A publication of the International Society for Horticultural Science

Chronica Horticulturae

Horticultural highlights

From Africa to the world: indigenous fruits and nuts • Feeding the future: tropical and subtropical fruit and nut systems sustainability • Cooperative approaches to standardize hemp phenotyping • Carrot, a major vegetable crop in France

Symposia and workshops

Jujube • Tropical and Subtropical Ornamentals • Mineral Nutrition of Fruit Crops • Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems • Biotechnology as an Instrument for Plant Biodiversity Conservation • Controlled and Modified Atmosphere Research • Growing Media, Soilless Cultivation, and Compost Utilization in Horticulture • Plum and Prune Genetics, Breeding and Pomology • Persimmon • South-Eastern Europe Vegetables and Potatoes

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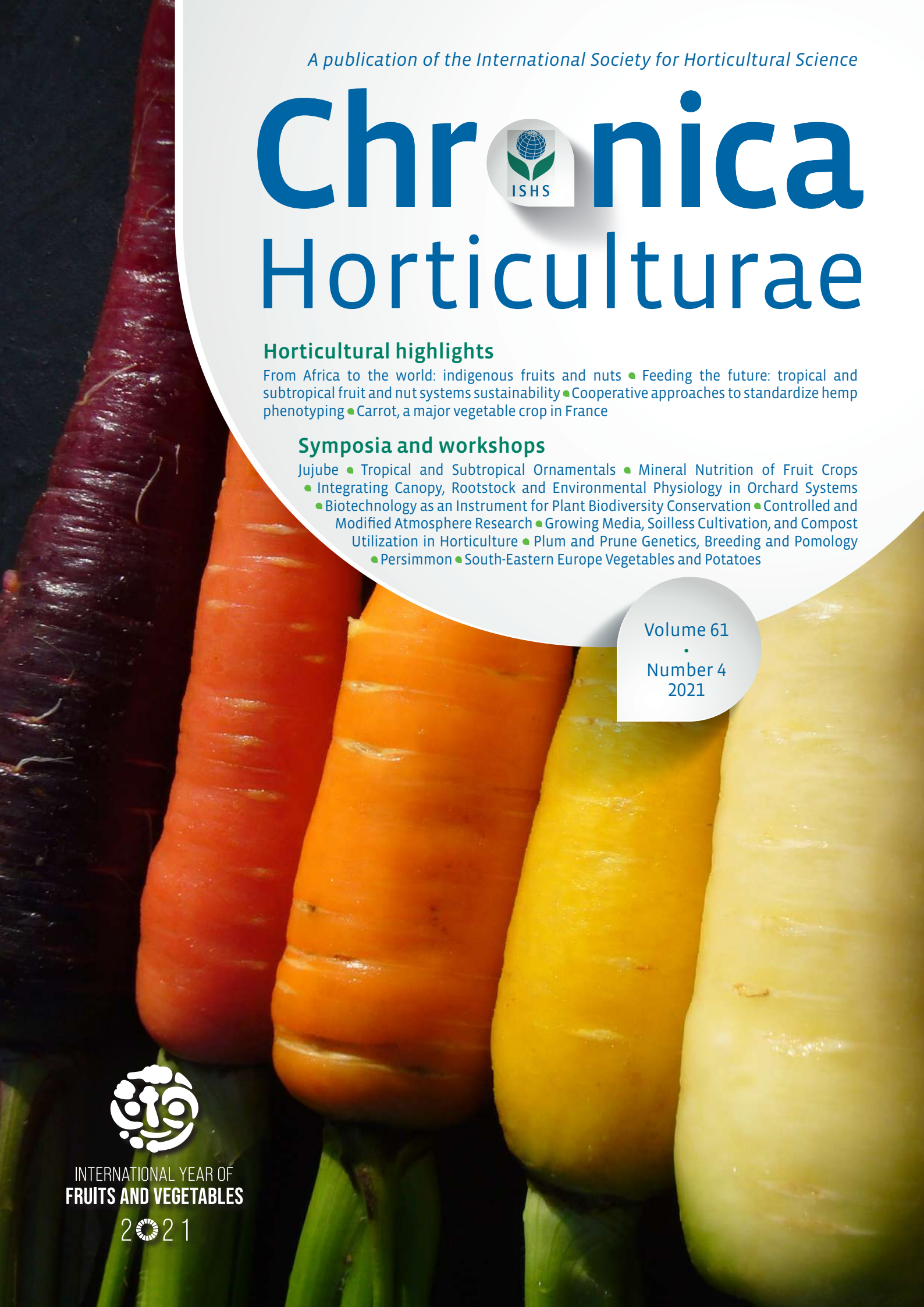

INTERNATIONAL YEAR OF
FRUITS AND VEGETABLES
2021

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Cover photograph: A cavalcade of carrots: the French diversification of colors and flavors. Photo by Emmanuel Geoffriau. See article p.27.

Grow and eat more fruit and vegetables: a call from the United Nations on the International Year of Fruit and Vegetables 2021

Sisir Mitra

Sisir Mitra, ISHS Board Member Responsible for Publications

Fruit and vegetables are an essential part of the diet and, increasingly, are shown to positively contribute to human health. A growing body of evidence suggests that regular consumption of a phytochemical-rich diet reduces the risk of many chronic human illnesses and increases the span and quality of life. There is substantial evidence to this effect, and meta-analysis has clearly established the link between the intake of fruit and vegetables to a reduced risk of chronic diseases, including cancer, cardiovascular, and neurodegenerative diseases. For example, fruit and vegetables have been shown to be beneficial for people suffering from chronic obstructive pulmonary disease by reducing oxidative stress and inflammation which, consequently, improves lung function (Scoditti et al., 2019). It is suggested, therefore, that incorporating fresh fruits and vegetables into the diet of a person with chronic obstructive pulmonary disease should reduce their chances of serious illness or death infected with diseases such as COVID-19, as well as providing overall health benefits.

Fruit and vegetables are rich sources of essential minerals, vitamins, fibre and phytochemicals. This latter category is believed to contribute to many of the health benefits that have been demonstrated. The World Health Organization (WHO) recommends a daily minimum intake of fruit and vegetables of 400 g per adult person per day. However, The State of Food Security and Nutrition in the World Report estimated that the average per capita availability of fruit and vegetables throughout the world is only 390 g per day (FAO et al., 2020). In some regions it is much less. For example, the per capita availability of fruit and vegetables is only 191 g per day in Africa and, in low-income countries, as a whole, it is only 142 g per day. A recent study (Seer-Uke et al., 2021) on nutritional status of children under the age of five in Benue state, Nigeria, indicated that the overall prevalence of stunting (reduced height) and wasting (underweight) was 44 and 8%, respectively. An estimated 45% of deaths of children under five in low- and middle-income countries are linked to malnutrition (Black et al., 2013).

There are 690 million undernourished people living in the world today, 750 million people are suffering from food insecurity, 2 billion people are lacking access to safe and nutritious food, and 3 billion people are unable to afford a healthy diet (FAO and CIRAD, 2021).

The consumption of fruit and vegetables is also below desirable levels in most if not all developed countries. This has led to initiatives such as the Five-Plus-a-Day programs that are sponsored by both industry and Government in countries such as New Zealand (see https://www.5aday.co.nz/). The five plus relates to five servings plus handfuls of fruit and vegetables.

Fruits and vegetables are “nutrient-dense foods” in that they provide substantial amounts of micronutrients, such as minerals and vitamins. The deficiency of micronutrients, referred to as the hidden hunger, afflicts more than 2 billion individuals globally. Its adverse effects on child health and survival are particularly acute within the first 1000 days of a child’s life, from the conception to the age of two, resulting in serious physical and cognitive consequences. The most recognized micronutrient deficiencies across all ages are caused by lack of iodine, iron, and zinc. A diet rich in fat and sugar and a decreased intake of fiber has been implicated in a wide variety of diseases and associated with changes in the bacteria in gut microbiota. The emerging importance of the gut microbiota in human physiology and its modulation by fruit and vegetables provide insights to their beneficial impacts on health. It is now recognized that polyphenols, but also fibres, glucosinolates, and other molecules, can positively modulate gut microbiota, reducing the harmful presence of pathobionts and favouring the presence of beneficial probiotic bacteria. Polyphenols present in fruit and vegetables also play a key role in immunological responses and are potent drivers of the signals passing between the gut and the brain. They are thus involved in the prevention of cognitive decline, and probably in many physiological responses involving the central nervous system, which can dictate our behavior and mood (Desjardins, 2021).

At its 74th session, the United Nations (UN) General Assembly proclaimed 2021 to be the International Year of Fruits and Vegetables (IYFV). The IYFV provides a unique opportunity to raise awareness of the important role of fruit and vegetables in human nutrition, food security and health, while also advancing the UN Sustainable Development Goals (SDGs). This initiative will promote international efforts to boost fruit and vegetable production. It will also encourage value chains to be sustainable and safe, bringing into focus the need to reduce losses and waste in fruit and vegetable supply chains from production to consumption. The IYFV 2021 invites relevant stakeholders to strengthen the capacities of developing countries to adopt innovative approaches and technologies in combating loss and waste of fruits and vegetables. In addition, special attention is paid to the role of women, not only in the production of food, but also in assuring the food security of their families and communities. The fruit and vegetable sector has to drive not only food security but global nutritional security. The IYFV

2021 advocates for actions to strengthen the role of small-scale and family farmers in sustainable farming and production in order to reduce hunger and poverty, enhance food and nutrition security, improve livelihoods, and contribute to better natural resource management (FAO and CIRAD, 2021).

At the international level, research activities on fruit and vegetables are very small compared with those on staple crops. A core partnership among CIRAD, FAO and the ISHS intends to raise the visibility of the sector and will engage civil society, scientists, and policy makers through a global approach. ISHS is conducting several webinars to encourage growing and eating more fruits and vegetables, such as "Plant genetic resources for food security," "What does science say about fruits and vegetables and health?", "Agroecology," and "Vertical farming," apart from the scheduled symposia (https://www.ishs.org/calendar) of the year.

To be successful, these programmes require a collective effort by farmers, all stakeholders and different international organizations working for the development of a greater involvement in horticultural production and horticultural research.

Today the message is loud and clear: "Grow and eat more fruits and vegetables to live a healthy life."

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Spotlight on Honoured ISHS Members

› Sue Gardiner

Previous position

Principal Scientist, The New Zealand Institute for Plant and Food Research Ltd (PFR); Retired December 2019

ISHS honour

ISHS Fellow

1. Tell us a bit about yourself (hometown, present location, family, hobbies, community involvement).

I live on the outskirts of Palmerston North, in the North Island of New Zealand, with my husband Lindsay Davies, also a retired scientist and passionate gardener. We have developed a large garden on our 10-acre property over the past 40 years, and this occupies most of our time. We do not have children and share our home with two Burmese cats, Talia and Chico, as well as a fox terrier, Mae, who has rabbit control responsibilities. As an Honorary Research Fellow at Plant and Food Research (PFR), I still go into the office on Fridays to continue my own writing, as well as mentoring of younger colleagues. I am a lover of rhododendrons, currently serving a second term as President of the New Zealand Rhododendron Association. I have developed skills in *Rhododendron* propagation as a hobby and am participating in a New Zealand initiative for their ex situ conservation. We have identified a garden further south, in Dunedin, that is a treasure trove of unlabelled *Rhododendron* species, many of which are on the International Union for Conservation of Nature's Red List of Threatened Species. I have been visiting there twice each year for the past five years, identifying plants, and bringing home scions for propagation and distribution to conservation sites. This project has also given me the opportunity to co-supervise a PhD student who will utilise some of the genomic technologies that my PFR team developed for fruit crops, to determine the degree of genetic relatedness among putative species in a taxonomicly tangled subsection of *Rhododendron*. Distinct species have priority for conservation in 'large genera', of which *Rhododendron* is one, with over 1,000 species.

Ling Hu, the PhD student, arrived just before the first COVID-19 lockdown in February 2020. Initially, she talked with her three supervisors weekly by Zoom meetings. When restrictions eased, her first field work was a foray into our garden but later trips have been further afield. Ling definitely helps keep my brain active in my retirement! Oh yes, I have also developed an *Iris ensata* breeding programme, kick started by the gift of seed from Chad Harris, a well known US breeder of *I. ensata*.

2. What got you started in a career in horticultural science?

I have always been interested in nature and the outdoors, having been raised on an 5,000-acre sheep and cattle farm in the South Island. I was home schooled by my mother, also a keen gardener, until I went to boarding school at age 10, because the property was a considerable distance from the local school. This experience definitely made me a self starter, and I had responsibility for my younger brothers outdoors from an early age. I was permitted to help my father once I had finished the day's lessons. Two to three hours into the morning saw me at his heels, often on my pony, herding sheep and cattle.

I remember enjoying the Correspondence School Nature Study modules. One project was to follow the development of a small branch on an oak tree on the back lawn. At Otago University, I took courses in both plant and animal science, finally settling for plants, due to my dislike of killing animals in Physiology classes. Lectures from Professor George Petersen of the Biochemistry Department kindled my interest in DNA and genetics. This was at the very beginning of the DNA era. George, who died recently, is known in New Zealand as the 'father of DNA'.

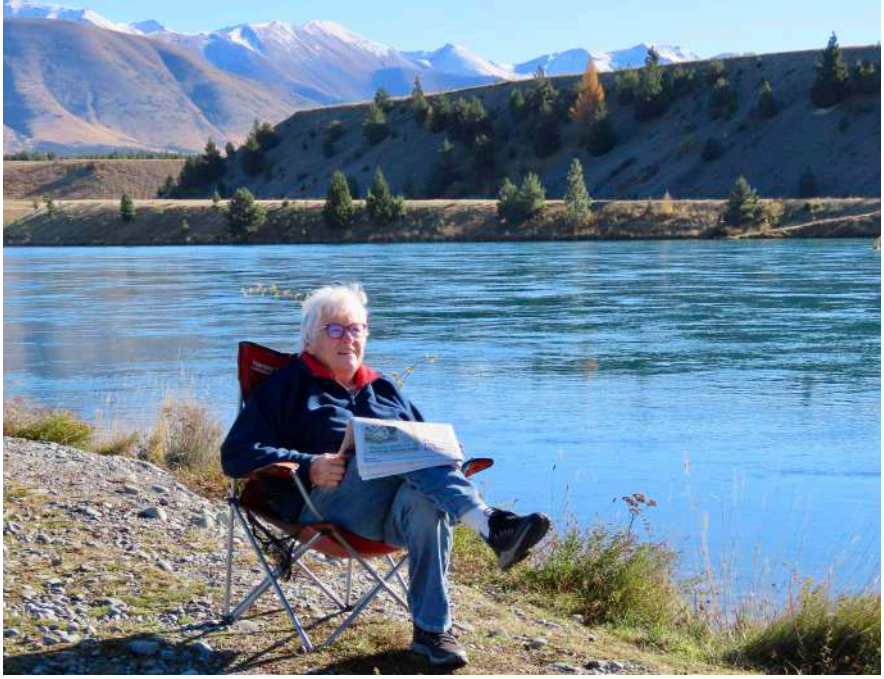
3. Give a brief overview of your career/achievements.

