sustain yields of large-size fruit) on yield, fruit size and quality compared to well-watered control trees receiving irrigation-applied fertilizer; and (4) to provide a cost:benefit analysis. Even modest reductions of only 20% imposed during the critical period of exponential fruit growth reduced the yield of commercially valuable fruit (packing carton sizes 88, 72, 56 and 48) and grower income. Neither foliar-applied fertilizers, nor irrigation-applied cytokinin (4 g/tree) mitigated the effects of reduced irrigation rates on yield or fruit size. Savings in annual water use at reduced irrigation rates did not offset the revenue losses resulting from lower yields and smaller fruit size caused by reduced irrigation rates.

Keywords: *fruit size, fruit quality, tree nutrient status, cost:benefit analysis*



Comparison of Different Foliar-Fertilization Strategies on Yield, Fruit Size and Quality of ‘Nules’ Clementine Mandarin

Carol J. Lovatt

Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124, USA;
carol.lovatt@ucr.edu

Foliar fertilizers reduce the potential accumulation of nutrients in soil, run-off water, surface water (streams, lakes, ocean), and groundwater (drinking water supply), where they can contribute to salinity, eutrophication and nitrate contamination, which have deleterious effects on the environment and human health. Thus, it is prudent to replace soil-applied fertilizer, at least in part, with foliar-applied fertilizer. Foliar fertilization is a rapid, efficient way to improve crop nutrient status during periods of high demand or when soil conditions (low temperature, salinity, pH) render soil nutrients and soil-applied fertilizers less available to the plant. Foliar fertilization provides the nutrients required for photosynthesis and other important metabolic functions essential to plant growth and productivity. However, not all nutrients move efficiently into leaves or other target organs. A priori knowledge (research) is necessary to develop a foliar fertilization program for a crop. Growers need this information to make cost-effective choices. Yield losses resulted when ‘Nules’ Clementine mandarin trees (*Citrus reticulata*) were sprayed with water containing no fertilizer. Thus, to attain yields equal to or greater than untreated control trees, foliar-fertilization strategies must compensate for the negative effect of application. For citrus, the standard time for applying foliar fertilizers is when leaves are 1/3 to 2/3 expanded (March-April) to take advantage of the thin cuticle, yet large surface area. No increase in total yield or fruit size has been reported for foliar fertilizers applied at this time versus soil-applied fertilizers. In contrast, foliar fertilizer applications made prebloom, at bloom or during fruit set and development have been documented to increase citrus yield, fruit size and quality. For ‘Nules’ Clementine mandarin, applying foliar fertilizers at 2/3-leaf expansion versus other stages of tree phenology had no effect on total yield, but application time and fertilizer formulation significantly affected fruit size and fruit quality.

Keywords: *tree nutrient status, cost:benefit analysis*



Effects of Calcium and Boron Application on Salak Quality and Nutrient Composition

Naree Phanchindawan and Pornthiwa Kanyawongha

Program in Soil Science, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand; kpnaree@kmitl.ac.th

Salak or snake fruit is a species of palm tree in the Areaceae family. It is an economically important fruit and widely consumed in Thailand due to its sweet and acidic taste. The most significant problem in Salak production is localized symptom of flesh necrosis which results in cell collapse and color change from orange to dark brown. The symptom usually occurs when fruits mature and reach harvesting stage during the rainy season. Calcium (Ca) and, in some cases, Boron (B) have been related to many physiological disorder of tropical fruits. The objective of this study is to investigate whether flesh necrosis in Salak is related to Ca and B deficiencies and if flesh necrosis can be reduced by applying Ca and/or B via soil or foliar application. The experiment was carried out at a mature Salak commercial orchard in Chanthaburi, Eastern Thailand. The soil was sandy loam with pH 4.87, Ca content of 702 mg kg⁻¹ and B content of 0.44 mg kg⁻¹. The experiment consisted of four treatments in RCBD, i.e. 1) control, 2) soil Ca application, 3) soil Ca and Ca spray and 4) soil Ca and Ca + B spray. Soil Ca was applied as gypsum in September 2008. The Ca spray was applied six times using 2% CaCl₂.2H₂O while B spray was applied three times using 0.25% of solubor. The fruits were harvested in May and September 2009. They were then opened to determine the number of normal fruits and those with necrosis. Concentrations of K, Ca, Mg and B in the flesh were analyzed. It was found that soil Ca application significantly reduced fruit with necrosis from 59.5% to 27.8%. The addition of Ca spray does not reduce the number of necrosis fruit any further. The application of B spray not only did not help reduce the number of fruit with necrosis, but also resulted in a slightly deformed distal end of the fruits. Surprisingly, it was also found that the Ca, B, and Mg concentrations in necrosis tissues were in fact higher than in normal tissue. Despite this surprisingly result, it can be concluded necrosis in Salak fruit can be reduced by application of soil Ca.

