

CHRONICA HORTICULTURAE

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Horticultural Highlights

Revisiting the Green Revolution: Seeking Innovations for a Changing World • Closed Greenhouse Systems: Multiphase Recycling of Solid and Liquid Organic Waste • Roses in China: Germplasm, Production, and Cultivation • New World Record for Giant Pumpkin, 2010 • The Marigold: History and Horticulture • Introduction and Migration of Ornamental Trees to India

Symposia and Workshops

Tropical Horticulture • Pear • Tropical Wines • Kiwifruit • Phylloxera • Biological Control of Postharvest Diseases • Soilless Culture • Organic Greenhouse Horticulture

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Cover photograph: 'Durango Yellow' marigold (*Tagetes patula*). See article p. 24.

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The Work Continues

Yves Desjardins, ISHS Board Member Responsible for Publications



Yves Desjardins

This is the first editorial for 2011 and even if we are three months into the year, let me wish you all the best for this new year on my behalf and on that of my colleagues from the Board. I hope 2011 will be as good as 2010 was for ISHS, considering the success of the Lisbon quadrennial meeting. Thanks to the hard work of our Portuguese colleagues, IHC2010 was the best ever. The organizing committee certainly deserves a good rest by the beach of Cascais. Yet, they are far from indulging themselves in "la dolce farniente." In fact, they are still busy coordinating the *Acta* publications of the proceedings of the eight Colloquia and 18 Symposia held during the event. Considering the record attendance of more than 3100 and the large number of abstracts submitted, the IHC organizing committee has undertaken the immense task of publishing the *Acta Horticulturae* volumes of the Congress. This is indeed a huge undertaking that will mobilize symposia conveners, a cadre of 5 to 10 reviewers for each *Acta*, and the whole IHC2010 publication committee. Taking into account the large number of papers presented at the different symposia, colloquia, and seminars (4400+), the organizers are expecting 24 volumes of *Acta Horticulturae* to be published. Thus almost 300 people are at work reviewing the manuscripts with a collective goal of having these volumes published within the next year. This goal is ambitious, considering that it took two years to publish the Seoul *Acta* volumes and as long for the IHC2002 in Toronto.

We are all eager to consult the printed version of the many stimulating talks we heard during the horticulture congress. Being impatient by nature, I have always been anxious to receive my hard copy of *Acta* and I had the feeling that the publishing process was unnecessarily long. The ISHS Secretariat tells me that it takes, on average, about one year to publish an *Acta* between the time a meeting is over and the delivery of a book to attendees or libraries. But this is an average and we have seen *Actas* being published in some cases after a much longer period. Such a delay for publishing symposia proceedings is in my mind too long and certainly defeats the purpose of the series. This raises the question: "Why does it take so long to publish *Acta*?" Asking this question may actually be the first step in understanding the place *Acta Horticulturae* occupies for our Society and in the scientific publication arena.

Thanks to the work and vision of the past Chair, Dr. Jules Janick, and the ISHS publication committee, the quality of *Acta Horticulturae* has increased considerably over the last decade. So much so that *Acta* is increasingly being regarded as a quality reviewed journal and some data bases are including papers from *Actas* in their calculation of impact factors, a trend likely to rise in the future. This increase in quality of scientific content comes with a cost: a longer time required for publication because of the extra reviewing processes being used. The improved quality of the *Actas* also brought some confusion as to the role played by this publication in terms of dissemination of scientific information.

Over the years, we have forgotten the advantages of publishing our symposia proceedings in *Acta Horticulturae*. To paraphrase Lafontaine's fable, we have behaved like the puffed-up frog who wanted to become a cow. We acted as if we were ready to trade the unique niche occupied by *Acta*, which has served ISHS so well, to masochistically submit ourselves to the "tyranny of impact factors." Are we willing to accept high rates of paper rejection and cut ourselves from our roots, the timely publication of essential information to the horticulture sector?

We should not confuse genres. There are many advantages for publishing results of symposia proceedings in *Acta*. First, *Acta Horticulturae* is a focused publication exploring a particular topic in great depth, yet analyzing it from many angles. The contents of *Acta* are very diverse spanning across production trends in different countries all the way through to genetics, biotechnology and fundamental cellular physiology. One can readily obtain a complete overview of a specialized horticulture discipline by such an ISHS symposium or consulting its subsequent proceedings. *Acta* has also become an invaluable tool to become acquainted with what is happening in different parts of the world. This is of huge importance in the context of globalization of commerce and scientific exchanges. The proceedings are fully reviewed for language and scientific value and could easily become fully refereed symposium proceedings with few adjustments. One further advantage of *Acta* that should not be neglected is its large readership. Actually, *Acta Horticulturae* is delivered to most of the large institutional libraries around the world and issues are automatically given

to all full registrants of a meeting. In addition students at universities subscribing to *Acta* can download articles free of charge. The impact of papers is also magnified by their indexing by the scientific web database services like Google Scholar and Scopus and the reality of electronic downloads.

So back to our original question, "Why does it take so long to publish our symposia proceedings?" One simple explanation stems from our "slowness" in submitting manuscripts to the conveners after a symposium. Indeed, even if authors are requested to hand-in their manuscripts before or at the meeting, we know that many wait weeks, even months, before doing so and often conveners have to chase the papers and remind authors repeatedly about deadlines. This obviously delays the publication process. Moreover, the handling of manuscripts by E-mail or physically between the editors, reviewers and authors can also slow the process down. Finally, the inexperience of some conveners in the edition and publication procedures of *Acta* is often responsible to publication impediments. Even if the staff at the ISHS Secretariat closely tracks the outcome of every symposium proceedings, their fate remains, in the end, in the hands of the conveners.

What should we thus do to hasten the publication of *Acta* and preserve its original purpose? First, conveners should systematically adopt the new on-line publishing system made available by the Society. Much work has been put into conceiving and implementing a system to streamline the flow of manuscripts between authors, conveners, and the ISHS Secretariat. This online system is easy to use, is readily accessible and allows for an optimized tracking of manuscripts during the editing process both for symposium editors and for the publisher, ISHS. If the editor or convener understands the system, s/he can prevent bottlenecks and rapidly identify where the revision process is stalling. Even better, this service is provided free by the Society and constitutes a real time and money-saver for the user. Second, we should collectively encourage and accept that manuscripts be provided in advance of a symposium

and that this should become a requirement for registration and presentation of a paper to an ISHS meeting. Implementing such a procedure, on top of accelerating the publication of *Actas*, would remind conveners of the importance of the *Acta* publication process for the success of a symposium and of the importance to allocate human and financial resources to the task. The

adoption of such a process by our Society will require a drastic mind shift from both members and conveners and an important change in the publication guidelines. Yet, if this is organized efficiently, participants to a symposium would receive their final copy of *Acta* on arrival at the venue. Several Commissions and Sections have already used this practice with great success

during the past few years, and it was greatly appreciated by symposium attendees.

On the whole, we must continue to improve the quality of *Acta Horticulturae*, but above all we must make sure that the publication plays the role it was initially intended: to rapidly and efficiently disseminate the information conveyed during our symposia.



Two International Congresses you Must Attend



..... Brisbane: venue for IHC2014.

A major development within the ISHS over the past decade has been the very significant growth in individual, country and institutional memberships from Asian countries. This has been associated with a strong increase in the number of large scientific conferences held in that region over the past decade, most notable of which was the International Horticultural Congress in Seoul in 2006 and the 1st Asian Horticultural Congress held in 2008.

These developments are scheduled to increase over coming years and the relationships between the ISHS and the Asian region are set to strengthen with regard to membership services, scientific meetings and related areas. This is entirely fitting given the pre-eminence of horticultural crops and professional activities to the economies of many Asian nations.

In the spirit of that overall increased collaboration, Professor Kanahama, the President of the Japanese Society for Horticultural Science, and Professor Rod Drew, co-President of IHC2014, would like to invite all ISHS members to attend

the 2nd Asian Horticulture Congress (AHC2012) in Tsukuba from 27-30 March 2012; and, the 29th International Horticulture Congress (IHC2014) in Brisbane from 17-24 August 2014. The organising committees of both congresses are working together to ensure each congress

..... Famous Japanese cherry blossoms which will be in flower during AHC.



is an outstanding event that ISHS members and others will enjoy and remember.

The theme of AHC2012 is "A New Era of Horticultural Research in Asia" and will comprise scientific sessions on Fruit Trees, Vegetables, Ornamental Plants, Protected Horticulture and Environmental Control, Biotechnology and Genetics and Postharvest Physiology and Technology. The aim of this congress is to provide and exchange information about recent progress in Asian horticultural research. The event will provide the opportunity to learn about technological applications to open a new era in horticultural production in Asia. Towards the end of March, the weather is getting milder and the cherry blossom season starts in certain regions. This season is considered the best time to visit Japan.

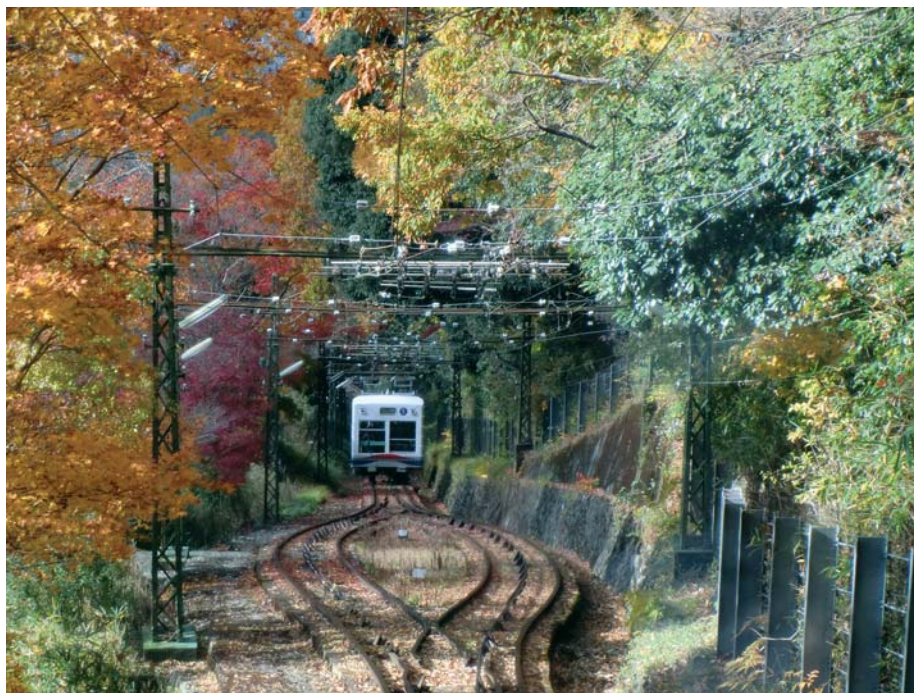
AHC2012 will be held in Tsukuba at the Tsukuba International Congress Centre. Tsukuba is a world-class science city where >18,000 researchers conduct scientific and industrial research at approximately 300 government and private research organisations. The Tsukuba International Congress Centre features state-of-the-art facilities such as a 400-inch high vision projector in the main hall, simultaneous interpretation in up to 6 languages, and a satellite teleconference system. You are assured of a wonderful and stimulating environment to meet, work and relax with your fellow international colleagues.

IHC2014 is being hosted by Australia, New Zealand and the Pacific Islands. This will be a unique opportunity for many horticulturists worldwide to learn from and visit our colleagues



in Pacific Island Countries, in addition to being exposed to the multi-billion dollar horticulture industries in Australia and New Zealand. Pre and post conference tours will feature the Pacific Islands, New Zealand, Tropical Northern Australia and Southern Australia with its famous wine industry. The theme for IHC2014 is "Horticulture – Sustaining Lives, Livelihoods and Landscapes" and will comprise sub-themes on Tropical Horticulture, Horticulture for Human Health and Wellbeing, Sustaining Landscapes, and Quality of Horticultural Products. The scientific committee in collaboration with the ISHS executive committee are developing plenary sessions, symposia and workshops within each sub-theme to explore how innovation in horticultural science can benefit commercial and lifestyle enterprises, which are faced with ever-changing environmental influences; and help sustain life in a world of ever increasing poverty and food crises.

Brisbane is a popular city with a population of two million. Its climate is subtropical so at the



Autumn is an enjoyable time of year in most parts of the world. The heat of summer has passed and is replaced by cooler, more bracing air. The leaves lose their vigour and put on a final performance of colour that rivals any artwork that mankind can produce. Nowhere is this more beautiful than in Kyoto, Japan. The city is nestled into the foothills of mountains, and after a particularly long hot summer this year, the trees throughout the city and over the mountainsides have responded with a grand display of autumn leaves.



end of August, you will experience mild winter weather with day temperatures of 21-25°C. The Brisbane Convention Centre, where the congress will be held, is within walking distance of downtown, hotels, fine restaurants and shops. The Brisbane Convention Centre is an excellent venue and has been officially ranked in the top three centres worldwide. Brisbane is close to major tourist destinations like the Gold and Sunshine Coasts, Fraser Island, Australia Zoo and rainforests of the hinterlands.

The organising committees of AHC2012 and IHC2014 encourage you to mark 27-30 March 2012 and 17-24 August 2014 in your diaries and plan to come to each of these important and significant meetings. You won't get a better chance to experience the fascinating cultures of the Asia/Pacific region with its friendly people and world class horticulture. We look forward to welcoming you at these congresses.

Koki Kanahama and Rod Drew

In ISHS, there have been many discussions about advocacy in Horticulture. Those who are currently working on this topic might study the approaches used in relation to horticulture in Japan. Much could be learned from the importance and support that is given to research and training to ensure security of food production in this country. A. Elevated bed system for strawberry production in Japan. Photographed by Prof. Y. Yoshida, Okayama Univ., Japan. B. Dried persimmon production in Japan. Photographed by Prof. Emer. A. Sugiura, Kyoto Univ., Japan.

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Revisiting the Green Revolution: Seeking Innovations for a Changing World

Rodomiro Ortiz

The research, development, and technology transfer that happened between 1943 and the late 1970s – known collectively as the Green Revolution – increased production in agriculture in many nations of Asia and Latin America. Crop yields in the developing world would have been at least 20% less and food prices about 19% higher than they were in 2000 without the innovations brought by the Green Revolution. Likewise, calorie consumption would have dropped by about 5% and the number of malnourished children increasing by at least 2%; i.e., the Green Revolution helped improve the health status of 32 to 42 million pre-school children. Today the world continues facing an increasing demand for nutritious and quality food, feed, fiber and fuel. Furthermore, there will be 1.7 billion more people to feed by 2030, but with a declining ratio of arable land between 40 and 55%, and many people living in environments affected by water scarcity, land erosion, drought intensity, stalled progress on crop productivity, declining ground water aquifers, overgrazing of pastures, tropical deforestation, species extinction, overfishing, and anthropogenic climate change. These new global challenges require a more complex integrated agricultural research-for-development agenda that focuses on livelihood improvement coupled with agro-ecosystem resilience, eco-efficiency and sustainability rather than just on crop productivity gains. Intensifying sustainably agro-ecosystems by producing more food with lower inputs, adapting agriculture to climate change, conserving agro-biodiversity through its use, adding value throughout the food chain, improving nutritious quality of the human diet, and making markets to work for the smallholders are needed to address the main issues of our time. Agriculture will need to contribute towards a healthy and wealthy society in this 21st Century by providing more nutritious and healthy food through both genetic improvement and sound crop and resource management. Horticulture can diversify profitably intensive agro-ecosystems and provides food items for a balanced diet to achieve healthy human growth and life. Appropriate policy, innovative public institutions, agribusiness enterprises that accept corporate social responsibility and dynamic smallholders who make profits from their field harvests are needed to succeed in this endeavor.

ably other resources. Such agro-ecosystems should show resiliency, rely on eco-efficiency, enhance agro-biodiversity, and provide means for harvesting profitably enough food of high nutritious quality.

The Green Revolution was the term used in the 1960s-1970s to describe the yield gains on rice and wheat fields in South Asia as a result of changes in plant architecture and phenology, input use and policy promoting such research innovations. This Green Revolution helped South Asia and other developing countries to ensure food supply to their growing populations. Some small, resource-poor farmers and marginal rural inhabitants were however excluded from this technology-based agriculture and its benefits because market-purchased inputs were needed to take advantage of the few, newly bred high-yielding cultivars. Likewise, its focus on energy-rich crops such as rice and wheat, and to a lesser extent on maize brought an unforeseen consequence: the rapid rise in micronutrient malnutrition in many nations that adopted this approach to prevent large-scale starvation. Hence, knowledge-based innovations for improving food supply and quality should consider not only crops that provide enough calories to meet the energy needs of the human populations, especially the poor people, but also they should be capable of delivering balanced diets with all the essential nutrients needed for adequate nutrition and health, as well as enhancing sustainably crop yields without jeopardizing the environment and associated biodiversity. This paradigm shift requires a more complex agenda in today's global agriculture; i.e., from just seeking high yield potential of staple crops to diversifying and intensifying sustainably farming systems that feed the world.

High crop yields of main staples will still be needed for freeing land to cash or more nutritious crops such as fruits and vegetables, as well as to prevent biodiversity losses and protect the environment by avoiding the use of today's forests, woodlands, pastures, rangelands and mountain sides for agriculture. Furthermore, recent research shows that investment in crop yield gains compares favorably with other commonly proposed climate change mitigation strategies, and should be a priority target to reduce greenhouse emissions. However,

"Let us never forget that world peace will not be built on empty stomachs or human misery"

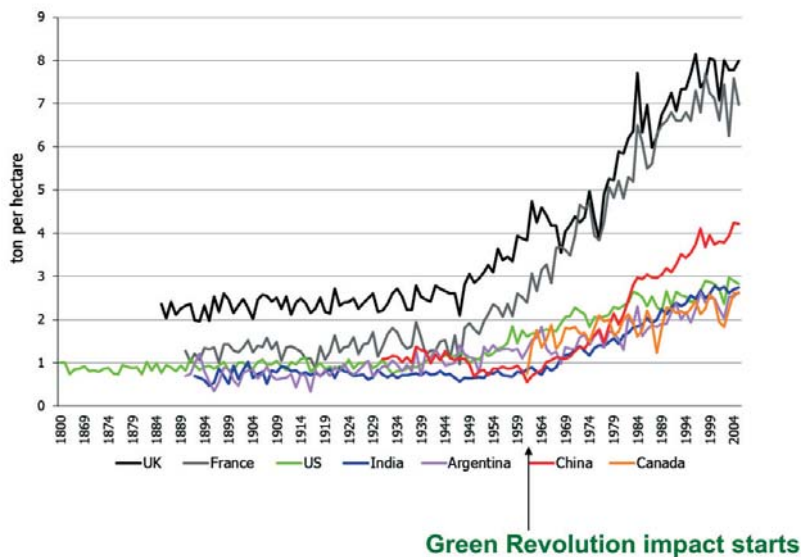
Norman E. Borlaug



The late 1970 Nobel Peace Prize Laureate Norman E. Borlaug (1914-2009): Father of the Green Revolution.

The agenda for a new Green Revolution needs to consider new approaches that promote innovations in plant science and benefit farmers and consumers at a time when the world population keeps increasing (about 78 million annually); about 1 billion human beings suffer from hunger, 3 billion malnourished people live with less than US\$ 2 daily, and anthropogenic climate change continues affecting food output and quality. Today's agriculture needs not only to provide enough and safe food but it should also help enhancing human health through better nutrition for the poor and well-balanced diets for the rich, diminishing the use of fossil fuels, adapting to extreme weather and water stresses, reducing environmental degradation and decline in the quality of soil, water, air and land resources in an increasingly urbanized world. Hence, a new paradigm for agriculture will rely on applying locally knowledge from biology, ecology and sociology to develop eco-efficient and resilient systems without compromising the ability of future generations to meet their needs for food while using sustain-





Impact of the Green Revolution on yield trends in wheat.

as noted from the changes of agricultural land area from 1960 to 2005, the agricultural intensification, ensuing mostly from the Green Revolution approach, was generally accompanied by decline or stasis in cropland area at a national scale only in countries importing grains and having conservation set-aside programs. Hence, policy interventions are needed for cropland abandonment that may provide means for benefiting from other environmental services in such ecosystems.

Fortunately, the World already possesses the know-how and research capability required to achieve the main objective for transforming

agriculture into a fully natural resource-based system that manages eco-efficiently its surrounding environment and associated biodiversity. Agro-ecological approaches are known to improve farming system productivity, reduce pollution through sound methods of nutrient and pest management, maintain biodiversity reserves, and enhance habitat quality through careful management of soil, water, and natural vegetation. Infrastructure (particularly roads and irrigation), incentives, institutions and other innovations beyond agriculture are also needed to implement such a global change of rural landscapes in the short- to mid-terms.

SUSTAINABLE INTENSIFICATION OF AGRO-ECOSYSTEMS FOR A CHANGING CLIMATE

Intensive agro-ecosystems are central to food security and reducing rural poverty, e.g. rice-wheat in South Asia or rice systems in Southeast Asia. These highly productive systems are subject to significant and increasing forces of change. They may face serious natural resource management problems, e.g., unsustainable exploitation of water and soils, inefficient use of chemical inputs, and emerging or worsening pests. Important research breakthroughs in plant physiology, eco-physiology, agro-ecology, and soil science are needed for achieving ecological intensification of these cereal-based cropping systems to meet the expected increase in food demand. Intensive agro-ecosystems should emphasize improvements in system productivity, host plant resistance and enhance use-efficiency of inputs such as water and fertilizers. Water use-efficiency (WUE) and water productivity (WP) are therefore being sought by agricultural researchers worldwide to address water scarcity in drought-prone environments across the world. Under water scarcity, yields, of some crops, are a function of the amount of water used by the crop, how efficiently the crop uses this water for biomass-growth (i.e., water-use efficiency or above-ground biomass/water use), and the harvest index; i.e., the proportion of grain yield to above-ground biomass. WUE is the ratio of total dry matter accumulation to evapo-transpiration and other water losses; i.e., water entering and lost from the system that is not transpired through the plant. An increase in transpiration efficiency or a reduction in soil evaporation will increase WUE. More recently, WP was re-defined at the crop level as the ratio of biomass with economic value (for example grain yield of cereals) compared to the amount of water transpired (WPT). This WP has been labeled as "productive" because transpiration is the only water flow in a field actually passing through the crop. Both WUE and WP may be improved through plant breeding, as can biomass accumulation and harvest index.

The use of plant species or genotypes of same species efficient in absorption and utilization of N is an important strategy in improving N use efficiency (NUE) in sustainable agricultural systems. Whole-plant physiology, quantitative genetics, and forward and reverse genetics approaches are providing a better understanding of the physiological and molecular controls of N assimilation in crops under varying environments. Crops are being bred for NUE because this trait will be a key factor for reducing N fertilizer pollution as well as for improving yields in N-limiting environments. Recently, the "Princes of Serendip" helped finding a promising NUE gene technology: the gene *Alanine aminotransferase* from barley was found to catalyze a reversible transamination reaction in the N

Indian women harvesting carrots in a field of the rice-wheat based intensive agro-ecosystems of the Indo-Ganges.



assimilation pathway. The over-expression of this enzyme led to increased N uptake especially at early stages of growth. The technology was licensed to a private biotech company, which was founded in the last decade with the aim of promoting sustainable agriculture by running a profitable company. A patent issued few years ago gave to this company the rights to use this NUE gene technology in major cereals – wheat, rice, maize, sorghum and barley – as well as sugarcane. Today they are testing the technology with rice in China, and researching further with rice and wheat in India, and planning to assess its value for maize and rice in sub-Saharan Africa.

Nitrous oxide (N₂O), which is a potent greenhouse gas susceptible to denitrification, is generated through use of manure or nitrogen (N) fertilizer. In many intensive cropping systems common N fertilizer practices lead to high fluxes of N₂O and nitrous oxide (NO). Several groups of heterotrophic bacteria use NO₃⁻ as a source of energy by converting it to the gaseous forms N₂, NO, and NO₂. N₂O is therefore often unavailable for crop uptake or utilization. Proper amounts and timing of N applications can reduce NO₂ emissions (50% less) in intensive irrigated agro-ecosystems without significantly affecting crop yields. An optical, hand held sensor that calculates the normalized differential vegetative index (NDVI), thereby assessing yield potential as plants grow, can reduce unneeded N fertilizer inputs, saving farmers' money and protecting the environment by reducing trace gas emissions.

Genetic enhancement of crops shows great potential for reducing N₂O emissions from soils into the atmosphere. Some plants possess the capacity to modify nitrification in situ because they produce chemicals that inhibit nitrification in soil. This release of chemical compounds from plant roots that suppress soil nitrification has been called biological nitrification inhibition (BNI), which seems to vary widely among and within species, and appears to be a widespread phenomenon in some tropical pasture grasses, e.g. *Brachiaria humidicola*. Nitrification inhibition also enhances agro-ecosystem fertility in a sustainable way especially under high nitrate leaching and denitrification fluxes, which may account for the ecological advantage of African grasses over indigenous grasses in South-American pastures. BNI may be an interesting target trait of crop genetic engineering for mitigating climate change.

AGRO-BIODIVERSITY FOR INTENSIFYING SUSTAINABLY AND FOR ADAPTING TO CLIMATE CHANGE

Agro-biodiversity components act similarly in agro-ecosystems to biodiversity in other ecosystems. Agro-biodiversity consists of genetic diversity (or the genetic variation within the

species), species diversity (i.e., the variation existing for a species in a specific region), and ecosystem diversity, which comprises the variation between agro-ecosystems within a region. A region could have homogeneous or heterogeneous agro-ecosystems, e.g. cereal-based systems may also include vegetables and livestock. Agro-biodiversity uses are various, e.g. genetic broadening or for introgression in plant breeding, regulation of the size of a population, allelopathy, ecological niches for natural enemies, pollination, decomposition of biomass, nutrients transfer and accumulation, and biological control.

Monoculture means growing a single plant species in one area often following the same type of crop year after year. Monoculture should however not be regarded as synonymous to a single crop cultivar in farmers' fields. Furthermore, genetic diversity within an agro-ecosystem depends on between and within population variation. For example, a crop under monoculture could be a mixture of distinct landraces or cultivars having genetic variation within each population; i.e., such a monoculture shows intra-specific genetic diversity. Intra-specific crop diversification could provide a means for controlling effectively pathogens and pests over large areas and therefore contributing to sustainable intensification of crop production. However, not all cultivar mixtures could provide functional diversity to a given crop pathogen population neither anyone can predict for how long such use of intra-specific diversity may remain effective in plant health management.

The expansion to arid, cold and variable environments of wheat production by North American farmers since 1839 provides an example of adapting a monoculture to climatic and other challenges as a result of adopting genetically enhanced seed-embedded technology and changing crop husbandry in both Canada and the USA. Nonetheless, an agro-ecosystem with many species of different taxa will be richer in species diversity than another agro-ecosystem where many species of the same taxon occur. Genetically diverse populations and species-rich agro-ecosystems may show greater buffer potential for adapting to climate change.