After completing my PhD in Biochemistry, I spent two years at Freiburg University, Germany, working with Professor Kraus Hahlbrock on the molecular biology of the phenylpropanoid pathway. This was definitely a fun time, where I insisted on speaking German, which I had learnt in evening classes during my PhD. Never mind that my lab mates wanted to practise their English. Back in New Zealand, I obtained a scientist position at the Plant Physiology Division of the Department of Scientific and Industrial Reseach (DSIR) at Palmerston North, in 1980, investigating the biochemistry of the control of plant lipid biosynthesis.

Ten years later, I initiated research into the development of molecular markers as a tool for apple breeders to create new varieties that are naturally resistant to critical pests

› With some mentees on retirement day, 19 December 2019.

› Day after, mowing in the *Iris* patch, 2019.



› Trout fishing at Lake Ruataniwha, winter 2021.

and diseases. Over the years, as DSIR changed and developed into a series of new entities, I grew the project and the team that I developed and led. I have particularly enjoyed the opportunities I have had to interact with international colleagues in the USA, Europe, and most recently, China. Oddly enough, I have often felt more appreciated internationally than in New Zealand. Overseas collaboration gave me the opportunity to participate in the sequencing of the apple and pear genomes, which enabled the development of new classes of very specific, high throughput DNA markers – this was REALLY exciting!

4. What do you consider to be your greatest achievements?

My greatest satisfaction has come from seeing molecular markers developed by my PFR team being utilised by international breeders of apple, pear, and kiwifruit. It is wonderful to see that team still developing and working in a whole range of new crops. The International Rosaceae Genomics Initiative III meeting I co-organised in New Zealand, in 2006, provided the opportunity for a set of fiercely independent researchers to get to know each other in unfamiliar surroundings and sparked the beginning of the era of cooperative research in the *Rosaceae*. I must admit to getting a special buzz when my good friends in the RosBREED genetics community obtained two cycles of USDA funding, following several years of my working on grant proposals with them.

5. Did you encounter difficulties along your career path and how did you deal with them or how did you turn them into opportunities?

I certainly was misunderstood and treated badly by several misogynistic male managers during my career. Fortunately they were not at the same site as I was, and I used the opportunity to perform some initial research under the radar. Other colleagues located onsite with these managers were more closely monitored. Besides, I figured that if I waited long enough, and I did, the culprits might somehow disappear from the organisation. And they did. I do not give up quickly. I acknowledge the supportive men who encouraged me to hang in there. My only woman mentor, Margot Forde, died too early.

6. Tell us about one funny/exciting/interesting experience that happened to you during your career.

The oddest thing I experienced, is that just over a year after my retirement, I received news of my election as a Fellow of the Royal Society of New Zealand, AND a Fellow of the ISHS in the same week!

7. What made you become a member of ISHS and why did you keep the membership? What contribution or role has ISHS played in your career?

I joined the ISHS when I attended a symposium, I cannot remember which. I found membership a useful way of networking and ended up as Chair of ISHS Working Group Biotechnology of Horticultural Species.

8. What advice would you give to young people interested in a career in horticulture/horticultural science?

Go for it! You don't know what you can do until you try. Find a mentor. Science is a team activity.

9. What are the most interesting new roles or opportunities you see emerging in the future within horticultural science?

It is hard to be specific, but we need to realise that technological developments are enabling former "minor crops" to become leaders in science. Who could have foreseen the sequencing of polyploid kiwifruit 10 years ago! Or that it would be feasible to undertake genomic research in *Rhododendron*, when I could not afford to use my own technologies to breed my favourite plant during my career.

› Induction as Fellow of the Royal Society of New Zealand, 2021.

› PFR Fellow at work 2021.

From Africa to the world: indigenous fruits and nuts

Isaac Aiyelaagbe, Chidinma Peter-Onoh, Isijokelu Ojeifo and Askira Mohammed Sadiqqui

› Diversity: fruits and nuts from Africa.

Africa has a diverse ecology that ranges from desert, montane, tropical dry to tropical humid. These ecologies abound in diverse indigenous fruits and nuts, which if adequately utilized, could address issues of food and nutritional security, conservation of biodiversity, eco-tourism, job creation and foreign exchange earnings, all culminating in improved livelihoods. Nonetheless, their potentials remain underutilized as these commodities are often hardly known beyond their respective sub-regions of origin/diversity. In spite of the copious literature on the ethnobotany of African fruits and nuts, many of them are still gathered from the wild, consumed locally and their availability is subject to a lot of vagaries. Crops that are gathered from the wild are endangered because they are often depleted during land clearing for commercial cultivation or urbanization projects. However, a few have been selected, domesticated, and feature at low populations in the cropping systems and are traded locally and sometimes nationally (Aiyelaagbe, 1992).

In Africa, indigenous fruits and nuts have consistently been rated low in importance compared with the exotic and adapted exotic ones. They are priced low and are hardly traded internationally. Neither do they receive major concerted research and development input to upgrade them to commercial status. Consequently, there is little incentive by growers, gatherers or vendors to make investments in upgrading their quality. The International Year of Fruits and Vegetables aims at raising awareness of, directing policy attention to, and sharing good practices on the nutritional and health benefits of fruit and vegetable consumption, the contribution of fruit and vegetable consumption to the promotion of diversified, balanced and healthy diets and lifestyles, and reducing loss and waste of fruits and vegetables. Consequently, this article seeks to contribute to this goal by making some of the indigenous fruits and nuts of Africa better known and to stimulate national and international interest in their improvement, commercial cultivation and utilization. When this is achieved, their diverse benefits can be exploited to improve livelihoods globally. The focus of this article is identification and description as well as a look at current and potential uses of indigenous fruits and nuts from the sub-regions of Africa.

North Africa

Argan (*Argania spinosa*) (*Sapotaceae*) is a multipurpose medium sized thorny tree indigenous to calcareous semi-arid southwest Morocco and Algeria. It produces small, oval shaped fruits about the size of an olive, which take about a year to mature. The fruits enclose up to three almond-shaped nuts. They are aromatic but have an unpleasant tasting pulp. The nuts are the commodity of commercial interest in the fruit because they can be processed into oil, which contains vitamin E, oleic acid, linoleic acid, palmitic acid and stearic acid. The oil is edible, useful in the cosmetics industry and has other industrial applications. The fruits are available in July when they fall to the ground. They are collected for processing by splitting the kernel for nut extraction and roasting. Thereafter, the nuts are crushed and the slurry squeezed to extract the oil. The argan tree is also useful for fodder and apiculture but is endangered due to pressure from browsing by livestock.

Sycamore fig (*Ficus sycamorus*) (*Moraceae*) is one of the few indigenous fruits of Egypt. It is a semi deciduous tree that attains a height of 35 m and a main trunk diameter of 2 m. It has a dense crown, nonetheless it can be

› A) Grafted seedling and fruit of *Irvingia gabonensis*. B) Grafted seedling of *Cola acuminata*.

grown as a bonsai. It is propagated largely vegetatively through stem cuttings and cleft or whip grafting. In Egypt it grows along water courses. The fruits grow in clusters mostly on the trunk suspended on peduncles and are available April-December. They turn buff-green, yellow or red on ripening. They have a yellow flesh, are moderately sweet and contain trace amounts of magnesium, potassium and sodium, but they also contain anti nutritional factors. They can be eaten fresh or dried for later use, or fermented into wine. It is an endangered species because it does not propagate naturally (by seed).

East Africa

Christ's thorns/jujube (*Ziziphus spina-christi* (L.) Desf.) (*Rhamnaceae*) features in enclosed pastures in semi-arid zones of East Africa. It is a drought tolerant spiny shrub that could grow into a small tree or attain a height of 10 m (Gebru et al., 2019). The fruits are sweet and consumed fresh or dried. They are a good source of B vitamins, calcium, potassium, sodium, phosphorous, copper, iron, and zinc. They are also used as fodder and in apiculture. Fermentation increases bioavailability of the nutrients in the fruits. Jujube has a great potential of addressing food security and mitigation of effects of climate change.

Desert date (*Balanites aegyptiaca* (L.) Delile) (*Zygophyllaceae*) features in African woodlands along the Sahara southern border running through Sudan and Ethiopia. It is very tolerant to drought and can thrive with an annual rainfall of 200 mm. The tree begins to flower and fruits at 5 to 7 years of age. The fruit is an oblong-shaped drupe. Young fruits are green and tomentose, turning yellow and glabrous when mature. The fruit pulp is bitter-sweet. The fleshy pulp of both unripe and ripe fruit is edible; it can be eaten dried or fresh. The mesocarp contains 1.2-1.5% protein and 35-37% sugars and 15% organic acids. They can be processed into drinks or an alcoholic liquor, sweet meats, and soup ingredients. The aqueous extract of fruits has spermicidal activity; thus, it can be exploited for birth control. The kernels produce an edible oil used for cooking and pharmaceutical applications. The seed cake residue after the oil is extracted is commonly used as animal fodder. The seeds of *B. aegyptiaca* have a molluscicide effect on *Biomphalaria pfeifferi* (Ahmad and Mariod, 2019), thus it can be used in the development of biopesticides.

Tamarind (*Tamarindus indica*) (*Fabaceae*) grows into a large evergreen tree in arid Ethiopia and semi-arid Uganda where it is a highly valued food tree species. The fruits are small brown clustered pods that enclose a coffee-brown mesocarp containing dark, flat seeds. It grows in the wild or in home gardens and provides food supplements that are useful especially when staples are scarce. It also has veterinary, medicinal, cultural, social and environmental amelioration uses. Local communities distinguish between sour and sweet tamarind. The ripe, sweet fruits are eaten fresh and are sold in the market. They can also be de-husked and soaked in cold water to extract the sweet flavour. Thereafter, the seeds and fibre are separated from the pulp to make a concentrate, which is diluted to make a cold beverage popular with all ages. Sugar or honey may be added to sweeten the beverage. *T. indica* is also used as a food preservative.

Southern Africa

Wild plum (*Harpephyllum caffrum*) (*Anacardiaceae*) is a large evergreen tree found in the riverine forests of South Africa Eastern Cape northwards through KwaZulu-Natal, Swaziland, southern Mozambique, Limpopo and into Zimbabwe. Nonetheless, it is drought resistant. It is found in the wild but can also be commercially grown in groves. It is propagated by seeds or stem cuttings and can be trained into a bonsai. The red plum-like fruits have a slightly sour taste and are rich in antioxidants. They can be processed into commercial products such as jams, jellies or drinks and rosé wine. Fruits have use in herbal medicines for curing an assortment of ailments.

Maraula (*Sclerocarya birrea* ssp. *caffra*) (*Anacardiaceae*) is a medium-sized deciduous tree, indigenous to the miombo woodlands of southern Africa. It is one of the most important indigenous fruits of southern Africa. The fruit is an oblong aromatic drupe with a leathery exocarp enclosing a white mesocarp. The fruits mature January-April, fall to the ground green, ripen to yellow and are picked. They are rich in ascorbic acid and nutritionally important essential fatty acids. They can be eaten fresh or processed into jams, jellies or fermented into beers or liquor. The fruit juice has bacteriostatic properties that could be exploited in the food industry (Mariod et al., 2019). The nuts are edible when roasted. They contain oil that could be used for culinary purposes, biodiesel, or soap making. It has been identified as a key species to support the development of rural enterprises built around the fruit, beer, oil, or nuts.

West and Central Africa

Bush mango (*Irvingia gabonensis*) (*Irvingiaceae*) is one of the most important indigenous fruits in the humid ecozone of West and Central Africa from Sierra Leone to Equatorial Guinea. It is a large evergreen tree that occurs in the wild or in fallow plots. It has been domesticated and cultivated/protected in food crop plots as an upper storey component. It could be propagated by grafting or patch budding seedlings, marcotting and rooted stem cuttings. Nonetheless, planting materials are raised mainly from seedlings because this is easier. The germination of the seed is enhanced when it is de-pulped, air dried for two days and planted with the stipule facing downwards in sawdust mixed with forest topsoil in equal ratio volumetrically (Nzekwe et al., 2002). The seedlings take about six years after planting to fruit. The fruit is an oblong-spherical drupe about the size of a hockey ball (6-8 cm diameter) at maturity. It is available towards the end of the mango season (April-July). It is green when unripe and becomes aromatic and pale yellow at ripening. At this stage, it has a sweet taste and yellow mesocarp. The fruits are often picked since these have better flavour than those plucked. The degree of sweetness and firmness of the pulp is used to classify bush mango. Although the fruits could be used in jam, jelly and wine making, this potential remains largely underexploited. Most of the fruits are consumed fresh and the kernel from the seeds is used as a lower grade component to adulterate those of *I. wombulu*, which are sold as seasoning for soups. The kernel is reputed to lower total plasma cholesterol. It is packed and marketed on a limited scale as a food supplement. The ethylene content of the fruit is exploited in ripening of plantains at staple food crop.

Bitter bush bango/dika nut (*Irvingia wombulu*) (*Irvingiaceae*) can be found in dryland forests from Senegal to southern Sudan, south to Angola, Congo and Uganda. It is prevalent in southwestern Togo. It is a close relative of *I. gabonensis*, but its fruits are smaller, have less pulp and are astringent to taste. The fruits are available later in the year than *I. gabonensis* thus, together they extend the *Irvingia* season. *I. wombulu* has higher economic value than *I. gabonensis* due to its larger and more slimy kernels (Awe et al., 2012). The peel and pulp are rich in protein, fat, crude fibre and essential oils such as squalene (Oduntan et al., 2019). The kernel 100 g edible portion contains 4 g water, 2918 kJ (697 kcal) energy, 8.5 g protein, 67 g fat, 15 g carbohydrate, 120 mg Ca, 3.4 mg Fe, 0.22 mg thiamine, 0.08 mg riboflavin, and 0.5 mg niacin. They are extracted from the fruits, dried whole and sold or milled into a slurry that is poured into moulds and smoked to extend the shelf life. These products are traded extensively throughout the West African sub-region (Ewane et al., 2009). The kernels are processed into seasoning for soups and dika cake for long shelf life. They are also included in health foods for weight loss.

Bush butter/safou (*Dacroydes edulis*) (*Burseraceae*) is an evergreen resinous tree with a bole up to 2 m above the ground before it branches. It is found in the evergreen rainforest zone of West and Central Africa. It has been extensively domesticated and planted in multi-storied home gardens, small-scale commercial orchards or as shade crops in cocoa plantations, which feed urban markets (Aiyelaagbe et al., 1998). The fruit is an ellipsoid drupe with a purple-pink exocarp. There are two varieties of bush butter; *D. edulis* var. *edulis* and *D. edulis* var. *parvicarpa*. The fruit of *D. edulis* var. *edulis* is large and cylindrical with a thick pulp, while that of *D. edulis* var. *parvicarpa* is smaller and has a thinner pulp. Bush butter has two seasons, the main one July-September and a minor one November-March. Thus, it is available almost all year round, depending on the latitude. It has a queer flat taste and high protein and oil content. To make it more palatable, it is steeped in hot water or roasted and eaten as a snack along with boiled maize or roasted plantain. Its potential as salad dressing or industrial oil remains underexploited. Its short shelf life poses a challenge for long-distance transport.