Keywords: *flesh necrosis, potassium, magnesium, physiological disorder*



Better Fruit Quality on Apple Orchard and Sustainability of The Fertilization Through Fertigation with Balanced Nutrition

Duilio Porro, Tommaso Pantezzi, Stefano Pedò, and Daniela Bertoldi

Technological Transfer Center, IASMA – Edmund Mach Foundation, Via Edmund Mach 1, 38010 - S. Michele all'Adige (TN), Italy; duilio.porro@fmach.it or duilio.porro@iasma.it

In the last years in Trentino area (North-East Italy) a gradual conversion of irrigation system on apple orchards occurred, from traditional sprinkler irrigation to drip irrigation. In the same time the traditional fertilization of apple trees was carried out with granular fertilizers distributed under the canopy and concentrated only in one or two times during the season: thanks the sprinkler irrigation the water supply solubilized the fertilizers easily permitting to be readily absorbed by plants; on the other hand with drip irrigation it is not possible to solubilize the prills of the fertilizer placed on the soil, and the solubilization could be possible only by the rain: it means promote a decrease of effectiveness of granular fertilizer.

For the reasons above mentioned we have placed an experimental trial (in cooperation with Haifa Italia - Haifa Chemicals Ltd.) at the end of 2008. The trial was carried at Tres (TN) in a Golden/M9 orchard, planted in 1997, divided into a receiving daily shift, using 20 m³/Ha/gg distributed in an hour, and another receiving a 50% reduction of water, using the drip flow rate of 4 L/hr per each one dripper. Within the orchard were compared two treatments replicate three times, one of granular fertilizers by soil application and other one of fertilizers in fertigation, using volumes of water at full dose or reduced one per each one fertilization treatments.

Yearly quantitative and qualitative data were collected, as well as nutritional and physiological parameters by SPAD and NDVI measurements and by analyzing the content of mineral in both leaves and fruits at different times of the growing season.

Fertigation, compared with granular fertilizer significantly increased leaf greenness (SPAD) and nitrogen and depressed the content of phosphorus in the fruitlets collected both in July and at harvest. The NDVI values significantly were affected by water application dose, whilst none effect for fertilization type was recorded.

The reduction of 50% water, however, significantly changed the content of boron and calcium in leaves and fruits, decreasing the values.

The three-years results of Trentino apple trial suggest a positive effect of the fertigation that increased the effectiveness of fertilization and allowed to obtain balanced plants: slight increments on yield and fruit quality were recorded, even if interaction with water supply needs further investigations in order to investigate the most appropriate interaction between units of fertilizer and irrigation volumes and to identify technical recommendations to growers. A calibration of the two factors becomes a topic in order to satisfying the apple orchard's nutritional requirements at the right time with right quantity, without create negative excess of vigor that should promote negative effect on quantitative and qualitative parameters.