Agro-biodiversity at the gene, species and agro-ecosystem levels increases resilience to the changing climate. Promoting agro-biodiversity remains therefore crucial for local adaptation and resilience of agro-ecosystems. Adapting agriculture to climate change will rely on matching crop cultivars to future climates and plant breeding for coping both with climate variability and extremes, but also on promoting farmer resilience and adaptability.

Vegetables are often sensitive to climate extremes such as high temperatures and limited soil moisture; both are the major factors limiting vegetable yields in the tropics. For example, in tomato-growing locations temperatures are rising and the severity and frequency of above-

optimal temperature episodes may increase in the next decades. Adapting stable high yielding cultivars to the changing climate will be a main target for the short-term. For example, some Latin American environments with high temperature favored marketable fruit yield of tomato breeding lines bred for warm environments. Research shows that some stable hybrid tomato cultivars in high yielding environments also had high and stable yield in average and low yielding environments. Neither the heterogeneous composition of an open-pollinated cultivar nor the heterozygosity *per se* of a hybrid could account for tomato yield stability across environments in this region. Alleles that confer broader adaptation may likely be required to achieve tomato yield stability across environments. In the past, tomato breeders have incorporated alleles from several wild species to breed host plant resistance, improve fruit quality and adaptation to abiotic stresses. Wild tomato species from South America are also important sources of alleles for improving tomato adaptation to heat, drought, flooding and salinity, e.g. *Solanum chilense* grows in the desert due to its long primary roots and extensive secondary root system, whereas *S. pennellii* increases its water use efficiency under drought, and *S. cheesmanii* or *S. peruvianum* may grow in salty coastal areas. This genetic resource endowment can be further used for developing climate-resilient genetically enhanced seed embedded technology, which can be a cost-effective option for tomato farmers to meet the challenging climate of this century.

Recent analyses of genetic diversity trends in 20th century cultivars of various crops showed a lack of substantial reduction in the regional diversity of crop cultivars released by plant breeders. A significant loss of genetic diversity was noted for some crops in the 1960s when comparing to their genetic diversity in the 1950s, whereas after the 1960s and 1970s plant breeders were able to again increase the genetic diversity in released cultivars. Such results challenge the widespread view, which often lacks supporting experimental data, of a gradual narrowing of the genetic base as a result of plant breeding.

Agro-biodiversity remains as the main raw material for sustainable intensification of agro-ecosystems and to cope with climate change because it can provide traits for plant breeders and farmers to select input-efficient, resilient, climate-ready crop germplasm and further release of new cultivars. Wild species also play an important role as animal feed, source of fuel, raw materials for processing and as supplementary food in the seasonal "hunger" period (before harvest) or after a crop failure for rural people in some areas of the developing world. Recent modeling research suggests however that some crop wild relatives may become extinct by the mid of this century. Collecting samples of endangered species to be preserved in genebanks will be therefore the first step, but



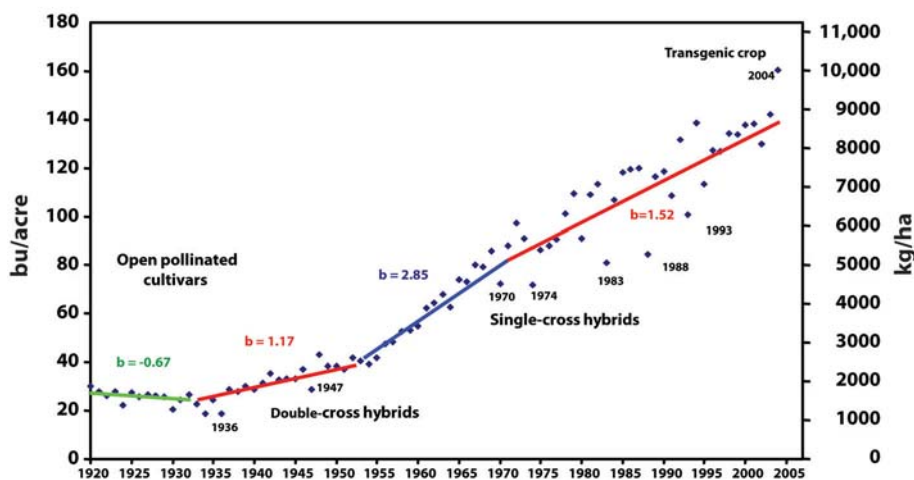
also protecting the habitats where they thrive should be a must to ensure the in situ evolutionary processes of wild species contributing to agro-biodiversity. Analog crop areas for many future climates should be promising locations where to focus collecting and conserving crop genetic resources.

AGRO-BIOTECHNOLOGY INNOVATIONS FOR SUSTAINABLE AGRICULTURE

Agro-biotechnology includes several options used in food systems and agriculture, e.g. micro-propagation of clean planting materials, the genetic enhancement of crops and livestock, characterization and conservation of genetic resources, pathogen and pest diagnosis, vaccine development, and improvement of feeds. Agro-biotechnology contributes to sustainable agriculture by conserving plant genetic resources (by providing better insights into crop endowments), preserving the environment (e.g. by reducing pesticide use or facilitating conservation agricultural practices), responding to social requirements (by targeting improvement of traits to meet end user demands), and being economically competitive and profitable as shown by the use of some agro-biotechnology products (including the knowledge therein) in today's agro-ecosystems.

Plant breeding may benefit from recent advances in genotyping and precise phenotyping, and by increasing the available agro-biodiversity through the use of genomics-led approaches. Today marker-aided breeding is applied to a broad range of crops and could facilitate domesticating entirely new crops. Crop genomics has been also improving in the last decade and today there are faster and cheaper systems that are increasingly used in genebanks, genetic research and plant breeding, e.g. for studying interactions between loci and alleles such as heterosis, epistasis and pleiotropy, or analyzing genetic pathways. Advances in crop genomics are providing useful data and information for identifying DNA markers, which can be further used for both germplasm characterization and marker-aided breeding. Genomics-assisted breeding approaches along with bioinformatics capacity and metabolomics resources are becoming essential components of crop improvement programs worldwide.

Progress in crop genome sequencing, high resolution genetic mapping and precise phenotyping will accelerate the discovery of functional alleles and allelic variation that are associated with traits of interest for plant breeding. Genome sequencing and annotation include an increasing range of species such as banana/plantain, cassava, citrus, grape, model legumes, maize, potato, rice, sorghum, sugarcane, soybean, and the wheat relative *Brachypodium distachyon*, among other species. Perhaps, one day further research on the genome of a plant



Seed technology evolution and national maize yields (bushel per acre) in the USA. USDA data. (1 bushel (56 lb.)/acre = 62.8 kg per ha).

species from a drought-prone environment may assist in breeding more hardy and water efficient related crops due to gene synteny.

The use of transgenic crops remains controversial worldwide after more than 1.5 decades of introducing them into the agro-ecosystems using specific frameworks to regulate their release and commercialization. While conventional plant breeding that utilizes non-transgenic approaches will remain the backbone of crop improvement strategies, transgenic crop cultivars should not be excluded as products capable of contributing to development goals. Breeding of transgenic crops to date seems to have been responsible and regulatory agencies have proceeded with caution in releasing transgenic crops. Available commercial transgenic crops and products are at least as safe in terms of food safety as those ensuing from conventional plant breeding. Farm level profitability will ultimately determine whether farmers adopt and retain new transgenic crop technology, which may also depend on much more than technical performance particularly in the developing world; e.g. national research capacity, environmental and food safety regulations, intellectual property rights and agricultural input markets.

Decisions, policies and procedures about monitoring transgenic crops should be science-based, and this approach requires education. There will be continuing assessment on the need for, and type of monitoring as new (and unique) products are developed and released to agro-ecosystems. For example, when deploying transgenic crops with host plant resistance to an insect pest (e.g. expressing Cry insecticidal proteins derived from *Bacillus thuringiensis* or *Bt*) numerous experiments are conducted to determine effective insect resistance management strategies for farmers. Collecting baseline data is indeed essential for effective monitoring and guiding research on transgenic crops. Environmental, food and feed safety aspects

should be also investigated before releasing transgenic crops. Another research area should focus on the unintentional spread of transgenic traits into conventionally-bred crop or landrace gene pools of the same species, particularly in the centers of crop diversity or origin. Transgene flow raises a new set of ecological and economic issues for scientists and policymakers to consider for transgene containment. Appropriate measurements should be also taken when transgenic and conventional crops of the same species coexist in the same locations if some farmers wish to grow crops for transgenic-free markets. The global spread of transgenic crops has also significant implications for organizations involved in germplasm conservation and genetic enhancement. Protocols, which are most likely based on polymerase chain reaction (PCR) markers for detecting specific recombinant DNA sequences in bulked samples collected from sentinel plots, are therefore needed for monitoring unintentional transgene flow in genebanks and breeding plots.

DIVERSIFYING INTENSIVE AGRO-ECOSYSTEMS

Intensive cereal-based cropping systems are being transformed by market forces and changing consumer demands, e.g. horticulture could diversify profitably the intensive rice-wheat cropping system of the Indo-Ganges. High cereal crop yields, conservation agriculture (particularly through zero and reduced tillage), and accessing markets are providing a platform for sustainably intensifying the diversification of this agro-ecosystem of South Asia. Furthermore, agro-biodiversity can provide a means for a greener revolution in sub-Saharan Africa, e.g. crop diversification with shrubby legumes can enhance profitably environmental and food security in maize monocultures. Likewise, as noticed in Southeast Asia and Latin America, a shift towards high value crops leads

to economic growth by increasing farmers' income and generating new jobs both in rural and urban areas, thereby alleviating poverty and improving in the long-term the sustainability and profitability of intensive agro-ecosystems. Such an agricultural development approach will also require a combination of enabling policy, secure land rights, output markets, and sharing new knowledge and technology with farmers.



● Horticulture helps to diversify maize and other cereals monocultures and enhances the quality of human diets.

Local (and profitable) crops grown by smallholders for many generations across variable climates can provide a complementary source for diversifying neighboring high-yielding monocultures of other highly intensive agro-ecosystems. NUE and WUE cultivars should be also bred to fit into particular local crop husbandry and resource base management. This agro-biodiversity can also offer new tastes for shifting consumer patterns in wealthy urban areas demanding now high quality and more nutritious diets. The concerns of consumers on the provenance and potential impacts on the environment and health throughout the agri-food value chain are also influencing the improvements we are witnessing nowadays elsewhere.

FOOD QUALITY AND SAFETY FOR HUMAN NUTRITION AND HEALTH

Assuring food quality and safety remains a priority public health imperative and should be an intrinsic aspect for ensuring high food standards in human diets. Gaining further insights on the links between agriculture, food systems and population health became therefore a priority research in the last decade. There is however a knowledge gap on what really constitutes a safe and healthy diet and how the dietary patterns and human health can be affected by the agri-food system, particularly in the developing world.

Many millions of people (both adults and children) suffer from food-borne toxins, especially in the developing world. Some staple crops, vegetables (e.g. stored dry chilli pepper) or nuts can be the source of mycotoxins, which are highly toxic metabolites produced by a

number of fungi especially in drought-prone environments, unseasonably rainy environments, or high moisture during and after harvest. Human exposure to levels of mycotoxins from nanograms to micrograms per day may occur through consumption of dietary staples in several tropical countries. The chronic incidence of aflatoxin – which are secondary metabolites produced by some *Aspergillus* fungi during production, harvest, storage, and food processing – in diets is evident from the presence of aflatoxin in human breast milk in some areas of the developing world. Children exposed to aflatoxin may become stunted, underweight, and more susceptible to infectious diseases in childhood and later life. Frequent consumption of low levels of aflatoxin has been also associated with chronic diseases like cancer because mycotoxins in foods can be cumulative in humans. Furthermore, if small farm-landholders are to participate in global markets and take advantage of growing demand for food in the developed world, where food safety concerns are high, they will need greater capacity to implement food safety protection standards mandated by sanitary and phytosanitary regulations. An important research target should be therefore to develop and promote robust and integrated strategies that significantly augment food security and safety for consumers but also increase profits from agricultural produce, which meet international food safety standards. The potential of biological control (particularly using atoxigenic strains of *Aspergillus flavus*), good crop husbandry and store practices, and host plant resistance breeding has been shown to reduce aflatoxin contamination in various crop harvests and foods.

Atmospheric CO₂ concentrations might affect quality characteristics of important crops that feed the world. For example, flour from cereal grains grown under elevated CO₂ or low nitrogen fertilization shows a diminished nutritional and processing quality and an altered elemental composition. Likewise, stoichiometric theory suggests that high CO₂, as a rule, should alter the elemental composition of plants, thus affecting the quality of human nutrition. Published data support this claim because there seems to be an overall decline of the essential elements-to-carbon ratio, thereby leading to lower nutritional quality of crops. High CO₂, as a result of greenhouse gas emissions, may therefore have a much larger impact on food quality than many anticipated and will intensify the already acute problem of micronutrient malnutrition, especially in the developing world.

Micronutrient malnutrition – also known as “hidden hunger” – affects billions people worldwide because of low contents of minerals and vitamins in their diets. Fruits, vegetables and meat are micronutrient-rich but not affordable by poor consumers, especially in the developing world. They eat staples such as grains or roots and tuber crops, which only have a few micronutrients. The genetic enhancement of

micronutrient-dense crops – also known as biofortification – provides a means for a cost-effective delivery of more nutritious staple crops, particularly in remote rural areas, where often fortification and supplementation programs do not reach target groups. Biofortification research began in the mid-1990s and now there are several groups working on biofortifying staple crops around the globe. The success of biofortification will depend on the advances in breeding micronutrient-dense crops, the improvement of micronutrient status in human diets through the use of biofortified crops because sufficient and bioavailable micronutrients are retained after processing and cooking, and the acceptance of these newly bred cultivars by farmers and consumers.



● Choclo ‘Blanco Urubamba’ – a cultivar from the specialty green maize race Cusco Gigante that shows the largest kernels and is often eaten fresh after boiling with cheese or hot pepper sauces in the Andes of South America.

Diversifying diets with micronutrient-rich fruit and vegetables will be a complementary approach to biofortification for fighting malnutrition. A diverse and balanced diet also helps to achieve healthy human growth and life. In some rural areas, people depend heavily on home-grown crops or cheap food purchased in local markets. Diet diversification with locally grown fruits and vegetables could provide quick means for getting essential micronutrients in such areas.

Agro-processing adds value, provides options for new jobs in the agri-food chain, reduces postharvest losses, and breaks the seasonality of the produce making them available



year long. Appropriate post-harvest handling raises the safety and quality of the food items. Furthermore, better linkages between farmers and agribusiness entrepreneurs are needed to overcome any shortcomings caused by ineffectual markets, low levels of technology use, and inadequate policy and regulatory systems. Small-scale processing chains and vertical integration of selected commodity subsectors may provide means for linking profitably growers with their respective agribusinesses along the value chain.

BIO-ENERGY: ONE-STEP FOR A BIO-BASED ECONOMY?

Alternative renewable energy sources in today's world bring diverse opportunities and challenges, e.g. how to integrate with potential biofuel markets, deal with impacts on food security, alleviate poverty, and manage crop and natural resources sustainably. The increasing demand, particularly by the industrialized world, for biofuels should take into account the agro-ecosystems and its biodiversity to ensure their healthy management. The agricultural systems required for producing biofuels need to be sustainable for an efficient use of biomass, and partitioning it among energy, feed, food and CO₂ fixation demands. They should be more eco-efficient for using existing farmland or marginal (dry, waterlogged, saline) tracts.

Although some advocate that bio-energy can play a role for mitigating climate change by reducing greenhouse emissions, appropriate life-cycle analysis will be needed on a case-by-case basis to determine the use of land resources and estimate net carbon emissions of each suggested renewable energy technology. The agenda for plant breeding may include increasing plant grain and biomass productivity, optimizing the chemical and physical attributes of biofuel sources, and improving specific traits in first- and second-generation biofuel crops, within a framework of sustainable agriculture.

Frontier approaches should be applied to study the possible advantages of perennial biofuel crops that are more photosynthetically productive, entail lower input costs, and improve soil nutrient input and retention. Through alliances with the bio-energy industry, research should also adapt industrial processes to biomass sources and sources to promising processes. Biofuels should form therefore part of a global, cross-cutting agenda of agricultural research, involving partners in the farming and energy sectors.

"BALANCING" AGRICULTURE AND ENVIRONMENT - TOWARDS A WEALTHY AND HEALTHY SOCIETY

Biological sciences play a prominent role in sustainable intensification by breeding crops with tolerance to stresses and host plant resistance to pathogens and pests, or producing stably high crop yields using renewable inputs, which avoids depletion of minerals and preserves agro-biodiversity and natural capital plus protects ecosystem services. Innovations based on both agro-biodiversity and sustainable intensification will help to accelerate crop yield gains that bring bumper harvests and protect the environment. Furthermore, agro-biodiversity conservation through its use needs to capitalize on locally available resources, be environmentally sustainable, socially acceptable and culturally sensitive, and it should provide alternatives based on equity and justice.



● **Mobile phones are helping African woman smallholder farmers to link to urban markets and seek better prices for their produce.**

Today we are faced with the changes in the environment brought by the evolving climate, the need for using renewable resources (including bio-energy), and to be more efficient for conserving and utilizing agro-biodiversity. Hence, priority should be giving to conserving biodiversity through its use, which creates wealth, enhances environmental services, brings resilience and eco-efficiency to ecosystems, and helps to develop, where and when appropriate, a bio-based economy, particularly in smallholder systems. There are about 1.5 billion people living in households that depend on small farms. New evidence shows that with the right policy framework farming by small farmers can be a viable option out of poverty. Policy interventions can therefore assist smallholders by providing them with better infrastructure and access to credits, markets and knowledge-intensive agriculture.

A sustainable development approach in agriculture, whose outcome ensues from biological, ecological and social processes, should aim to reconcile economic growth, the conservation of both agro-biodiversity and the environment, and equity for developing sustainably rural areas, particularly in the agro-ecosystems of the developing world. An innovation agenda for agriculture needs to consider people, agro-biodiversity, natural resources management, environmental services, participatory value chains, institutions and policy-makers. Its ensuing knowledge and technology will contribute to transforming lives and landscapes in the global agro-ecosystems during the next decades.

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Closed Greenhouse Systems: Multiphase Recycling of Solid and Liquid Organic Waste

Martine Dorais and Yves Dubé

During the last decade, several sustainable management practices have been proposed by researchers and extension services, mainly because of the increased importance of incorporating environmental considerations into agricultural production systems. For greenhouse production, three main factors should be considered to reduce environmental burdens: 1- waste management, 2- nutrient emission, and 3- fossil energy use.

Firstly, organic waste represents a significant source of biomass production for protected crops. For instance, leaf waste biomass of greenhouse tomato production can reach as much as 4.5 tonnes (t) per ha per week. These wastes are usually discarded in sanitary landfills or directed to other waste management sites such as composting sites or accumulated near the production facility thus constituting a major phytosanitary problem for some countries. They contain compounds that are not only lost as nutrients but in many cases that degrade to form harmful compounds such as greenhouse gases (N_2O , CH_4 , CO_2).

Secondly, when drainage water from producing greenhouse vegetables is not completely recycled, nutrient emission into the groundwater may represent a major environmental impact. A non-recirculating greenhouse production system such as tomato generates annually up to 3000 to 4500 m³ per ha of wasted nutritive solution containing 4 to 10 t of environmental unfriendly nutrients such as nitrogen and phosphorus. Water of high quality is getting scarce worldwide. As a consequence, it can be expected that more severe legislation will restrict the waste of this natural resource by the agricultural industry in the near future.

Thirdly, greenhouse culture production uses a significant quantity of fossil fuel energy, in the form of heat (10-40% of production costs), CO_2 -enrichment, and fertilizers. Thus, management of significant quantities of organic solid and liquid waste produced by greenhouse crops as well as the use of renewable energy constitute a challenge that can be partly solved by more sustainable production systems. The process we are describing below could be a significant step towards achieving this goal. Our integrated closed-loop process recycles both solid and liquid organic waste, and converts the waste into renewable energy (CH_4), CO_2 , and liquid and solid fertilizers. Organic waste products and drained water are then reintroduced into the irrigation system. This ensures minimal risks using biological processes such as anaerobic digestion and nitrifying bioreactor, artificial wetlands and passive bioreactors to reduce nutrient pollutants and sulfate content as well as risks associated to pathogens. This integrated production system uses organic growing media or soil with organic fertilizers as well as liquid organic culture (Fig. 1), and constitutes a sustainable organic production system achieving a productivity level as high as conventional growing systems. For Northern countries, supplemental lighting (SL) may be used for a year-round production in a self-sufficiency context, although sustainability of SL is questionable.

ANAEROBIC DIGESTION

Plant biomass such as tomato leaves constitutes an important source of carbon (1.2-1.7 g C/ tomato leaf), and is rich in nutrients such as nitrogen (2.0 to 4.9% dw), potassium (2.7 to 5.9% dw), phosphorus (0.3 to 0.6% dw), calcium (2.4 to 7.3% dw), magnesium (0.4 to 0.8% dw) and minor elements (Mn 55-220 ppm; Zn 20-85 ppm; Fe 98-391 ppm; B 32-97 ppm; Cu 8-16 ppm; Mo 1-10 ppm) (Adams, 1986; Gary et al., 1998; M. Dorais et al., unpubl. data). In order to recover the nutrients

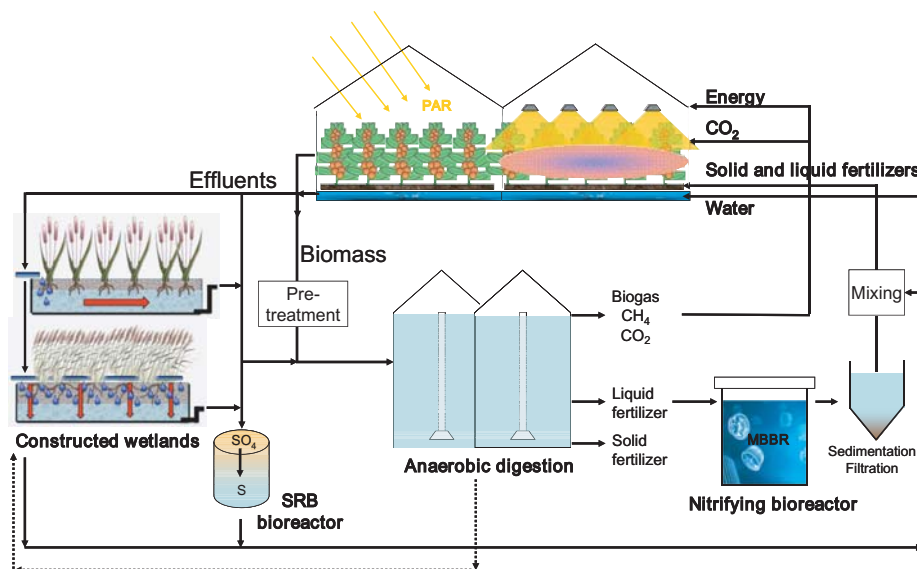
within the cropping system, the main process of our closed-loop production system consists of the anaerobic digestion (AD) of waste biomass. AD involves a series of processes (hydrolysis, acidogenesis, acetogenesis and methanogenesis) in which a microbial community breaks down organic matter in the absence of oxygen, resulting in methane, CO_2 , liquid and solid fertilizers (Pain and Hephherd, 1985; Marchaim, 1994). AD offers several advantages for a greenhouse production system compared to other forms of organic waste treatment, including the ability to: (1) treat wet wastes of less than 40% dw;

(2) provide a source of carbon neutral energy in the form of biogas; (3) reduce greenhouse gas emission compared to other organic waste management such as composting and incineration; (4) provide a renewable source of fertilizers easily available for plant uptake; (5) reduce water pollution from nutrients (Tafdrup, 1995; Mata-Alvarez et al., 2000; Ward et al., 2008); (6) remove or reduce pathogens, with a higher efficiency for multi-stage digesters or when a pasteurization step is included in the process; and (7) provide CO_2 that can be used for greenhouse enrichment. In comparison with composting process, no or minimal loss of nutrients or greenhouse gas occurs. By confining the decomposition processes in a sealed environment, potentially damaging methane is prevented from entering the atmosphere, and subsequent burning of the gas will release carbon-neutral carbon dioxide back to the carbon cycle (Ward et al., 2008).

Depending on the biomass and process used (psychrophilic, 15-25°C; mesophilic, 35-40°C; thermophilic, 50-60°C) methane production generally ranges from 50 to 75% of the total biogas, while CO_2 might represent 25 to 45%, the remaining gas being H_2O (2-7%), N_2 (0-2%), O_2 (0-2%), and H_2S (0-2%) (Ward et al., 2008; Bouallagui et al., 2009). Methane, which is then burned to produce heat, provides additional CO_2 for greenhouse crop enrichment. Our research group observed for a psychrophilic anaerobic sequencing batch reactor (Massé, 1995) that values for specific methane production with tomato leaves were similar or higher to those obtained with pig manure. In our study, methane content in the biogas range was 57% on average, while CO_2 was 39% (Brisson et al., 2009). Values for specific methane production varied from 0.22 to 0.43 L CH_4 /g COD (chemical oxygen demand) fed to the bioreactors during the startup (Brisson et al., 2010). At the end of our AD process, a significant amount of dry matter and organic carbon were observed in the digestate suggesting that the AD performance can be optimized. Because sulfur content of tomato leaf usually ranges between 1.0 to 3.2% (Adams, 1986), H_2S , a corrosive biogas contaminant and microbial inhibitor, was also present in the biogas of each bioreactor (0.08-2.2%) (Brisson



Figure 1. Closed-loop multiphase recycling system recovering solid and liquid organic waste from the greenhouse culture, pre-treating the solid organic waste depending on the physicochemical characteristics of the organic waste, anaerobically digesting the resulting pre-treated digestible mixture, nitrifying the digestate emitted from the anaerobic digestion, marsh filtering the liquid organic waste, reducing sulfate and pathogen using bioreactors or artificial wetlands, and reintroducing various resulting products back into the greenhouse for crop production: fertilizing sludge from the anaerobic digestion, effluents from the marsh filtering and bioreactors, and organic liquid fertilizer produced by nitrification. Top and inter-lighting ensure year-round fruit production.



et al., 2009). Multi-stage digesters, separating the hydrolysis/acidification processes from the acetogenesis/methanogenesis processes (do not share the same optimum environmental conditions), can improve the digester performance in terms of specific methane yield as with poorly-degradable feedstocks, the hydrolysis stage is more likely to be the limiting step compared to the methanogenesis process (Ward et al., 2008). For fruit and vegetable waste, separation of the acidification process from methanogenesis by the use of sequencing batch reactors has been shown to give higher stability, a significant increase in biogas production and an improvement in the effluent quality (Bouallagui et al., 2004). The methane-producing potential of various agriculturally sourced feedstocks has been reported by several authors and varies largely according to the optimization of AD processes and fed substrates used. Table 1 presents a brief summary of methane yield from animal and plant agricultural biomass. The addition of fruit and vegetable waste to animal manure increased the methane yield (Callaghan et al., 2002). When expressed on a fresh weight unit, potential yield ranged from 13 to 238 m³/t according to biomass sources, e.g. 13 to 32 m³ biogas/t of liquid bovine manure; 16 to 23 m³ biogas/t of liquid pig manure; 61 to 112 m³ biogas/t of poultry manure; 145 m³ biogas/t of hay silage; 162 m³ biogas/t of wheat silage; 197 m³ biogas/t of corn silage; 238 m³ biogas/t of food waste (Ricard et al., 2010). Assuming that around 524 K m³/ha of natural gas is needed annually under the conditions in the Eastern part of Canada, our first AD trials with tomato

leaf as the only source of substrate represented only 0.5 to 1.4% of the energy needed for heat, and 7 to 22% of the requested CO₂ when CO₂ enrichment is based on 45 kg CO₂/h-ha (12-h per day, no enrichment when ventilating, total of 90 000 kg CO₂ per ha per year). In order to improve the methanogenic potential of our system, further trials with a pre-treatment process will be conducted using greenhouse waste biomass alone or mixed with different types of agricultural waste biomass. With higher gas yield, up to 7.6% and 85% of the heating and CO₂ requirement, respectively, could be reached with the same bioreactor capacity (Table 2). Regardless of the growing period (winter vs. summer), an average capacity of 77 to 193 tons of fresh biomass per week is needed to fulfill the Canadian greenhouse heating requirement.