Star apple (*Chysophyllum africanum*) (*Sapotaceae*) is a medium sized tree with a convoluted trunk. It occurs wild in the evergreen forests in Ghana, Nigeria, Kenya, Sierra Leone, Sudan, and Uganda. However, in southwest Nigeria, it is domesticated and planted in cocoa plantations as an upper storey shade tree. The fruit is a spherical berry with leathery, brown exocarp enclosing a fleshy copper-coloured mesocarp. The mesocarp is chewy, sticky and has the consistency of chewing gum. The ripe fruits exude a sticky, sweet, white sap and enclose four hard shelled seeds that are covered with a white, sweet testa. The tree fruits profusely, early in the year towards the end of the dry season before many staple food crops become available (late February – early May). Thus, they make a major contribution to food and nutritional security as well as farm income from the sale of the fruits when staple food stocks are almost depleted. It contains 54.57% carbohydrate, 13.25% fat, 3.85% crude protein, 706.850 mg kg^{-1} Ca, 325.500 mg kg^{-1} Mg, 40.875 mg kg^{-1} Fe, 3.275 mg kg^{-1} Cu, and 4.625 mg kg^{-1} Zn (Ibrahim et al., 2020), thus it has high but underutilized potential as a food supplement (Arueya and Ugwu, 2017). It makes good jam but the stickiness of the fruit has to be overcome to upscale this potential to commercial level (Umelo, 1997).

Velvet tamarind (*Dailum guineensis*) (*Fabaceae*) is found in the savannahs of West Africa. The fruit gets its name from the black velvety brittle shell. The fruits are small, clustered and dry. They are popular with children because one cluster can be shared by many of them. When cracked, they contain a powdery pulp that encloses a small round brown hard-shelled seed. The fruit pulp has a citrus flavour. The high anthraquinone content could be exploited as food and beverage colorants. They are harvested from the wild and hardly cultivated. They could be popularised by using them in urban greening projects.

Kola (*Cola* spp.) is a medium sized evergreen tree growing in the humid lowlands of West and Central Africa. It is a domesticated species that features prominently as overstorey trees in cocoa plantations in West Africa. It is highly valued in West and Central Africa and is sometimes a mandatory component of hospitality. There are two major species; *C. acuminata* (*Malvaceae*) and *C. nitida* (*Sterculiacea*). *C. acuminata* has more alkaloids than *C. nitida*. The kola fruit (pod) is a large green follicle that splits along one side when ripe. It contains about 10 large white, pink or deep red nuts enclosed in a sweet, fleshy testa. The nuts are chewed locally as a stimulant due to their caffeine content. They are also extracted as part of soft drinks and used medicinally in the treatment of diverse ailments. There is a large demand for kola nuts globally. However, in Ghana (and most producer countries in West Africa) problems of postharvest handling and food safety need to be addressed to comply with international standards to fully exploit the opportunities on the international market (Amon-Armah et al., 2021)

› A) Nuts of *Cola* sp. B) Fruits of *Chrysophyllum africanum*. C) Nuts of *Garcinia cola*.

Pepper fruit (*Dennettia tripetala*) (*Annonaceae*) is a small tree grown in the forests of the humid lowlands of West Africa. It is domesticated and features in home gardens. The fruits are finger-shaped and born along the trunk and branches of the tree. They are green when unripe and turn bright red as they ripen. It is valued for its distinctive spicy taste, high protein, carbohydrates and antioxidant content. It also has applications in food preservation due to its antibacterial constituents and seasoning as well as traditional pharmaceuticals where it is used to treat different ailments. The fruits also have analgesic effects and are reputed to have potential in the cure of prostate cancer and glaucoma – a degenerative eye disease. They are also included in the recipe of herbal cure of local orthopaedists. The fruits are available between March and May, but they can be sundried and stored for later use throughout the year.

Baobab/monkey bread (*Adansonia digitata*) (*Malvaceae*) is a deciduous tree with an unusually large trunk (up to 9 m in diameter) and digital leaves found in the semi-arid lowlands (savannahs) of Africa. The fruit is large, oval and pendulous with a long peduncle. They contain large edible seeds that have a white mucilaginous pulp with a citrus flavour. The fruit is nutrient dense, prebiotic and rich in fibre, calcium, phosphorus, potassium, magnesium, polyphenols, and antioxidants. It is used as food supplement. Furthermore, the pulp can be dehydrated into powder and used to flavour drinks, jam, yoghurt, and ice creams. The leaves are collected during the rainy season and dehydrated for use in soups during the dry season when greens are scarce.

African breadfruit (*Treculia africana*) (*Moraceae*) is a tropical evergreen tree with dense foliage adapted to the acid soils of the humid lowlands of West Africa. It is the largest tropical fruit each weighing about 8 kg. It contains many seeds shaped like groundnuts, which is the part of interest to the consumers and merchants. In southeast Nigeria, the fruit is picked by women after dropping and fermented to facilitate extraction of the seeds. Thereafter the seeds are washed, air dried, parboiled for 30 minutes, strained out, left to cool and then dehulled. The seeds could be sold thereafter or roasted or processed into seasoning for soups before sale. The seeds contain phytochemicals with high antioxidant activity. *T. africana* hydrolysates as antioxidants have potential in reducing food spoilage and management of oxidative stress-related metabolic disorders.

Bitter kola (*Garcinia cola*) (*Clusiaceae*) is an understorey multipurpose tree that features in the rainforests of West Africa. It produces red-yellow spherical fruits containing oblong bitter seeds that are highly valued mainly for their medicinal attributes. Constituents have indicated antiviral, anti-inflammatory, antidiabetic, bronchodilator, and antihepatotoxic properties (Dadjo et al., 2020). The seeds and bark contain many nutrients such as vitamins, minerals, proteins, and carbohydrates in different quantities as well as phytochemicals like alkaloids, flavonoids, tannins, cyanogenic glycosides, and saponins. Its branches are sold as chewing sticks to promote dental hygiene. In Cameroon the bark and roots are collected, thus threatening its availability. Nonetheless in Nigeria and Benin, it is cultivated albeit at very low population in combination with many food crops, thus the threat of extinction is lower (Aiyelaagbe et al., 2003).

African wall nut (*Tetracarpidium conophorum* syn. Pluknett) (*Euphorbiaceae*) is a thick, woody perennial vine with dense foliage that grows in the wild leaning on forest trees. It is prevalent in cocoa plantations from Sierra Leone through Congo to Gabon. It produces angular diamond-shaped fruits containing 4-5 cream-coloured nuts enclosed in a dark brown shell. The fruit matures May-June, which coincides with the first crop of maize making it strategic for food security. The nuts are eaten boiled as a snack. They taste like macadamia nuts, but have a characteristic sour bitter after-taste if water is drunk soon after eating the nuts. The nuts are high in protein and contain oils that are reputed to lower cholesterol levels. The crude extracts of the nuts also have significant antioxidant activity, which makes them a valuable health food (Oriakh et al., 2018).

Wild custard apple (*Annona senegalensis*) (*Annonaceae*) is a shrub or small tree usually 2-6 m tall. It is found in semi-arid to sub-humid regions of Africa and especially in Botswana, Cameroon, Congo, Cote d'Ivoire, Ethiopia, Gambia, Guinea, Kenya, Lesotho, Mali, Mozambique, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, and Uganda. It occurs along riverbanks, fallow land, swamp forests and at the coast. It grows as a volunteer plant in the understorey of savannah woodlands of Africa. It is propagated by root suckers. The fruit is a complex fruit formed from the fusion of many carpels. It is ovoid or globose, green when unripe. The pulp is white and encloses many flat brown seeds. It turns yellow to orange on ripening with a peasant aroma and has a pineapple like taste. It contains essential oils, phytochemicals that have potential in nutrition and health. The fruits of *A. senegalensis* have the potential to make immense contributions to improved nutrition and food security, foster rural development and support sustainable land care especially in the semi-arid zones in the tropics.

Future outlook

The information above confirms the tremendous but underexploited potential impact African fruits and nuts can have on nutrition, health and livelihoods. Although national research institutions are making some contributions to reduce information gaps, the quantum of output is too low and the rate of technological advances too slow to match the needs. To unleash the potential, a series of coordinated actions have to be undertaken in the Africa Region as follows:

- Advocacy: the rural communities in partnership with the relevant national government agencies must make these fruits and nuts better known through the promotion of their commercial products, especially in the urban centres where most of the potential consumers are.
- Initiation of local and sub-regional networks to prioritise species and articulate medium and long-term research and development plans for collaborative research to execute interventions required based on comparative advantage.
- The National Agricultural Research Systems (NARS) must be empowered by their governments to take the lead in interventions involving postharvest handling and product development, conservation of biodiversity, genetic improvement and silvicultural aspects. Furthermore, they must build partnerships with the relevant CGIAR institutions such as the World Agroforestry Centre (ICRAF) and Centre for International Forestry Research (CIFOR) to tackle the high-tech aspects using mega-funds secured from multilateral agreements or competitive grants.
- The higher education curricula must be reconfigured to address skills, gaps in competencies in the production, protection and utilization of African indigenous fruits and nuts.
- The interest of the private sector must be enlisted at the various stages of intervention and especially in the uptake of commercial prototypes that address health needs.
- Outcomes of research and development must be disseminated widely during the All Africa Horticultural Congresses or similar meetings and by publishing them in high impact factor journals with international readership.

Although Africa will be making a late start, the need to rebuild a world that has been devastated by the scourges of COVID-19 and climate change creates an opportunity to cover much ground by offering new products for health remedies, food and raw materials for industry. It is an opportunity Africa cannot afford to ignore.

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Feeding the future: tropical and subtropical fruit and nut systems sustainability

Karin Hannweg

As the world population continues to grow, much more effort and innovation will be needed to sustainably increase production, improve the global supply chain, decrease food losses and waste, and ensure that all who are suffering from hunger and malnutrition have access to nutritious food. At the same time, the impacts of climate change and declining natural resources will have to be considered. In fact, these issues all form part of the 2030 Agenda for Sustainable Development – and 2030 is less than ten years from now (United Nations, General Assembly, 2015)! Sustainability must be underpinned by horticultural science and adapted at both country and community level if these challenges are to be addressed. Horticultural crops, including tropical and subtropical fruits and nuts, will therefore require continuous development for improved nutrition and yield as well as adaptation to less than optimal growing conditions.

Tropical and subtropical fruits and nuts are critical for food and nutrition security. While there are more than 50,000 edible plant species in the world, only several hundred contribute significantly as food sources. Furthermore, only fifteen staple food crops provide 90% of the world's food energy intake with rice, maize, and wheat accounting for two thirds of this consumption – by 80% of the world's population (Fuleky, 2009). Unfortunately, while staple foods are energy-dense, they do not meet total nutritional needs and therefore a variety of foods is required, particularly for children, the elderly, as well as other vulnerable groups. Fruits and nuts, including tropical and subtropical species, are a rich source of a variety of essential minerals, vitamins, fatty acids, antioxidants, protein and fiber. It is therefore essential that a variety of fruit and nut products are consumed, not only in developing countries, but also in the highly developed countries where the trend towards energy-dense, less nutritious fast foods has resulted in the rapid development of non-communicable diseases (Mitra et al., 2014; Wallace et al., 2020).

The impact of non-communicable diseases

Non-communicable diseases (NCDs) such as hypertension, cardiovascular diseases, cancers, respiratory diseases, diabetes, and various dementias including Alzheimer's, arise as a result of genetics, physiology, environment, and behavior. According to the FAO, they result in over 40 million deaths per year (FAO, 2021). NCDs affect people of all ages, ethnicities, regions and countries around the world and result in increased premature deaths in both developed and developing countries with almost 80% of these deaths being in middle- to low-income countries (FAO, 2020). One of the key drivers of NCD development is an unhealthy lifestyle facilitated by poor diet, lack of physical activity, use of tobacco, and alcohol abuse. Unhealthy diet, malnutrition and NCDs are closely linked. The NCD burden is associated with diets low in amongst others, fruits and nuts. Evidence shows that consumption of sufficient fruits, nuts, and vegetables substantially reduces the risk of dying from NCDs or other causes of death (Lock et al., 2005; WHO, 2011).

Supply, demand, need and sufficiency

Lock et al. (2005) showed that while there is more than enough commercial production of fruits, nuts and vegetables globally to

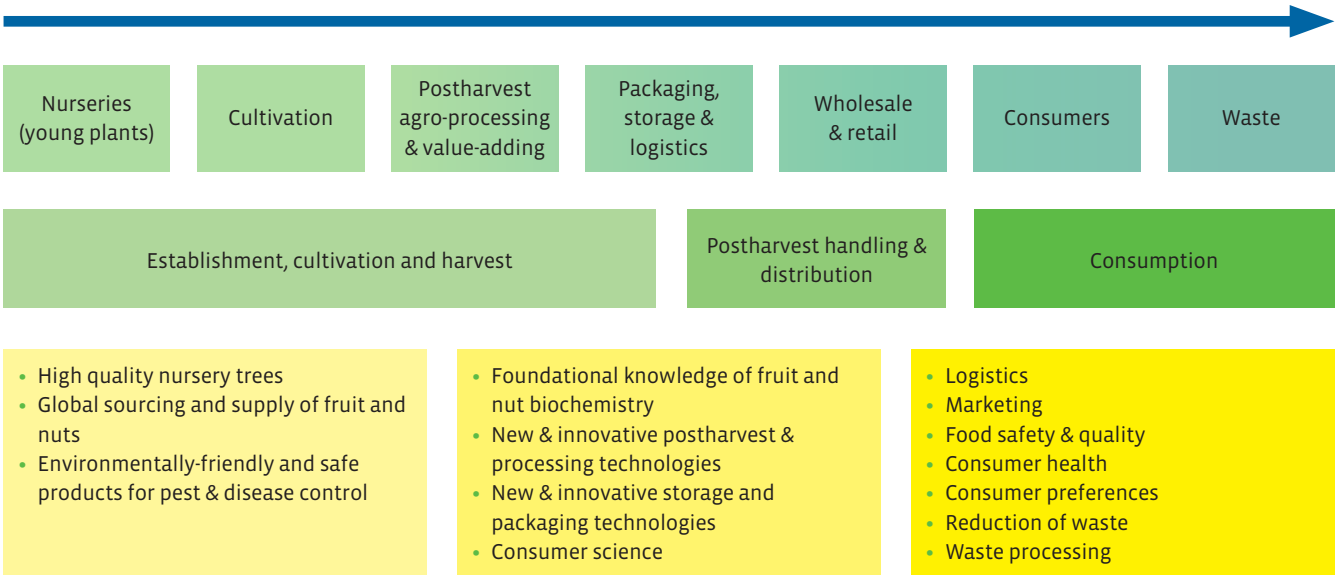

Figure 1. The value-chain. Food systems will have to become more sustainable, effective and efficient by using implementable and innovative tools and approaches.