Keywords: granular fertilization, water volume, leaf and fruits analyses



Effects of Soil pH and Aluminum Saturation on Leaf Mineral Nutrition and Incidence of Translucent Fruit Flesh Disorder of Mangosteen in East Thailand

Hirokazu Higuchi¹, Shuntaro Fukumoto¹, Naoko Kozai², Tomohiro Kondo¹, Theerawut Chutinanthakun³ and Sombat Tongtaw³

¹ Trop. Agric., Kyoto Univ., Kyoto 606-8502 Japan; higuchi@kais.kyoto-u.ac.jp

² JIRCAS, Okinawa, 907-0002 Japan

³ CHRC, Chanthaburi, 22110 Thailand

Mangosteen translucent fruit flesh disorder is known to reduce quality and has worried growers. Excess moisture, Ca deficiency, and other factors have been pointed out to be causes of this disorder, although detailed mechanism of the occurrence has not been elucidated. Low pH soil is prevailing over east Thailand, the major production area of mangosteen, where the inhibition of nutrient absorption such as Ca may occur under excess Al. That is often observed in the tropics. The Ca deficiency was reported to cause water-core disorder in apple or Japanese pear and soft-nose disorder of mango. The symptoms of translucent disorder are similar to those of the above disorders. In this study, the concern of Ca deficiency under excess Al was investigated at 23 commercial orchards in Rayong, Chanthaburi, and Trat provinces in east Thailand. The incidence of disorder, soil pH, and CEC (Al, Ca, Mg, K, Na, H) were recorded at each orchard. Al saturation was calculated. Leaf mineral components such as Al, Ca, Mg, K were measured as well as SPAD value. The root length density was also analyzed. Al saturation was commonly high level, which was considered to cause inhibitions of nutrient uptake and root growth. The higher Al saturation soils showed the higher leaf Al content with the lower Ca, suggested excess Al limited Ca absorption. The disorder incidence varied 0-44% among orchards. The orchards with the higher leaf Ca indicated the lower incidence of disorder. Ca might relate to the mechanism of flesh disorder occurrence. Low pH soils decreased root length density and leaf Ca content, but increased leaf Al. However, Al saturation nor pH of soil did not correlate disorder incidence statistically. No direct toxicity of Al excess was observed while low pH inhibited root growth and nutrient absorption.

Keywords: exchangeable cation content, fruit quality, mineral components, soil pH



Effects of Nitrogen on Growth, Leaf Nutrient Concentration, Flowering and Fruit Quality in Off-Season Longan

Yuttana Khaosumain, Chiti Sritontip and Sunti Changjeraja

Agricultural Technology Research Institute, Rajamangala University of Technology Lanna (RMUTL), Muang District, Lamphang, 52000 Thailand; k_yuttana@hotmail.com

The effects of nitrogen concentration on growth, leaf nutrient concentration, flowering and fruit quality in off-season longan were studied. The experiment was carried out on 9-10 years old longan trees cv. Daw with 4 meter canopy width, at Agricultural Technology Research Institute, Rajamangala University of Technology Lanna (RMUTL). The experiment was CRD with 0, 40, 60, 160, 320 and 640 g N/leaf flushing. The result showed that all treatments had no effect on plant height and stem diameter. The no nitrogen treatment decreased canopy width compared to other treatments. Nitrogen application from 160 to 640 g resulted in highest canopy surface area. All treatments were non significant in the percentage of leaf flushing, leaf width and leaf area index (LAI). The 320 g nitrogen treatment gave the highest shoot length, shoot diameter and leaf length. The high nitrogen rate treatments (320 and 640 gN) had less flowering percentage than the low nitrogen rate treatments while all nitrogen rates had no effect on the number of fruit and fruit weight per panicle. In contrast, fruit size and fruit quality were lower with increasing nitrogen rates. Leaf nitrogen concentration increased but leaf P ($p < 0.05$) and Ca ($p < 0.05$) decreased with the rate of nitrogen applied. However, all treatments had no effect on leaf K and Mg concentrations.