NUTRIENT

As around 67-72% of the total dry matter is allocated to tomato fruits, 18-24% to leaves and around 8-10% to the stem (Heuvelink and Dorais, 2005), nutrient recovery from the on-farm tomato leaf AD can only fulfill part of the fertilizer requirement. Even though a large proportion of the nutrients absorbed by a mature tomato plant are found in the fruit (56-60% N, 60-63% P, 57-63% K of the respective total plant ion uptake), leaves are rich in Ca (~71% of the total plant uptake) and have ~27% of the N uptake, ~25% of P, ~20% of K and ~32% of Mg (Adams, 1986). The distribution of nutrients between plant organs, however, varies according to plant development, leaf age,

fruit load and the fertilization management (N-forms, ion balance, EC). For an average leaf nutrient content of 2.9% N, 0.4% P, 4.0% K, 0.8% Mg and 5.4% Ca, the AD of 4500 kg fw (~3 pruned leaves per plant per week per ha) can provide 13.4 kg N, 1.9 kg P, 18.5 kg K, 25 kg Ca and 3.7 kg Mg under perfect recovery system conditions. Assuming that the average daily tomato plant uptake of nitrogen, phosphorus, potassium, calcium and magnesium is around 114-118 mg/plant, 25 mg/plant, 212-293 mg/plant, 91 mg/plant and 17 mg/plant, respectively, or based on the mean values of uptake concentrations of N (123-134 mg/L), P (27-34 mg/L), K (238-316 mg/L), Ca (88 mg/L), and Mg (22 mg/L) (Adams, 1986; White, 1993; Voogt and Sonneveld, 1997), sludge nutrients represent 52-61% of the absorbed N, 28-39% of P, 32-45% of K, 85-110% of Mg and 142-146% of Ca. Calculated values, however, do not take into account nutrients used by microorganisms, adsorbed, precipitated or leached.

Nitrogen is a unique nutrient that can be absorbed as either cation (NH₄⁺) or anion (NO₃⁻). This characteristic of nitrogen influences plant nutrition in general (i.e. soil pH, which then influences nitrification rate by *Nitrosomonas* and *Nitrobacter* groups; cation uptake, cation-anion balance in plant tissues) and it has a strong impact on fertilization in intensive horticulture such as greenhouse crops. The detrimental effect of NH₄⁺ on vegetative growth, fruit production, and tomato fruit quality is well documented (see reviews by Dorais et al., 2001, 2008). High concentrations of N-NH₄ reduce K, Ca and Mg plant uptake and may cause severe metabolic disorders, which suppress plant growth and yield of sensitive species such as tomato (Britto and Kronzucker, 2002). For soilless tomato, it has been well established that N-NH₄ form exceeding 10% of total nitrogen decreases plant growth (Adams, 2002) and increases fruits with blossom end rot (BER) (Dorais et al., 2001). For organic growing plants, a synergetic effect between N-NH₄ and N-NO₃ may be obtained at higher ratios. As the N-form is under the ammonium form after the AD of the biomass, the digested solution has to be totally or partly nitrified before it can be reintroduced into the greenhouse growing system. To convert ammonium to nitrate, several aerobic biological treatments were developed with different impacts of treatment process on gaseous emissions such as N₂O (Metcalf and Eddy, 2003; Bernet and Béline, 2009). Suspended carrier biofilm process (i.e. moving bed biofilm reactor) has been found suitable for treatment of various wastewater from dairy and fish farms as well as from municipality (Luostarinen et al., 2006; Rusten et al., 2006), and constitutes an appropriate process for our closed-loop growing system. Several reviews have been recently published on biological treatment of wastewaters such as nitrification and nitrogen removal processes, and on their impact in terms of greenhouse gas emissions

Table 1. Methane yields of different feedstocks.

Feedstock origin	Methane yield (mg/kg volatile solids)	Authors
Banana peel	0.277	Gunaseelan, 2004
Beef cattle manure	0.328	Hashimoto et al., 1981
Cabbage	0.277	Cho et al., 1995
Calf manure	0.386	Béline and Gac, 2007
Carrot leaves	0.241	Gunaseelan, 2004
Carrot petiole	0.309	Gunaseelan, 2004
Cauliflower leaves	0.190	Gunaseelan, 2004
Cauliflower stem	0.331	Gunaseelan, 2004
Cellulose	0.356	Cho et al., 1995
Cereal straw	0.154-0.450	Béline and Gac, 2007
Dairy cattle manure	0.148	Moller et al., 2004a,b
	0.044-0.296	Béline and Gac, 2007
Duck manure	0.400	Béline and Gac, 2007
Faba bean straw	0.441	Petersson et al., 2007
Food industrial waste + sludge	0.8-1.0	Murton et al., 2004
Food waste	0.475-0.550	Béline and Gac, 2007
	0.472	Cho et al., 1995
FVW	0.420-0.610	Bouallagui et al., 2005, 2009
	0.409-0.529	Gunaseelan, 1997
FVW + cattle/chicken manure	0.450	Callaghan et al., 2002
FVW + slaughter house wastewater	0.850	Bouallagui et al., 2009
Garden beet leaves	0.231	Gunaseelan, 2004
Grasses	0.342-0.420	Gunaseelan, 1997
Hay	0.267-0.462	Béline and Gac, 2007
Leafy biomass	0.181-0.429	Gunaseelan, 1997
Lemon pressings	0.473	Gunaseelan, 2004
Maize crop silage	0.300-0.400	Béline and Gac, 2007
	0.390	Amon et al., 2007a,b
Maize early to late harvest	0.31/0.37-0.27/0.29	Amon et al., 2007a,b
Mango	0.373	Gunaseelan, 2004
Oilseed rape	0.420	Petersson et al., 2007
Onion peel	0.400	Gunaseelan, 2004
Pea pods	0.390	Gunaseelan, 2004
Pig manure	0.356	Moller et al., 2004a,b
	0.49	Hashimoto, 1983
	0.244-0.343	Béline and Gac, 2007
Potato peel	0.267	Gunaseelan, 2004
Radish shoots	0.304	Gunaseelan, 2004
Slaughter house wastewater	0.560	Bouallagui et al., 2009
Sow manure	0.275	Moller et al., 2004a,b
	0.260-0.334	Béline and Gac, 2007
Sugar beet leaves	0.219	Amon et al., 2007a,b
Summer barley straw	0.189	Amon et al., 2007a,b
Sunflower crop silage	0.300	Amon et al., 2007a,b
Tomato fruit	0.298	Gunaseelan, 2004
Tomato processing waste	0.597	Sarada and Nand, 1989
Turnip leaves	0.314	Gunaseelan, 2004
Vegetable waste	0.360-0.403	Béline and Gac, 2007
Winter rye	0.360	Petersson et al., 2007
Winter wheat straw	0.189	Amon et al., 2007a,b
Yard waste grass	0.209	Owens and Chynoweth, 1993
	0.101-0.601	Béline and Gac, 2007
Yard waste leaves	0.123	Owens and Chynoweth, 1993

Adapted from Ward et al., 2008; see Gunaseelan, 1997 for municipal solid waste, grass, woody, weed, marine and other fruit and vegetable waste (FVW) feedstocks.

and nitrogen and phosphorus management (Ahn, 2006; Eding et al., 2006; Paredes et al., 2007; Bernet and Béline, 2009). However, ammonium concentration of the digestate coming from the tomato leaf AD is really high (>1000 mg L⁻¹) compared to commonly treated wastewater (i.e less than 1 mg L⁻¹ N-NH₄ for fish wastewater). Consequently, a high performance closed system should be developed considering the residual organic load, the dissolved oxygen concentration, the total ammonium concentration, the pH and alkalinity, and temperature. The nitrifying inhibitor components should also be considered (Metcalf and Eddy, 2003; Paredes et al., 2007) for the design and operating nitrifying strategy.

CONSTRUCTED WETLANDS AND PASSIVE BIOREACTORS

Water tables are falling due to over pumping of groundwater in most parts of the world, while worldwide water demands tripled during the last half-century along with population and consumption growth. From that demand, agriculture accounts for around 70% of world water use (Postel and Vickers, 2004). Recent projections indicate that by 2025 numerous river basins and countries will face a situation in which 30% or more of their irrigation demands will not reliably be met because of water shortages (Postel and Vickers, 2004). From this perspective, integrated production systems that would increase the efficiency of water and nutrient use on farms need to be developed. Environmental concerns about the amount of waste generated by conventional hydroponic systems have led to the development of more sustainable production practices including containment and recirculation of the effluents. Many environmental and economical advantages are involved with the use of the proposed closed growing systems. However, risks of contamination with disease-causing microorganisms are important, especially with pathogens that can be disseminated through water (Stanghellini and Rasmussen, 1994; Ehret et al., 2001). Disinfection processes, such as chlorination, ozonation, and ultraviolet irradiation can be used in recirculation systems, but are relatively expensive in terms of investment, maintenance and energy (Ehret et al., 2001), and are less efficient to treat effluent with high organic load. Treatment of wastewater of different origin using constructed wetlands (CW) has been widely studied (Faulwetter et al., 2009; Kadlec and Wallace, 2009), and is designed to benefit from physiological, chemical and biological processes in a controlled and predictable manner. CW are efficient, cheap and require low maintenance compared to commercially available waste water treatment systems. Because denitrification processes occur mainly under anaerobic conditions and sulfate reduction by sulfate-reducing bacteria (SRB) is inhibited by a high concentration of nitrate,



Table 2. Methane yield from different waste biomass and their theoretical contribution to the heat and CO₂ greenhouse tomato production grown under Canadian climatic conditions, assuming a perfect recovery.

Waste biomass	m ³ CH ₄ /t feedstock	Authors	CO ₂ /t feedstock (kg)	Bioreactor capacity (t feedstock/week)	% heat requirement/year ⁶	% CO ₂ requirement/year ³
Grass silage	145-197	Ricard et al., 2010	261-355	4.5	5.6-7.6	63-85
Greenhouse tomato leaves	11-37	Brisson et al., 2009, 2010	28-93 ¹	4.5	0.5-1.4	7-22
MSW ⁴ , FVGW wastes	60-150	Tafdrup, 1995	108-270 ⁵	4.5	2.3-5.8	26-65 ⁵
	60-150	Tafdrup, 1995	108-270 ⁵	193-77	100	1110
	60-150	Tafdrup, 1995	108-270 ⁵	17.5-7.0	9	100
Sweet sorghum ²	107	Antonopoulou et al., 2008	193	4.5	4.15	46

¹ Theoretical value estimated from the CO₂ production anaerobic digestion process (39% biogas) and CH₄ combustion.

² Based on an averaged energy need of 557 400 m³ CH₄/ha-yr in Canada.

³ Based on a CO₂ enrichment of 50 kg CO₂/h-ha during 12h/day (no enrichment during venting).

⁴ Municipal solid waste (MSW); Fruit, vegetable and garden waste (FVGW).

⁵ Based only on the CH₄ combustion.

⁶ Aebic digestion (AD) of the hydrogenogenic process effluent + AD of the solid residues after the extraction process.

different wetland compartments in series, with different conditions (i.e. filling medium, oxygenation and plant species), should be used to optimize highly charged waste water such as greenhouse effluents. CW implanted with *Iris*

versicolor, *Juncus* sp. and *Phragmites australis* reduced the nutrient load of greenhouse effluents, although wetlands with *Typha latifolia* were more efficient due to its high tolerance to SO₄ (Gravel et al., 2009, 2010; Lévesque et al.,

2009, 2010). For different types of CW (vertical subsurface flow, horizontal subsurface flow, surface flow), our recent works showed that 60 to 84% of nitrate and 65-100% of phosphate were removed from the effluent (Lévesque et al., 2009, 2010). The efficiency of the commercial vertical subsurface flow CW was similar throughout the year as the lower distribution level located at 0.6 m of depth was used during the winter time and the top one during the summer season (Fig. 2). Adding a source of carbohydrate to the greenhouse effluent under a high nutrient load increased the microbial population of CW and consequently reduced the mineral content of the wastewater, but significantly increased the emission of greenhouse gases such as N₂O by 25 to 50 times. Greenhouse gas emission was in general higher for surface flow CW than for subsurface flow CW, and was 10 to 200 times higher than soil amended with cow or pig manure (Lévesque et al., 2010).

Nutrient accumulation in recycled water, especially bivalent ions, can negatively affect the crop and fruit quality by an ion competition (SO₄²⁻ vs. NO₃⁻; Ca²⁺ and Mg²⁺ vs. K⁺) and an osmotic effect (Dorais et al., 2001). In the end, this results in a reduction of water and nutrient absorption by roots. For organic crops recycling drained water, we observed that SO₄ accumulation is a main problem as organic fertilizers are rich in SO₄. Several studies were conducted to find the best mixture of natural organic substrates for SRB-bioreactor and their optimal operating conditions (Neculita et al., 2007). Using a mixture of pozzolana, leaf compost, poultry manure, maple sawdust and maple wood chips, or pozzolana with a simple carbon source, SO₄ content in the treated effluent was reduced up to 100% and the residual sulfides precipitated with Fe (Gruyer

Figure 2. A) Vertical subsurface flow constructed wetlands built at a commercial greenhouse facility (Les Serres Nouvelles Cultures - Sagami, Ste-Sophie, Quebec, Canada) to treat tomato effluents; B) A lower distribution level located at a depth of 0.6 m is used during the winter time, and the top one during the summer season. A meteo station collects air and soil temperatures at different levels of the constructed wetlands (CW) as well as the rain water; C) A tomato crop grown into an organic growing medium where the effluents are collected and treated via the CW.



et al., 2010). In addition to their potential to reduce nutrient load in greenhouse effluents, CW and passive bioreactors have been found to reduce pathogen populations with varying but significant degrees of effectiveness (Kadlec and Wallace, 2009; Gruyer et al., 2009). For greenhouse effluent, our works showed that when small scale CW were inoculated with 10^6 cfu/ml of *Pythium ultimum*, no pathogen was detected in the treated wastewater (Gruyer et al., 2009, 2010). Similar results were obtained for *Fusarium* spp. using CW and passive SRB bioreactors (Gruyer et al., 2010, unpubl. data).

SUSTAINABLE ORGANIC GROWING SYSTEM

Organic agriculture is an ecological production management system that (1) promotes biodiversity, biological cycles and soil biological activity; (2) minimizes the use of external inputs; and (3) uses cultural practices that maintain ecological harmony (Dorais, 2007). Organic farming aims at profitability with no or minimal impact on the environment. Growth in sales of organic food has been 15-21% each year, as compared with 2 to 4% for total food sales, with an estimated value for 2006 of US\$40 billion; organic vegetable crops are second in importance (Willer and Yussefi, 2007; Willer and Kilcher, 2009). The increasing demand by consumers for organic food is mainly due to health concerns over pesticide residues, but the environmental concern is also becoming important. In the past 25 years, the organic greenhouse industry has greatly evolved and some organic growers have developed successful cropping systems reaching yields close to conventional operations. Nevertheless, excessive irrigation to control soil salinity, and the mismatching of nutrient availability in regards to plant nutrient needs often leads to an over-fertilization of soils in organic greenhouses, resulting in nutrient leaching into groundwater. Negative relationships between the soil water content and the soil biological activity, expressed as CO_2 efflux, were also reported (Pepin et al., 2009; Dorais et al., in press). Balancing production needs with potential environmental concerns, in the case of excessive nitrate and phosphate from annual compost applications, is still a key issue for sustainable organic systems (Delate et al., 2003; Raviv, 2010). This is even more important for soil with high porosity. Typically only approximately 10% of their total N is mineralized over a 20-30-week incubation period (Hadas and Portnoy, 1994). On the other hand, organic residues act not only as a source of nutrients and organic matter, but may also increase size, biodiversity and activity of the microbial populations in soil, thereby influencing structure, nutrient turnover, and many other related physical, chemical and biological parameters (Albiach et al., 2000). Therefore, the successful production of organic greenhouse crops relies on solid and liquid sources of organic fertilizers (Peet et al., 2004; Rippey et al., 2004; Tüzel et al., 2004).

Figure 3. A) Organic growing system at Laval University (Quebec city, Canada) where effluents of 6 types of soil (replicated 6 times, total of 36 units) are independently monitored and recycled to the crop; B) Collecting reservoirs located at the basement of the greenhouse where effluents are individually monitored and pumped back to the crop to eliminate nutrient and water emissions into the environment.



For several crops, previous studies showed the fertilizer value of digester effluents from AD of animal manure (Marchaim, 1994; Cushman and Snyder, 2002; Adeli et al., 2003; Chantigny et al., 2004; Cheng et al., 2004; Liedl et al., 2006). Yields lower than those for conventional systems have nonetheless been reported for greenhouse tomato crops in connection with low concentrations of Ca^{2+} and Mg^{2+} and/or high salinity levels in growing media irrigated with AD liquid effluents (Cheng et al., 2004; Ponce et al., 2004). Hydroponic production of lettuce using moderate concentration of effluent was comparable to commercial nutrient solution, while tomato was negatively affected by the N-NH_4 form (Liedl et al., 2006). The two types of AD effluent, solid and liquid, have different nutrient compositions, which could be helpful in meeting nutrient management goals for growers (Liedl et al., 2006). On the other hand, our previous works showed that organic tomato cropping system on raised-bed containers where the main nutrients are given by compost and solid amendments, and drained water are recycled (Fig. 3), gave similar yield and fruit quality to conventional hydroponic growing systems (Gravel et al., 2009, 2010, in press). The recirculation of crop effluent and the use of nitrified AD-treated nutrient-rich green or animal manure as a source of fertilizer are promising avenues, though a better understanding of the temporal dynamics of nutrients, organic compounds and microorganisms is needed. Effluents coming from aquaculture are also a useful waste product for greenhouse crops that may contribute to improve the sustainability of these food industries. For example, aquaponics, defined as an integrated combination of aquaculture and hydroponics in which the fish waste provides nutrients to the plant and the plant acts as biofilter removing toxic compounds such as ammonia, may totally (i.e. leafy vegetables and herbs) or partly (i.e.

fruit vegetables) provide requested nutrients to the crop. Recent results have shown for some species that similar or higher productivity than conventional growing systems may be reached under high fish density and appropriate environmental conditions (Pantarella et al., 2010; Nichols and Savidov, in press; Savidov et al., 2007). Although certificated organic hydroponics using fish, bioreactor effluents or other organic liquid fertilizers is not allowed in most parts of the world except in USA and some Scandinavian countries, it may constitute a promising avenue to reduce nutrient emission (closed system) and reduce environmental burdens of this intensive cropping system. In contrast to conventional hydroponic growing systems using inert substrate and synthesized fertilizers, this living liquid organic culture system also contains beneficial compounds (amino acids, humic acids, phenolic compounds, etc.) and microorganisms that promote plant growth and productivity as well as protect the plant against pathogens.

SUPPLEMENTAL LIGHTING

Under Northern growing regions (e.g., 40 to 60°N latitude), the most limiting growing factor during winter time is the photosynthetic photon flux density (PPFD) as fruit vegetable greenhouse crops need around $30 \text{ mol m}^{-2} \text{ d}^{-1}$ of daily light integral (DLI), which is the amount of photosynthetic light accumulated within a 24-hour period, for an optimal growth and fruit quality. For reasonable production during winter, light sums of more than $12 \text{ mol m}^{-2} \text{ d}^{-1}$ are required to minimize risk of flowers or truss abortion (Dorais, 2004). Consequently, this technology may be integrated to our closed-loop growing system to provide year-round vegetables in a self-sufficiency context. During the last 20 years, it has been shown that SL under low light natural conditions such as found in Canada



increased vegetable yield of high quality and allowed a year-round production of locally-grown products (Gosselin et al., 2001; Dorais and Gosselin, 2002; Dorais, 2004; Heuvelink et al., 2006). Moreover, the use of high-pressure sodium (HPS) lamps may significantly contribute to the heating requirement. For ornamental, herbs and vegetable crops, recent studies have demonstrated that SL improves energy use efficiency (EUE) and economical feasibility, which has prompted the adaptation of SL in cucumber production across Canada (Dorais and Gosselin, 2002; Dorais et al., 2006; Erhioui et al., 2002; Hao and Papadopoulos, 2005). Because of the electrical cost increases in the last years, good progress has been made on lamp efficiencies and new lighting strategies have been proposed (Moe et al., 2006; Sterk et al., 2009). Under Finnish growth conditions, it was demonstrated for cucumber that SL given inside the plant canopy increases average yearly yield by 20% (19% during winter and 32% during spring). For tomato, the use of inside canopy lighting enabled a 10% increase of crop photosynthetic rate as compared to conventional top lighting although both had the same light energy integral (Van Ieperen and Trouwborst, 2008). The combination of HPS SL with inside canopy supplemental blue lighting (LEDs) increased cucumber growth (Ménard et al., 2006). Recently, various light sources and spectra have been examined. Results indicated that light quality and distribution pattern during the day may improve the biomass production of vegetables, and constitute a powerful tool to initiate specific physiological responses that improve EUE (Ménard et al., 2006; Moe et al., 2006). Supplemental photosynthetic light at the base of the crop canopy enables higher plant productivity since older leaves have a similar photosynthetic capacity to younger leaves (Hovi et al., 2004; Trouwborst et al., 2009).

CONCLUSION

Due to the increasing cost of fossil energy and conventional fertilizers, governmental regulations, environmental concerns and consumer demand for organic food products, growers are looking for more sustainable and organic systems. Under Mediterranean regions, the main negative impact of greenhouse tomato production derives from the biomass and plastic wastes (Antón et al., 2005) as well as the high consumption of fertilizers (Antón, 2008). In the case of landfill disposal, the environmental impact is mainly expressed by climate change, eutrophication, and photo-chemical oxidant formation (Antón et al., 2005), while reduction of 36% in N fertilizers leads to a 60% decrease in the potential impact of eutrophication (Munoz et al., 2008). For European Northern countries, however, energy use is responsible for about 75% of the total environmental impact of greenhouse tomato crop (van Woerden, 2001). To reduce the environmental

impact of greenhouse production systems and maintain its competitiveness, the use of renewable energy sources and suitable nutrient and waste management are becoming essential. Combining AD of agricultural waste, nitrification of AD digestate, and passive bioreactor or wetland can offer environmental and economic alternatives to improve the sustainability of the greenhouse industry. Our previous works showed that AD of pruned leaves is a promising biotechnology in terms of nutrients, CO₂, and green energy supply. The use of wetlands to treat runoff greenhouse effluent reduced by 65 to 100% the phosphate content and by 60 to 84% NO₃, which might have a significant environmental impact limiting the eutrophication.

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Roses in China: Germplasm, Production, and Cultivation

YunFeng Liu, ManLi Li and QingLin Liu

There are 95 *Rosa* species in China of which 65 are endemic. There are 54 Old China Rose cultivars distributed in Shandong, Henan, and Jiangsu Provinces. Many new rose cultivars are being bred in China such as 'Bingqing', 'Wangri Qinghuai', 'Yunxi', and new releases have been increasing. Almost every city in China has a rose garden and rose remains as a popular cut flower. The production of cut roses has been climbing continuously. In 2009, the production area of cut roses was 9021 ha, with 4 billion cut stems sold with a value of 172 million euros.

Among modern ornamentals, the rose holds an extremely important position throughout the world. Rose has a long history in China. Records can be traced back to the Han Dynasty, 206 BCE-220 CE (*Miscellanies about West Capital*) (Zhang and Zhu, 2006). The variability of climate and topography in China offers unique conditions for the distribution of *Rosa*, rose cultivation, cut flower production, and the construction of rose gardens.

DISTRIBUTION OF ROSA IN CHINA

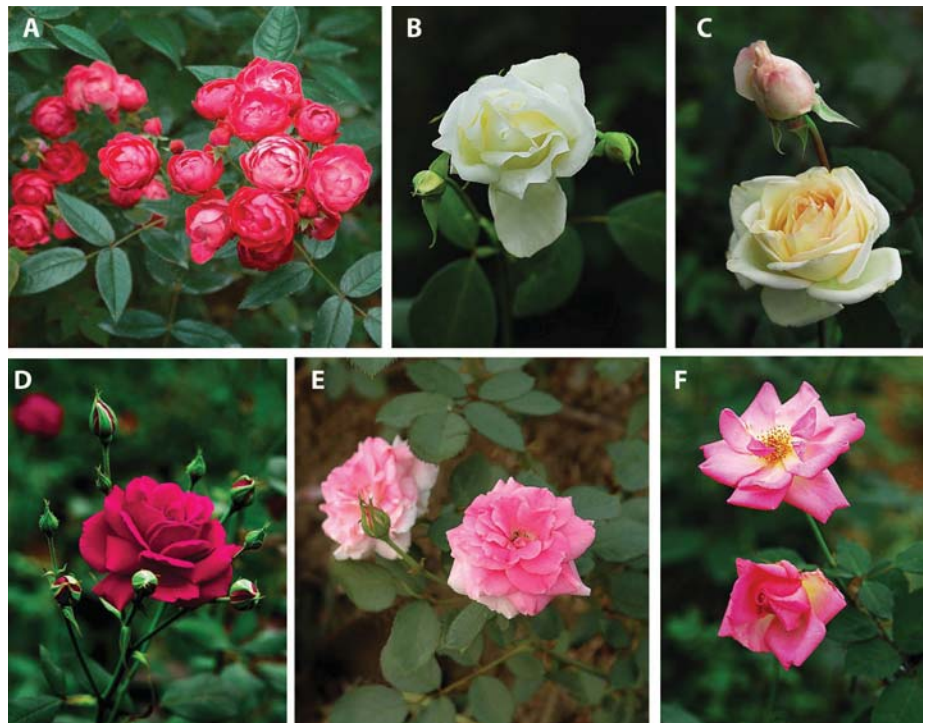
There are about 200 species of *Rosa* distributed from the subtropical to the cool temperate zones of the world, including Asia, Europe, North Africa, and North America. China is an important world center for *Rosa* and 95 species, nearly 48% of the total, are found in China, of which 65 are endemic (Hu et al., 2002). One species (*Rosa berberifolia*) belongs to the subgenus *Hulthemia* and the rest to the subgenus *Rosa*, which is divided into 8 sections: *Banksianae*, *Bracteatae*, *Chinenses*, *Cinnamomeae*, *Laevigatae*, *Microphyllae*, *Pimpinellifoliae*, and *Synstylae*.