› Breeding fruit cultivars rich in vitamins and other nutraceuticals is critical for food and nutrition security (photos: C. Human and K. de Jager).

› Global tropical and subtropical fruit and nut production zones (adapted from https://content.meteoblue.com/en/meteoscool/general-climate-zones).

meet the recommended nutritional requirements for the human population, there is an enormous amount of wastage during transport and after purchase, particularly, but not only, in developed countries. In addition, in many developing countries, poverty is a compounding factor that seriously limits consumption of affordable and highly nutritious food that is rich in essential vitamins and minerals. However, in complete contrast, home and community gardens provide fresh produce that is consumed by millions of people in developing countries although reliability and sustainability of supply is key. It is important to note that while there certainly should be enough availability (and affordability) of these horticultural products on a global scale, supply is not equitably distributed. This scenario therefore provides the opportunity for developing efficiencies right across the value chain. This includes production and harvest capabilities, effective postharvest and processing technologies and product development, packaging and logistics, and food safety in not only developed countries with access to high-tech technologies but also in developing countries where rural development initiatives at grassroots level have shown that village economies can be sustainably developed providing much-needed income and economic activity.

The value chain – efficient and sustainable horticultural production systems

With the global population expected to reach almost 9 billion by 2030, the world's declining natural resources are under severe pressure. Food systems will have to become more sustainable, effective, and efficient by using implementable and innovative tools and approaches. Economic (job creation), social (reduction of hunger and malnutrition) and environmental (preservation of natural resources) sustainability are all central to sustainable horticultural systems. These systems are all inter-connected throughout the value chain (Figure 1). Genetic resources, cultivation and harvesting practices, postharvest handling and storage, as well as market supply and demand intricacies are key components which must all be integrated such that there is sufficient good quality produce for all. Crop production faces not only sufficient production of food for a growing population but also needs to minimize not only the environmental impact of cultivation practices but also increasing input costs. These are further exacerbated by abiotic stress because of climate change effects. Sustainable crop production therefore requires the adoption of innovative strategies for the management of agroecosystems.

- Genetic resource improvement is the foundation on which horticultural systems hinge. New high quality, high yielding cultivars able to withstand changing climatic conditions and associated pest and disease pressures will need to be developed. Conventional breeding, selection and evaluation strategies for fruits and nuts as well as a suite of biotechnological tools will need to, and have already started to, provide the impetus for superior genotype development. Furthermore, the establishment of biobanks and germplasm collections will be required to conserve and ultimately be used to identify useful traits from these collections for the future.

› Optimum control of flowering and tree management ensure that growers will still be able to produce fruit of high quality and yield even under sub-optimal climatic conditions (photos: R. Cronje and M. Schoeman).

› Sustainable production of fruit trees in rural villages stimulates local and regional development.

- Cultivation practices will need to consider both tree management and the optimisation of water and nutrition with both water and nutrient use efficiencies being critical for sustainability. Global water resources are dwindling as industrialisation is increasing with horticultural production competing with other industries making crop water use efficiency critical. With the increasing global demand for food, there is a concomitant increasing demand for fertiliser nutrients. To prevent excess run-off of nutrients such as nitrogen and phosphorous, which lead to several knock-on deleterious effects on the environment, growers will increasingly have to focus on nutrient use efficiency of crops, including fruit and nut crops. Contrastingly, but similarly, poor soil nutrient content because of continual mineral extraction will also require a focus on nutrient use efficiency. Nutrient use efficiency is dependent on crops' ability to take up, transport, store and use nutrients from the soil. Nutrient use efficiency should lead to increases in yield. However, efficient nutrient use is a fine balance between plant, soil, fertiliser and irrigation management. Furthermore, novel and innovative production systems focusing on tree management that will increase yield and quality on a smaller hectarage or protect crops from emerging pests and diseases and/or inclement weather events such as drought, hail and wind, will also be required to ensure sustainability.
- Postharvest handling, agro-processing and value-adding technologies are also critical to ensure that produce integrity and quality is maintained until reaching the consumer. These technologies need to be both locally relevant and export-orientated. Furthermore, with the ever-increasing list of banned chemicals, environmentally friendly and safe pre- and postharvest treatments will need to be sought. Since several developing countries are well-suited to the production of tropical and subtropical fruit and nuts, not only is smallholder development, in terms of locally relevant cultivation technology transfer, important but enterprise development and job creation opportunities are enormous in terms of agro-processing and the development of value-added products. These in turn facilitate local economic development with knock-on effects in terms of regional development.

› Agro-processing and value-adding technologies are used to develop innovative products (photos: K. de Jager and K. Hannweg).

Capacitating the future

All aspects of horticulture are underpinned by sound foundational knowledge. However, as highlighted above, with the increasing need to focus on sustainability because of the increasing negative impact of factors such as climate change and emerging pests and diseases, innovative solutions for advancement of tropical and subtropical horticultural systems need to be found and adopted. Generally, in developing countries, the numbers of horticultural science students and graduates are increasing as the importance of horticulture to the health of a country's population as well as its value in creating job opportunities is recognized. In contrast, however, investment in capacity development in developed countries has decreased dramatically. There are no longer sufficient skilled graduates to not only deal with emerging challenges to ensure industry sustainability, but also to fill the gap left by retired, experienced scientists. Of major concern is the fact that the impact of horticultural science on food and nutrition security is unfamiliar to many potential young entrants to the science. Inspiring the youth to contemplate careers in science, particularly horticultural science, is critical for ensuring not only

› Capacitating the future – incoming, passionate young scientists are critical for the sustainability of horticultural science.

sustainability but also advancement. Many countries, both developed and developing, have programmes targeted at attracting potential young scientists to science subjects including horticultural science. Many of these programmes are presented at undergraduate or even post-graduate level. However, more emphasis needs to be placed at school/secondary level where learners make subject choices, which later have an impact on the selection of tertiary studies.

Facilitating sector advancement – Division Tropical and Subtropical Fruit and Nuts

The International Society for Horticultural Science (ISHS) provides a global network of collaboration of like-minded horticulturists and horticultural scientists. It is underpinned by its extensive symposium programme and publications, which provide a platform for global conversation. The Society comprises a diverse range of Divisions (of which the Tropical and Subtropical Fruit and Nuts Division is one), Commissions and Working Groups. This diversity provides the impetus for further research and technological development right across the entire value chain and encourages collaborative conversation not only within the Division but also between Divisions. The COVID-19 pandemic has not only separated us, but has also brought us all together. The widespread use of virtual platforms, while not the same vibe as face-to-face meetings around the world, have paved the way for both fully virtual and hybrid symposia. These symposia allow those unable, due to travel restrictions and/or high cost, to attend and present their work to colleagues on the international stage. The Division encourages dialogue between all ISHS members as this cross-pollination will see technology advancement not only within this Division but across all Divisions, Working Groups and Commissions. We look forward to meeting you at IHC2022 in Angers, France, whether it be in-person or online!

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Cooperative approaches to standardize hemp phenotyping

Zachary Stansell and Anya Osatuke

Introduction

During an 8,000 year history of human cultivation, hemp (*Cannabis sativa* L.) has been used across cultures for diverse purposes including textile fibers, woody pulps, edible seeds and oils, medicinal products, and psychoactive substances, while being adapted to broad geographic ranges and undergoing dramatic natural and artificial selection, resulting in a profusion of genomic and phenomic diversity (de Meijer, 1995; de Meijer and Keizer, 1996; Salentijn et al., 2015; Clarke and Merlin, 2016; Kovalchuk et al., 2020). In the past two decades, an increasing number of public and private entities have begun to explore the expansion of agricultural hemp across conventional and novel market classes (Fine, 2014; Mi et al., 2020).

These efforts have greatly intensified basic biological research, production of genomic datasets, and breeding for elite and locally-adapted germplasm. However, a complex patchwork of national and international policies have restricted access and exchange of genetically and geographically diverse hemp crop genetic resources, in turn, hindering germplasm conservation, research, and breeding. The US Department of Agriculture, Agricultural Research Service has established a hemp genetic resource collection at the Plant Genetic Resources Unit in Geneva, NY, to address these constraints by collecting, conserving, evaluating, and distributing diverse germplasm resources to domestic and international stakeholders.

As hemp research expands to incorporate genetically and geographically diverse germplasm resources, we have observed that robust and statistically valid phenotypic evaluation methods for priority agronomic and horticultural quality traits are currently underdeveloped. Phenotyping has been encumbered by non-standardized evaluation, imprecise nomenclature or evaluation scales, or the need for standardized approaches has been simply ignored. Establishing a coherent understanding of hemp phenotypic diversity within its larger pool of genomic diversity is needed to both effectively conserve and breed improved and locally adapted cultivars.

Collaborative public and private partnerships led by the Plant Genetic Resources Unit will gather high-quality phenotypic data for online publication within the USDA-ARS information management system GRIN-Global (https://www.grin-global.org/). In September 2021, the Plant Genetic Resources Unit published a collaborative USDA Hemp Descriptor and Phenotyping Handbook (https://www.ars.usda.gov/northeast-area/geneva-ny/plant-genetic-resources-unit-pgru/docs/hemp-descriptors/) as a freely-distributed web-based document to systematize passport data collection and aggregate useful, coherent, and consistent phenotyping protocols within the broader pool of hemp germplasm diversity. The primary goals of the handbook are to:

- assist breeders and researchers in identifying accessions with specific traits to facilitate germplasm selection within hemp improvement programs;
- identify gaps in existing hemp genetic resource collections and help formulate strategies for future collection and conservation efforts;
- designate and maintain a core collection of critical materials;
- increase National Plant Germplasm System user utility and accessibility to hemp germplasm and associated data;
- identify duplicate accessions and reduce costs of hemp genetic resource conservation.

Here, we describe the framework, methods, and collaborative approach that we implemented to generate the USDA Hemp Phenotyping and Descriptors Handbook. While our efforts were specific to hemp, we believe these methods could be broadly applicable to plant genetic resource conservation, breeding, and research within other crop groups.

› Dr. Larry Smart of Cornell University donated the first accessions to USDA-ARS Hemp Germplasm Repository. This accession was collected from the site of a colonial-era rope factory in Northern NY.

Methods

We conducted a literature review to examine and capture the array of evaluation techniques previously applied to hemp. This effort gathered 374 peer-reviewed publica-

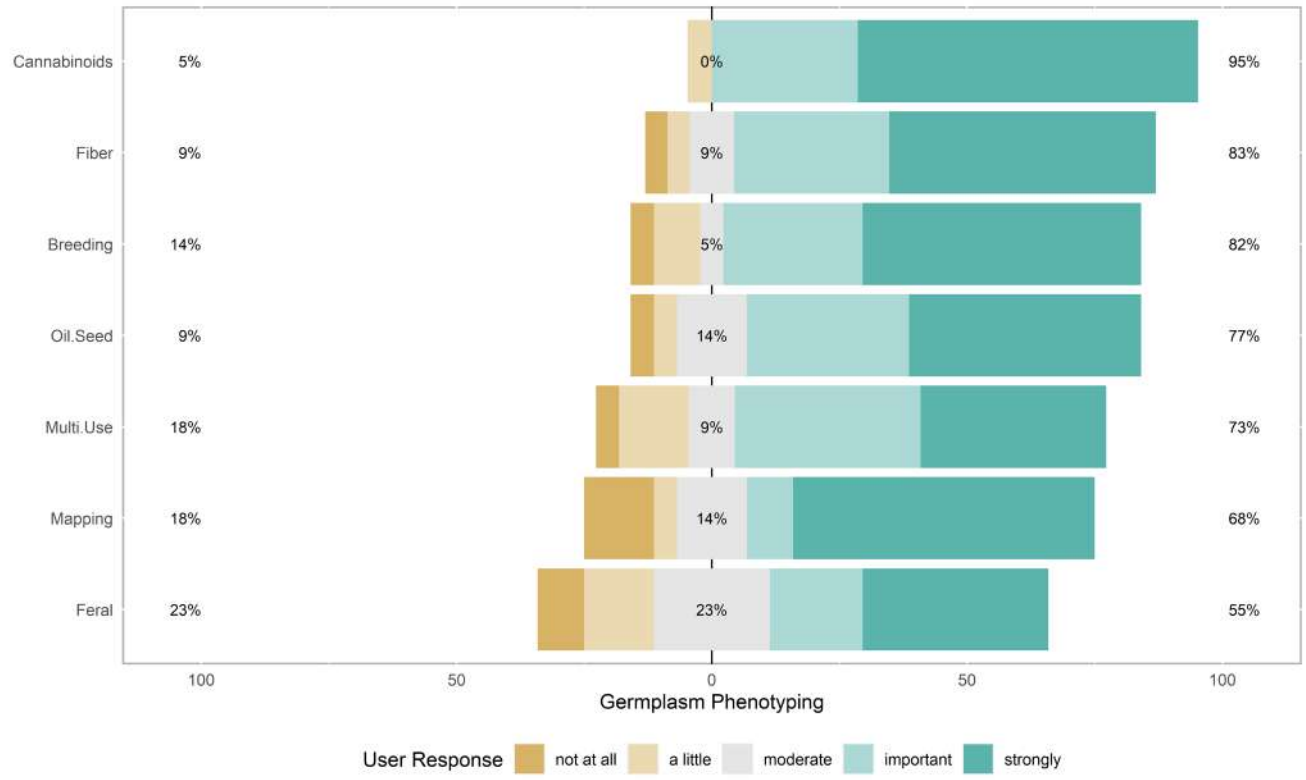

Figure 1. Summarized ranked choice Hemp Stakeholder Survey responses for value of germplasm usage class phenotyping. Leftmost percentage is cumulative "not at all important" and "a little important", center percentage is "moderately important", and the rightmost percentage is cumulative "important" and "strongly important". Data were pulled using the Qualtrics API and visualized in R. N=23.

tions, books, trade publications, existing protocols, historic documents, and web resources. The publication dates of these materials spanned over 400 years (1620 to 2021). A body of applicable Russian language text was gathered and translated by Anya Osatuke. All documents and metadata were added to a Zotero library.

In parallel with the literature review, we developed an online hemp stakeholder survey through the Qualtrics Survey platform that was distributed by collaborators at Cornell University to diverse NPGS stakeholders, e.g., scientists conducting basic research, public and private sector hemp breeders, germplasm conservationists, and educators. These respondents were queried for input across multiple domains, including anticipated hemp phenotypes of interest (Table 1; Figure 1):

- Affiliation (e.g., university, private, government, extension);
- Work scope (e.g., breeding, research, conservation);
- Do you anticipate receiving or contributing hemp germplasm?
- Hemp usage class, genotypes, and phenotypes of interest.