Keywords: longan , nitrogen, off-season flowering



Prunus Rootstocks Influence Peach Leaf and Fruit Nutrient Content

Gregory Reighard¹, Newton A. Mayer², and Brad Rauh¹

¹Clemson University, Department of Horticulture, Clemson, SC 29634, USA

²Embrapa Clima Temperado, Pelotas-RS, Brazil; grghrd@clemson.edu

Prunus interspecific hybrids and plum species have replaced *P. persica* as the preferred rootstock for peach in Europe and some regions of North America. However, compatibility and nutrient uptake have not been assessed with many peach cultivars. Redhaven peach was grafted to a total of 24 rootstocks represented in 2 replicated trials near Clemson, South Carolina. These trials were planted in 2006 and 2009 on a Cecil gravelly, sandy loam with a pH of 5.0 (no pre-plant lime) and 6.4 (pre-plant limed), respectively. The rootstock cultivars included 8 interspecific *Prunus* hybrids and 6 non-peach *Prunus* species. Leaf and fruit nutrient analyses were done on mature leaves (> 100/tree) and ripe fruit (4/tree) collected in June 2011. Highly significant differences among rootstocks were found for scion leaf nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), sulfur (S) and sodium (Na). There were no significant differences due to rootstock for leaf copper (Cu) and iron (Fe). Only leaf Zn and Cu concentrations from trees on several rootstocks were below the minimum recommended. Highly significant differences among rootstocks for fruit flesh nutrients were found for P, Mn, and S. Lesser differences occurred for K and Mg. Ca and Cu levels in the fruit of all rootstock combinations were below what has been reported in the literature for Redhaven. Annual soil K and foliar Cu applications may have competed with Ca and reduced Cu root uptake, respectively. Differences in mineral uptake between specific rootstock cultivars and rootstock species were observed in this study and may be indicators of efficiency for absorbing and transporting nutrients to peach scion cultivars. These observations will be discussed.

Keywords: *Prunus persica*, nitrogen, interspecific hybrids



Effect of Plastic Bagging on Growth and Nutrient Content of Mangosteen Fruit

Wannisa Pludbuntong and Sumitra Poovarodom

Program in Soil Science, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkraban, Bangkok 10520, Thailand; s_a_s312@hotmail.com

The physiological disorders of translucent flesh and gamboge in mangosteen are reported to be caused by Calcium (Ca) and Boron (B) deficiencies. The lack of these nutrients in mangosteen can be caused by many reasons. Among them is the inability of the nutrients to be transported into the fruits during critical stage of the fruit development, likely within the first 6-7 weeks after the fruits set. It was also suggested that the transport of phloem-immobile Ca and B can be inhibited during rainy period because of reduced plant transpiration. The objective of this study is to investigate the impact of limited transpiration on fruit growth and nutrient accumulation in mangosteen and to determine if there is a certain period where nutrient accumulation is most impacted by limited transpiration. In this study, limited transpiration was simulated by bagging the mangosteen fruits with polypropylene plastic bags. The experiment was carried out at a commercial orchard in Chanthaburi, Eastern Thailand during 2009/2010 growing season. Eight trees were used in the study. After the fruits set, 15 fruits from each tree were bagged with a polypropylene plastic bag every week for the first four weeks. Two corners of the bags were cut so that no water accumulated inside. The bags remained on the fruits until the fruits were collected at the 7th (rapid fruit growth stage) and 12th (maturing stage) weeks along with the non-bagged control fruits. The whole fruits were cleaned, weighed, their diameter measured. Then, they were separated into three parts: calyx, peduncle and fruit. Nutrient concentrations of each part were determined. First, it was found that bagging during the first two weeks after fruit setting resulted in significantly smaller and lighter fruits. Bagging after the first two weeks had no impact on the size of the fruit. Secondly, bagging, regardless of when it was done, has no effect on fruit K, Ca, Mg and B concentrations at either the 7th or 12th week after fruit set. The total nutrient accumulation in fruits bagged during the first 2 weeks was lower than the control, but only because the fruit size and weight were smaller. Very small change in Ca content in both bagged and non-bagged fruits was detected between the 7 and 12 weeks old fruits, indicating that Ca was not moving into fruits after 7 weeks. By contrast, B was still transported into the fruit during the same period. In conclusion, bagging during the first two weeks after setting resulted in smaller fruits. However, limited transpiration as simulated by bagging did not affect nutrient concentration in mangosteen regardless of when the bagging was done.