Species of *Rosa* are found in 29 provincial administrative regions in China, the exceptions being Beijing, Tianjin, Shanghai, Hong Kong, and Macao. The Southwestern, Southern, Central, and Northwestern part of China share the widest distribution, and Taiwan alone has 13 species with 6 endemic (Table 1). Germplasm resources are indispensable for the genetic improvement of roses. For example, the perpetual flowering gene is derived from *Rosa chinensis* and the fragrance gene is derived from *Rosa odorata* (Zhang and Zhu, 2006).

Table 1. Distribution of *Rosa* spp. in China.

Province	Species		Province	Species	
	Total	Endemic		Total	Endemic
Anhui	10	1	Jiangxi	9	—
Chongqing	3	2	Jilin	9	1
Fujian	14	1	Liaoning	9	1
Gansu	27	—	Ningxia	2	—
Guangdong	13	—	Qinghai	5	—
Guangxi	11	1	Shaanxi	30	1
Guizhou	22	2	Shandong	5	—
Hainan	1	—	Shanxi	7	—
Hebei	8	—	Sichuan	57	11
Heilongjiang	6	—	Taiwan	13	6
Henan	11	1	Tibet	18	2
Hubei	23	—	Xinjiang	15	10
Hunan	7	—	Yunnan	48	13
Inner Mongolia	5	—	Zhejiang	15	2
Jiangsu	10	—			

Figure 1. Old China Roses. A. 'ChiLong HanZhu'; B. 'ChunShui LvBo'; C. 'JinOu FanLv'; D. 'RuanXiangHong'; E. YunZheng XiaWei'; F. 'YuShiZhuang'.



and the fragrance gene is derived from *Rosa odorata* (Zhang and Zhu, 2006).

OLD CHINA ROSES

Old China Roses have a long history in China (Fig. 1). According to the records of *New*

Rose Spectrum by Wen Sima of the Song Dynasty (960-1279) 17 rose cultivars were considered top grade. In the Qing Dynasty (1644-1911), 131 cultivars are recorded in the *Rose Spectrum* including 57 reds, 38 whites, 11 yellows, 11 purple-blacks, and 4 complex colors of which 10 were rated top

Table 2. Existing Old China Roses.

Location Cultivar	Color
Huaian	
DaFuGui	Pink
DanYun WeiYu	Light pink
EZhang JinBo	Yellow
FeiGe LiuDan	Yellow
JinOu FanLv	Light pink
RuanXiangHong	Purple
ShuangCuiNiao	Light green
ShuiMeiRen	Pink
SiMianJing	Dark red
YangChun BaiXue	White
YiJiFen	Pink
YinZhu QiuGuang	White
YuLingLong	Pink to white
YunZheng XiaWei	Pink
YuShiZhuang	Orange
Laizhou	
ChiLong HanZhu	Red
ChunShui LvBo	Green
DanMo EHuang	Yellow
GuoGuo DanZhuang	White
JinOu FanHuang	Yellow
LanTian BiYu	White
LiuChao JinFen	Yellow
XiaoFeng CanYue	White
YuYe FuRong	White
ZhaoXia CaiYi	Yellow

Figure 2. Modern rose releases of China: A. 'Bing Qing'; B. 'Fen Zuan'; C. 'Fu Rong Shi'; D. 'Hu Qing Shi'; E. 'Qiao Yu'; F. 'WangRi QingHuai'.



grade (Zhao and Zhang, 2008). Old China Roses remain a precious national heritage, and also an important source of germplasm for modern rose breeding. For example, 'Qiushui Furong' is still used as a source of disease resistance (Ma and Chen, 1993) and many cultivars of modern hybrid tea roses are based on Old China Roses.

During the past century, many valuable old cultivars have been lost for various reasons, and only about 54 old ones are left (Table 2). The China Rose Society has investigated and collected many old rose cultivars, which are currently conserved in various cities including Yangzhou and Huaiyin of Jiangsu Province, Laizhou and Pingyin of Shandong Province, Zhengzhou and Luoyang of Henan Province, and Xiaoshan of Zhejiang Province (Zhu, 1994; Wang, 2008).

NEW ROSE CULTIVARS BRED IN CHINA

The breeding of modern roses (Fig. 2) in China has recently received attention although the quantity and quality of new cultivars need to be improved. Since the start of the 21st century, a few scientific research institutes and flower companies have bred a number of high-quality cultivars (Table 3) including 'Beijing's Star' and 'Juxian', bred by Beijing Rose Society, and 'Bingqing' and 'Friendship' released by the Kunming Yang Rose Hort. Co., Ltd. However, there are limitations relating to the cultivation of modern roses in China due to lower

Table 3. New rose cultivars bred in China.

Year	Cultivar	Breeders	Year	Cultivar	Breeders	
2000	BingQing	Yang Rose	2005	YaSuNa	Tonghai Lidu	
	WangRi QingHuai	Yang Rose		YunMei	FRI	
2001	JingZhiXing	BRS	2006	YunXi	Tonghai Lidu	
	JuXian	BRS		YunFen	FRI	
	LuoXia	BRS		2009	FenZhuang	FRI
	NongXiangXie	BRS			FuRong Shi	Yang Rose
	Tongtong	BRS			HongWuYue	BILG
YanFen	BRS	HuaGuiRen	Jinyuan			
2002	YouYi	Yang Rose	HuangYing	Jinyuan		
2003	HongBaoShi	Yang Rose	HuQingShi	Yang Rose		
2005	AiFoLi	FRI	JinQingShi	Yang Rose		
	AiLi	Tonghai Lidu	KongQueShi	Yang Rose		
	AnQiLa	Tonghai Lidu	LianRenDao	Tonghai Lidu		
	FenZuan	Yang Rose	LiSha	Tonghai Lidu		
	LiNa	FRI	MiTang	FRI		
	MiQi	FRI	QiaoYu	Yang Rose		
	MiYa	Tonghai Lidu	Xin	Jinyuan		
	WaDi	FRI	YueGuang AiRen	Tonghai Lidu		
	YaMei	Tonghai Lidu	YunYan	FRI		

BILG = Beijing Institute of Landscape Gardening;
 BRS = Beijing Rose Society;
 FRI = Flower Research Institute, Yunnan Academy of Agricultural Sciences;
 Jinyuan = Kunming Jinyuan Flower Industry Co. Ltd.;
 Tonghai Lidu = Yunnan Tonghai Lidu Flower Industry Co. Ltd.;
 Yang Rose = Kunming Yang Rose Horticultural Co. Ltd.

demand as compared to Europe and America. Institutes or individuals focusing on new cultivar breeding are presently centered in Yunnan and Beijing. In 2004, Kunming Yang Rose Hort. Co., Ltd. obtained Plant Breeder's Rights for 'Bingqing' and at the present time 22 cultivars in Yunnan have been granted this protection. 'Bingqing', 'Wangri Qinghui' and 'Yunxi' have been placed into commercial production.

PRODUCTION OF CUT ROSES IN CHINA

Rose is presently the world's largest cut flower, and retains an important position in the flower industry. The cut rose production and sales in China have increased yearly (Lin and Liu, 2007). According to the statistical data of agriculture in China (Ministry of Agriculture of the People's Republic of China, 2003-2009), the production area, sales volume and sales value of cut rose have been growing continuously, but the unit yield and price had a peak in 2003 followed by fluctuating decline and increase in recent years (Fig. 3). The quality of cut rose has been increasing, which has contributed to the growth of unit price and sales value. However, unit yield still requires improvement.

ROSE GARDENS IN CHINA

A number of well-known rose gardens have been established for exhibition, research, and production. These gardens promote the development of the rose industry, and serve as important leisure places for local citizens (Table 4). Located in different parts of China, the gardens include a wide range of plant species and landscape features, embody the unique geographical and climatic conditions of their regions, and highlight the richness and diversity of rose germplasm (Fig. 4).

The Rose Garden in the Temple of Heaven in Beijing was established by Mrs. Endian Jiang from 1959 to 1963 and used to be the largest rose garden in Central China. Taicang Endian Rose Garden in Jiangsu Province was created to celebrate the centennial birthday of Mrs. Jiang, and is the first rose theme park named after a person.

The Rose Garden of Beijing Botanical Garden is one of the most famous in China. The Shenyang Expo Rose Garden covers an area of 10,000 m² with more than 3,000 rose cultivars. Huaian Rose Garden as well as Laizhou Rose Garden have the largest collection of Old China Roses.

Shijiazhuang Rose Park celebrates views, leisure, popularization of science, and scientific research. It is now the largest rose park in North China and the largest theme park of flowers in Hebei Province. Zhengzhou Rose Park was established in 1989 and became a free Rose Park, open to the public in 2005. Since

Figure 3. Area, sales quantity, and sales value of cut roses in China, 2003-2009.

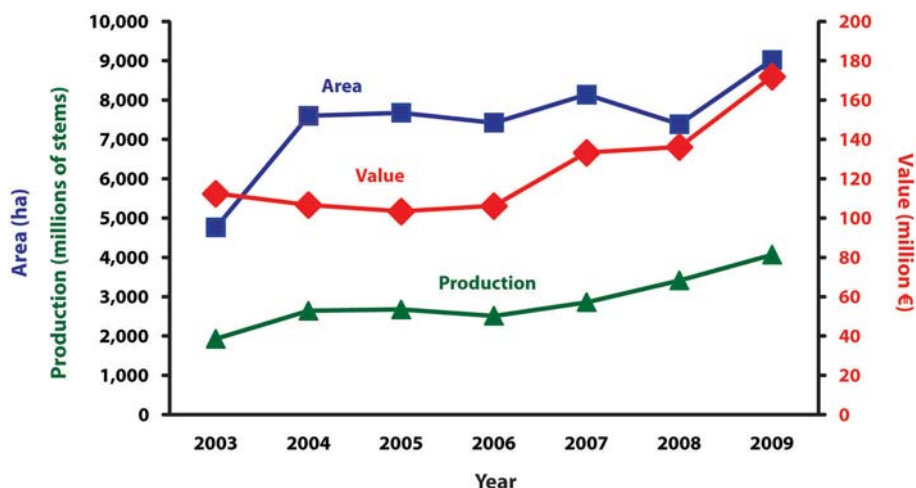


Figure 4. Rose gardens of China: A. ChangZhou Rose Garden; B. ShenZhen Renmin Park; C. Shijiazhuang Rose Park; D. ZhengZhou Rose Park.



Table 4. Rose gardens in China.

Name	Place	Year founded	Area (hm ²)	No. cultivars
Temple of Heaven Rose Garden	Beijing	1963	1.4	—
Huaian Rose Garden	Huaian, Jiangsu	1986	4.9	500
Laizhou Rose Garden	Laizhou, Shandong	1987	0.8	300
Zhengzhou Rose Park	Zhenzhou, Henan	1989	7	1000
Shenzhen Renmin Park	Shenzhen, Guangdong	1992	13.0	300
Beijing Bot. Gar. Rose Garden	Beijing	1993	7	800
Shijiazhuang Rose Park	Shijiazhuang, Hebei	2003	8.4	500
Shenyang Expo Rose Garden	Shenyang, Liaoning	2004	1	3000
Taicang Endian Rose Park	Taicang, Jiangsu	2008	15	700
Shengze Lake Rose Garden	Suzhou, Jiangsu	2008	40	600

Figure 5. Rose bonsai in ShenZhen Renmin Park.



the 1980s, its horticulturists have selected more than 10 new rose cultivars including 'Yellow Wave'. Rose Park in the Shengze Lake Ecological Zone forms a natural barrier around the Taihu Lake basin and takes on an important role for ecological environment protection and management. Shenzhen Renmin Park has developed rapidly since its establishment and is famous for its rose bonsai products (Fig. 5), which won the Garden Excellence Award by the World Federation of Rose Societies in 2009.

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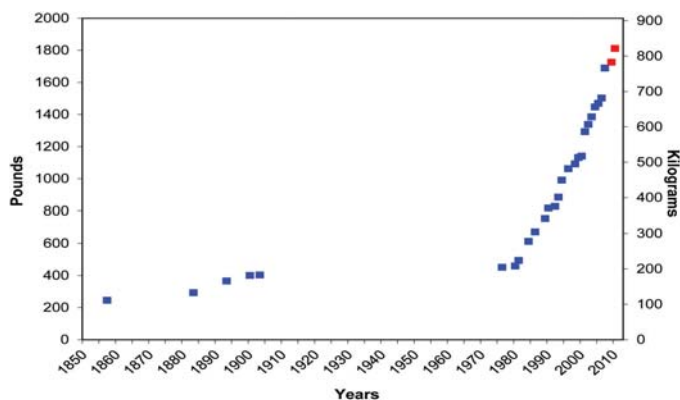
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New World Record for Giant Pumpkin, 2010

Don Langevin and Jules Janick

A new world record was achieved on October 8, 2010 when Chris Stevens of New Richmond Wisconsin, USA, brought in a 1,810.5 pound (821.4 kg) giant pumpkin at the Stillwater Harvestfest and Pumpkin Weigh off in Stillwater, Minnesota (Fig. 1). The 2009 record was broken by 85.5 pounds and the trend line since 1979 persists (Fig. 2). The weight of competing pumpkins at sanctioned contests for 2010 is astonishing: 433 exceeded 1000 pounds, 300 exceeded 1100 pounds, 186 exceeded 1300 pounds, 63 exceeded 1400 pounds, 28 exceeded 1500 pounds, 11 exceeded 1600 pounds, 2 exceeded 1700 pounds, and one exceeded 1800 pounds. In the last 17 years the record was broken 15 times indicating that 2000 pounds and then 1000 kg is within striking distance.

Figure 2. World records of pumpkin fruit weight, 1857 to 2010. The red squares are the 2009 and 2010 records, posted after the last article (Janick, 2008), indicating that the trend line since 1979 continues.



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Figure 1. Chris and Amy Stevens and their daughters Kailey and Amber celebrate their world record pumpkin at the Minnesota weigh-off.



ABOUT THE AUTHORS



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HISTORY

The Marigold: History and Horticulture

Judith M. Taylor

Marigolds (*Tagetes* spp., *Asteraceae*) are some of the most commonly grown and beloved ornamental bedding plants in the world. Their bright colors, very ease of culture, and ubiquity lead some sophisticated gardeners in Western countries to avoid them. The residents of Mexico and India have no such ambivalence. They adore them unconditionally. In Mexico, their center of origin, marigolds have religious significance. Catholic ritual has been superimposed on ancient Aztec practices, and the marigold flowers known as *flor de muertos* (flower of the dead) are used in the Day of the Dead celebrations associated with All Souls day. In more rural areas the plants still have culinary and herbal uses. In India, marigolds are one of the most important flowering plants. They are widely used in wreaths, sold everywhere, and common in many Hindu religious rites and ceremonies, as well as for culinary, industrial, and medicinal purposes. The way in which this foreign flower became so popular is not well understood, but there is no doubt that its golden color and vigorous growth symbolized the life giving force of the sun.

USES

In the United States, the marigold is a widely used bedding plant and some of the largest users of marigolds are public parks (Fig. 1). Parks need organized displays of reproducible flowers in clear bright colors making very forthright statements. Sturdy hybrids answer this purpose. Among their other virtues marigolds are remarkably resistant to the noxious gases in city air.

Decoctions of the flower heads are used as a tea in rural Mexico. Some are stimulating and



Figure 1. Marigolds in the park landscape make a vivid and striking statement.
Photo courtesy M. Dana.



diuretic, but others are relaxing and lead to mild euphoria. Because the plants were so exceedingly common in rural areas, the people collected the stems, formed them into bales, dried them, and used them as fuel. A modern use for the marigold is as a supplement to poultry feed. The standard commercial poultry ration even though otherwise adequate and nutritious is low in zeaxanthine and cryptoxanthine (yellow pigments). The carcasses of chickens fed this diet look pallid and unappetizing, because the subcutaneous fat is white rather than yellow, and the yolks of their eggs are pale. Poultry firms tried to make up for this deficiency in different ways but nothing worked very well. Marigold petals are rich in carotenoid pigments and industrial chemists recommended adding an extract of them to the poultry feed (Meyer, 2005). In the 1960s, the owners of Ralston Purina approached David Burpee, owner of Burpee Seeds for help. He developed the deeply pigmented 'Orangeade', 'Deep Orangeade', and more recently 'Scarletade' for this purpose. These series were grown on a gigantic scale in Mexico and Peru, but India and China currently grow the largest crops to supply this market.

Living marigolds have allelopathic effects due to bioactive compounds produced in their roots and have been used to control various species of nematodes (Wang et al., 2007). Burpee introduced 'Nema-Gone' (*T. patula* 'Single Gold') in 1997. 'Crackerjack' was reported to be effective against root lesion nematodes (*Platylenchus penetrans*) in tea (*Camellia sinensis*), but the cost of growing them on a large scale precludes their use (Neher, 1965).

BOTANY AND TAXONOMY

The genus *Tagetes* contains about 50 species. Despite the use of common names such as "French marigold" and "African marigold," *Tagetes* species are endemic to the Americas, primarily Mexico and Central America (Kaplan, 1960; Neher, 1965). Two species, the diploid *T. erecta* (African marigold), $2n=2x=24$, and the tetraploid *T. patula* (French marigold), $2n=4x=48$, are the basis of almost all of the modern garden cultivars. Note that the mari-

gold of the New World is not the marigold of Shakespeare which is clearly *Calendula officinalis* (Ellacombe, 1884).

Tagetes erecta, is called the "African" marigold because the first European herbalists thought the plants originated there (Fig. 2). The plant is tall and bushy with a rather uncompromising habit. For many years the flower was called "the rose of the Indies." Returning Spanish and Portuguese travellers probably carried seeds from Mexico back to Spain with them in the decade after Columbus' encounter with the New World.

Figure 2. *Tagetes erecta* plants. Photo courtesy M. Dana.



Tagetes patula was named the "French" marigold because early scholars thought it originated in France but little is known how it got there. The seeds were sent to the royal garden in Paris quite soon after the plant was found by the Spanish, under the impression that it came from China. The plants are considerably smaller than *T. erecta*, and much more graceful with variable coloring ranging from pale yellow to deep mahogany red (Fig. 3). It is this feature which has permitted the development of so many attractive commercial cultivars.

Inter-specific crossing has produced the triploid group of marigolds, $2n=3x=36$, bushy annuals that are derived from crosses of *T. erecta* and *T. patula*. The ability to breed modern cultivars of *T. erecta* efficiently and relatively inexpensively was facilitated by the discovery of spontaneous clusters of apetalous, pistillate plants in a field belonging to Burpee Seeds in the early 1950s.

Figure 3. *Tagetes patula*. Photo courtesy M. Dana.



A distant third species in the horticultural trade is *T. lucida*, a smaller plant with lacy foliage and delicate panicles of much smaller flowers (Fig. 4). This plant is very aromatic, resembling the flavors of licorice and fennel. *Tagetes lucida* the "sweet marigold," was grown for many years but is not part of modern commercial breeding and is sold by nurseries specializing in culinary herbs. Neher (1965) in a revision of *Tagetes* considers this type to be subgeneric.

A dwarf form of *T. pumila* is sometimes referred to as a separate species, *T. tenuifolia*. It was discovered in the early years of the 20th century, and has been used extensively to provide a miniature gene in commercial breeding. Burpee's 'Signet Pumila' is of this type. This species is sometimes found in modern gardens because of its attractive feathery foliage.

Figure 4. *Tagetes lucida*. Courtesy Hunt Institute of Botanical Documentation, Carnegie Mellon University Pittsburgh.



HISTORY

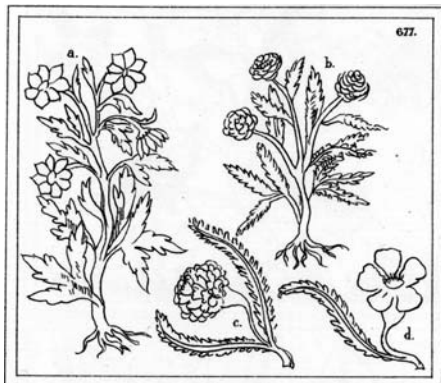
New World

The history of *Tagetes* and its migrations has not been clearly documented. Unlike valuable drug plants or spices, marigold seems to have reached Europe through the "back door" and its movements can only be discerned by inference. Long before any reliable descriptions of the flower were recorded in America, the marigold was found to be growing in Spain. It probably arrived in the first decade of the 16th century and appeared in Lisbon and North Africa over the next 20 years. All else is conjecture.

The first authoritative descriptions of marigold came from two reliable Spanish observers, Fray Bernardino Sahagún (1499-1590) and Dr. Francisco Hernandez (1514-1587). Their careful work established that the plants originated in Mexico and Central America. Fray

Sahagún's *Historia General de las Cosas de Nueva Espana*, known as the *Florentine Codex*, written between 1540 and 1585, was devoted to medicine and herbals. He mentioned a plant with yellow flowers he called *Cempo* (also spelled *sempo*)-*alxochitl*. *Xochitl* means ornamental flower in Nahuatl. Sahagún described both single and double forms of marigolds and thought they had a nice odor. Although most of the marigolds he saw were grown intentionally, he noticed plants coming up as volunteers. He included black and white drawings of the flowers now thought to be *T. erecta* (Fig. 5), although few would say that the odor is pleasant. He also mentioned the Nahuatl term "yhautili" and associated it with a flower possibly a marigold but distinct from *Cempo-alxochitl*.

Figure 5. Drawings of marigold by Fray Bernardino Sahagún *Historia General de las Cosas de Nueva Espana*, now thought to be *Tagetes erecta*. Courtesy Bancroft Library, University of California at Berkeley.



Before Fray Sahagún's work was completed two of his former Aztec students (Martin de la Cruz and Juan Badianus) prepared what is now known as the *De La Cruz-Badianus Aztec Herbal* of 1552. De la Cruz painted pictures of the flowers and plants and Badianus squeezed the Latin words into the rest of the space (Fig. 6). The tiny book, about 15 cm tall, was done with extreme care. The manuscript ended up in the Vatican Library where it was found by the American scholar Charles Clark in 1928. Its discovery created a minor sensation (Gates, 1939; Emmart, 1940).

Plantas y Animales de las Nueva Espana, by Dr. Francisco Hernandez, appointed Protomedico by Philip II for New Spain, was completed in 1577 but not published until 1651. The work confirmed Sahagún's observations about *Cempo-alxochitl* (Varey et al., 2000). Hernandez noted that the Spanish called this flower the "dianthus of the Indies," not a bad description.

Herbals

The authors of the early European herbals, Jerome Bock (Hieronymus Tragus), Leonhart Fuchs (Leonhardus Fuchs), Mattias de L'Obel

Figure 6. Illustration of *Copaliyac xiuhtontli* from the *De la Cruz-Badianus Manuscript*, plate 52, identified as *Tagetes* spp. (Emmart, 1940). Courtesy San Francisco Garden Club.



(Lobelius) and Charles de L'Écluse (Carolus Clusius), worked from both the plants themselves and the accounts of travellers who had seen them in Spain, Portugal, France, and North Africa. Most were unaware the plants came from the Americas. None of the Spanish texts described above would have been available to them. Very little is known about how the plants migrated but it is hardly surprising that an attractive and useful plant would emigrate to new lands.

In his herbal *De Stirpium* of 1552, Bock described a flower which was clearly *T. erecta* under the name of *Garyophyllis indica*. Bock reports that the flowers reached Germany in the time of the Emperor Charles V, 1500-1558. Fuchs, in his famous herbal of 1543, *De historia stirpium commentarii insignes*, was the first person to use the word *Tagetes* (Meyer et al., 1999). However, he was convinced the plant was a type of *Artemisia* (*A. monoclonos*) and mentions that it was called *Tanacetum* by Apuleius, a corrupt form of *Tagetes*, and *Rienfarn* in German because it closely resembles a fern in appearance and grows on the banks of streams. He also confirms it was called *Garyophyllos indos*, as mentioned by Bock. He states that "for this reason we have called it *Tagetes indica*, but in German *Indianische nege-len*. A painting identified as *Tagetes patula* can be found in his unpublished work now called the *Vienna Codex* (Fig. 7).

Mattias de L'Obel published a drawing and description of *T. erecta* in *Plantarum, seu,*

Figure 7. Painting from an unpublished work of Leonhart Fuchs known as the *Vienna Codex* and identified as *Tagetes patula* (Meyer et al., 1999). Courtesy Austrian National Library, Vienna.



Stirpium Historia in 1576. In a later book published in 1581, he was the first author to use the term *Flos africanus*. He thought the plant came from North Africa and commented that the flowers grew spontaneously on the banks of the Tagus River.

Charles L'Écluse, known by his Latin name of Carolus Clusius, 1526 to 1609, was an extraordinary botanist. After a long and distinguished career in several countries he retired to Leiden in The Netherlands and established a botanical garden for the city, the Hortus Academicus. His meticulous records made it possible to reconstruct the garden. He did not include *Tagetes* in his planting lists of 1594 and 1596 but did include it in 1600 (Gerda van Uffelen, pers. commun.) Clusius was also involved in setting up the collection of floral paintings later known as *Libri Picturati* that included marigolds (Fig. 8).

India

Marigolds are so entwined with religious life in India that it is hard to imagine they were only imported a few hundred years ago. No other flower is as popular in India (Figs. 9 and 10). The flowers are braided into garlands and swags for weddings and decorate temples for various ceremonies. The flowers are also used as a dye, for medicinal purposes, and as a flavoring. Its name varies by province and local language, indicating how deeply it penetrated Indian culture.

The route of *Tagetes* to India is an enigma. Sir George Watt, an Indian civil servant and former superintendent of the industrial section of the



Figure 8. *Tagetes erecta*, watercolor from the collection *Libri Picturati*, commissioned by Karel van Sint Omaar. Painted by Jacob van Corenhuyse, ca 1560. Courtesy Jagiellonian Library, Jagiellonian University, Krakow.



Indian Museum, suggested in his *Dictionary of the Economic Products of India*, 1893, that the plant's primary appearance in Western India coincided with the activities of the Portuguese colonists in Goa but this has been difficult to substantiate. There is one clue. Goa acted as an escape valve for many Portuguese Jews who emigrated to avoid the Inquisition (Garcia da Orta, 1563). This angered the Jesuit Francis Xavier, 1506-1552, a colleague and student of

Ignatius Loyola and one of the seven priests who initiated the Society of Jesus. He travelled to Goa in 1541 and was so upset by the presence of Jews as well as by what he called "rice Christians," Hindus who had converted after being bribed with food, that in 1546 he wrote to King Joao III and asked him to send representatives of the Inquisition to restore the purity of Christianity in Goa. Among the rice Christians' "crimes" was the use of turmeric, basil leaves, incense, or *marigolds*.