We analyzed the literature search and the results of the stakeholder survey to assign keywords to each article in our Zotero database. Keywords were chosen carefully based on feedback gathered from survey results and comments. Assigning keywords allowed us to subdivide the body of literature across multiple domains. For example, we could apply Boolean operators to select documents that describe both "fiber" and "monoecy."

From this literature search, we compiled a spreadsheet of 411 unique candidate hemp passport or phenotyping methods and their associated metadata. These records were sorted into discrete classes: passport, agronomic, fiber, oil, metabolite, sex/flowering, seed quality, horticultural quality, biotic/abiotic resistance, genetics, and experimental design. We created a separate column to delineate if these candidate records were population-level or individual-plant specific. If the latter, another column recorded the specific plant tissue under consideration. If there were redundant or quasi-redundant phenotyping approaches for a trait, they were marked for later head-to-head comparisons.

Table 1. Hemp Stakeholder Survey responses to query of utility of phenotypic data class as percent affirmative response, N=23.

Stakeholder interest in hemp phenotyping by category (%)	
Cannabinoid profile	82.6
Fiber	78.3
Agronomic traits	78.3
Oil/seed	73.9
Day length sensitivity	69.3
Other secondary metabolites	60.9
Plant architecture	60.9
Plant sexual expression	60.9
Seed quality	60.9
Detailed passport data	52.2
Historic usage	52.2

Once the list of candidate records was identified, we began to select our list by several criteria:

- Was the trait deemed sufficiently important to our stakeholders?
- We chose or added passport fields that were congruent with current accession intake reporting in GRIN-Global while including additional collector-specific fields (e.g., Persistent Unique Identifiers) to increase compatibility with international standards set in Bioversity International (https://www.bioversityinternational.org/e-library/publications/detail/faobioversity-multi-crop-passport-descriptors-v21-mcpd-v21/);
- We preferentially chose direct, quantitative phenotyping approaches rather than nominal or ordinal measurement scales. For example, we preferred numerical measurements of plant architecture traits in centimeters over nominal categories (short, medium, tall);
- We preferentially chose phenotypes with a higher likelihood of being "future-proof". For example, we selected agronomic phenotypes that could likely be captured by conventional horticultural methods and precision agricultural methods such as uncrewed aerial vehicles;
- When competing candidate phenotypes were ranked as near-equivalent, we interviewed specialists to help balance concerns of accuracy and precision, reproducibility, cost, and ease-of-capture.

This pruned spreadsheet was then prepared hierarchically as a Google Document and shared with a diverse set of public and private hemp stakeholders. Stakeholders were asked to provide technical feedback and suggest improvements. This crowd-sourcing step produced several hundred recommendations via online commenting or other forms of personal correspondence.

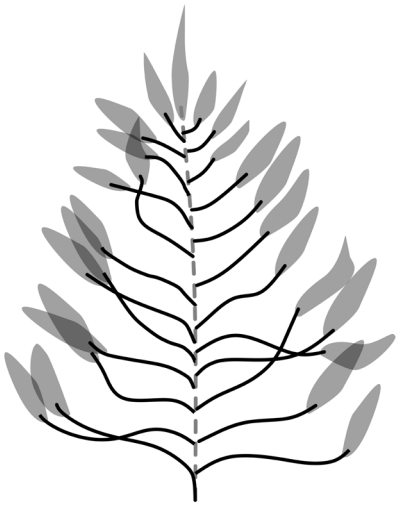

Figure 2. Branches phenotype illustration.

The Hemp Descriptor and Phenotyping Handbook lists 84 descriptors that spans several sections: Passport, Architecture, Leaf, Sex & inflorescence, Seed, Fiber, Secondary metabolite, and Pathogen/pest. Collected data can be stored in a spreadsheet with the trait_name as column headings and the persistent unique identifier as row name and shared with the hemp curator for inclusion within GRIN-Global (https://www.ars.usda.gov/northeast-area/geneva-ny/plant-genetic-resources-unit-pgru/docs/hemp-descriptors/#trait_name).

Hemp traits are named in bold font with the data type and units in brackets, followed by a written description of how data are to be collected. The written description includes links to publications that have utilized this method. For example:

> **branches** [int]
>
> Measure plant architecture traits as the mean of 10 unpruned plants during the week of harvest. When grown from seed, typically branching is initially opposite, transitioning to alternate as the plant matures. Plants propagated from cuttings generally have alternate branching in the whole plant. See Stack et al. (2021). Modified Carlson et al. (2021).

Traits are accompanied by visual aids (Figure 2) when appropriate, using images or scalable-vector graphics (SVG). With the Inkscape open-source tool we created flexible vector-based schematics (Yuan et al., 2016). A scanner-based imaging protocol for documenting and evaluating hemp anatomy is described in the USDA Hemp Descriptor and Phenotyping Handbook based on previous work with other crop collections held at PGRU. If appropriate, high-resolution images of plant material can be effective in conveying detailed information and may be augmented with arrows and circles to highlight key areas. For example, high-resolution photographs of insect pests were generously provided by entomologist Dr. Kadie Britt.

We compiled the USDA Hemp Descriptor and Phenotyping Handbook with the markup language R Markdown to increase document portability and flexibility. For example, documents written in R Markdown as implemented within the R statistical environment can be easily "knitted" into html, pdf, or Microsoft Word format. R + Markdown supports bibliography generation, advanced equation typesetting, hyperlinking, and other useful features. We produced the USDA Hemp Descriptor and Phenotyping Handbook as a html file that was then directly uploaded to the PGRU website (https://www.ars.usda.gov/northeast-area/geneva-ny/plant-genetic-resources-unit-pgru/docs/hemp-descriptors/). Once the document was compiled, the handbook was submitted to the New Crops Crop Germplasm Committee (https://www.ars-grin.gov/CGC) for review.

Discussion

As a reemerging crop, hemp offers many challenges and opportunities for knowledge synthesis across institutional lines and disciplinary boundaries. The Hemp Phenotyping and Descriptors Handbook drew from a substantial yet heterogeneous body of literature. For example, examining Russian and Ukrainian language text written during times of general prohibition in Western Europe and the United States illuminated important perspectives and obstacles, such as descriptions of cannabinoid deficient Ukrainian germplasm (Virovets et al., 2012), ecological descriptions of ruderal Siberian hemp (Antipova, 2008; Aistova, 2009; Pis'markina et al., 2019), and agronomic descriptions of dual-purpose fiber and seed hemp provide insight into domestication and modern breeding efforts (Crosby, 1965; Spitsina and Okhotina, 2011; Clarke and Merlin, 2013; Romanenko et al., 2016).

Previous hemp description efforts have focused on visual assessment of qualitative traits, such as stem and seed coat color. Two such documents are the Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability for Hemp, published by the International Union for the Protection of New Varieties of Plants (UPOV, 2012), and the Procedure of Hemp (*Cannabis sativa* L.) Varieties Examination for Distinction, Homogeneity and Stability developed by the Institute of Bast Fibers in Glukhov, Ukraine (Migal et al., 2014).

The International Union for the Protection of New Varieties of Plants guidelines rely on a library of test varieties that exemplify the desired traits, rather than defining quantitative phenotyping parameters. These descriptors were developed to define hemp cultivars in the absence of genetic testing and rely heavily on visual ordinal scale ratings which reduce intraclass correlation coefficients due to rater variability (Stansell et al., 2017). For example, the distinction between "light green" and "yellow-green" stem color is subjective and easily replaced by modern colorimetric methods, such as evaluation of CIELAB color space. Furthermore, phenotypic variability of descriptors within named hemp cultivars has been documented and is often driven by age and environment factors (Vergara et al., 2017). As one example, seed pattern intensity tends to increase with days after seed set and temperature during seed maturation (M. Loos, pers. commun., 2021).

The USDA Hemp Descriptor and Phenotyping Handbook addresses variability in several ways. Traits with predominately environmental control are typically deprecated. When possible, traits are measured quantitatively with instrumentation chosen to reduce rater variability or directly documented by scanning or other imaging methods. Finally, accurate passport data (e.g., date and location of observation) are systematically gathered to help disentangle conflating environmental or phenological effects.

This work relied heavily on diverse contributors who shared their knowledge of hemp as a biological organism, an ecosystem component, and economic commodity. Applying an open approach and incorporating stakeholder input will enable the USDA-ARS Hemp Germplasm Collection to specify optimal phenotypic data gathered by experts within their respective fields. Several contributors provided expertise in biological data formatting and the GRIN-Global system, and other contributors illuminated nascent areas for future hemp phenotyping efforts, including applications of precision agricultural methods, hemp-insect-cannabinoid interactions, biofuels, and advanced fiber quality characterization.

The stakeholder survey provided insight into user priorities that we attempted to capture and expand within the USDA Hemp Descriptor and Phenotyping Handbook. A stakeholder-involved approach is congruent with the broader mission of USDA-ARS's goal to increase access and value of associated crop genetic resource information by directly integrating input within conservation and characterization decisions. Moreover, the format of the handbook is a freely-accessible online document that is both user-friendly and flexible for future improvements.

The USDA Hemp Descriptor and Phenotyping Handbook will hopefully serve as a research support tool for methodology selection, data management, and literature reference. By unifying methodologies and data formats used to evaluate hemp, we hope to support the development of robust and reliable datasets that describe heritable traits by quantitative descriptors. We anticipate such datasets will assist the USDA-ARS Plant Genetics Resource Unit to maintain hemp germplasm resources in support of future hemp breeding efforts.

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Anya Osatuke is the Western NY small fruits specialist at Cornell Cooperative Extension, Ithaca, NY, USA. She works with a team of extension specialists to support berry production systems in New York State. She has worked as a Russian-to-English translator of horticultural research for Mann Library at Cornell University, the New York Botanical Garden, and most recently for the United States Department of Agriculture in collaboration with Zachary Stansell. Anya is a graduate of Cornell University, where she studied under Marvin Pritts to quantify inputs for strawberry production systems in New York State. E-mail: osa.tuke.anya@gmail.com

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ISHS Young Minds Award winner summaries

Below is a selection of research summaries from winners of ISHS Young Minds Awards for best oral and poster presentations at ISHS symposia. To view other exciting research summaries by other winners, please visit www.ishs.org/young-minds-award.

Optimizing plant density in strawberry cultivation in Martell Valley (South Tyrol, Italy)

Sebastian Soppelsa

After finishing my Ph.D. under the supervision of Professor Carlo Andreotti at the Free University of Bozen-Bolzano (Italy), I joined the working group "Berries and Stonefruits" at the Laimburg Research Centre (Italy). My academic experience, including the internship done at the Sant'Orsola agricultural cooperative (leader of the Italian berries market) gave me a broad background of knowledge about strawberry cultivation.

Considering the large number of issues and challenges that berry producers are facing, scientific research should provide valuable and affordable solutions, whenever possible. My research activity is currently mainly focused on strawberry cultivation and can be divided into variety comparison tests and agronomical trials (suitable planting density and planting materials, evaluation of different cultivation systems, solutions to soil-borne diseases). My research on planting density was presented at the IX International Strawberry Symposium. Optimizing profitability is a challenge that strawberry farmers face to remain competitive. Within this framework, optimum plant density plays a central role in strawberry cultivation. Increasing plant density is considered the main way to increase yield per hectare. Nevertheless, this improvement is attributed to the greater number of plants per area planted and not to a higher yield per plant, which could often even suffer a reduction. According to our preliminary results, wide row spacing allowed for more balanced plant growth in terms of leaf and root system with positive consequences on fruit production. Moreover, fruit from the low plant density treatment showed a significantly higher sugar level and a higher color index (more densely red) than in fruits from the high plant density treatment. Finally, farm profit must consider the costs (especially related to the plant material and harvesting) that are certainly higher under the high plant density than under the low-density regime.

Sebastian Soppelsa won the ISHS Young Minds Award for the best poster at the IX International Strawberry Symposium, which was held virtually in Italy in May 2021.

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Silicon effect on vegetative growth of young olive K-starved plants

› Inmaculada Martos-García

Inmaculada Martos-García got her BS degree in Agrifood Engineering and the Rural Environment at the University of Córdoba, Spain, in 2016. After graduation, she started her master's studies in olive growing and olive oil technology at the same institution in 2019. She is currently immersed in her PhD studies under the supervision of Professor Dr. Ricardo Fernández Escobar and Dr. María Benlloch González in the Department of Agronomy of Cordoba University, Spain. Currently, 80% of the olive orchard area is in the Mediterranean basin, where it is common to find nutritional imbalances caused by nitrogen (N) and potassium (K). N shows as problems of excess, because farmers associate the higher quantity applied with higher yield. Potassium shows as deficiency problems particularly in soils that lack moisture, have low clay contents, or K immobilization due to interactions with other nutrients. Silicon (Si) is not considered an essential element for plant growth. However, there is increasing evidence in herbaceous and horticultural crops that Si fertilization benefits all aspects of N nutrition including uptake, availability in soil, and transport efficiency through up-regulation of genes encoding N transporters. Related to Si effects on K nutrition, less research has been performed, but this element seems to have a positive effect on K-uptake, K concentration in leaves, and amelioration of K-deficiency-induced oxidative stress in K-starved plants. Inmaculada is focused on the effects of silicon fertilization in olive trees, considering the limited available information of Si interaction with N and K nutrition. She is examining the effects on the vegetative growth when Si is applied to leaves or through the irrigation water. She is specifically looking for potassium and nitrogen absorption and organ distribution in plants treated with different doses of potassium (KCl; 0.05 and 2.5 mM) or nitrogen ($Ca(NO_3)_2$; 0, 100 and 400 ppm N). She is paying special attention to the advantageous role played by Si lessening the negative effects caused by nitrogen and potassium interactions.

Inmaculada Martos-García won the ISHS Young Minds Award for the best poster at the IX International Symposium on Mineral Nutrition of Fruit Crops, which was held virtually in Israel in June 2021.