Keywords : calcium, boron, *Garcinia mangostana* L., transpiration



Acidity of Passion Fruit as Affected by Potassium Fertilizer

Tomohiro Kondo and **Hirokazu Higuchi**

Graduate School of Agriculture, Kyoto University, Japan; higuchi@kais.kyoto-u.ac.jp

Passion fruit generally has high citric acid content. Less acid passion fruit has been increasingly demanded for fresh consumption. In this study, the effect of K fertilizer on the fruit quality, especially acidity, was examined. Two-year-old passion fruit plants grown in 1/5000a Wagner pots filled with river sand were used for experiment. Nutrient solutions containing 0, 6.3, 12.5, and 25.0 mM K were applied to these plants from June 6 to September 6. Artificial pollination was conducted from June 17 to July 6 and the number of fruits per plant was regulated less than six. After harvest, fruit weight and dimensions, titratable acidity (TA), Brix sugar content, and juice weight were measured, and days after pollination to harvest (DAP) were recorded. Juice K concentration was measured and the relationships with TA or Brix sugar content were examined. Leaf SPAD value was measured and then leaves were sampled monthly to measure leaf K, Ca, Mg, and Fe contents. TA decreased at lower K supply. Low K content juice had low TA. Brix sugar content was low at nil K supply, but no relationship between Brix and juice K was observed. DAP increased at lower K supply. Elongation of DAP may be one of reasons of TA decrease. K nutrient had no effect on juice weight, fruit weight and dimensions. Leaf K content decreased at lower K supply. In nil K treatment, leaf K content was 1.4-2.2 % at harvest. Leaf Ca and Mg content increased at lower K supply. Leaf Fe content and SPAD value were not affected by K supply. Neither deficient nor excess symptoms were observed. These results indicated that keeping leaf K content at 1.4-2.2 % might be effective to produce less-acid passion fruit.

Keywords: *citric acid, fruit quality, juice potassium content, leaf analysis, passiflora*



Influence of Foliar Applied Phosphorus on Color Development and Anthocyanin Content of 'Braeburn' Apples (*Malus domestica* Borkh.)

Jan Bizjak, Franci Stampar and **Robert Veberic**

University of Ljubljana, Biotechnical faculty, Jamnikarjeva 101, 1000 Ljubljana, Slovenia;
robert.veberic@bf.uni-lj.si

Phosphorus is an essential element in many biochemical processes in plants. Beside the primary metabolism of fruit plants it influences also the secondary one. The aim of our study was to investigate if foliar application of phosphorus fertilizer can have a significant influence on apple fruit color. Therefore we have applied foliar phosphorus fertilizer two times in the ripening period of 'Braeburn' apples and monitored the development of red blush as well as primary and secondary fruit metabolites. The trees were grafted on M9 rootstock. They were similar in vegetative potential and each tree was thinned to 80 fruits per tree. Five trees for the phosphorus treatment and five for the control treatment were selected. Five fruits per tree were labeled and color measurements were performed each time on the same fruit. The experiment was started approximately three weeks before the onset of the commercial harvest. At the first measurement prior to spraying there was no difference in red blush between two treatments. The spraying was performed in 10 days interval. Already after first spraying the measured color parameters indicated improved red blush development on fruits of the phosphorus treated trees. This difference remained throughout the experiment till the commercial harvest. The same pattern was noticed also on the anthocyanin content measured by high performance liquid chromatography coupled with mass spectrometer (HPLC-MS). Other primary metabolites and other phenolic groups appeared to be less affected by the foliar treatment. Spraying phosphorus fertilizer in the ripening period of 'Braeburn' apples showed to be an effective tool in improving red blush as an important quality parameter.