Once the English were entrenched in India, a number of pioneering British botanists studied the flora using Western scientific methods. William Roxburgh's *Flora of India* (1820) contained a brief entry about the marigold. Marigold was also noted almost 20 year later in *A Catalogue of Plants Growing in Bombay* by John Graham (1839). Each author knew the flower was not native to India but neither commented on how the plant might have arrived there.

United States

Three species of *Tagetes* appear sporadically in 19th century in American nursery as well as English catalogues. Although some species of *Tagetes* are native to the American Southwest, that flower was not commonly cultivated. The Meso-American species were introduced into the United States at different times (Adams, 2004).

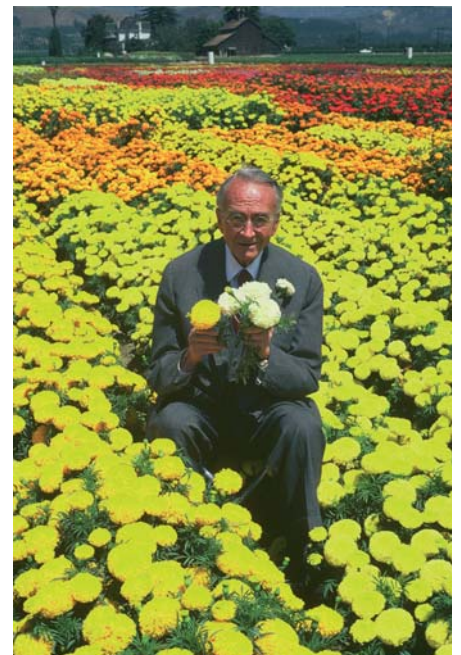
The mid-1930s saw a large increase in the available number of hybrid *Tagetes* available, of both *T. erecta* and *T. patula*. An analysis of 100 years of Burpee catalogues indicates that the firm offered between 10 and 12 cultivars for sale annually between 1887 and 1931, and then the numbers grew exponentially (<http://horthistoria.com/?p=270>).

Figure 10. Elephants made of marigold flower heads used at Indian festivals. Photo courtesy R.K. Roy.



Many of the modern marigold's manifest virtues were instilled into them in California over the past 80 years. Much of this was due to the enthusiasm and drive of one man, David Burpee, the son of W. Atlee Burpee (1858-1915) who founded Burpee Seeds and established the Floradale Farms in Lompoc, California in 1909 (Fig. 11). David took over the company at the death of his father. Marigolds were listed in Burpee's catalogues from 1887. In 1905 Burpee Seeds offered 'Lemon Gold', the first fully double marigold. Marigolds were not yet very popular in the United States and David Burpee wanted to encourage their growth. He would stop at nothing to build his business.

Figure 11. David Burpee in a field of marigolds. Photo courtesy Mark Mondry.



Before World War II Burpee Seeds released many new cultivars by selecting from open-pollinated seed but thereafter new cultivars were released as a result of hybridization programs. In 1937 Burpee released the 'Crown of Gold'

Figure 9. Street vendor in India selling marigold garlands. Photo courtesy Jules Janick.



which won a gold medal at the All-America Selections show that year. In 1939 the 'Red and Gold' marigold, the first interspecific hybrid, was released, and in 1966 'Nuggets', the first of the triploid series was introduced. These three cultivars were to change marigold history.

F₁ hybrid breeding was becoming feasible on an industrial scale when Burpee introduced its "Climax" series in the late 1950s. These were tall "African" cultivars with fully double flowers. Burpee called the series 'Climax' because it was the end of a very long period of experimentation.

Through the years Burpee Seeds introduced more than 330 marigold cultivars. In the roughly 70 years of the All-America Selections trials, there have been 48 awards for marigolds and three gold medals. Burpee Seeds won 17 of the 48 awards. At present Burpee Seeds features 23 cultivars of marigolds for sale. More than half of them are old stalwarts which have been in commerce for more than 20 years. One of these, 'Sunset Giants', was released in 1941, 70 years ago. 'Orange Ball' remained in the catalogue for 71 years (1892-1962). The new 'Cottage Red' is a cultivar of *T. tenuifolia*. Other major breeders of modern marigold cultivars in the United States include the firms of Ball, Bodger, Denholm, and Goldsmith (cover photograph).

David Burpee was unrelenting in his single-minded search for a pure white marigold (Fig. 12) and announced a national competition to find one, offering \$10,000 in 1954. The prize was awarded to 67-year-old Alice Vonk of Sully, Iowa in 1975. Burpee had released an almost white marigold 'Man in the Moon' in 1954 (withdrawn in 1962) but a similar one was introduced in 1971 under the name 'Man on the Moon' to honor the successful NASA moon landing in 1969.

Figure 12. White cultivar of *Tagetes erecta*, introduced by Burpee Seeds. Photo courtesy Mark Mondry.



The release of marigold seed treated with gamma rays to induce mutations for school children science fairs became the inspiration for a Pulitzer Prize winning play, "The Effect of Gamma Rays on Man-in-the-Moon Marigolds" written by Paul Zindel, a New York City school teacher in 1971. The closing lines spoken by the young girl in her science project still reverberate:

"For one thing, the effect of gamma rays on man-in-the-moon marigolds has made me curious about the sun and the stars, for the universe itself must be like a world of great atoms – and I want to know more about it. But most important, I suppose,

my experiment has made me feel important – every atom in me, in everybody, has come from the sun - from places beyond our dreams. The atoms of our hands, the atoms of our hearts..."

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Introduction and Migration of Ornamental Trees to India

R.K. Roy

The migration of trees from one country to another is a result of social, cultural, political and trade interaction. In India, many new tree species were introduced by the British, Portuguese, Mughal rulers, travelers, traders, and garden enthusiasts from the 15th to 18th centuries. The main sources of new plants were other countries in Asia as well as America, Australia, Africa, and Europe. With the passage of time, many of these taxa have been so naturalized that they have become part of Indian flora. A number of them are quite remarkable for their unique flowers, fruits, and form. Some adorn Indian gardens but have not been well documented and a few are so rare that only a few living specimens exist. The migration routes of trees to India and a census of introduction made will help to formulate strategies for future conservation.

India have old specimen plants of this species. A 200-year-old specimen is in existence in a remote hamlet of the state of Uttar Pradesh and has been given several local names ('*Parijat*', '*Kalpavirksh*') and is a tourist attraction due to its curious shape. There are many classic examples of immigrant tree species in India.

India has a wide variety of agro-climatic conditions classified into 10 phyto-geographic zones. Moreover, Indian flora is rich in diversity with many endemic species. It is estimated that over 45,000 species of plants can be found, which represent 11% of the known plant species of the world. Angiosperms constitute 15,000 species, which represent 6% of the world's known flowering plants (Rao, 1968, 1994).

Many new tree species were introduced to India particularly during the Mughal period (1526-1658) and colonial era (1529-1900).

PLANT MIGRATION TO INDIA

Plant migration is a global phenomenon that has been accelerated by conquerors, traders, travelers, sovereigns, diplomats, missionaries, botanists, and plant explorers (Janick, 2007; Taylor, 2009, 2010). Most of our crop plants are a result of this massive, global migration. The same is true for ornamental plants and trees that have been exchanged due to their attractive flowers and foliage, new fragrances, delicious fruits, and medicinal values. In India, some of these ornamental tree introductions have been naturalized and are now considered part of the natural flora. For example, *Adansonia digitata* (Fig. 1), a native of Africa, has become acclimatized and naturalized in India. The tree

has an interesting structure, particularly the caudiciform trunk. The fruits are fleshy, sour, high in calcium and antioxidants. This is also known as '*gorakh imli*' (Imli = tamarind or sour taste), "upside-down" (due to un-common branching pattern). Many botanical gardens, zoological gardens, and heritage garden sites in

Figure 1. *Adansonia digitata*.



Figure 2. Major migration routes to India.



Figure 3. Prominent botanical gardens in India involved in plant introduction.



Portuguese, Dutch, and French invasions for trade also contributed new introductions. These new plant species further enriched diversity and new ornamental trees were incorporated in Indian gardens. However, the dates of introduction are often unknown since proper records were not maintained. Furthermore, data on these immigrant trees are not included in the census of Indian flora making it difficult to trace information on their introduction and source (Roy, 2008a).

ROUTES AND RECORDS OF MIGRATION

The main sources of introduced ornamentals were Central and South America, Tropical Africa, Australia, China, and various other Asian countries including Japan, Malaysia, Myanmar, Mauritius, Philippines, and Sri Lanka (Fig. 2). However, the exact routes and records of introduction of plant species had not been documented properly making it difficult for accounting and evaluation of present status. The gardening renaissance in India initiated by Mughal emperors, true lovers of plants, started this process (Janick et al., 2010). Many new flowers and ornamentals from Persia and Central Asia were introduced for their gardens. Buddhist monks, travelers, and other religious leaders who visited India frequently from China, Japan and other Asian countries also brought in new plant species to India enriching its flora (Villiers-Stuart, 1913; Randhawa, 1976).

British rule beginning in 1529, encouraged the introduction of ornamental plants by missionaries and civil servants while at the same time Indian native flora was introduced to Europe. The establishment of Agricultural and Horticultural Societies, Botanical and Horticultural Gardens in India by the British rulers was a significant step towards introduction, evaluation, and popularization of new ornamental and useful plant species. The first Flower and Vegetable Show was organized at the Garden of The Agricultural Society, Calcutta as early as 1828 (Bose, 1966; Randhawa, 1983).

Botanical Gardens played a key role in the introduction of new plants to India (Fig. 3). The main center of introduction was the Royal Botanic Garden (established 1787), in Calcutta, West Bengal. This Garden was credited with the introduction of ornamentals such as *Amherstia nobilis*, *Bougainvillea*, *Brownea* spp., *Swietenia* spp., *Victoria amazonica*, *Lodoicea maldivica* and economic plants such as tea, coffee, coca, cotton, vanilla, oil palm (Bose et al., 1987). Lalbagh Botanical Garden (established 1760) in Bangalore, Karnataka was another landmark center introducing *Agathis* sp., *Amherstia nobilis*, *Araucaria* sp., *Averrhoa bilimbi*, *Brownea grandiceps*, *B. rosea*, *B. ariza*, *B. kewensis*, *Callistemon lanceolatus*, *Castenospermum australe*, *Cola acuminata*, *Corypha umbraculifera*, *Couroupita guianensis*, *Cupressus* sp., and *Swietenia mahagoni* (Anon., 2002).

Table 1. Prominent introduced genera in India and their source.

AFRICA

TROPICAL AFRICA

Genera: *Adansonia*, *Baikiaea*, *Blighia*, *Bridelia*, *Colvillea*, *Cola*, *Colvillea*, *Dolichandrone*, *Fugosia*, *Gilircidia*, *Kigelia*, *Kleinhovia*, *Markhamia*, *Monodora*, *Mitriostigma axillare*, *Napoleona*, *Nauclea*, *Oncoba*, *Peltophorum*, *Ravenala*, *Solanum*, *Spathodea*, *Tamarix*

Families: *Annonaceae*, *Bignoniaceae*, *Bombacaceae*, *Caesalpinaceae*, *Euphorbiaceae*, *Fabaceae*, *Flacourtiaceae*, *Lecythidaceae*, *Malvaceae*, *Musaceae*, *Myrtaceae*, *Rubiaceae*, *Sapindaceae*, *Solanaceae*, *Sterculiaceae*, *Tamaricaceae*

SOUTH AFRICA

Genera: *Podocarpus*, *Schotia*

Families: *Fabaceae*, *Podocarpaceae*

SEYCHELLES

Genus: *Lodoicea maldivica*

Family: *Palmae*

AMERICAS

NORTH AMERICA

Genus: *Gleditsia ferrox*

Family: *Caesalpinaceae*

SOUTH & CENTRAL AMERICA

Genera: *Andira*, *Bixa*, *Bombax*, *Brownea*, *Caesalpinia*, *Calophyllum*, *Chorisia*, *Chrysophyllum*, *Citharexylum*, *Clusia*, *Cordia*, *Couroupita*, *Crescentia*, *Gilircidia*, *Guaiacum*, *Guazuma*, *Gustavia*, *Hura*, *Hematoxylon*, *Inga*, *Ipomoea*, *Jacaranda*, *Muntingia*, *Parkinsonia*, *Parmentiera*, *Plumeria*, *Prosoqueria*, *Samanea*, *Solanum*, *Swietenia*, *Tabebuia*, *Tipuana*, *Tripalis*

Families: *Apocynaceae*, *Bignoniaceae*, *Bombacaceae*, *Boraginaceae*, *Bixaceae*, *Caesalpinaceae*, *Convolvulaceae*, *Elaeocarpaceae*, *Euphorbiaceae*, *Fabaceae*, *Guttiferae*, *Lecythidaceae*, *Meliaceae*, *Polygonaceae*, *Mimosaceae*, *Rubiaceae*, *Sapotaceae*, *Solanaceae*, *Sterculiaceae*, *Tiliaceae*, *Verbenaceae*, *Zygophyllaceae*

ASIA

CHINA

Genus: *Koelreuteria paniculata*

Family: *Sapindaceae*

MYANMAR

Genera: *Amherstia*, *Cananga*, *Millettia*, *Pentace*

Families: *Annonaceae*, *Tiliaceae*, *Caesalpinaceae*, *Fabaceae*

MALAYSIA

Genera: *Artocarpus altilis*, *Kleinhovia*, *Syzygium samarengense* 'Rosea'

Families: *Moraceae*, *Sterculiaceae*, *Myrtaceae*

PHILIPPINES

Genus: *Agathis*

Family: *Arucariaceae*

SRI LANKA

Genera: *Peltophorum*, *Schleichera*

Families: *Caesalpinaceae*, *Sapindaceae*

AUSTRALIA

Genera: *Acacia*, *Ailanthus*, *Araucaria*, *Brassaia*, *Bursaria*, *Callistemon*, *Castenospermum*, *Casuarina*, *Eucalyptus*, *Grevillea*, *Melaleuca*, *Polyalthia*, *Wrightia*

Families: *Annonaceae*, *Apocynaceae*, *Araliaceae*, *Araucariaceae*, *Casuarinaceae*, *Fabaceae*, *Mimosaceae*, *Myrtaceae*, *Pittosporaceae*, *Proteaceae*, *Simarubaceae*

EUROPE

Genera: *Salix*, *Juniperus*

Families: *Salicaceae*, *Cupressaceae*

Other important centers that played significant roles in the introduction, acclimatization, and popularization of various plant species include the botanical gardens at Lucknow (1800) and Saharanpur (1817), Uttar Pradesh;

Lloyd Botanical Garden (1878), Darjeeling (West Bengal); the Government Gardens of Mysore (1856) and Ootacamund (1847) as well as the Agricultural-Horticultural Societies in Calcutta (1830), Madras (1836), and Bombay (1830).



People who made significant contributions in the field of introduction and domestication of new ornamentals, including crop plants, include Col. Robert Kyd (1787-1793), Dr. William Roxburgh (1793-1815), Rev. William Carey (1813-1817), Dr. Nathaniel Wallich (1817-1820), Joseph Hooker (1848-1863), and Mr. S. Percy Lancaster (King, 1895; Burns, 1930; Burkill, 1953). There are various taxa named to commemorate these personalities such as *Putranjiva roxburghii*, *Careya arborea*, and *Lagerstroemia* 'Lancasteri'.

IMMIGRANT TREES

In order to make a census of the trees introduced to India, the available literature, publications, historical documents, and lists of germplasm collections from various institution's societies and botanic gardens, were analyzed and gardens were surveyed for physical verification. On the basis of this study, it is estimated that 70-80 new genera / species belonging to 30-35 families have been introduced from abroad. The major families involved are *Bignoniaceae*, *Caesalpiniaceae*, *Fabaceae*, *Lecythidaceae*, *Myrtaceae*, and *Sterculiaceae*, and the main sources of germplasm were tropical parts of America, Africa, and Australia (Table 1).

A number of these immigrant tree species have become rare due to lack of attention, propagation problems, and changing effects of climate (Roy and Goel, 2007; Roy, 2008b, 2009). An inventory of rare trees has been prepared along with their location to draw attention to the conservation measures required (Table 2).

Napoleon's Button (*Napoleona heudelotii* Beauv., *Lecythidaceae*)

Napoleona heudelotii (Fig. 4) was first noticed by A.P. Beauvois, a Frenchman, during his trip to central Africa (around 1800) and the genus

Figure 4. *Napoleona heudelotii*.



Table 2. Some immigrant rare trees and their locations in India.

Family	Species	Location
<i>Annonaceae</i> <i>Bignoniaceae</i>	<i>Monodora grandiflora</i> <i>Crescentia cujete</i> <i>Kigelia pinnata</i> <i>Parmentiera cereifera</i>	A few specimens (AHSI) Selected gardens (AHSI, IBG, NBRI) Selected gardens (NBRI, IBG, LBG) Selected gardens (NBRI, LBG)
<i>Bombacaceae</i>	<i>Adansonia digitata</i>	Very old specimens (NBRI, LBG, ZG). Bears viable seeds, requires popularization (AHSI, NBRI, IBG)
<i>Caesalpiniaceae</i>	<i>Bombax ellipticum</i> , <i>B. ellipticum</i> 'Album' <i>Amherstia nobilis</i>	Probably best introduction of flowering trees, requires conservation measures. A few specimens exist in eastern & southern India (AHSI, IBG, LBG)
	<i>Baikiaea insignis</i> <i>Caesalpinia cacalaco</i> , <i>C. coriaria</i> <i>Brownea coccinea</i> , <i>B. grandiceps</i> , <i>B. macrophylla</i> , <i>B. kewensis</i>	(AHSI) (AHSI, NBRI) Unusual, fascinating flowers (AHSI, IBG, LBG)
<i>Convolvulaceae</i> <i>Euphorbiaceae</i> <i>Fabaceae</i>	<i>Ipomoea arborescens</i> <i>Hura creptance</i> <i>Castanospermum australe</i> <i>Schotia latifolia</i> <i>Tipuana tipu</i>	(NBRI) (NBRI) (AHSI, NBRI) (AHSI, LBG) (LBG)
<i>Lecythidaceae</i>	<i>Couropita guianensis</i> <i>Gustavia augusta</i>	(AHSI, IBG, LBG) (AHSI, IBG)
<i>Myrtaceae</i>	<i>Napoleona heudelotii</i> <i>Melaleuca leucadendron</i> <i>Syzygium samarengense</i> 'Rosea'	One plant exists (AHSI) (NBRI, IBG, LBG, BARC) (AHSI)
<i>Polygonaceae</i> <i>Rubiaceae</i> <i>Tiliaceae</i> <i>Verbenaceae</i>	<i>Triplaris surinamensis</i> <i>Nauclea orientalis</i> <i>Pentace burmanica</i> <i>Citharexylum quadrangular</i>	(NBRI, LBG) (AHSI) One plant (AHSI) (AHSI, IBG)

AHSI = The Agri-Horticultural Society of India, Calcutta, West Bengal;
BARC = Bhabha Atomic Research Centre, Bombay, Maharashtra;
LBG = Lalbagh Botanical Garden, Bangalore, Karnataka;
IBG = Indian Botanic Garden, Howrah, West Bengal;
NBRI = National Botanical Research Institute, Lucknow, Uttar Pradesh;
ZG = Zoological Gardens, Lucknow, Kolkata.

was named after French Emperor Napoleon. It is presumed that the tree travelled from France to the United Kingdom and was then brought to India. It is a tree of medium height with curious flowers resembling a shallow cup with lobes in a crown shape, reddish in color, borne on the leaf axil. A single live specimen exists in the Garden of AHSI, Calcutta.

Orchid Tree (*Monodora grandiflora* Benth., *Annonaceae*)

Monodora grandiflora (Fig. 5) is native to central Africa and reached Europe from Jamaica and Trinidad in the 18th century. It was probably introduced to Calcutta from Europe. The plant is very difficult to propagate vegetatively and there is no seed set. The orchid-like flowers

Figure 5. *Monodora grandiflora*.



Figure 6. *Amherstia nobilis*.



Figure 7. *Tipuana tipu*.



Tipu Tree [*Tipuana tipu* (Benth.) Hubb. & Rehd., Fabaceae]

This beautiful tree from South America, commonly known as pride of Bolivia and rose wood, is mainly grown for its golden yellow pea-like flowers (2 cm in diameter), borne on long panicles and bright green foliage (Fig. 7). 'Tipa' is a vernacular name of this tree in Bolivia and the species was described and named by Hubbard & Rehder as *Tipuana tipu*. The details of its introduction to India are unclear. A few trees exist in the Lalbagh Botanical Garden.

LANDSCAPE USE

Introduced ornamental trees (Fig. 8) have been widely used in landscaping and their popularity has created great opportunities in the nursery trade even more so than Indian genera. Attractive flowers, curious fruits, and graceful foliage have been highly appreciated by garden lovers. Initially, they were

planted in botanical gardens as well as the residential gardens of civil servants. Over the decades, many of the introduced trees became well acclimatized and soon adorned many Indian gardens and landscapes. The most popular introduced genera were *Acacia*, *Adansonia*, *Araucaria*, *Caesalpinia*, *Callistemon*, *Casuarina*, *Chorisia*, *Couroupita*, *Grevillea*, *Jacaranda*, *Milletia*, *Plumeria*, *Spathodia*, *Swietenia*, and *Tabebuia*. A few have been so popular and integrated that they have been associated with religious pursuits and given new local names.

CURRENT RESTRICTIONS ON GERMLASM MIGRATION

Access, exchange, and trade of the plant genetic resources of the world by individuals or institutions are now governed by several international conventions and laws including Convention of Biological Diversity (CBD), 1993; The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1975; International Union for the Protection of New Varieties of Plants (UPOV), 1961; and Agreement on Trade Related Aspects of Intellectual Property Right (TRIPS), 1994. In addition, there are many Intellectual Property Rights (IPR) issues. These laws regulate, restrict, and monitor movement, trade, and conservation. The objective is sustainable utilization of plant genetic resources and the encouragement, recognition, and sharing of benefits equitably (Anon., 1992; Kallo, 2005). These restrictions make possible the documentation and tracing of the movement of plant genetic resources.

Before the enactment of these laws, there was open access to the world plant genetic resources, still considered desirable by many.

Figure 8. Attractive introduced ornamental trees: (A) *Harpullia pendula*; (B) *Koelreuteria paniculata*; (C) *Couroupita guianensis*; (D) *Gustavia insignis*; (E) *Tabebuia palmeri*; (F) *Triplaris surinamensis*.



with yellow-red spots in pendent peduncle are extremely attractive.

Queen Amherstia (*Amherstia nobilis* Wall. Caesalpinaceae)

Amherstia nobilis (Fig. 6) is considered to be the Queen of Flowering Trees. It was first noticed in 1826 in Burma (Myanmar) by Dr. Nathaniel Wallich, the Danish discoverer who was also Director of Royal Botanic Garden, Calcutta and the monotypic genus was named after Countess Amherst (British Governor) and her daughter, Lady Sarah. Flowers are gorgeous and appealing in graceful hanging racemes. The tree was introduced in the then Royal Botanical Gardens, Calcutta from Burma by Dr. Wallich and spread to different royal residences and the gardens of Calcutta.

This resulted in the movement of genetic resources from one country to another for various purposes, especially commercial. This was thought by some to result in over-exploitation and genetic erosion without benefit sharing. The fallout was the enactment of international laws / conventions for the protection of plant genetic resources.

In view of current international laws and their applicability world wide, many countries have enacted their own laws to protect their genetic resources. They have identified organizations and institutions for issuing permits for import and monitoring movement of plant genetic resources including utilization. The National Bureau of Plant Genetic Resources (Indian Council of Agricultural Research), New Delhi (1976) has been entrusted with this responsibility in India. It is suggested that botanical institutions, gardens and agri-horticultural societies cooperate to survey introduced ornamental tree species, as the rare specimens are in need of conservation measures. The partners of such an initiative could be the Botanical Survey of India, Biological Research Institute of CSIR, Bombay Natural History Society, Mumbai; Asiatic Society, Kolkata; Agricultural & Horticultural Society (Kolkata, Chennai, Bangalore, New Delhi), and the many botanical gardens of India.

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 List of Germplasm Collection / Records of Agri-Horticultural Society of India, Calcutta, West Bengal, India.
 List of Germplasm Collection / Records of Lalbagh Botanical Garden, Bangalore, India.
 List of Germplasm Collection / Records of Botanic Garden, National Botanical Research Institute, Lucknow, India.
 List of Germplasm Collection / Records of Indian Botanic Garden, Calcutta, India.
 Proceedings of the 150th Anniversary Volume of Royal Botanic Garden, Calcutta.

ACKNOWLEDGEMENTS

The author is grateful to the authorities of Agri-Horticultural Society of India, Calcutta; Botanical Survey of India, Calcutta; Lalbagh Botanical Garden, Bangalore for allowing access to the old records / proceedings besides granting permission for imaging live specimens of trees. Inspiration to write this paper was drawn from the book *The Global Migrations of Ornamental Plants* by Judith M. Taylor. The exchange of views with her on historical aspects of global migration of plants is gratefully acknowledged. Expert opinion received from Dr. A.K. Goel, Scientist-in-Charge, Botanic Garden, NBRI, Lucknow on various aspects on plant introduction and *ex-situ* conservation status of ornamental trees in India is also appreciated.