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Chemotyping and in vitro conservation of strawberry tree *Arbutus unedo* L., *Ericaceae*

› João Martins

João Martins is a PhD student at the University of Coimbra and University of Aveiro, Portugal, under the supervision of Prof. Jorge Canhoto and Prof. Glória Pinto. His thesis aims to understand the mechanisms behind abiotic and biotic stress resistance of *Arbutus unedo* (*Ericaceae*, strawberry tree), a high resilient Mediterranean tree, with a great ecological importance and valuable applications in the pharmaceutical and food industries. To shed light on this neglected crop, three main lines of research are being followed: i) study of the tolerance mechanism under water limitation, ii) microbiome characterization and chemical fingerprint and their relevance for plant defence, and iii) breeding and propagation of selected superior genotypes. To tackle these themes, physiological, biochemical and metabolomic data were collected from plants under water stress. Bacteria and fungi communities were identified by 16S and ITS rRNA sequencing, and biochemical tests were carried out to assess their ability to solubilize phosphate and to produce ammonia, siderophores and indole-3-acetic acid (IAA). Enzymatic studies using specific substrates were also performed and their antagonistic ability against *A. unedo* pathogens was tested. The main findings were that strawberry tree has a typical isohydric behaviour under drought, through tight stomatal control. Several key hormones (e.g., abscisic and salicylic acids) were up-regulated on plants under stress and a specific metabolomic profile was determined on high tolerant genotypes. Furthermore, strawberry tree harbours a diverse fungi and bacteria community that produces several enzymes. These enzymes can reduce the effect of the most relevant strawberry tree pathogens, such as *Phytophthora cinnamomi*, playing a key role in plant defence mechanisms. A similar antagonistic effect was obtained from a crude extract of *A. unedo* leaves as well as isolated phenolics (arbutin and hydroquinone), which revealed a complex and intricate defence mechanism. Finally, selected genotypes are being micropropagated, for conservation purposes and large-scale production. These findings are expected to have an impact in strawberry tree research and improve farming and forestry practices in the near future.

João Martins won the ISHS Young Minds Award for the best oral presentation at the IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (physiological, biochemical, embryological, genetic and legal aspects), which was held virtually in Thailand in July 2021.

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Orchidantha deceives flies using stinking mucilage released from osmophores

› Possathorn Nopun

Fetid as its name, *Orchidantha foetida* Jenjitt. & K. Larsen, an unusual ginger-like species endemic to Thailand in the *Zingiberales* order, has a strong rotten odor. This plant secretes mucilage from its flowers.
A recent study on anatomy, micromorphology, and histochemistry of *Orchidantha* flowers revealed papillae, small nipple-like projections, and a blistered and parallel wrinkled epidermis on the flower's upper lip surface. In addition, this surface is sprinkled with minute droplets of substances that were secreted from the epidermal cells. These features likely developed over evolutionary time in a symbiotic relationship with this species to attract saprophilous pollinators like flies.
Histochemical results revealed the location of these scent-containing structures on adaxial epidermal cells. These cells may act as osmophores with a scent releasing function. The experiment also observed the presence of mucilage, phenolic compounds, and terpene accumulation inside adaxial epidermal cells. These secretions are known to allure and deceive pollinators, because these compounds are not present for food.
This report was summarized from the manuscript entitled "Micromorphology and histochemistry on lip of *Orchidantha foetida* (*Lowiaceae*)," presented by Possathorn Nopun. He is pursuing a Ph.D. in Botany and received the ISHS Young Minds Award for the best poster presentation of the IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (Physiological, Biochemical, Embryological, Genetic and Legal Aspects). This symposium was held virtually in Thailand, in July 2021. Mr. Nopun has worked within the Department of Plant Science, Faculty of Science, Mahidol University, for his BS, MS, and now for his PhD degree. Under the supervision of Assistant Professor, Dr. Sasivimon Chomchalow Swangpol, Mr. Nopun's research focuses on micromorphology, anatomy, histochemistry, floral scent analysis, and pollinator observations on fetid flowers of *Orchidantha* species to explore more about the relationship between plants and animals.

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Rootstock and irrigation induced different response in berry aromatic characteristics in 'Merlot' and 'Sangiovese' grapevines

› Giacomo Palai

Giacomo Palai is a PhD student at the Department of Agriculture, Food and Environment of the University of Pisa, Italy. He is supervised by Dr. Giovanni Caruso and Prof. Claudio D'Onofrio. His research focuses on the sustainable management of water resources in viticulture, with the objective to increase fruit quality. To achieve this aim, he has conducted a study on the effect of different deficit irrigation strategies and cultivar-rootstock combinations in grapes. He is researching berry aroma profile in fully productive 'Sangiovese' and 'Merlot' grapevines grafted on 1103 Paulsen and SO4 rootstocks during two consecutive seasons. 'Merlot' and 'Sangiovese' are two important international red grapevine cultivars and were grafted onto two rootstocks with a different response to the water deficit. Cultivar-rootstock combinations were subjected to water stress from fruit set through veraison (pre-veraison), and from veraison through harvest (post-veraison), whereas they were fully irrigated for the rest of the irrigation period. Control grapevines were fully-irrigated throughout the entire season. The results showed a higher concentration of volatile organic compounds (VOCs) on 'Merlot' berries contrasted with 'Sangiovese' berries. The two cultivars were different in their berry aromatic profile, characterized by monoterpenes, C_{13}-norisporenoids and benzene derivatives in 'Sangiovese', and phenols, vanillins and benezene derivatives in 'Merlot'. The total VOCs and the typical aroma classes that characterize the cultivars were increased under pre-veraison water stress treatment, probably triggering the biosynthetic pathways of VOCs. Furthermore, 'Merlot' and 'Sangiovese' showed a different response towards the water stress magnitude imposed on pre-veraison treatment, providing an indication to manage vines' water status and irrigation in a specific way depending on the cultivar. On the contrary, post-veraison deficit irrigation treatment was detrimental or irrelevant on VOCs accumulation, affecting the main biosynthetic pathways in a critical phase. The rootstocks affected berry VOCs concentration especially under pre-veraison water deficit. In particular, SO4 grafted grapevine showed higher VOCs amounts with respect to 1103 Paulsen, magnifying the irrigation effect and the typical cultivar-related berry flavour characteristics. These results suggest that deficit irrigation represents a useful tool to enhance grape berry aroma. The rootstock-scion combination can significantly magnify or reduce this effect.
Giacomo Palai won the ISHS Young Minds Award for the best oral presentation at the XII International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems, which was held virtually in USA in July 2021.

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Molecular characterization of soft-rot disease pathogen from *Phalaenopsis* and intraspecific response differences to its infection

› I Putu Wahyu Sanjaya

I Putu Wahyu Sanjaya is currently a second-year PhD student in the Plant Breeding and Biotechnology Study Program at IPB University, Bogor, Indonesia, working on his dissertation entitled "Molecular analysis of *Phalaenopsis* resistance to soft-rot pathogen (*Dickeya dadantii*)." He has been working on the *Phalaenopsis* resistance studies since 2018. He obtained his MSi (Master of Science, Indonesia) degree working on similar topics from the same study program at IPB University. His interest is in molecular biology, plant-pathogen interaction, plant tissue culture, plant physiology, and plant breeding. All of his studies and research were sponsored by the Indonesian Ministry of Research and Technology for Higher Education under the Master Program of Education Leading to Doctoral Degree for Excellent Graduates (PMDSU) supervised by Dr. Dewi Sukma and Prof. Sudarsono from IPB University, and Prof. Ming-Tsair Chan from Academia Sinica Biotechnology Center in Southern Taiwan.

Phalaenopsis is an important ornamental plant in Indonesia and in the world. The distribution of *Phalenopsis* species is mainly in tropical to subtropical areas, which have high temperature and humidity. These plants are easier to grow In Indonesia than in some subtropical areas because only a minimum of environment control is required. Small to medium scale nurseries usually use shading or net houses to grow their *Phalaenopsis*. Unfortunately, the shading/net house does not protect *Phalaenopsis* from pathogen infection and pest infestation. One of the most devastating *Phalaenopsis* diseases in Indonesia is soft-rot disease (SRD). Wahyu screened *Phalaenopsis* species using *Dickeya dadantii*, the pathogen that causes SRD. He determined resistance classes. He validated that *Phalaenopsis amboinensis* is the most resistant species as compared with *P. pantherina, P. bellina, P. cornu-cervi, P. mentawaiensis, P. amabilis*, and *P. schilleriana*. He also found higher defense enzyme activities including peroxydase and phenylalanine ammonia-lyase in more susceptible species. He found a varied level of responses to *D. dadantii* infection within the intraspecific populations of *P. amboinensis* and *P. amabilis*. For a population of *P. amboinensis*, at least 2.1% were either very susceptible or susceptible, 4.3% – moderate resistant, and 91.5% – resistant, while for *P. amabilis*, 20.7% were very susceptible, 3.5% – susceptible, 13.8% – moderately susceptible, and 62.1% – resistant. The data indicated that *Phalaenopsis* breeders who want soft-rot resistant plants could screen intra-specific populations of *Phalenopsis*. Wayhu also obtained progeny arrays for interspecific *Phalaenopsis* hybrids to study genetic inheritance of soft-rot resistance and evaluate molecular mechanisms associated with that resistance.

I Putu Wahyu Sanjaya won the ISHS Young Minds Award for the best oral presentation at the II International Symposium on Tropical and Subtropical Ornamentals, which was held virtually in Indonesia in July 2021.

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Understanding low oxygen stress in apple fruit during postharvest storage

› Suzane Pols

The modern consumer has become accustomed to a year-round supply of apple fruit. This continuous availability is possible through long-term storage techniques. Growers are able to extend fruit quality by controlling the immediate atmosphere around the apple, combining a low oxygen and high carbon dioxide gas mixture with low temperatures. This form of long-term storage is referred to as controlled atmosphere (CA) storage.

In some cases, the storage conditions are too severe for the fruit and result in storage disorders. This is caused by the low oxygen environment, but details surrounding the stress regulation on a genetic level and how it results in or helps to prevent the storage disorders, still remain unclear. Studies conducted on model organisms, including *Arabidopsis thaliana* and *Oryza sativa*, showed that low oxygen stress in plants is regulated by the group VII ethylene response factor (ERF-VII) gene family. The family consists of five genes responsible for sensing low oxygen levels in the plant environment, particularly during flooding, and subsequently triggering the required survival response. Because limited information is available on this stress response pathway in fruits, this project aimed to elucidate stress regulation in apple fruit during CA storage, particularly at the genetic level.

The project expanded on traditional postharvest techniques by incorporating biotechnology approaches, including phylogenetic analysis to identify apple gene homologs for the ERF-VII gene family. The next step was to functionally characterize the identified genes. Both in vitro protein characterization and ectopic studies in over-expressing *A. thaliana* reporter lines were conducted to further elucidate the gene function during CA storage. Due to the practical limitations of working with apple trees to obtain over-expressing apple fruit, it was decided to study gene activity in vivo, by creating over-expressing apple callus reporter lines. By incorporating these biotechnology-based techniques, we aim to better understand the stress fruit experience as a result of the low oxygen atmosphere, ultimately preventing the development of internal disorders during CA storage.

Suzane Pols won the ISHS Young Minds Award for the best oral presentation at the XIII International Controlled and Modified Atmosphere Research Conference (CAMA2021), which was held virtually in Belgium in August 2021.

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Establishment of a CRISPR/Cas9 genome editing system in the Indonesian orchid, *Dendrobium lineale* Rolfe

› Lailia Zubaidah

Lailia Zubaidah is a Master's student in the Laboratory of Biotechnology, Faculty of Biology, Universitas Gadjah Mada, Indonesia. She is working on a thesis entitled "Genome editing in *Dendrobium lineale* Rolfe an Indonesian orchid using CRISPR/Cas9." This study focuses on a plant DNA transformation method to transfer T-DNA into the plant genome, and characterize transformant plants.

Orchid is one of the most popular ornamental plants in the world. It is appreciated for its beautiful flowers and the adaptability of the plants in containers. *Dendrobium* is endemic in Indonesia. It has high value for horticultural or medicinal uses. This orchid can be used as a parental plant in crosses to produce characteristics to meet the consumers' needs. However, the juvenile stage is long until the flowering stage is reached. We wanted to evaluate new phenotypes of *Dendrobium* with appealing leaves. We considered the use of biotechnological applications to obtain the consumers' expectations without requiring the flowering state. CRISPR/Cas9 is a new method for genome editing. It has been developed and used on plants. CRISPR/Cas9 can induce double strand breaks (DSBs) in DNA with the Cas9 nuclease enzyme, followed by repair using two mechanisms called non-homologous end joining (NHEJ) and homologous direct repair (HDR). The genome sequence information of *Dendrobium* facilitated the sgRNA design based on the similarity of the homologous gene of interest. This method was successfully used in *Dendrobium officinale*. The objective of our study was to determine whether CRISPR/Cas9 could be used as a tool for genome editing in *Dendrobium lineale*. The rapid confirmation of phenotype mutations could be seen when the chloroplast gene was used as an indicator. Variegation of a yellowish-white pattern on the leaves can be found in nature. This phenomenon could also be induced by mutating the chloroplast genes, such as *VAR2 (VARIEGATED2)*. The interest gene encodes filamentous sensitive (FtsH) enzyme family, a metalloptrotease ATP dependent that exists in the thylakoid membrane. According to Yu et al. (2004) *var2* mutation in *Arabidopsis thaliana* showed variegation in leaves. *Agrobacterium*-mediated transformation is a tool widely used to transfer T-DNA into the plant genome. Eight-week-old protocorms were used as plant materials. The construct of T-DNA *Ubi :: Cas9 :: U3 :: VAR2*/pRGEB32 in the *Agrobacterium tumefaciens* strain EHA 105 was transferred into the orchid's protocorm. In this study, we optimized hygromicin sensitivity with various concentrations of hygromicin antibiotics and inoculation times (15, 30, and 45 min) to introduce *A. tumefaciens* into the plant genome. Furthermore, genotypic and phenotypic analysis was checked from putative transformants of *D. lineale*. The results showed that 18.9 µM hygromicin on New Phalaenopsis (NP) medium was the concentration closest to the lethal dose (LD_{50}). The highest efficiency of transformation was obtained with a 45-min infection period (1.16%), compared to 15 min (0.17%) and 30 min (0.25%). Confirmation of T-DNA integration into the plant genomes was obtained by PCR analysis using primers from several genes, i.e., *Cas9, HPT, VAR2* and trnl-F cpDNA as internal control. The sequence analysis showed mutation in the form of substitution at the target site, and slightly different color changes on the leaves in the transformant plants, as compared to that in wild type (WT). The result of this study showed that the Cas9 and sgRNA complex disrupted the DNA of the *D. lineale* genome in genotype analysis but phenotypes showed less color differences between transformants and non-transformants. This study remains in progress to establish the extent of the effectiveness of using CRISPR/Cas9 on orchids.

Lailia Zubaidah was the second winner of the ISHS Young Minds Award for the best oral presentation at the II International Symposium on Tropical and Subtropical Ornamentals, which was held virtually in Indonesia in July 2021.

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› References

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The development of microbially enhanced plant growing media

› Thijs Van Gerrewey

Thijs Van Gerrewey is a Ph.D. candidate in the Faculty of Bioscience Engineering at Ghent University, Belgium, under the supervision of Professors Danny Geelen (HortiCell) and Nico Boon of the Center for Microbial Ecology and Technology (CMET). Together with Urban Crop Solutions (a turnkey vertical farming system solutions provider) and Agaris (a leading European growing media supplier), they are developing microbially enhanced plant growing media to improve plant quality and health in (vertical) hydroponics.