Keywords : *anthocyanin, phenolics, sugars, organic acids, fruit quality*



Effect of Humic Acid on Antioxidant Activities and Fruit Quality of Hot Pepper (*Capsicum annuum* L.)

Hossein Arouiee¹, Mohammad H. Aminifard¹, Majid Azizi¹ and Hossein Neamati¹

¹Horticultural Department, College of Agriculture, Ferdowsi University of Mashhad, Iran
arouiee@ferdowsi.um.ac.ir

²Ph. D. Student, ¹Horticultural Department, College of Agriculture, Ferdowsi University of Mashhad, Iran

In order to determine the effect of humic acid (HA) on antioxidant compounds and fruit quality of hot pepper (*Capsicum annuum* L.), an experiment was conducted in open field. Pepper plants were treated with humic acid at various concentrations (0, 25, 100, 175 and 250 mg kg⁻¹). HA treatments positively affected fruit antioxidant compounds (antioxidant activity, total flavonoid, capsaicin, lycopene and β -carotene). But, no significant differences were found in total phenolic and carbohydrate between HA and control treatments. It was observed that humic acid applied to at 100 mg kg⁻¹ resulted to the highest capsaicin and lycopene contents, while the lowest values were recorded in the control. Total soluble solids and titratable acidity significantly increased in response to HA treatments and the highest values were obtained from the most level of humic acid treatment (250 mg kg⁻¹). Moreover, the pH of the fruits was significantly lower when treated in humic acid.

Keywords: pepper, humic acid, antioxidant activities, fruit quality



Effects of Glyphosate on Berry and Wine Quality: Preliminary Results

Adamo D. Rombolà¹, Gilmar A. Marodin², Giuseppina Parpinello³, and Volker Roemheld⁴

¹Department of Fruit Tree and Woody Plant Science, University of Bologna, Viale G. Fanin 46, 40127 Bologna, Italy; adamo.rombola@unibo.it

²Departamento de Horticultura e Silvicultura, Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

³Department of Food Science, University of Bologna, P.zza Goidanich 60, 47023 Cesena (FC), Italy

⁴Institute of Plant Nutrition, University of Hohenheim, 70593 Stuttgart, Germany

Glyphosate is the most widespread herbicide in the world and it is extensively applied in agriculture. The use of glyphosate can cause side-effects on non-target plants such as growth inhibition, lowering nutritional status of plants and higher susceptibility to pathogens. The herbicide inhibits the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPs) enzyme that plays a key role in the shikimic acid pathway and, consequently, also hampers polyphenol biosynthesis. Glyphosate can be translocated from target (weeds) to non-target plants (crops) through root system/rhizosphere interactions. With the aim of assessing the effects of this herbicide on grapevine, a field experiment (Tebano, Ravenna, Italy) has been conducted during 2008 on Ancellotta vines submitted to two different soil management techniques along the vine row: superficial tillage and glyphosate application. Berry maturation has been monitored by analyzing soluble solids, pH and total acidity. At harvest skin anthocyan levels have been determined and cluster samples have been micro-vinificated for measuring anthocyan and phenols concentration in the wine. The concentration of anthocyan was significantly lower (-20%) in the berries collected on glyphosate-treated vines compared with the non-treated controls. Glyphosate did not affect berry growth, soluble solids concentration and total acidity, whereas decreased berry pH at harvest. Data indicate possible adverse effects of glyphosate on berry quality. Analysis of wines did not show differences between treatments.