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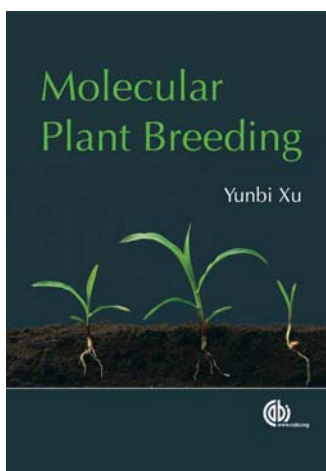


New Books, Websites

BOOK REVIEWS

The books listed here are non-ISHS-publications. For ISHS publications covering these or other subjects, visit the ISHS website www.ishs.org or the Acta Horticulturae website www.actahort.org

Molecular Plant Breeding. Yunbi Xu. 2010. CABI Publishing, Wallingford, Oxfordshire, UK. 734p. ISBN 978 1 84593 392 0 (Hardcover). £125.00 / \$240.00 / €175.00. www.cabi.org

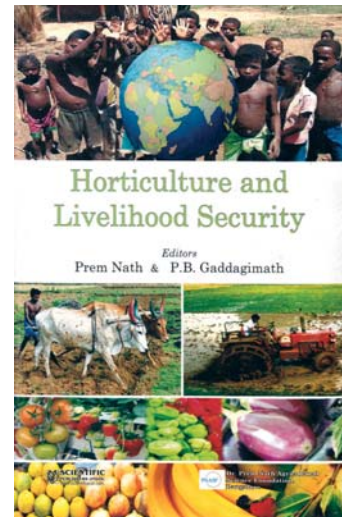


Yunbi Xu (molecular maize breeder with the International Maize and Wheat Improvement Center (CIMMYT) in China) wrote a comprehensive overview of molecular plant breeding in this book. The forewords were written independently by the late 1970 Nobel Peace Laureate Norman E. Borlaug, and Regents and McKnight Professor Ronald L. Phillips (Univ. of Minnesota). This book includes 15 well-written chapters on various topics: DNA marker technology, "omics" science, gene mapping, quantitative genetics, plant genetic resources, marker-aided breeding methodology (both theory and practices), genotype-by-environment interaction, genetic transformation, breeding informatics, decision support tools, and intellectual property rights (emphasizing plant variety protection). Each chapter provides up-to-date information with supporting tables, figures and cited references, whose list is included at the end of the book. The introductory chapter, which sets the scene for reading the book, gives an appropriate over-

view on various issues: from domestication of crop plants through major developments in the history of plant breeding – including the Green Revolution – to modern genetic enhancement methods aided by molecular tools. This first chapter also provides a summary on quantitative genetics and selection theory. The next two chapters are on breeding tools and explain the theory behind genetic markers and maps (Chapter 2), as well as "omics" and arrays (Chapter 3). The fourth chapter on populations will be very useful for those searching for offspring options for their further research in plant genetics and breeding. Chapter 5 deals with plant genetic resources management, evaluation and enhancement. The next four chapters are devoted to molecular dissection of complex traits and marker-assisted selection (MAS). The various approaches and statistical methods for mapping quantitative trait loci (QTL) receive significant attention in Chapter 6, whereas Chapter 7 answers questions on number of genes controlling QTL in segregating populations, separating closely linked QTL into single units, comparing QTL across different genetic backgrounds and developmental stages, epistasis, or handling multiple traits and expression QTL. The components of MAS, marker-aided gene introgression and pyramiding, selection for quantitative traits and long-term selection are included in Chapter 8. The practice of MAS is discussed amply in Chapter 9, which highlights the diverse selection schemes available to plant breeders, the bottlenecks that may limit its application in plant breeding, its cost-benefit analysis, and traits suitable for MAS. The analysis, interpretation, molecular-aided understanding, and management of genotype-by-environment interactions (GEI) are included in Chapter 10. The isolation and functional analysis of genes is the subject of Chapter 11, while Chapter 12 focuses on gene transformation technology and its use for producing transgenic crops. Chapter 13 provides comprehensive information on intellectual property rights and plant variety protection. New topics in a plant breeding book are included in Chapters 14 and 15: breeding informatics and decision support tools, respectively. They are unique, worth reading, and the author does well by adding them to this book because they are very important in today's plant breeding.

Reviewed by Rodomiro Ortiz

Horticulture and Livelihood Security. P. Nath and P.B. Gaddagimath. 2011. Scientific Publishers, Jodhpur, India. 550p. ISBN 978-81-7233-674-5. \$115. www.scientificpub.com



Horticulture and Livelihood Security is a 550 page book published by the Scientific Publishers (India), Jodhpur (www.scientificpub.com) and Dr. P.N. Agriculture Science Foundation (PNASF), Bangalore. It contains the principal papers of the International Conference on Horticulture held in November 2009 in Bangalore, India. The book contains 39 articles in six sections: (1) Impact of horticulture on livelihood security; (2) Studies on food, nutrition and health security and income generation; (3) Contribution of horticulture technology; (4) Delivery of technology and products; (5) Government policies and development programmes; and (6) National and international cooperation.

NEW TITLES

Ghiggi, D. 2010. *Tree Nurseries Cultivating the Urban Jungle*. Lars Müller Publishers, Baden, Switzerland. 239p. ISBN 978-3-03778-218-7. €35.00 / \$55.00 / £35.00 (English or German). www.lars-muller-publishers.com

Valavi, S.G., Peter, K.V. and Thottappilly, G. 2011. *The Jackfruit*. Studium Press, New Delhi, India. 549p. ISBN 1-933699-61-2 (hardbound). US\$ 95. studiumpress.in



Courses and Meetings

The following are non-ISHS events. Make sure to check out the Calendar of ISHS Events for an extensive listing of all ISHS meetings. For updated information log on to www.ishs.org/calendar

Conference on Innovative Ideas in Pest and Weed Control in Field Vegetables, 13 April 2011, Harpenden, UK. Info: Rebecca Morgan, Association of Applied Biologists, The Warwick Enterprise Park, Wellesbourne, Warwick, CV35 9EF, UK, Phone: +44 (0) 2476 575195, Fax: +44 (0) 1789 470234, Email: rebecca@aab.org.uk, Web: www.aab.org.uk

SOI Advanced Course on Biomechanics of the Trees, 20-23 June 2011, Florence, Italy. Info: Società di Ortoflorofruttilcoltura Italiana (SOI), email: soifi@unifi.it

IX Master in Olive Growing and Oil Technology, September 2011, Córdoba, Spain. Info: Prof. Ricardo Fernández Escobar, Departamento de Agronomía, Universidad de Córdoba, Campus de Rabanales, Edificio C4, Carretera de Madrid km. 396, 14071 Córdoba, Spain, Fax: +34 957 218569, email: masterolivicultura@uco.es, web: www.masterolivicultura.org



SYMPOSIA AND WORKSHOPS

Section Ornamental Plants – Section Tropical and Subtropical Fruits – Commission Education, Research Training and Consultancy

First Int'l Symposium on Tropical Horticulture (TropHort2010)

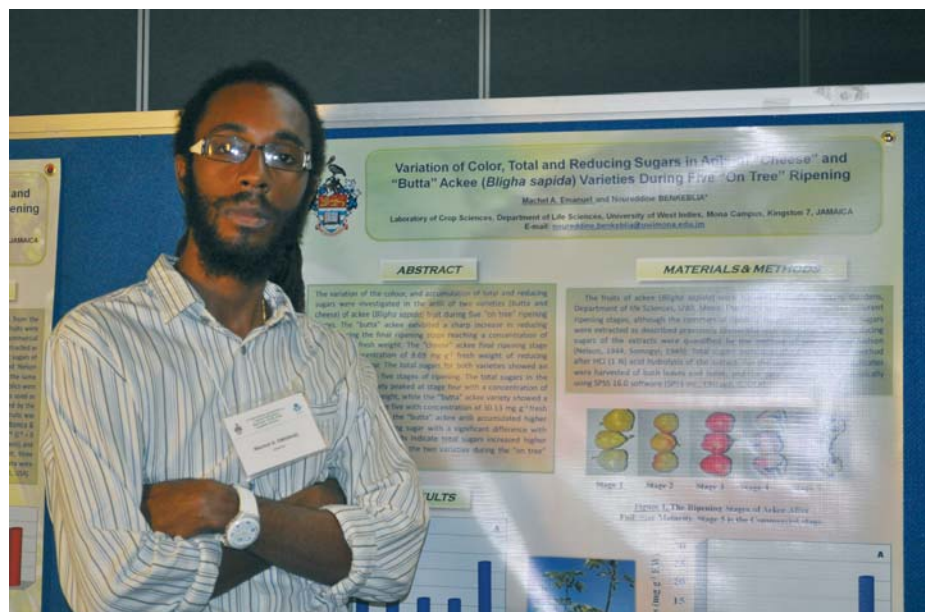
This First International Symposium on Tropical Horticulture was held in Kingston, Jamaica, from the 22nd to the 26th of November, 2010. The meeting was organized by the University of West Indies (UWI), under the umbrella of the International Society for Horticultural Science (ISHS). This first symposium devoted to tropical horticulture was supported by the following sponsors: Graduate Research & Studies (UWI, Mona), Grace Food Kennedy (<http://www.gracefoods.com/site/index.php>) and GlobalHort (<http://www.globalhort.org/>), and the Convener and Chair of the Organizing Committee was Prof. Dr. Noureddine Benkeblia, Department of Life Sciences, UWI, Mona, Jamaica.

The symposium was attended by 55 participants, coming from 12 countries of the five continents (Europe, Asia, North America, South America, and Australia). The theme of this symposium was dedicated to the development of tropical horticulture, and the meeting was organized into five different sessions. After the introduction of the symposium by the Convener, and the opening ceremony announced by Professor Ishenkumba Kahwa (Dean of the Faculty of Pure & Applied Sciences, UWI, Mona), Professor Ronald Young (Pro-Vice Chancellor, UWI, Mona) and Dr. Mona Webber (Head of Department of Life Sciences, UWI, Mona), the first session

– Botany, anatomy, nomenclature and physiology of tropical crops - was started by the talk of Dr. Philip Rose (UWI, Mona) on Horticultural crops in Jamaica and the Caribbean region:

Botany and distribution. During his talk, Dr. Rose introduced the genera of seed plants in the Caribbean, including endemic flowering plants and gymnosperms (Microcyacas).

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 Selected "Best Poster" of the symposium, presented by Mr. Machel A. Emanuel.



He reported that all the endemic genera are confined to the Greater Antilles, while 118 are restricted to single islands. Interestingly, it was reported that naturally occurring food plants are extremely few, and many of these fruits are with a fleshy pericarp, but few are used to any extent by people. Medicinal plants are also widely dispersed in Jamaica and the Caribbean, and a number of potential ornamental shrubs (e.g. *Gesneria* spp., *Lisianthus* spp., *Portlandia* spp.), trees (e.g. *Chorizanthe fadyenii*, *Thespesia grandiflora*), cacti (e.g. *Rhodocactus cubensis*), epiphytes (e.g. many bromeliads and orchids), climbers (e.g. *Passiflora* spp., *Solandra* spp.) and ferns are also found.

The second session - Growing, irrigation, and pest management of tropical crops - started with the talk of Dr. Robert G. Hollingsworth (USDA-ARS, Hawaii), and for this talk, specific examples drawn from the literature and from the author's personal experience were presented and used to support the summary statements. Dr. Hollingsworth reported on the population dynamics of insect pests, their natural enemies and the plants on which pests depend are heavily influenced by the occurrence of a cold winter in temperate areas of the world. Pest management in temperate areas frequently involves judicious use of insecticides to slow the growth of pest populations until populations of natural enemies can catch up, or until harvest, whichever comes first. In contrast, population swings of tropical pests are muted, particularly in the absence of a strong dry season. This muting occurs because crop cycles are more overlapping, but also because plants with indeterminate growth provide year-round habitat for populations of pests and natural enemies. Arguably opportunities are greater in the tropics for achieving natural pest control through the use of trap crops, companion plantings, and the development of permaculture systems. The tropics enjoy relative advantage due to environmental stability and socioeconomic factors. However, development of these approaches has been minimal in the tropics, owing mainly to a lack of research effort and a lack of knowledge about the factors affecting insect populations.

The third session - Postharvest physiology, biochemistry, and technology of tropical crops - starting with the talk of Professor C.M. Sean Carrington (UWI, Barbados) and reporting on the firm focus on tropical fruit ripening attracted the attention of participants. After a brief review of tropical fruit types, the talk focused on an overview of ripening as a coordinated process involving changes in pigmentation, flavour, texture, respiration and surface waxes, and ripening-related fruit softening was explored in depth. To understand the basis of the softening phenomenon, modifications in either the polysaccharides that comprise the cell wall, or the enzymes that catalyse such changes, in both cases looking for correlations between these and softening, were examined. Molecular biology approaches have allowed



Participants at the Blue Mountains.

a more detailed understanding of how such enzymes are regulated, but more importantly using genetic engineering techniques it has been possible to silence or overexpress specific proteins and more directly test the role of such enzymes in fruit softening. A review was made of ripening-related softening in the major tropical fruits, avocado, papaya, banana and guava. With such diversity of fruits, it is not surprising diverse mechanisms of softening come into play rather than one simple, shared "softening" reaction.

The session four - Biotechnology and processing of tropical crops - was started with the talk on "Coffee biotechnology: implications for crop improvement and germplasm conservation" presented by Dr. Sarada Krishnan, from the Denver botanical garden, USA. The talk raised the interest of not only scientists, but also participants from the coffee board industry of Jamaica. As reported by Dr. Krishnan, coffee, one of the most important beverages in the world, is produced in about 80 tropical countries with an annual production of nearly seven million tons of green beans. Many livelihoods in developing countries are dependent on this crop. Explosion of plant biotechnology has led to many advances in the field of coffee production, including breeding and cultivar development, resistance to pests and diseases, quality improvement (aroma, flavor and caffeine content), product diversification, and post harvest technology. The cultivated species of coffee have a very narrow genetic base. Wild species of coffee offer future breeding potential for crop improvement. With many wild species being lost due to various land uses, conservation of these valuable genetic resources in ex situ genebanks and through seed banking becomes imperative. Utilization of modern biotechnology techniques such as tissue culture, genetic transformation and molecular marker techniques offer great potential for future

advances in crop improvement and germplasm conservation.

The fifth and last session - Miscellaneous topics on tropical horticulture crops - was highlighted by two talks. The first talk presented by Professor Bernd Markert (Zittau University, Germany) focused on the global problems of environmental changes. The extensive and increasing agricultural activities are one of the tremendous effects of worldwide human growth, and food production is partly responsible of ecological and health related problems. Additionally, negative effects of human diet can be introduced by too high concentrations of toxic chemical substances in agricultural products, and tropical and sub-tropical agricul-

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- At the gala dinner ceremony, Prof. Dr. Margrethe Serek, Chair of the ISHS Section Ornamental Plants, handed over an ISHS certificate and medal to Prof. Dr. Noureddine Benkeblia, Convener of the 1st International Symposium on Tropical Horticulture, Jamaica.



ture in "less economically developed" regions of the world are influenced by these effects. So called bioindicators/biomonitoring can be of scientifically and practically sound assistance in identifying these effects, and a newly developed strategy - the Multi-Marker Bioindication Concept (MMBC) - with its functional and integrated windows for prophylactic health care was presented during this talk. The second talk of this session was presented by Mr. Derrick Record from Grace Food Kennedy (Jamaica), and reported on the most globally recognized and commercially significant liquid endosperm deriving from the tropical crop coconut *Cocos nucifera* L. The talk reported on this liquid endosperm, which is naturally rich in essential nutrients (sugars, amino acids, minerals and vitamins). Coconut water is also a refreshing drink and is often referred to as a natural "isotonic" beverage, and is therefore the perfect commercial vehicle through which to develop and market natural and credible functional

beverage products, globally. One of the focal points of the work on this product is to attain a consistent mineral content for new products developed using raw material (coconut water) from different geographical regions. Strategic research is therefore undertaken to determine how competing products compare.

On the third day of the symposium, a symposium tour to the popular Blue Mountain was arranged to show plantations of where the famous and worldwide known "Blue Coffee Mountain" is cultivated and produced. The last day and during the discussion meeting, two potential candidates to organize the Second International Symposium on Tropical Horticulture showed their interests. Finally, the decision after a vote was made and the second symposium will be held in Thailand with Dr. Peerasak Chairprasart (Department of Agricultural Science, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand) as Convener.

Overall, the symposium was quite successful and the organization was well appreciated by the attendees. This symposium was indeed a good opportunity for those involved in tropical horticulture to: (i) share their experience and knowledge, (ii) interact with the scientific community working on tropical crops, and (iii) develop further tropical horticulture by involving policy and decision makers.

N. Benkeblia

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Section Pome and Stone Fruits Eleventh Int'l Pear Symposium



Participants of the Symposium.

The XI International Pear Symposium was held in the beautiful Rio Negro and Neuquen Valley of Argentina from 23-26 November 2010. The Symposium was organized under the auspices of the ISHS, INTA and the Governments of the Provinces of Rio Negro and Neuquen. More than 120 researchers, industry managers, growers and students from 25 countries attended the Symposium.

In the opening ceremony, Dr. Tony Webster emphasized the importance of Argentina as a pear producing country. Also, the representatives of both provinces welcomed the

participants and the Convener, Dr. Enrique Sánchez, described the activities involved in the Symposium, especially the open day dedicated to local participants.

A total of 117 papers (6 invited, 38 oral and 73 posters) were presented and covered all aspects of pear production and management from the orchard through postharvest as well as biotechnology. The sessions were Economics, Pear Biology, Genetics and Biotechnology, Rootstock and Cultivar Breeding and Evaluation, Plant Protection and Biology of Pests and Diseases, Orchard Designs, Training and Pruning Systems,

Nutrition, Soil and Water Management, Fruit Set Control and Growth Regulators and Postharvest Physiology and Technology.

Most of the papers emphasized the need to improve orchard systems to ensure profitability and sustainability of the pear industry around the world taking into consideration the increasing labor cost. Contributions dealing with topics of interest to the Argentine pear industry were selected and simultaneously translated into Spanish for one-day registered professionals. Thus we accomplished one of our important objectives in this Symposium... "To put the



Argentine folkore dancing.



Field day: visit to a typical pear orchard.

recent knowledge into the growers' hands". The Symposium had an outstanding scientific level and was complimented by the participants. The open day program was an innovative feature in this kind of meeting and the selected papers provided new information on orchard systems and breeding programs around the world, aspects that are relevant for the Argentine pear industry. Over 100 local industry participants joined the Symposium for the open day.

The social events included a reception and closing dinner along with tango and folkore shows that greatly contributed to the cozy atmosphere and friendly environment of the Symposium. The technical tour included visits to conventional and organic pear orchards, a packing house visit and a sightseeing tour to the valley.

At the business meeting the members of the ISHS voted that the XII International Pear Symposium will be held in 2014 in Belgium with Dr. Tom Deckers as convener.

The organizers want to thank all participants, sponsors and the Institutions for a very fruitful and enjoyable meeting.

Enrique Sánchez

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Section Vine and Berry Fruits Second Int'l Symposium of Tropical Wines



Part of the symposium participants.

The Second International Symposium of Tropical Wines, held on 26-28 May 2010 in Petrolina-PE, Brazil under the aegis of ISHS, was organized by Embrapa Semiárido and Embrapa Uva e Vinho, Brazil, co-promoted by Chaire Unesco "Culture et Traditions du Vin" Bourgogne University, Group of International Experts of Vitivinicultural Systems for

Cooperation (GiESCO), International Organisation of Vine and Wine (OIV), Sebrae, Assitur and Vinhovasf, and supported by Embrapa, Facepe, AD-Diper – Economic Development Agency of Pernambuco, Ibravin - Brazilian Wine Institute, and Codevasf.

Traditional winemaker regions are located in temperate zones, like Europe (France, Spain, Ita-

ly, Germany and Portugal), USA, Australia, South Africa, Chile, Argentina and South of Brazil, where it's possible to harvest grapes once a year. In tropical zones, like India, Thailand, Venezuela and Northeast of Brazil, it's possible to harvest twice a year and to choose what time (month) to harvest grapes, due to the high solar radiation availability and irrigation throughout the year.





• Closing session. From left to right: Symposium Convener Giuliano Pereira (Embrapa, Brazil) addressing the audience, Jorge Tonietto (Embrapa, Brazil), Guillermo Vargas (Universidad Barquisimeto, Venezuela), Visootha "Nikki" Lohitnavy (Granmonte Vineyards, Thailand) and José Gualberto Almeida (Vinhovaf, Brazil).



• ISHS representative Umberto Camargo (left) handing over the ISHS certificate to Symposium Convener Giuliano Pereira (right).

The Symposium was attended by a total of 130 participants from 8 countries (Brazil, Venezuela, Chile, Portugal, Spain, France, Greece and Thailand). The program consisted of the following sessions: Worldwide vitiviniculture, including diagnostics of some examples of producers countries; Tropical viticultural ecology, including climate, soil and wine landscapes; Tropical vitiviniculture, including adaptation and selection of cultivars for high quality wines in tropical and warm temperate zones, and production systems for wine grapes in tropical regions; Tropical enology, including analytical and sensory characteristics of tropical wines; Actions for consolidation of the tropical worldwide vitiviniculture; Technical visits, including vineyards in three wineries, with tastings of tropical and some temperate wines from different Brazilian regions. The main objective of the Symposium was to discuss about vitiviniculture and enological factors and influences on tropical wines. The participants started discussions to create an International

Group for Research about Tropical Vitiviniculture, to study, characterize and promote quality and typicity of tropical wines.

Twenty-one lectures were given about different subjects. Some works presented the influence of edafoclimatic characteristics on enological potential of grapes and wines. Experiences obtained in temperate and tropical climate zones were shown. Others talked about genetic materials used for rootstocks and cultivars in temperate and tropical zones, searching to improve grape enological potential, quality and typicity of tropical wines. Works developed in Brazil were presented about irrigation management and types to obtain grapes with high enological potential and to preserve environment conditions. Others showed analytical and sensory characterization of wines made in tropical conditions. Some lectures discussed international viticulture landscapes, in temperate and tropical conditions, to preserve and promote wines in gastronomic and tourism contexts. Brazilian



• Plots of vineyards in different phenological stages near the São Francisco river.

researches showed what is being carried out to actualize wine diagnostics in tropical countries and it was suggested to continue this work involving all tropical producer countries. The last lecture was about the relation of wine and health in the 21st century. There is not yet information available about the relation of tropical wines and health. Works need to be developed in this way to better understand the effects of these wines. The Symposium was closed with two technical visits to wineries close to the São Francisco River, where participants had lunch and tasted some wines. Every day, lunches and dinners were served with Brazilian tropical wines and all participants had the opportunity to taste the products of the region.

Giuliano Elias Pereira

• Visit to the vineyards in the region showing mechanization of the vines.



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Section Vine and Berry Fruits

Seventh Int'l Symposium on Kiwifruit

The 7th International Symposium on Kiwifruit was held in Faenza, Italy on September 12-17, 2010 and was organized by the Department of Fruit Tree and Woody Plant Science of the Faculty of Agriculture of the Alma Mater Studiorum, University of Bologna under the auspices of the ISHS Working Group on Kiwifruit and its Culture of the Section Vine and Berry Fruits. It is the 7th in the series of international symposia dedicated to the species *Actinidia*.

At the opening ceremony, Prof. Guglielmo Costa, Convener of the Symposium and Chair of the ISHS Working Group, welcomed more than 200 participants from more than 20 different countries and illustrated the Symposium structure: the first 4 days (12-15 September) were dedicated to the scientific presentations. The scientific program of the Symposium was organized in 5 main sessions as shown in Table 1.

The opening lecture was delivered by Dr. Allan Ross Ferguson of Plant and Food Research, Auckland, New Zealand, who gave a presentation on "Kiwifruit: the evolution of a crop". Monday started with the ISHS presentation by Prof. Errol Hewett followed by oral communications (more than 50 in total) and a poster session (more than 100 posters). Tuesday afternoon, a technical visit to Faenza and Bologna areas offered the possibility to the participants to visit a packing house, private orchards in Faenza area and the Bologna University experimental farm. At the University, the participants had the chance to visit kiwifruit orchards where germplasm collection, breeding selection, training systems and planting densities experiments are present. A country dinner was organised in the farm and 3 members of the Working Group (Dr. Ross Ferguson, Dr. Hongwen Huang and Prof. Guglielmo Costa) were awarded for their research work with a parchment and with three original paintings of kiwifruit species.

The last two days were dedicated to the post-symposium tour that led the participants to the Cesena area, where another packing house facility was visited, as well as *Actinidia deliciosa* 'Hayward' and *Actinidia chinensis* 'Jintao' orchards. The tour continued, leading to the North-East, where the participants had the chance to visit Venice. The next technical visits were organised in the Verona area, where the participants had the chance to visit orchards and a nursery of *Actinidia deliciosa*.

Participants and accompanying persons were entertained during the Symposium with a wide variety of Italian food and wine and Italian music and dance.

The objective of the Symposium was to provide not only a forum for scientists of scientific institutions all over the world and from companies and consortia involved in kiwifruit industry, but also to share experience on different aspects integrating science and practice to improve the cultivation of this species all over the world.

Chinese, New Zealand and Italian colleagues illustrated the results of their breeding program. New selections of *A. deliciosa* and *A. chinensis* red flesh cultivar, *A. eriantha* and *arguta* species, as well as *A. deliciosa* and *A. chinensis* green and yellow flesh cultivar, could probably be released in a short time, opening the

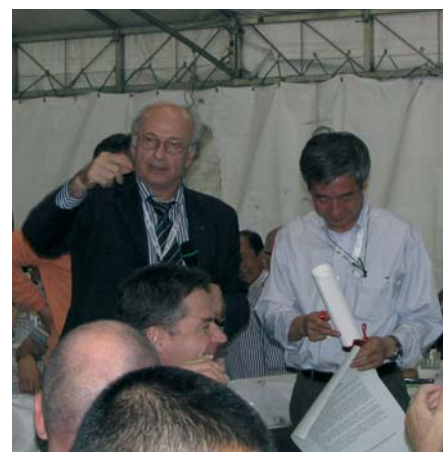
Table 1. Scientific program of the Symposium.

SESSION 1 Economy, Diffusion of the Culture: <i>Statistics, Market, Consumer evaluation</i>
SESSION 2 Breeding and Physiological and Molecular Aspects: <i>Molecular genetics, Genetic maps, Genetic traits of interest, Breeding strategies and objectives</i>
SESSION 3 Cultural Management: <i>Dormancy, Propagation, Training systems and pruning, Pollination, Plant nutrition, Water management, Growth regulators</i>
SESSION 4 Plant Protection: <i>Pests and diseases, Orchard and environmental protection</i>
SESSION 5 Storage and Fruit Quality: <i>Fruit ripening physiology, Harvesting, Cold storage strategies, Processing, Health attributes, Allergens, Quality assessment</i>

Kiwi-Meter, a non-destructive device for fruit quality assessment.



Prof. Guglielmo Costa (left), Dr. Ross Ferguson (center) and Dr. Hongwen Huang (right) receiving the ISHS WG Kiwifruit and its Culture awards.





Participants during the technical tour (left) and in Venice (right).

possibility to enlarge the cultivation to other production areas in the world. However, it was clearly stated that new cultivars must be accurately evaluated in each different environmental condition before introduction. The necessity to start breeding for disease resistance was put on the table, also considering that new diseases (i.e. "bacterial canker") are recently starting to create great problems to the cultivation.

Interesting results also concerned innovative cultural management techniques and the use of non-destructive devices for fruit quality assessment.

The Symposium ended with a round table discussion where Guglielmo Costa, Symposium Convener and Chair of the ISHS Working Group, Allan Ross Ferguson and A.R. Granger of Plant & Food Research, Auckland, New Zealand, Hongwen Huang of South Botanical Garden, South China Institute of Botany, Chinese Academy, P.R. China, and Z. Wang of Hunan Horticultural Research Institute, Changsha, Hunan, P.R. China, all acted as opinion leaders answering the questions on the floor and stimulating discussion of the following topics:

- How do we cope with the diseases that are occurring? Can we do anything to aid international cooperation?
- On a long term for the future, it looks as if we should start breeding for disease resistance – how do we encourage and support that?
- Do we need cooperative work on agreed definitions on fruit quality, storage life?
- Can we or should we encourage replicated trials and comparisons of some of the major new cultivars, comparisons at one or several sites?
- Red flesh kiwifruit.