Vertical farming can improve the food safety and security of the growing urban world population under the increasing occurrence of climate change. However, vertical farms are only profitable in specific niche markets (geographical niches or added value chain models) because of the high investment and operational costs. Therefore, to make vertical farming more widely applicable, these niches need to be expanded.

Many growing media materials (e.g., wood fiber, composts, coir pith) are being introduced as sustainable alternatives to peat. As the fast-expanding media market develops, different blends of materials are being used. A diverse rhizosphere is essential for plant health. Using microbial biostimulants could promote plant growth, however, growing medium composition may be a determining factor in the successful application of microbial biostimulants in (vertical) hydroponics. Our knowledge of the impact of different growing media materials on microbial functioning remains limited.

Therefore, we collected five lettuce rhizosphere inocula from different farms in Belgium. We then composed ten different growing media. Lettuce was grown in each growing medium, inoculated with the bacterial community inocula, and transferred to a vertical farm. At harvest, plant growth and quality were determined, and the rhizosphere communities were identified using 16S rRNA gene sequencing.

The main conclusions were: 1) inoculation effectiveness depended on the inoculum source and its interaction with the growing medium; 2) growing medium composition determined the rhizosphere community; 3) inoculation with a bacterial consortium allowed for more control over the rhizosphere compared to a single species inoculum; 4) increased plant performance was linked to higher bacterial diversity. Overall, these results show the potential of microbially enhanced plant growing media to modulate plant performance in (vertical) hydroponics.

Thijs Van Gerrewey won the ISHS Young Minds Award for the best oral presentation at the II International Symposium on Growing Media, Soilless Cultivation, and Compost Utilization in Horticulture in Belgium in August 2021.

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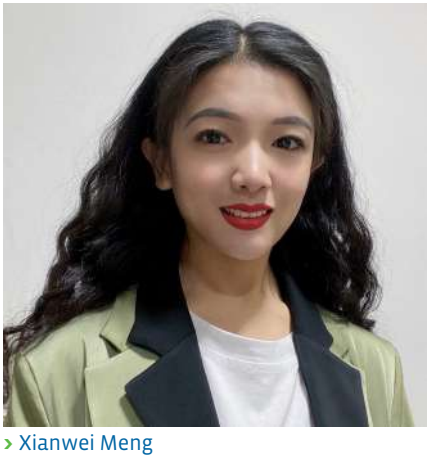
The regulatory pathways of distinct flowering characteristics in Chinese jujube



› Xianwei Meng

Xianwei Meng is a PhD student at Hebei Agricultural University, under the supervision of Prof. Mengjun Liu and Prof. Jin Zhao. Her research focuses on the molecular mechanisms of phase change and flowering regulation in Chinese jujube (*Ziziphus jujuba* Mill.). Compared to most fruit tree species, Chinese jujube, one of the most economically important members of the diverse *Rhamnaceae* family, has unique characteristics that include a short juvenile phase and extremely fast flower bud differentiation. Revealing its molecular mechanism would be greatly significant to shorten the breeding cycle and flowering regulation not only of this species but of other woody fruit trees. Therefore, her research focused on two themes: the phase change of jujube seedlings and the regulation of jujube flowering. For the first study, the objective was to determine the regulation of jujube flowering. First, the timing of different stages of jujube flowering was analyzed from the morphological and cytological levels. Then the genes related to flowering were identified from the jujube genome, and the temporal and spatial expression rules of flowering were systematically compared. Likely, the photoperiodic response genes were closely related to flower bud differentiation. The photoperiodic pathway genes were actively involved in the phase change of jujube from the juvenile to the adult period. Then, the photoperiod regulation was carried out using wild jujube seedlings. The genes of photoperiod pathway actively responded to the regulation, and the seedlings could bloom early under long days. In addition, the ambient temperature pathway related gene, *ZjPIF4*, significantly responded to the flowering process with increased temperatures in greenhouse. Finally, the interaction among *ZjPHYs*, *ZjFT*, *ZjCO5*, and *ZjPIF4* was verified at the protein level, indicating an interaction between the photoperiod and the temperature sensitive pathway of jujube. At present, Xianwei is committed to studying the molecular mechanism of phase change of jujube seedlings, and the data are under analysis.

Xianwei Meng won the ISHS Young Minds Award for the best oral presentation at the V International Jujube Symposium in China in September 2021.

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Carrot, a major vegetable crop in France

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Valérie Le Clerc, Mathilde Briard, Valentine Cottet, Ségolène Dandin and Emmanuel Geoffriau

When the Russian novelist Anton Chekhov was asked, "What is life?" he would have answered "*That's like asking what is a carrot?. A carrot is a carrot, and there's nothing more to know.*"
There is actually a lot to say, and more yet to understand!

A highly diversified vegetable production in France

France is the third largest vegetable producer in Europe with 5.6 million tons, after Spain and Italy. For potato production, France, with 6.9 million tons, is second after Germany. The vegetable production in France includes 30,800 growers with more than 202,000 ha. About 39% of the production is dedicated to processing. Organic production is increasing with about 25% of vegetable growers on 10% of the vegetable production area.
The fresh market vegetable production is based on the following types of growers: open-field mixed farms with cereals as the major activity, open-field specialized farms with a few vegetable crops, diversified vegetable farms, and greenhouse specialists. Specialized vegetable farms produce from one to four vegetable crops based on a single cropping system. French diversified vegetable farms can produce as many as 18 different crops, not to mention the high number of varieties for each crop. Specialized vegetable farms represent about 10% of the farms producing vegetables. The average land surface per grower in vegetable production is 6 ha, whether for specialized or mixed farms, with less than 2 ha in peri-urban areas and direct commercialization, to more than 50 ha for open field vegetable production. Some regions are highly specialized and can be considered as cropping centers. Brittany is such an area for artichoke and cauliflower; northern France for endive; northwestern France for shallot; Burgundy for onion; or Nantes for lamb's lettuce.
Among the vegetables produced in France, carrot has a particular importance because it is the second most consumed vegetable product in France. About 9 kg year^{-1} inhabitant^{-1} is consumed (after tomato, 14 kg). This fine crop is also the second produced vegetable in France (9% of the volume of fresh vegetables, while tomato is 12% of that production volume).

Figure 1. Traditional sandy carrots in wood boxes (left) and washed carrots in 10-kg plastic bags (right) in Angers wholesale market. Photo: Emmanuel Geoffriau.

Key data of carrot production in France

France is the fifth largest producing country for carrot, just after UK, Poland, Germany and the Netherlands, with 532,515 metric tons over 12,501 ha (FranceAgriMer, 2019). It is also the first producer of carrot seed in Europe and the second worldwide, after the USA.
In France, carrots are produced for two types of markets: the fresh market (57%) and the processing one (43%). The main fresh market French production region is New Aquitaine, in southwestern France, with about 3,900 ha, which represents more than 46% of the production area. Next is Normandy, in northwestern France, with an area of 1,600 ha, i.e., 19% of the national production area.

Figure 2. Young, juicy and sweet carrots in bunches, especially in early season. Photo: Emmanuel Geoffriau.

Figure 3. Colored carrot is a way to diversify carrot consumption. Photo: Emmanuel Geoffriau.

Figure 5. Breeding evolution in the *Nantes* type, from yellow large (left) to reduced concolor root core. Photo: Emmanuel Geoffriau.

The Hauts-de-France (northern France) is the main region of carrot production for the processing market with 55% of the land surface, i.e., more than 2,300 ha of carrots.

"Carottes de France" is the national growers' association, which federates and defends the interests of more than 250 growers and 9 professional organizations, representing 60% volume of the French production.

Most of the carrots are commercialized through wholesale markets and supermarket chains with various packaging (Figures 1 and 2). Carrot benefits from a health-related image and a high (88%) penetration rate in households. Carrot is actually the most purchased vegetable from organic production in French household purchases. Besides the orange carrot, colored carrots are commonly present as a niche market (Figure 3).

History of carrot breeding in France

Carrots began appearing in France by the 11th century, after Spain and Italy, but before Germany, the Netherlands, or the UK. Gibault (1912) cited the 14th century "Ménagier de Paris" in which "Garroites are red roots that are sold in the markets in bundles, each bundle containing a white one". De La Quintinie reported in 1690, in *Instructions for fruit and vegetable gardens* that "carrots are a kind of roots, some white, other yellow." From the 14th to the 17th century, the carrots consumed in Europe included purple, yellow, or white ones, with a predominance varying according to the country (Geoffriau, 2020a). White carrots were used particularly in France in the 17th and 18th centuries. Only at the end of the 18th century did orange carrots appear in France. The orange was derived probably from the four types of "Horn orange" carrots that appeared in the Netherlands in the 17th century: *Colmar* from the "Long Horn", *Chantenay* and *Nantes* from the "Half-long Horn", and *Paris Market* from the "Early short Horn". When considering the diversity and number of local carrot varieties, France could be viewed as a secondary diversity center for the cultivated carrot (Figure 4). Actually, the peri-urban vegetable growers, especially from green belts of important cities such as Paris and Nantes, can be considered as the first carrot breeders. They looked for local adaptation regarding production and marketing. The "Carotte rouge demi-longue nantaise" appeared in the middle of the 20th century. Since then, the *Nantes* type, characterized by a cylindrical root, has become the major carrot type cultivated worldwide. Similarly, the *Chantenay* type, from the name of a peri-urban growing area, today a suburb of Nantes, is a major type in Europe and the USA for storage and processing carrots. A major trend of the improved *Nantes* type and the subsequent hybrid varieties was a more tender, reduced and orange-colored xylem part or the carrot core (Figure 5).

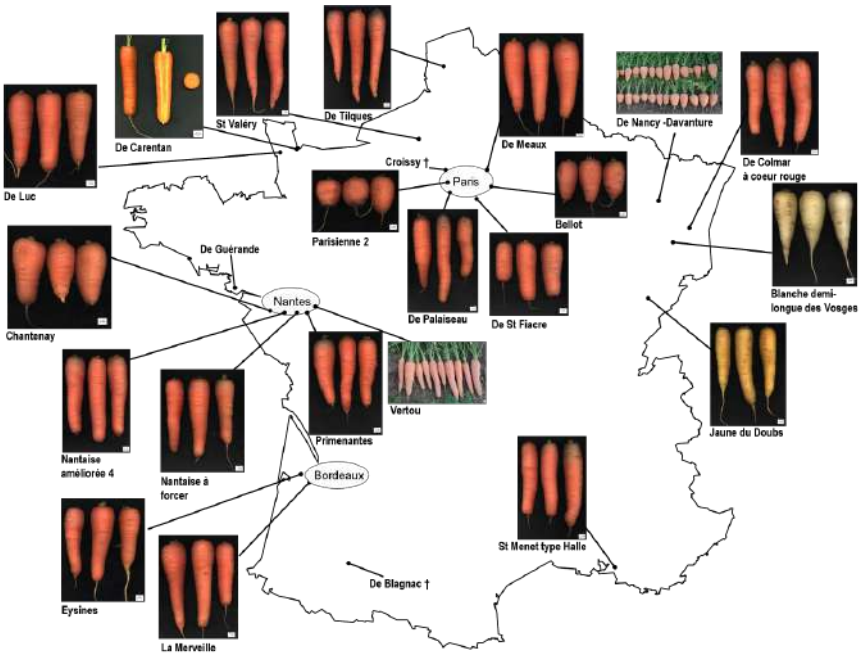

Figure 4. Distribution of French carrot landraces. Photos and elaboration: Emmanuel Geoffriau.

In 1963, the French institute for agronomical research (INRA) introduced two nucleo-cytoplasmic male sterility systems of US origin, the brown anthers and the petaloid stamens, in the *Nantes* type. The corresponding breeding lines were distributed to the private sector. 'Nandor' from Clause in 1977 was the first carrot hybrid variety in Europe. This led to a revolution in carrot production in France, with an improvement and a balance between homogeneity, yield, root cracking, and mechanical harvesting ability. Moreover, the quality of hybrid seeds paved the way for precision seeding, and the avoidance of manual thinning practiced until then. Other hybrid varieties developed by the seed companies Clause and Vilmorin, and also Bejo, Nickerson-Zwaan, Syngenta and Nunhems, were widely grown in France. As growers optimize their cropping systems over years depending on the variety, the renewal of varieties is slow and some varieties registered in the 90s are still cultivated significantly.

Since the financial farming margin is usually limited, yield is an important breeding trait (Geoffriau, 2019). Hybrid varieties increase commercial yield by reducing sorting waste. Resistance to leaf blight (mainly *Alternaria dauci*), in relation to the ability for mechanical harvest by top lifting, is a critical variety feature. Resistance to downy mildew, *Cercospora*, and cavity spot are the other

Figure 6. A) Populations of *Daucus carota* L. var. *carota* in an organic orchard. B) *Daucus carota* L. var. *gummifer* on the Channel coast. Photos: Emmanuel Geoffriau.

Figure 7. Winter early carrot production under tunnel in an organic farm. Photo: Emmanuel Geoffriau.

Figure 8. Carrot field in southwestern France in dark sandy soils with center pivot irrigation system. Photo: Ségolène Dandin.

disease-related traits important for French growers. Earliness, resistance to low temperatures, and resistance to bolting are breeding traits depending on the season and the growing area in France. Nutritional and sensory quality traits are requested by consumers, but a complex task for breeding due to significant environment impact (Chevalier et al., 2021), even if the genetic control of traits such as sugar and carotenoid content is better known (Jourdan et al., 2015; Simon et al., 2019; Geoffriau, 2020b).

Carrot genetic resources management in France

As for other allogamous crops, the dramatic advantages of hybrid varieties and the need for homogeneous, easy to harvest and to prepare products, along with a good shelf presentation, have led to the rapid drop-out of open-pollinated local varieties, which became genetic resources. To preserve the French genetic patrimony and anticipate new breeding or grower needs, initiatives to preserve genetic resources were taken in France by a specific organization through networks for plant and animal species and also micro-organisms. The network "Carrot and other *Daucus*" was created in 1996, and involved research institutes, seed companies, experimental and technical agencies as well as botanical gardens, all with a knowledge of the carrot species (Briard et al., 2007). The purpose of such a network is to inventory, collect, characterize, and evaluate carrot accessions to regenerate, store, and distribute authenticated carrot accessions in the national collection, corresponding to the French patrimony. Additional diverse carrot accessions of cultivated or wild *Daucus* are also conserved and studied for breeding or research. In relation to this network, research is conducted on genetic diversity to understand diversity, organization, and evolution, and help manage carrot genetic resources (Le Clerc and Briard, 2003). Collections of cultivated and wild carrot are maintained by the biological resource center "Carrot and other vegetable *Apiaceae*" (Roux-Cuvelier et al., 2021) in Angers in the framework of the national PGR coordination and the European program ECPGR (https://www.ecpgr.cgiar.org/working-groups/umbellifer-crops). The national patrimonial carrot collection can be accessed through https://crbcarotte-cn.agrocampus-ouest.fr/ and information can be requested at crbcarotte@agrocampus-ouest.fr.