Keywords: *herbicide, shikimic acid, 5-enolpyruvylshikimate-3-phosphate synthase, soil management, anthocyan*



- A**
Abadía, 10
Ak, 34, 55
Al-Karaki, 9
Aminifard, 88
Arouiee, 88
Awang, 13
Azizi, 88
- B**
Barnett, 30
Bertoldi, 11, 81
Bizjak, 87
Boaretto, 52, 53
Bolat, 55
Boliani, 58
Boonkerd, 45, 66, 77
Boonterm, 45
Bound, 60
Boyd, 30
Brown, 27, 71, 72
- C**
Calatayud, 10
Cannon, 47
Cassar, 73
Castro, 71
Catto, 30
Changjeraja, 68, 83
Chanthai, 66
Chen, 29, 37, 39
Chuennakorn, 54
Chutinantakun, 82
Covarrubias, 33
- D**
Desmet, 69
Dong, 63, 64
- E**
Eichert, 21
Eissenstat, 7
EL-Dawwy, 57
El-Jendoubi, 10
Espelien, 59
- F**
Faber, 78
Failla, 11
Fallahi, 17
Fan, 37
Fidan, 34
Frank, 22
Fukumoto, 82
- G**
Gorinstein, 43
Gracie, 60
Guerra, 73
Gulik, 47
- H**
Hammami, 18
Hannam, 44
Harriman, 20
Haruenkit, 43
Higuchi, 82, 86
Hu, 8, 19
Huang, 8, 19, 37
- I**
Ingrosso, 58
- J**
Jaidee, 77
Jiang, 8
Johnson, 72
Johnstone, 30
Jug, 75
Jutamane, 74



K

Kadir, 13
Kanyawongha, 80
Khaosumain, 68, 83
Kizildemir, 55
Kobayashi, 6
Kocsis, 51
Kocsisn, 51
Kondo, 82, 86
Kozai, 82
Krisornpornsan, 31
Kwast, 20

L

Leontowicz, 43
Li, 29
Lin, 39
Liu, 29
Losso, 47
Lötze, 38
Lovatt, 78, 79

M

Machikowa, 66
Madani, 13
Marodin, 89
Matoh, 6
Maurik, 51
Mavrič-Štrukelj, 75
Mayer, 84
Measham, 60
Mehdi, 14, 67
Mellouli, 18
Mesjasz-Przybylowicz, 38
Michel, 14
Midwood, 44
Millard, 44
Morales, 10
Muhammad, 27, 71

N

Namiesnik, 43
Natale, 52, 53
Neamati, 88
Nielsen, 44, 47, 61, 62
Ngennoy, 74
Nilnond, 31
Nyeki, 51

O

Oosthuyse, 32, 69, 70
Opstad, 59

P

Pacheco, 52, 53
Paiboon, 54
Pantezzi, 81
Paopun, 56
Parpinello, 89
Patil, 28
Pedò, 11, 81
Peryea, 61, 62
Phanchindawan, 80
Pludbuntong, 85
Poovarodom, 43, 56, 85
Porro, 11, 81
Przybylowicz, 38

R

Rim, 67
Rodrigues, 52, 53
Roemheld, 89
Rombolà, 33, 58, 89
Roos, 59
Ruamsuke, 43
Rusjan, 75



- S**
- Saa, 27, 71
Sanaa, 18
Scandellari, 12
Scott, 76
Sdoodee, 31
Shafii, 17
Shiesh, 39
Silapapun, 45
Smith, 47
Soltes, 51
Song, 63, 64
Sønsteby, 59
Sripunya, 77
Sritontip, 68, 83
Srivara, 77
Stainer, 73
Stampar, 87
Sun, 19
Szabo, 51
- T**
- Tagliavini, 12, 73
Tan, 19
Tangjaitrong, 77
Taylor, 47
TengkuMudaMohamed, 13
Tessarini, 58
Thanomchat, 56
Then, 65
Tong, 23
Tongtaw, 82
Trakhtenberg, 43
- U**
- Umrung, 56
- V**
- Vearasilp, 43
Veberic, 87
- W**
- Wang, 8, 23, 29, 37
Wilsdorf, 38
Wilson, 60
Wonprasaid, 66
- X**
- Xie, 63, 64
Xu, 8, 63, 64
- Y**
- Yingjajaval, 5, 54
- Z**
- Zamboni, 11
Zanotelli, 73
Zhang, 2