All participants were aware of the actual problems of the species although each area of production, because of the research level and the industry organisation characteristics, has different priorities. However, it has been agreed that international cooperation is very important, and that new agreements with the different countries and new fields of research must be encouraged and the existing cooperation must be strengthened.

It has been agreed that the next Symposium will be held in four years time in China. Dr. H. Huang will be the Convener and he was also elected Working Group Chair for the next four years.

The Proceedings of the Symposium will be published as a volume of *Acta Horticulturae*.

Guglielmo Costa

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Section Vine and Berry Fruits – Fifth Int'l Phylloxera Symposium Commission Plant Protection

The 5th International Phylloxera Symposium was hosted at the University of Natural Resources and Life Sciences in Vienna from 19th to 21st of September 2010 under the umbrella of the ISHS (International Society for Horticultural Science). The conference was organized by Prof. Forneck and colleagues from the Division of Viticulture and Pomology.

Forty-two scientists from 14 different countries came together to present their latest findings and to discuss acute phylloxera problems in viticulture. Once more it became apparent that

phylloxera is not a relic of former days, but gains in importance once again.

Background: Phylloxera was introduced from North-America to Europe in the middle of the 19th century with devastating effects on European grapevine cultivars causing enormous economic losses. The root system of susceptible cultivars is severely damaged by the formation of gall tissues, called nodosities and tuberosities.

Changing environmental conditions (climate change), adapted soil and water management

in regard to sustainable viticulture lead to increased population densities. Enormous numbers of infested roots cause a decreased water and nutrient uptake and root exudates release. With progressing damage levels soil-borne pathogens might enter the vascular tissue leading finally to the death of the vine. Based on the below-ground life-cycle of phylloxera any direct compartment is difficult. Therefore, grafting the susceptible European *Vitis vinifera* vines onto tolerant rootstocks is the only sufficient protection against phylloxera, so far.

For the start of the symposium a workshop, chaired by Prof. Tagu (France), was conducted aiming to provide a platform for studying the genome of phylloxera. Prof. Tagu stated that knowing the genome of phylloxera maintains to a better understanding of the interaction between phylloxera and grapevine, which is essential for a susceptible compartment. Further, phylloxera has some meaning for basic research as the oldest of all plant aphids. An informative "White paper" stating the importance of such a project was written.

An impressive movie about the asexual life-cycle of phylloxera from Dr. Lawo (Austria) and Prof. Wyss (Germany) provided a platform for the protagonist of the following two days (www.entofilm.com). Thereafter, intensive discussions about results from molecular biology, viticulture, plant protection and breeding followed. Besides questions from basic research, studies from North-America (Dr. Johnson) showed a promising application of pesticides against leaf-galling phylloxera – luckily they do not have any root-galling ones yet.

A successful monitoring of root-galling phylloxera was further discussed in detail. Three different possibilities were presented by Dr. Powell (Australia) - the latest two the most precise:

1. "Digging-method": Soil samples are taken and analyzed for root-galls.
2. "Sticky traps": A sticky substance is applied to small bins aiming to assess any movement from phylloxera between soil and vine.
3. "DNA-analysis": Soil samples are assessed for any phylloxera DNA.

To narrow down a spread of phylloxera an early detection of root-galling phylloxera is of major importance. Studies from Australia (Dr. Powell) revealed that the pigment content or different biomarkers of the leaves provide this knowledge. Prof. Kocsis (Hungary) demonstrated in



Participants of the Symposium (taken by Rainer Ressmann).



Leaf galls in a Viennese vineyard (taken by John-Philip Lawo).

his talk that rootstocks do not always provide the required protection against phylloxera.

A quarantine workshop chaired by Dr. Hoffmann (Germany) and Dr. Eder (Germany) discussed the possibilities of a successful compartment within Europe and its difficulties. Dr. Powell presented the quarantine strategies followed in Australia. It was concluded that any assistance of wine growers is essential.

The 5th International Phylloxera Symposium revealed that besides studies in basic research, aiming a better understanding of the phylloxera-root-interaction, intensive research is conducted dealing with an early detection of root-phylloxera and the screening for rootstock resistance. Nevertheless, the conclusion of this year's symposium is that much more research and international discussions are necessary. The next opportunity will be provided by the upcoming phylloxera symposium conducted in Bordeaux, France in 2013 which will be organized by Dr. Ollat and colleagues. In the meantime a Phylloxera Working Group, led by Prof. Forneck (Austria), discusses current phylloxera issues.

This year's symposium found its end with a visit of the winery "Cobenzl" (Vienna), a walk through the Viennese vineyards and a dinner at a typical Vienna "Heurigen".

Detailed information regarding the symposium is provided under: www.viticulture-research.com.

Nora C. Lawo

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Participants at the excursion at Cobenzl (taken by Sarah Bardakji).



Commission Plant Protection Int'l Workshop on Biological Control of Postharvest Diseases: Challenges and Opportunities



Participants of the Workshop.

The International Workshop on Biological Control of Postharvest Diseases was held in Leesburg, VA, on the outskirts of Washington D.C., USA, on October 25-28, 2010. Approximately 55 participants from 15 countries were in attendance representing researchers, industry representatives, and regulatory agencies. The workshop received financial support from the U.S.-Israel Binational Agricultural Research and Development Fund, United States Department of Agriculture-

Agricultural Research Service (USDA-ARS) Office of International Research Programs (OIRP) and Office of Technology Transfer (OTT), and the Agricultural Research Organization (ARO) of Israel. Dr. Edo Chalutz, Director of BARD, and Dr. Edward Knipping, Administrator of USDA-ARS were on hand to welcome the participants and discuss the role of BARD and USDA-ARS in this line of research. Welcoming remarks were also offered by Dr. Dariusz Swietlik, Area Director, USDA-ARS-North Atlantic Area.

The objectives of the present workshop were to assess the current status of postharvest biocontrol throughout the world, identify the barriers that limit this approach from wide scale application, develop a better understanding from industry about the requirements of developing new products, especially in relation to the regulatory guidelines for registration of biocontrol products. Additionally, critical areas of research were defined and information from other related fields of microbial research were presented to see how they may apply to the study of postharvest biocontrol.

SCIENTIFIC PROGRAM

The conveners, Dr. Michael Wisniewski (USDA-ARS) and Dr. Samir Droby (ARO), opened the meeting and the plenary speaker, Dr. Charles Wilson, gave a historical perspective on postharvest biocontrol: past, present, and future. Roundtable discussions were held at the end of each session.

Session I: **Epiphytic competence and microbial competence** – A range of speakers presented information on molecular approaches to studying microbial ecology (Johan Leveau), the biology and management of biofilms on plant surfaces (Michael Harding), the genetic control of plant microflora (Ann Stapleton), and engineering microbial consortia and applications of synthetic ecosystems (Rob Smith).

Opening reception (from left to right: Dariusz Swietlik, Michael Wisniewski, Ibrahim Shaquir, Samir Droby, and Edward Knipping).

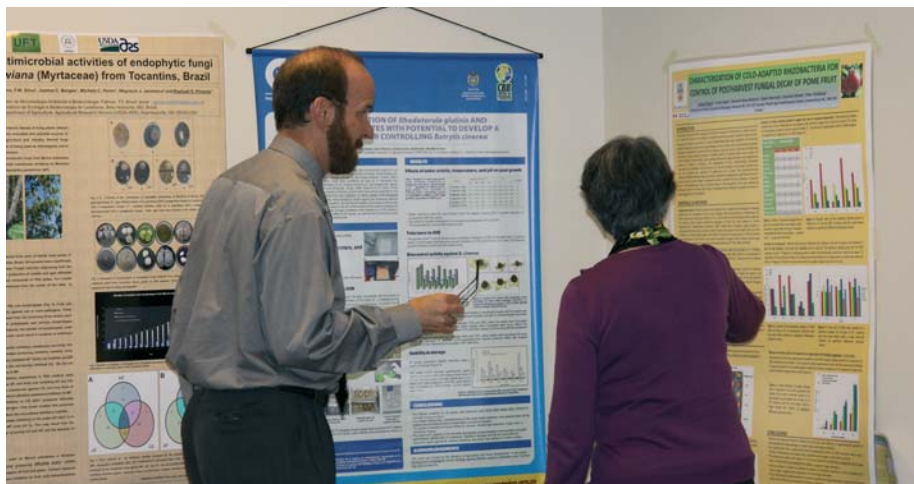


Session II: **Antagonist-pathogen-host interactions** – Six invited speakers (Samir Droby, Shiping Tian, Carole Bassett, David Spadaro, Sandra Wright, and Stefano Fiori) provided research on topics related to the tri-trophic interactions of biocontrol agents, pathogens, and host commodities. The mechanism of postharvest biocontrol agents, host response to biocontrol agents, metagenomic approaches to characterizing microbial diversity, the role of competition for iron and cell wall degrading enzymes in biocontrol activity, detoxification of fungal mycotoxins by yeast antagonists, and morphological dimorphism in yeasts were discussed.

Session III: **Integrated approaches for fruit crop disease management** – Invited speakers (Silvana Vero, Antonio Ippolito, Joseph Smilanick, Robert Prange, Jia Liu, and Gianfranco Romanazzi) presented a range of approaches that have been used to combine the use of postharvest biocontrol agents with other management approaches. Topics included, pre- and postharvest application of antagonists, use of GRAS and other natural compounds, and the use of both dry heat and hot water dips.

Session IV: **Discovery, formulation technology, and commercialization** – Research addressing the challenges of formulation, improving stress tolerance of biocontrol agents, the challenges of controlling latent infections, the use of UV-C to induce resistance, and the identification of new postharvest biocontrol agents was presented by six invited speakers (David Schisler, Neus Teixido, Ben Vorstermans, Wojciech Janisiewicz, Marie Therese Charles, and Carla Nunes).

Session V: **Commercialization – Regulatory and Industry Viewpoints** – Industry representatives (Agraquest – Jonathan Margolis and JBT FoodTech – Charlene Jewell) provided insight into the development of new biocontrol products and the importance of the product being able to integrate into current pack-



● **Discussing new postharvest biocontrol agents (David Schisler and Louise Nelson).**

inghouse practices. Michael Braverman (IR-4) talked about how his agency works to facilitate the gathering of data needed for registration

● **Recognition Awards being presented to Dr. Charles Wilson (left) and Dr. Edo Chalutz (center) by Dr. Samir Droby (right) for establishing and fostering postharvest biological control research.**



of new biopesticides. The potential of the use of natural products for decay control was presented by Emma Kvitnisky (Migal Ltd., Israel) and Kerry Everett discussed research on the application of GRAS agents to influence beneficial microbes on fruit surfaces. The scientific session ended with a roundtable discussion of the potential of postharvest biocontrol in different world markets (Alba Marina Cotes – South America, Boqiang Li – China, Pervin Kinay-Teksur – Turkey).

During the meeting, Dr. Charles Wilson and Dr. Edo Chalutz were recognized for their efforts in establishing and fostering this field of research. The Working Group on Biological Control of Postharvest Diseases was approved under the aegis of the ISHS Commissions on Plant Protection with additional support by Commission Quality and Post Harvest Horticulture and Commission Sustainability through Integrated and Organic Horticulture. Dr. Robert Prange, Chair of the latter commission led the business meeting in which Dr. Michael Wisniewski and Dr. Samir Droby were appointed as co-chairs of the working group. Dr. Pervin Kinay-Teksur agreed to organize the next workshop in Turkey in the spring of 2013.

Michael Wisniewski and Samir Droby

● **Panel discussion on future research directions (from left to right: Charles Wilson, Michael Harding, Johan Leveau, and Rob Smith).**



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Commission Plant Substrates and Soilless Culture Third International Conference & Exhibition on Soilless Culture



Delighted participants of the Conference.

The Third International Conference & Exhibition on Soilless Culture (ICESC-2010) was held from 8-13 March 2010 at Suntec Singapore International Convention & Exhibition Centre, Singapore – 039593. This event was supported by the International Society for Horticultural Science (ISHS), Food & Agricultural Organization (FAO), Singapore Tourism Board (STB), Agri-food & Veterinary Authority of Singapore (AVA), National Parks Board (N-Parks), and the Malaysian Agricultural Research & Development Institute (MARDI), Ngee Ann Polytechnic and other horticulture, food and environment-related institutions in Singapore and overseas.

A total of 68 delegates from 30 countries attended this event. In his Opening Address, the Chairman of the Conference Organizing Committee, Dr. Mallick F. Rahman, congratulated



Opening address by Dr. Mallick (left), and keynote addresses by Prof. Schnitzler (center) and Prof. Nichols (right).

lated all the delegates for “braving the global recession and making it to the conference”.

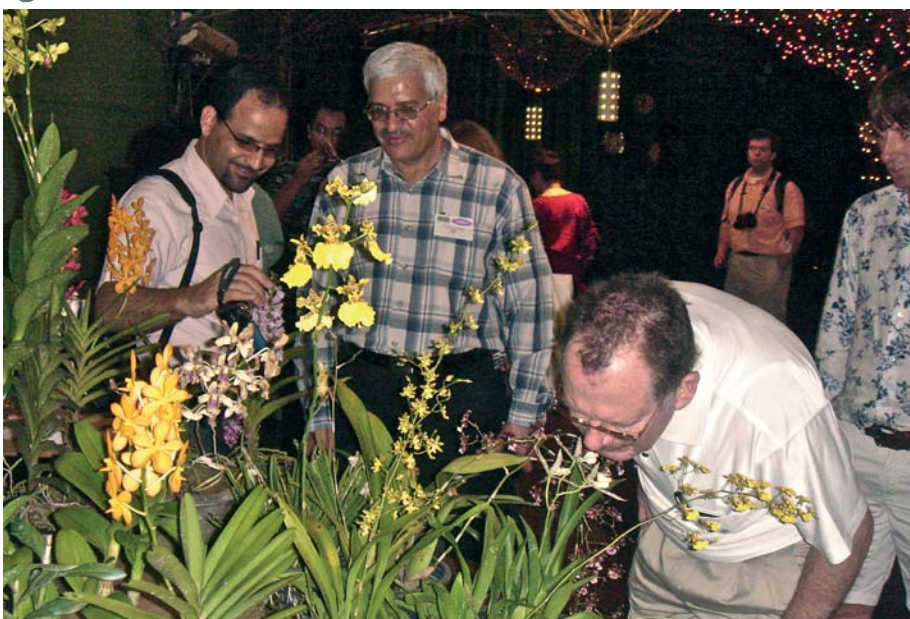
True to the Conference Theme of “Futuristic Environment-Friendly & Sustainable Farming Technologies For Growing Any Plants Any Time Any Where!” the conference kicked off with a keynote address on the “Role of Soilless Culture – the Road to Successful Plant Cultivation” by Prof. Em. Dr. Wilfried Schnitzler, former Chairperson of the ISHS Commission Plant Substrates and Soilless Culture. He also touched upon the Global Horticulture Initiative and the role of ISHS in the Global Food Supply. Later, Prof. Schnitzler awarded the prestigious ISHS Medal to Dr. Mallick, in recognition of his meritorious service to ISHS as Convener of the above event.

The second keynote speaker, Prof. Dr. Mike Nichols from Massey University, New Zealand spoke on “Soilless Culture – Yesterday, Today and Tomorrow”.

The keynote addresses were followed by eleven Technical Sessions, one Seminar and Workshop on Aquaponics, two local field trips, one overseas field trip (to Cameron Highlands in Malaysia) and two social visits.

All the oral presentations were of very high quality. Speakers from Australia, Bangladesh,

Visit to an Orchid Farm in Singapore.



China, India, Iran, Italy, Japan, Kuwait, Malaysia, New Zealand, Oman, Peru, Poland, Saudi Arabia, Singapore, South Korea and the United States updated the delegates on the latest developments in Soilless Culture in their respective countries. The details of the papers will be published in *Acta Horticulturae*, very soon.

All delegates were very serious during the oral and poster presentations and got an update on soilless culture around the world. Prof. Schnitzler (Germany), Prof. Mike Nichols (New Zealand), Dr. Alfredo Delfin (Peru) and Dr. Kazem Arzani (Iran) moderated the technical sessions. Mr. Gregory Chow (Singapore) coordinated the presentations.

Mr. John Pade and Ms. Rebecca Nelson from the Aquaponics Journal updated the delegates on the importance of aquaponics – a hybrid

technology that involves hydroponics and aquaculture. Their seminar and workshop attracted many questions and they delivered very inspiring and thought-provoking answers.

As expected, the tea sessions, lunch breaks and social trips helped in networking and generating global co-operation in soilless culture research and development.

Delegates enjoyed the field trip to the Strawberry Farm, the Malaysian Agrifood Corporation and MARDI's Agrotechnology Park in Cameron Highlands, Malaysia. They also visited an Orchid Farm in Singapore and picked up a few tips on growing Orchids – the National Flower of Singapore.

Over all, the conference was very successful. Most of the delegates reported in their feedback form that they had enjoyed a very valuable conference in Singapore.

All big events end with a grand finale - usually fireworks – but in Singapore ICESC-2010 ended with something else – water works at the Sentosa Island! All delegates were happy and went home fully satisfied!

Mallick F. Rahman M.

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Commission Protected Cultivation – Commission Sustainability through Integrated and Organic Horticulture

First Int'l Conference on Research on Organic Greenhouse Horticulture



Participants of the Conference.

From 11-14 October 2010 the First International Conference on Research on Organic Greenhouse Horticulture took place in Bleiswijk, The Netherlands at WageningenUR Greenhouse Horticulture. The conference was the first activity of the Working Group on

Organic Greenhouse Horticulture. A good international mix of scientists from Europe, America, Asia and New Zealand participated; 51 persons from Austria, Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Hungary, Iran, Israel, Italy, The Netherlands, New Zealand,

Saudi Arabia, South Africa, Spain, Sweden, Switzerland, United Kingdom and the USA attended the presentations and discussions during the four-day conference. Dr. Stefaan de Neve, Vice-Chair of the ISHS Commission on Sustainability through Integrated and



Organic Horticulture represented ISHS at the Conference. The conference was received very successful.

The conference program started with two and a half days of presentations and discussions, and ended with one and a half day of trips to commercial organic greenhouse growers and Eosta, an organic fruit and vegetable trader in The Netherlands. The scope of the subjects during the conference programme was broad. Plenary sessions took place about several themes regarding sustainable production: nutrient management, optimization of soil health, growing systems for organic production, robust planting material, ways to reduce attack by diseases and by pests, energy use and CO₂, economics and standards for organic greenhouse production, and also about the role of networks in organic research.

One of the subjects that resulted in a lot of discussion was the session on nutrient management. This session was focused on the availability of the nutrients according to plant demands and the environmental burdens due to leaching. Three different approaches were presented by the researchers: 1- match fertilization practices with plant uptake via the development of an organic fertilizer database and a decision support model for fertilizer and organic matter application, 2- match fertilization practices according to the biological activity of different soil types and plant uptake, and by recycling the drainage solution to the crop in order to reduce nutrient emissions, 3- use of organic hydroponic re-circulating systems such as aquaponics. All

proposed systems have shown their potential as production systems being more sustainable. Potentialities and limits were presented for each type of system. Within this session a controversy arose with regards to the definition of an organic growing system or what should be considered as an organic product. For instance, should soilless growing systems used for organic production be considered, especially in light of major problems related to soil diseases, nutrient leaching and lower yields? What would be the perception of consumers if an organic crop was grown in a soilless system? Should scientists take position on that aspect or let policy makers make decisions about them?

The session on soil health included presentations on how to prevent and reduce crop loss by root knot nematodes, which are a severe problem in organic greenhouse horticulture. Some of the discussed measures to control numbers of nematodes are an alternative crop rotation system, the Köver system, and biological soil disinfection. The success of the measures varies per crop type, growing system and soil type. With biological soil disinfection organic substances – other than grass - are brought into the soil and covered for some weeks with plastic, in order to control soil-borne diseases and pests. These substances seem to be profitable. A protocol is now being developed by the researcher to apply the method and to monitor the effect in the period after application.

One of the presentations in the session on reduce of diseases was about minimizing the risk

of bacterial canker spread through composting infected by bacterial canker plant material. The suppressiveness of composts against *Clavibacter* was described. Already 1 day after application of the compost an effect on *Clavibacter* was noticeable. *Clavibacter* is present in organic tomato greenhouse production in several countries, among others in The Netherlands, Austria and Israel. In horticulture in Israel deep steaming is not possible for economic reasons, which makes this method very interesting. The use of compost for controlling *Clavibacter* in other countries was discussed as most growers want to remove infected plants as far as possible for their greenhouse.

The conference was sponsored by the Dutch Ministry of Agriculture, Nature and Food Quality.

Carin van der Lans

CONTACT

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FROM THE SECRETARIAT

New ISHS Members

ISHS is pleased to welcome the following new members:

NEW INDIVIDUAL MEMBERS:

Argentina: Federico Miranda, Laura Vita; **Australia:** Dr. Ian Biggs, Ms. Alison Brinson, Ms. Claire Hetzel, Ms. Marion Lawson, Mr. Brent Searle, Mr. Russell Soderlund; **Belgium:** Dirk Bruyninckx, Dr. Pieter Verboven; **Brazil:** Dr. Marluca Santana, Mr. Jorge Santos; **Bulgaria:** Dr. Elitsa Atanasova, Mr. Kostadin Kostadinov, Sabin Tihov; **Cameroon:** Mr. Zephania Yufonyui Fai; **Canada:** Mr. Timothy Bessada, Adriano Ferreira, Ms. Dana Gheorghe, Mr. Ken Haggerty, Jim Halvorson, Mr. Bill Hardy, Mr. Jean-Paul Soucy, Mr. Harry Van Belle, Dr. Youbin Zheng; **Chile:** Prof. Richard Bastias;

China: Myrick Hatch, Dr. Guitong Li; **Chinese Taipei:** Ms. Yung Chi Huang; **Congo:** Mr. Bruno Kitiaka; **Croatia:** Mr. Marin Krapac; **Denmark:** Dr. Merete Edelenbos, Ms. Mette Marie Loekke, Mr. Svend Pedersen, Dr. Helene Fast Seefeldt; **Egypt:** Dr. Shaban D. Abou-Hussein; **Finland:** Nigel Kilby; **France:** Ms. Elise Felix, Alain Meilland, Mr. Antoine Petigny-Samuels, Mr. Franck Poirier, Mr. Eric Prudhon, Dr. Annie Sauton, Mr. Robert Sporschill, Tahar Tarhouni, Prof. Dr. Laurent Urban; **Germany:** Dr. Moritz Hoeffe, Prof. Dr. Wolfgang Rohde; **Greece:** Mr. Vangelis Papadogiannakis; **Guatemala:** Jose Rueda; **Hong Kong:** Mr. Ting Wai Liu, Mr. Kwok Hing Man, Ms. Pui Kuen Lois Poon; **India:** Mr. Srinivasan Balasubramanian, Mr. lakshminarayana Gogineni, Dr. Shaik Mahammad Khasim, Mr. Jayesh Patil, Mr. Saurabh Rathi; **Indonesia:**

Harto Kolopaking, Dr. Asep Setiawan; **Ireland:** Mr. Oliver Kiernan; **Israel:** Dr. Eran Barak, Amiel Berkovich; **Italy:** Dr. Giancarlo Rocuzzo; **Japan:** Prof. Dr. Toshio Ando, Assist. Prof. Kenji Sakurai; **Korea (Republic of):** Mr. Darren Jung, Prof. Hwayeong Kim; **Latvia:** Dr. Ina Alsina, Ms. Laila Dubova; **Lebanon:** Nadine Jaffal, Elie Rmeily, Mona Sibli; **Madagascar:** Ms. Blaise Cooke; **Malaysia:** Prof. Dr. Maziah Mahmood; **Mexico:** Knud Hansen; **Netherlands:** Gen de Jong, Mr. Jan de Smet, Mr. Klaas Plas, Dr. Wessel van Leeuwen, Mr. Robert Zuyderwijk; **New Zealand:** Ms. Molly Callaghan, Mr. Matt Flowerday; **Nigeria:** Mr. Olugbenga Awe; **Norway:** Dr. Jens Rohloff, Ms. Silje Aase Wolff; **Oman:** Ms. Fawzia Al Bulushi; **Portugal:** Margarida Davó, Dr. Natalia Tomas Marques; **Romania:** Dr. Doina Danila, Ms. Camelia

Stefanache; **Singapore:** Ms. Irenei Camila Basman; **Slovenia:** Maja Mikulic Petkovsek; **South Africa:** Ms. Wilhelmiën De Villiers, Dr. Lynn Hoffman, Mr. Fanie Meyer, Prof. Willie Nel, Prof. Dr. Gerhardus Venter; **Spain:** Sergi Garcia-Barreda, Mr. Marco Vaz; **Sweden:** Mr. Thomas Bjelkeman-Pettersson; **Turkey:** Assist. Prof. Ali Fuat Gokce; **Turkmenistan:** Prof. Dr. Mustafa Var; **United Kingdom:** Dr. Layla Abdel Rahman, Mr. Matthew Brown, Mr.

Rhydian Morgan-Jones, Ms. Maria e. Rogers, Mr. Mariusz Skibicki, Ms. Maggie Tisserand, Mr. Steve Waller, Dr. Deborah Wilson; **United States of America:** Mr. Alvin Arthur, Prof. Ricky Bates, Jenna Bayer, Dan Boozer, Christopher Cervený, Mr. Richard Cochran, Janet Cole, Jeremy Cowan, Mark Davis, Adam Englehardt, Dr. Elizabeth Flickinger, Dr. Franka Gabler, Mr. John Gallant, Al Hamman, Mr. Roger Hicks, Mr. Bryan Hobbs, Mr. David Hurst, Dr. Valtcho

Jeliazkov, Emily Lavelly, Dr. Paul Norris, Dr. Jack Okamoto, John Qua, Mr. Brian Roethemeier, Mr. Tarcisio Ruiz, Paulo Santos, Dr. Mark Steinberg, Mr. Richard Tuck, Dr. Simona Vallone, Dr. Vance Whitaker, Warren Willey, Dr. Guy Witney, Caroline Yourcheck, Dr. Qian Zhang; **Virgin Islands:** Andrew Simpson

Calendar of ISHS Events

For updates and more logon to www.ishs.org/calendar. To claim the reduced registration for ISHS members make sure to mention your membership number when registering and ensure your ISHS membership is current. If in doubt: check your membership status online at www.ishs.org/directory/

YEAR 2011

- March 14-17, 2011, Salatiga (Central Java) (Indonesia): **I International Symposium on Sustainable Vegetable Production in South-East Asia.** Info: Prof. Dr. Stefaan De Neve, University of Gent, Coupure Links 653, 9000 Gent, Belgium. E-mail: stefaan.deneve@ugent.be or Dr. Sri Rochayati, Indonesian Soil Research Institute, Jl. Juanda, Bogor, Indonesia. E-mail: sri.rochayati@gmail.com E-mail symposium: VegSEA2011@ugent.be Web: <http://www.vegsea2011.ugent.be/>
- March 19-23, 2011, Davis, CA (United States of America): **I International Symposium on Wild Relatives of Subtropical and Temperate Fruit and Nut Crops.** Info: Dr. Mallikarjuna Aradhya, USDA Germplasm Repository, One Shields Avenue, University of California, Davis, CA 95616, United States of America. Phone: (1) 530-752-6504, Fax: (1) 530-752-5974, E-mail: aradhya@ucdavis.edu or Dr. Daniel Kluepfel, USDA ARS - 378 Hutchison Hall, Dept. Plant Pathology, Univ. Ca, Davis, One Shields Ave., Davis, CA 95616, United States of America. E-mail: dakluepfel@ucdavis.edu Web: <http://www.wildcrops2011.org/>
- March 24-26, 2011, Djerba (Tunisia): **IV International Symposium on Medicinal and Aromatic Plants SIPAM2011.** Info: Dr. Houcine Khatteli, Institut des Régions Arides, Route de Djouf, Km 22,5, 4119 Médenine, Tunisia. Phone: (216)75633121, Fax: (216)75633006, E-mail: h.khatteli@ira.rnrt.tn or Dr. Mohamed Neffati, Institut des Régions Arides (IRA), Route de Djourf Km 22,5, 4119 Medenine, Tunisia. Phone: (216)75633839, Fax: (216)75633006, E-mail: neffati.mohamed@ira.rnrt.tn E-mail symposium: sipam@ira.rnrt.tn Web: <http://www.sipam.ira.rnrt.tn/>
- April 4-7, 2011, Adelaide (Australia): **International Symposium on Organic Matter Management and Compost Use in Horticulture.** Info: Mr. Johannes Biala, PO Box 74, Wynnum Queensland 4178, Australia. Phone: (61)7-39011152, Fax: (61)7-33962511, E-mail: biala@optusnet.com.au Web: <http://compost-for-horticulture.com/>
- May 8-12, 2011, Volterra (Italy): **VIII International Workshop on Sap Flow.** Info: Prof. Dr. Luca Sebastiani, S.S.S.U.P. Sant Anna, Piazza Martiri della Libertà, 33, 56127, Pisa, Italy. Phone: (39)0508831111, Fax: (39)050883495, E-mail: l.sebastiani@sssupsup.it or Dr. Roberto Tognetti, Università degli Studi Molise, Dipartimento STAT - Univ. del Molise, Contrada Fonte Lappone, 86090

Pesche, Italy. Phone: (39)0874404735, Fax: (39)0874404678, E-mail: tognetti@unimol.it or Antonio Motisi, Dipartimento di Colture Arboree, Facoltà di Agraria, Univ. Di Palermo, Viale delle Scienze, 11, 90128 Palermo, Italy. Phone: (39)0917049021, Fax: (39)0917049025, E-mail: motisi@unipa.it E-mail symposium: sapflow8th@sssupsup.it Web: <http://www.sapflow8th.sssupsup.it/>

- May 15-19, 2011, Puebla (Mexico): **II International Symposium on Soilless Culture and Hydroponics.** Info: Dr. María de las Ni Rodríguez Mendoza, Area de Nutrición Vegetal. IRENAT, Colegio de Postgraduados, Montecillo, Texcoco Edo. Méx, 56230, Mexico. Phone: (52) 595 95 51030, Fax: (52) 595 95 1 01 98, E-mail: marinie@colpos.mx E-mail symposium: issch@colpos.mx Web: <http://www.soillessculture.org/>
- May 15-19, 2011, Alnarp (Sweden): **I International Symposium on Microbial Horticulture.** Info: Dr. Beatrix W. Alsanius, Dept. of Horticulture, SLU, Box 103, 230 53 Alnarp, Sweden. Phone: (46)40415336, Fax: (46)40465590, E-mail: beatrix.alsanius@ltj.slu.se or Dr. Hakan Asp, Department of Horticulture, Box 55, 230 53 Alnarp, Sweden. Phone: (46)40415326, Fax: (46)40415519, E-mail: hakan.asp@ltj.slu.se or Prof. Dr. Paul Jensen, Box 53, SLU, LTJ-Faculty, SE-230 53 Alnarp, Sweden. Phone: (46)706878960, Fax: (46)40 460421, E-mail: paul.jensen@adm.slu.se E-mail symposium: ishs-microhort@ltj.slu.se Web: <http://www.ishs-microhort.com/>
- May 16-19, 2011, Fukuoka (Japan): **VI International Symposium on Edible Alliaceae.** Info: Assist. Prof. Masayoshi Shigyo, Faculty of Agriculture, Yamaguchi University, Yoshida 1677-1, Yamaguchi 753-8515, Japan. Phone: (81)839335842, Fax: (81)839335842, E-mail: shigyo@yamaguchi-u.ac.jp E-mail symposium: isea2011@convention.co.jp Web: <http://www2.convention.co.jp/isea2011/>
- May 23-26, 2011, Wenatchee, WA (United States of America): **IV International Conference Postharvest Unlimited 2011.** Info: Dr. Jim Mattheis, USDA ARS FTFL, 1104 N. Western Ave, Wenatchee, WA 98801, United States of America. Phone: (1)5096642280ext249, Fax: (1)5096642287, E-mail: james.mattheis@ars.usda.gov Web: <http://www.postharvestunlimited2011.org/>
- June 5-10, 2011, Neos Marmaras-Sithonia, Chalkidiki (Greece): **International Symposium on Advanced Technologies and Management towards Sustainable Greenhouse Ecosystems - Greensys2011.** Info: Prof. Dr. Constantinos Kittas, University of Thessaly, School of Agricultural Sciences, Fytokou St., N. Ionia, 38 446, Magnesia, Greece. Phone: (30)2421093158, Fax: (30)2421093234, E-mail: ckittas@uth.gr E-mail symposium: info@greensys2011.com Web: <http://www.greensys2011.com>
- June 13-17, 2011, Quebec City (Canada): **International Symposium on Responsible Peatland Management and Growing Media Production.** Info: Dr. Line Rochefort, Department



of Plant Sciences, Université Laval, Pavillon P. Comtois, 2425, rue de l'Agriculture, Québec, QC G1V 0A6, Canada. Phone: (1)4186562131ext2583, Fax: (1)4186567856, E-mail: line.rockfort@fsaa.ulaval.ca or Jean Caron, Department of Soil Sciences, Université Laval, Pavillon P. Comtois, 2425 rue de l'Agriculture, Québec, QC G1V 0A6, Canada. Phone: (1)4186562131ext2881, Fax: (1)4186567856, E-mail: jean.caron@fsaa.ulaval.ca Web: <http://www.peatlands2011.ulaval.ca/>

- June 15-19, 2011, (Turkey): **I International Mulberry Symposium**. Info: Prof. Dr. Sezai Ercisli, Ataturk University Agricultural Faculty, Department of Horticulture, 25240 Erzurum, Turkey. Phone: (90) 442-2312599, Fax: (90) 442 2360958, E-mail: sercisli@atauni.edu.tr E-mail symposium: sercisli@hotmail.com

NEW

- June 19-23, 2011, Saint-Jean-sur-Richelieu (Canada): **IX International Symposium on Modelling in Fruit Research and Orchard Management**. Info: Dr. Gaetan Bourgeois, Agriculture and Agri-Food Canada, Horticultural R&D Centre, 430 Blvd. Gouin, Saint-Jean-sur-Richelieu, QC J3B 3E6, Canada. Phone: (1)4505152017, Fax: (1)4503467740 E-mail symposium: ISMFR2011@agr.gc.ca Web: <http://www.cshs.ca/modelling/>

- June 20-24, 2011, Yerevan (Armenia): **XV International Symposium on Apricot Breeding and Culture**. Info: Dr. Alvina Avagyan, Armenian State Agrarian University, 74, Teryan Street, Yerevan, Armenia. Phone: (374)93415037, Fax: (374)10202834x121, E-mail: alvinaav@mail.ru or Dr. Aleksandr Kalantaryan, 37 Mamikonyants street. ap.49, 00010 Yerevan, Armenia. Phone: (374) 10237805, E-mail: alikjan@gmail.com E-mail symposium: info@apricot2011.com Web: <http://www.apricot2011.com/>

NEW

- June 21-23, 2011, Lucknow (India): **Global Conference on Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses**. Info: Dr. Hutchappa Ravishankar, Central Inst. for Subtropical Hort., Rehmankhara, PO Kakori, Lucknow, Uttar Pradesh, 227 107, India. Phone: (91)5222841022, Fax: (91)5222841025, E-mail: drhravishankar@gmail.com E-mail symposium: mangosymposium@gmail.com

- June 22-26, 2011, Zlatibor (Serbia): **X International Rubus and Ribes Symposium**. Info: Prof. Dr. Mihailo Nikolic, Faculty of Agriculture, University of Belgrade, 6 Nemanjina, 11080 Belgrade, Serbia. Phone: (381)63 801 99 23, Fax: (381)11 21 93 659 or Dr. Brankica Tanovic, Pesticide & Environment Research Inst., 31b Banatska, 11080 Zemun-Belgrade, Serbia. Phone: (381) 11 31 61 773, Fax: (381) 11 30 76 133 E-mail symposium: x.rubusribes@agrif.bg.ac.rs Web: <http://www.x-rubusribes.agrif.bg.ac.rs/>

- June 27 - July 1, 2011, Kuala Lumpur (Malaysia): **II International Symposium on Underutilized Plants: Crops for the Future - Beyond Food Security**. Info: Festo John Massawe, Nottingham University Malaysia Campus, School of Biosciences, Jalan Broga, 43500 Semenyih, Malaysia. Phone: (60)389248218, Fax: (60)389248018, E-mail: festo.massawe@nottingham.edu.my E-mail symposium: cropsforthefuturesymposium@nottingham.edu.my Web: <http://www.cffsymposium2011.org/>

- June 29 - July 3, 2011, Nanjing (China): **III International Conference on Landscape and Urban Horticulture**. Info: Prof. Dr. Wuzhong Zhou, Institute of Tourism & Landscape Archit., Southeast University, No. 2 Si Pai Lou, Nanjing, Jiangsu, 210096, China. Phone: (86)2583692608, Fax: (86)2583690357, E-mail: wzzhou@seu.edu.cn E-mail symposium: sec.luh2011@gmail.com Web: <http://www.luh2011.org/>

NEW

- July 4-7, 2011, Wisley (United Kingdom): **I International Trials Conference: Assessment of Ornamental Plants**. Info: Ms. Prunella Scarlett, Royal Horticultural Society, Wisley, Woking, Surrey GU23 6QB, United Kingdom. Phone: (44)148322423, Fax: (44)1483211750, E-mail symposium: ornamentals2011@rhs.org.uk Web: <http://www.rhs.org.uk/Plants/ornamentals2011.asp>

- July 6-9, 2011, Saas-Fee (Switzerland): **I International Symposium on Medicinal, Aromatic and Nutraceutical Plants from Mountainous Areas**. Info: Dr. Christoph Carlen, Agroscope Changins-Wädenswil ACW, Centre de Recherche Conthey, Route des Vergers 18, 1964 Conthey, Switzerland. Phone: (41) 27 345 35 11, Fax: (41) 27 346 30 17, E-mail: christoph.carlen@acw.admin.ch Web: <http://www.agroscope.admin.ch/mapmountain/>

- July 17-21, 2011, Torino (Italy): **II International Conference on Quality Management of Fresh Cut Produce: Convenience Food for a Tasteful Life**. Info: Prof. Dr. Silvana Nicola, Dipartimento di Agronomia, Selvicoltura e Gestione del Territorio, Via Leonardo Da Vinci 44, 10095 Grugliasco (TO), Italy. Phone: (39)0116708773, Fax: (39)0112368773, E-mail: silvana.nicola@unito.it Web: <http://www.freshcut2011.org/>

NEW

- August 17-19, 2011, Flores, Petén (Guatemala): **International Symposium on Medicinal and Aromatic Plants; History of Mayan Ethnopharmacology** Info: Dr. Jalal Ghaemghami, Director of SHMEN Inc., PO Box 320172, West Roxbury, MA 02132, United States of America. Phone: (1)6176782157, E-mail: jalal@shmen.org E-mail symposium: ishs-tikal@shmen.org Web: <http://www.imaps2011-peten.org/>

- September 3-7, 2011, Xinzheng, Henan (China): **II International Jujube Symposium**. Info: Prof. Dr. Mengjun Liu, Research Center of Chinese Jujube, Agricultural University of Hebei, Baoding, Hebei, 71001, China. Phone: (86)312754342, Fax: (86)3127521251, E-mail: kjliu@hebau.edu.cn or Dr. Jubin Shi, Haoxiangni Jujube Co. Ltd., Xinzheng, Henan, 451150, China. Phone: (86)37162489919, Fax: (86)37162489198, E-mail: ijs2008@yahoo.com.cn

- September 5-7, 2011, Pitesti (Romania): **II Balkan Symposium on Fruit Growing**. Info: Dr. Mihail Coman, Fruit Research Institute, Str. Popa Sapca, Nr. 14, Cod. 110150, Jud. Arges, Pitesti-Maracineni 0300, Romania. Phone: (40)248278292, Fax: (40)248278477, E-mail: mihailcoman1@gmail.com E-mail symposium: office@icdp-pitesti.ro Web: <http://bsfg2011.icdp.ro/>

NEW

- September 10-12, 2011, Damghan (Iran): **I International Symposium on Mycotoxins in Nuts and Dried Fruits**. Info: Dr. Hossein Abbaspour, Islamic Azad University, Damghan Branch, Damghan, Iran. Phone: (98)2325235214, Fax: (98)2325235214, E-mail: abbaspour75@yahoo.com E-mail symposium: afshari@mycotoxinsymp.com Web: <http://www.mycotoxinsymp.com/>

- September 11-15, 2011, Warsaw (Poland): **XIII Eucarpia Symposium on Fruit Breeding and Genetics**. Info: Dr. Emilian Pitiera, Warsaw University of Life Sciences, SGGW - Department of Pomology, ul. Nowoursynowska 166, 02-787 Warszawa, Poland. Phone: (48)225932087, Fax: (48)225932111, E-mail: emilian_pitiera@sggw.pl Web: <http://www.eucarpia2011.woiak.sggw.pl/>

- September 12-16, 2011, Nelspruit (South Africa): **II ISHS Genetically Modified Organisms in Horticulture Symposium: Paving the Way for a Sustainable Future**. Info: Ms. Adri Veale, University of Pretoria, Faculty of Natural and Agric. Science, Department of Genetics, 0002 Pretoria, South Africa. Phone: (27)12-4203939, Fax: (27)12-4203960, E-mail: adri.veale@up.ac.za Web: <http://www.gmo2011.co.za/>

NEW

- September 17-19, 2011, Tunis (Tunisia): **I International Symposium on Cassava Market and Economy**. Info: Dr. Antonio Felice, Via Fiordiligi 6, 37135 Verona, Italy. Phone: (39)0458352317, Fax: (39)0458307646, E-mail: editor@greenmed.eu or Prof. Dario Salvatore Caccamisi, Monticello 10B, 41052 Guiglia (Modena), Italy. Phone: (39)059-792778, Fax: (39)059-792778, E-mail: dario.caccamisi.agronomo@hotmail.it

- September 18-22, 2011, Ghent (Belgium): **VII International Symposium on In Vitro Culture and Horticultural Breeding: IVCHB**. Info: Danny Geelen, Coupure Links 653, 9000 Gent, Belgium. Phone: (32)9264 60 76 E-mail symposium: IVCHB2011@UGent.be Web: <http://www.ivchb2011.ugent.be/>

NEW

- September 26-29, 2011 (postponed until further notice, please check www.ishs.org/calendar), Giza (Egypt): **V International Symposium on Vegetable Nutrition and Fertilization: Vegetable Farms Management Strategies for Eco-Sustainable Development.** Info: Dr. Ahmed Glala, Horticultural Crops Technology Department, Agriculture Research Division, National Research center, Dokky, 12622 Giza (El-Bhoos Street), Egypt. Phone: (20)122963894, Fax: (20)237601877, E-mail: aaa_glala@yahoo.com Web: http://www.ishs.org/calendar/5VNFsymp_1announcement.pdf
- October 9-12, 2011, Tirana (Albania): **V Balkan Symposium on Vegetables and Potatoes.** Info: Prof. Astrit Balliu, Agricultural University of Tirana, Faculty of Agriculture, Horticultural Department, Tirana, Albania. Phone: (355)686022105, E-mail: aballiu@ubt.edu.al E-mail symposium: ssecretary@ubt.edu.al Web: <http://5bsvp.ubt.edu.al/>
- October 10-12, 2011, Zürich (Switzerland): **I International Workshop on Bacterial Diseases of Stone Fruits and Nuts.** Info: Dr. Brion Duffy, Agroscope Faw, Schloss, Postfach 185, 8820 Waedenswil, Switzerland. Phone: (41)447836111, Fax: (41)447836305, E-mail: duffy@acw.admin.ch
- October 10-14, 2011, Salvador (Bahia) (Brazil): **International ISHS-ProMusa Symposium - ProMusa 2011.** Info: Dr. Edson Perito Amorim, Embrapa Cassava and Tropical Fruits, Embrapa Avenue, Cruz das Almas Bahia 44380000, Brazil. E-mail: edson@cnpmf.embrapa.br or Dr. Aristoteles Pires de Matos, EMBRAPA - CNPMF, Rua Embrapa s/n, Caixa Postal 007, Cruz das Almas, Bahia 44380-000, Brazil. Phone: (55)7536218000, Fax: (55)7536211118, E-mail: apmatos@cnpmf.embrapa.br
- October 16-19, 2011, University Park, PA (United States of America): **International Symposium on High Tunnel Horticultural Crop Protection.** Info: Dr. Michael Orzolek, 203 Tyson Bldg, The Pennsylvania State University, University Park, PA 16802, United States of America. Phone: (1)814 863-2251, E-mail: mdo1@psu.edu Web: <http://horticulture.psu.edu/cms/ishs2011/>
- October 16-22, 2011, Nebraska City, NE (United States of America): **V International Symposium on Acclimatization and Establishment of Micropropagated Plants.** Info: Prof. Paul E. Read, Univ. Nebraska, Inst. of Agr., & Nat. Resources, Dept. Hort., 377 Plant Sci., East Campus, Lincoln, NE 68583-0724, United States of America. Phone: (1)402-472-2854, Fax: (1)402-472-8650, E-mail: pread@unl.edu or Prof. Dr. John E. Preece, Supervisory Research Leader USDA-ARS, One Shields Avenue, University of California, Davis, CA 95616-8607, United States of America. Phone: (1)530-752-7009, Fax: (1)530-752-5974, E-mail: john.preece@ars.usda.gov
- October 17-21, 2011, Barcelona (Spain): **International Symposium on Growing Media, Composting and Substrate Analysis.** Info: Prof. Dr. Xavier Martínez Farré, Escola Superior Agricultura (ESAB-EUETAB), Campus Baix Llobregat, Av. Canal Olímpic s/n, 08860 Castelldefels, Spain. Phone: (34)935521094, Fax: (34)935521001, E-mail: xavier.martinez-farre@upc.edu E-mail symposium: growingmedia.composting2011@upc.edu Web: <http://www.upc.edu/growingmediacomposting2011>
- November 3-4, 2011, Launceston, Tasmania (Australia): **International Symposium on Pyrethrum, The Natural Insecticide: Scientific and Industrial Developments in the Renewal of a Traditional Industry.** Info: Mr. Brian Chung, Botanical Resources Australia, PO Box 852, Sandy Bay, Hobart, TAS 7006, Australia. Phone: (61)362244511, Fax: (61)362244473, E-mail: bchung@pyrethrum.com.au E-mail symposium: py2011@pyrethrum.com.au Web: http://www.ishs.org/calendar/pyrethrum_2011.pdf
- November 15-18, 2011, Chiang Mai (Thailand): **International Symposium on Medicinal and Aromatic Plants - Royal Flora 2011.** Info: Peyanoot Ms. Naka, Horticulture Research Institute, Department of Agriculture, Chatuchak, Bangkok 10900, Thailand. Phone: (66)819076821, Fax: (66)25614667, E-mail: peyanoot@hotmail.com or Dr. Somchai Charnnarongkul, Department of Agriculture, Phahonyothin Rd., Chatuchak, Bangkok 10900, Thailand. Phone: (66)25799636, Fax: (66)29405412, E-mail: tosomchai@yahoo.com E-mail symposium: royalflorasymposium2011@yahoo.com Web: http://www.royalflora2011.com/index_eng.html
- November 22-25, 2011, Buenos Aires (Argentina): **VII International Symposium on New Floricultural Crops.** Info: Dr. Gabriela Facciuto, INTA, Los Reseros y Las Cabañas s/n, Castelar, 1712, Argentina. E-mail: gfaciuto@cnia.inta.gov.ar Web: <http://www.inta.gov.ar/floricultura/newornamentals2011/index.asp>
- November 24-27, 2011, Chiang Mai (Thailand): **III International Symposium on Papaya - Royal Flora 2011.** Info: Dr. Jirakorn Kosaisawe, Director General, Department of Agriculture, Chatuchak, Bangkok 10900, Thailand. Phone: (66)25799636, Fax: (66)29405412, E-mail: jirakorn_k@yahoo.com E-mail symposium: royalflorasymposium2011@yahoo.com Web: http://www.royalflora2011.com/index_eng.html
- November 29 - December 2, 2011, Chiang Mai (Thailand): **International Symposium on Tropical and Subtropical Fruits - Royal Flora 2011.** Info: Peyanoot Ms. Naka, Horticulture Research Institute, Department of Agriculture, Chatuchak, Bangkok 10900, Thailand. Phone: (66)819076821, Fax: (66)25614667, E-mail: peyanoot@hotmail.com or Dr. Somchai Charnnarongkul, Department of Agriculture, Phahonyothin Rd., Chatuchak, Bangkok 10900, Thailand. Phone: (66)25799636, Fax: (66)29405412, E-mail: tosomchai@yahoo.com E-mail symposium: royalflorasymposium2011@yahoo.com Web: http://www.royalflora2011.com/index_eng.html
- December 3-6, 2011, Bangkok (Thailand): **International Conference on Quality Management in Supply Chains of Ornamentals (QMSCO 2011).** Info: Dr. Sirichai Kanlayanarat, King Mongkut's University of Technology, Thonburi, Division of Postharvest Technology, Thungkru, Bangkok 10140, Thailand. Phone: (66)2 470 7720, Fax: (66)2 452 3750, E-mail: sirichai.kan@kmutt.ac.th E-mail symposium: qmsco@kmutt.ac.th Web: <http://www.kmutt.ac.th/QMSCO2011/>
- December 3-6, 2011, Bangkok (Thailand): **Asia Pacific Symposium on Postharvest Quality Management of Root and Tuber Crops.** Info: Dr. Sirichai Kanlayanarat, King Mongkut's University of Technology, Thonburi, Division of Postharvest Technology, Thungkru, Bangkok 10140, Thailand. Phone: (66)2 470 7720, Fax: (66)2 452 3750, E-mail: sirichai.kan@kmutt.ac.th
- December 3-6, 2011, Bangkok (Thailand): **I International Symposium on Postharvest Pest and Disease Management in Exporting Horticultural Crops.** Info: Pongphen Jitareerat, King Mongkut's Univ. of Technology Thonburi, Div. Postharv.Techn. School of Biores.& Techn., 83 Moo 8, Tientalay rd., 10150 BKK -Bangkhuntien, Thakham, Thailand. E-mail: pongphen.jit@kmutt.ac.th Web: <http://www.kmutt.ac.th/ppdm2011/>
- December 3-6, 2011, Bangkok (Thailand): **Southeast Asia Symposium on Quality Management in Postharvest Systems (SEAsia2011).** Info: Dr. Sirichai Kanlayanarat, King Mongkut's University of Technology, Thonburi, Division of Postharvest Technology, Thungkru, Bangkok 10140, Thailand. Phone: (66)2 470 7720, Fax: (66)2 452 3750, E-mail: sirichai.kan@kmutt.ac.th Web: <http://www.kmutt.ac.th/SEAsia2011>
- December 9-12, 2011, Madurai (India): **I International Symposium on Cashew Nut.** Info: Dr. Ravindran Chandran, Assistant Professor, KVK, AC & RI, Tamil Nadu Agricultural University, Madurai, 625104 (Tamil Nadu), India. Phone: (91)452-2422955, Fax: (91)452-2422785, E-mail: ravi_hort@yahoo.com Web: <http://www.cashewnut2011.co.cc/>

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Chronica Horticulturae

Author Information

Chronica Horticulturae is the quarterly publication of the International Society for Horticultural Science (ISHS) and is received by all members of the Society and numerous libraries throughout the world. Members and non-members are urged to contribute articles for consideration. However, it needs to be understood that *Chronica* is not to be construed as a scientific journal that publishes original research. Research articles appropriate for *Acta Horticulturae* or horticultural science journals are usually inappropriate for *Chronica*. We seek horticultural articles of interest to a broad audience composed of ISHS members and the horticultural, scientific, and academic communities.

Chronica Horticulturae is currently made up of as many as eight sections as follows:

News & Views from the Board. This section is usually confined to editorials from Board Members as well as general announcements of the Society.

Issues. Articles of a broad focus that often involve controversial topics related to horticulture including broad social issues and economic development are appropriate for this section. These articles are intended to stimulate discussion. Often, guest writers are asked to contribute articles.

Horticultural Science Focus. This section is intended for in-depth articles on a topic of horticulture, generally, but not always, scientific in nature. Many articles are mini-reviews, and bring current topics of interest to the horticultural community up to date. We encourage these articles to be illustrated.

Horticultural Science News. Shorter current articles about particular topics including horticultural commodities and disciplines are welcome.

History. This section includes articles on the history of horticulture, horticultural crops, and ISHS.

The World of Horticulture. This section highlights articles on horticultural industries and research institutions of particular countries or geographic regions throughout the world. They are meant to be profusely illustrated with figures and tables. This section also includes book reviews, which are requested by the Science Editor. Members who wish to recommend a book review should arrange for a copy of the book to reach the Secretariat.

Symposia and Workshops. Meetings under the auspices of ISHS are summarized, usually by a participant of the meeting. These articles are delegated by the symposium organizers.

News from the ISHS Secretariat. This section contains information on membership, memorials for deceased ISHS members, and a calendar of ISHS events. Brief memorials (up to 500 words) should be sent to the Secretariat.

Authors who wish to contribute articles for *Chronica* should contact headquarters and their request will be transmitted to the Science Editor or another appropriate editor. Authors should be aware that most articles should have a broad international focus. Thus, articles of strictly local interest, are generally unsuited to *Chronica*. Illustrated articles are usually 1500 to 5000 words. There are no page charges for *Chronica Horticulturae*. Photographs submitted should be of high resolution. We encourage electronic submission. Send articles or ideas for articles to:

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