France as a diversity source of wild carrot

Wild relatives of carrot (*Daucus carota* L.) are of interest for evolution genetics studies and carrot improvement for nematode resistance and tolerance to abiotic stresses. Several taxa have been identified and collected in France in recent years (Geoffriau et al., 2017; Reduron et al., 2019). The subspecies *gadecaei* is endemic and protected, it exists mainly in Brittany and the Basque area. The subspecies *maximus* is present on the Mediterranean fringe. Plants of the *gummifer* subgroup are generally of Mediterranean distribution (Martínez-Flores et al., 2020). The subspecies *commutatus* exists only in Corsica (Calvi, Bonifacio, Lavezzi islands), as well as the subspecies *drepanensis* (Ajaccio, Ile Rousse, Bonifacio). The subspecies *gummifer* var. *fontanesii* is present on the Mediterranean rim and in several localities in Corsica. On the other hand, the taxon var. *gummifer* is very rare in the Mediterranean sector, and present on the Atlantic and northern coasts (Figure 6). The subspecies *hispanicus* is distributed all along the Mediterranean coast and it is well present in Corsica, especially in the sector of Bonifacio. A very high genetic diversity can be observed in the Mediterranean area, compared to the rest of the country.

Carrot cropping systems and root storage

The carrot production calendar in France is spread out over practically the whole year. The early production window is followed by the production of seasonal and storage carrots. French carrots are therefore available all year round.

Early carrots are sown between November and March for harvesting from April to July

Figure 9. Harvesting carrot by lifting tops. Photo: Emmanuel Geoffriau.

Figure 10. Crop partially resistant (left) and susceptible (right) to leaf blight. Photo: Emmanuel Geoffriau.

(Figure 7). These carrots for the fresh market can be either in bunches or bags. This production requires meticulous soil work to guarantee the production of roots that meet the marketing criteria. The first sowings are covered with a tarpaulin and post-sowing weeding must be carried out to avoid dirtying the plot under the tarpaulin. Carrots sold in bunches require disease-free foliage to ensure a correct appearance on the shelves.

Then, seasonal carrots are sown from May to July and harvested from late August to November (Figure 8). When a first crop of carrots has been grown on a plot, and if harvest timing allows, a second crop can be re-established with seasonal carrots. Weed and disease management in the first crop must be optimal to ensure a healthy second one.

Mechanical harvesting is realized lifting carrot tops (Figure 9).

Finally, storage carrots are harvested from the end of November until April depending on weather conditions. The root storage method is mainly wintering in the field, but postharvest cold storage is increasing. Traditionally, carrots are mulched with straw, or uprooted and turned over with soil on top as insulation. The choice of the method is made according to the type of soil and climatic conditions. Carrots can also be harvested and stored in cool chambers throughout the winter, for sale until July of the following year. This costlier technique makes it possible to preserve the intrinsic quality of the product (Dily et al., 1994) to limit losses and soil degradation, and to extend the marketing period for carrots, particularly in April and May. This specific technique depends on several factors. Indeed, not all varieties have the same reaction to cold. The root development stage and the harvesting method both influence the storage efficiency, and the climatic conditions at the time of harvesting can modify the conservation behavior of roots in cold storage. Finally, the speed and efficiency of cooling and storage conditions are factors to be considered.

Management of main carrot pests and diseases

As for many crops, carrot production in France is challenged by the restriction of synthetic pesticides imposed by health, environmental, and societal concerns. The development of more sustainable systems and alternative crop protection methods is a priority.

The most important carrot pests in France are nematodes and carrot fly being responsible for important root damage (Villeneuve, 2014; Collier and Villeneuve, 2020). Among nematodes, *Pratylenchus* spp. are mainly observed in southwestern France, while *Heterodera carotae* is more significant in Normandy. The carrot fly (*Psila rosae)* is present in all carrot production areas.

Carrot is also affected by a wide range of pathogens (du Toit et al., 2019; Le Clerc and Briard, 2020). Among them, *Alternaria dauci* (Ad) is responsible for the main foliar disease while *Pythium* spp. are the main causal agents for root diseases. Alternaria leaf blight is mainly a problem for carrot producers in southwestern France. Among the *Pythium* spp. responsible for cavity spot, the most frequent and aggressive one is *Pythium sulcatum* in Nouvelle-Aquitaine, in the southwest, while *P. violae* is mainly present in Normandy.

To control nematodes, because fumigants were banned in France in 2018, other means of protection such as soil disinfection by steam or solarization have been investigated, but are still difficult to implement and less effective than fumigants. Regarding the carrot fly control, many factors affect the

Figure 11. Carrot sensory evaluation based on grated roots. Photos: Valentine Cottet.

arrival and development of *Psila rosae* such as crop rotation, landscape, temperature, and wind. These factors vary in time and space, making risks linked to the carrot fly complex for a given plot. Chromatic traps remain a valuable and widely used decision support tool. Therefore, searching for substances or organisms that would allow natural regulation (biocontrol) as well as for varietal resistance, remain essential to limit the use of chemical insecticides. Traditionally, to counteract carrot leaf blight, producers rely on disease support systems for timing synthetic fungicide spray in combination with partially resistant varieties (Figure 10). However, to further decrease pesticide use, changes at the cropping system level are needed. The European H2020 OPTIMA project (Optimised PesT Integrated MAnagement to precisely detect and control plant diseases in perennial crops and open-field vegetables) intends to optimise already existing disease prediction models using agro-climatic and biological algorithms, user testimony and geostatistical methods, for the development of a decision support system (DSS). Combined with relevant training and innovative practices such as "smart" sprayers for pesticide applications increasing biological and technical efficacy through site-specific and precise applications, these new tools should contribute to reach the target of low environmental and health impacts. Finally, *Pythium* spp. are mainly controlled with fungicides with, up to now, no disease development prediction system available.

Among alternatives to synthetic pesticides, the use of bio-plant protection products (BioPPPs) is one eco-friendly solution. However, very few commercial BioPPPs are currently available in France to fight carrot pests and diseases. Some projects, part of the national Ecophyto-PIC program to reduce and improve the use of phytochemicals in France, intend to identify them, such as OPTIMA (http://optima-h2020.eu/), which aims to offer efficient protection against Alternaria leaf blight combining biocontrol with plant resistance, or BIODERA (https://www.ademe.fr/sites/default/files/assets/documents/biodera.pdf), which intends to combine fertilizers with biocontrol solutions against phytoparasitic nematodes. Commercial solutions are already available to counteract *Pythium* spp. with *Trichoderma atroviride* as an efficient antagonistic fungus. However, it is still necessary to precise use modalities. Original solutions are also emerging such as a wild relative-based carrot variety used to trap *Heterodera carotae* and therefore, control the nematode development.

Whatever the alternative methods, producers should combine them to obtain similar level of protection as the one obtained with chemical pesticides. Moreover, the compatibility between levers targeting different objectives (pests or diseases) must be carefully considered as well as their impacts on the final product quality (Le Clerc et al., 2019). For this, a systemic approach is essential. In the end, any new solutions have to be technically and economically proven to be accepted by producers and largely disseminated. In this regard, new research programs will rely on co-constructing agroecological vegetable systems with producers, breeders and consumers, such as the AlterCarot (https://www.picleg.fr/index.php/Projets/Les-projets-en-cours/AlterCarot) project that focuses on soil-borne pathogens, nematodes and weed management.

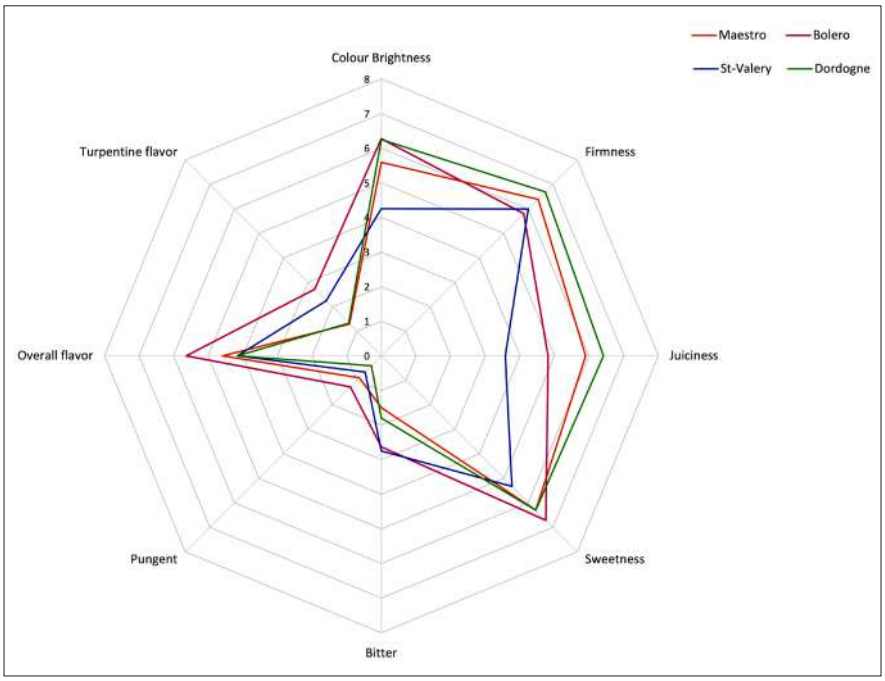

Figure 12. Sensory profile of three commonly grown hybrid varieties and one carrot landrace (St Valery). Elaboration: Valentine Cottet.

Organoleptic quality and French consumers' preferences

Organoleptic quality is studied using sensory analysis methodologies. The sensory profile method is based on the evaluation of the intensity of different descriptors by a group of trained panelists whose performance is monitored. The most appropriate sensory attributes to describe carrot quality are appearance, texture, taste, odour, and flavor (Cottet and Navez, 2020). However, the way in which carrots are tasted has an impact on human perception. A grated presentation (Figure 11) allows for better differentiation of flavours and aromas, while a sliced or stick presentation provides more information on the texture of the product. The main discriminating attributes are juiciness, sweetness, overall flavour, bitterness, and turpentine flavour (Figure 12).

The main factors affecting the sensory quality of carrots are genetics on one hand, and growing conditions on the other (Perrin et al., 2017), not to mention the many interactions between genotype and environment. As a consequence, the choice of plant material does not guarantee final product quality.

Various levels of plasticity for sensory quality were observed between varieties depending on the cropping system (Navez et al., 2017). The expectations and preferences of French consumers were also studied (Navez et al., 2015). Hedonic tests were conducted with 300 consumers in three cities (Paris, Angers, and Avignon). The creation of a preference map highlighted the drivers of preferences. Thus, the ideal carrot should combine juiciness, sugar, and aromatic intensity. Conversely, bitter and tasteless carrots are not appreciated. Nevertheless, there are specificities by population groups. Parisians are less demanding than provincials. Young people (18-25 years old) gave lower scores than did the over 65s, and were more demanding regarding carrot sensory quality.

In France, three types of consumers with specific expectations have been identified. Almost 20% of the respondents are looking for a better-quality product, while for 33% of the consumers, carrot is a basic food and they have no specific expectations. Finally, 48% of French consumers are satisfied with the current products but are potentially interested in a carrot that would stand out in terms of quality.

Conclusion

The status of carrot is an interesting example among vegetable crops in France, because

the sector is strongly structured, is supported by public and private entities, and is ready to take up several challenges. Both private sector and public research are conducting research in collaborative programs to propose varieties with various levels of plasticity adapted to specific conditions and harboring more resistance and quality features, to evaluate the combinations of alternative methods for crop protection, and to identify ways to segment the market, all together to bring more value to the growers and the sector, and satisfaction to consumers. A systemic approach is critical to respond to the current and future challenges and is more and more integrated by the stakeholders.

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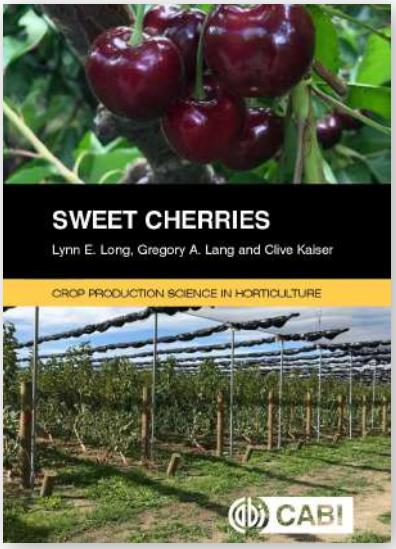
Book reviews

The books listed below 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

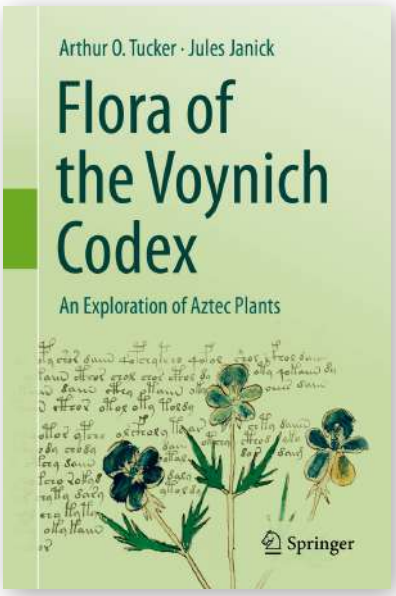


Long, L.E., Lang, G.A., and Kaiser, C. (2020). Sweet Cherries (Wallingford, Oxfordshire, UK; Boston, MA, USA: CABI), pp.391. ISBN 9781786398284 (paperback). £45.00 / €50.00 / $60.00.

A 25% discount will be received by entering the code "CCISHS25" when ordering through https://www.cabi.org/bookshop/book/9781786398284/

As the world population increases and usable agricultural lands and irrigation water decline, horticultural science and technology plays an even more important role in sustainability and increase in the production of food, including fruit crops worldwide. The consumption of sweet cherries has increased in the past two decades, mainly because of the medical discoveries of cherries as sources of vitamins and antioxidants. "Sweet Cherries," in the series "Crop Production Science in Horticulture," is authored by Lynn E. Long, Gregory A. Lang, and Clive Kaiser, and published by CABI. This book has 12 chapters of 391 pages. This book is the most comprehensive document in modern cherry production, physiology, and technology that I have read in my 37 years as a pomologist/horticulturist. The chapters are arranged in a logical order, covering flowering and fruiting, rootstock selection, orchard systems, physiology, and fundamentals in modern tree training, fruit ripening and harvest, pest and disease control, and the outlook for the future of cherry production. The book begins by describing the trend in modern cherry production and then clarifies the needs for the use of high density and dwarfing rootstocks for the maximum production of high-quality fruit from a given unit of land and water. Classification of rootstocks and planting high density orchards according to the rootstock vigor and productivity is one of the highlights. All three authors are world renowned authorities in pomology, particularly stone fruit physiology, and have cited numerous references of their own extensive research and those of other scientists in this book. Moreover, Prof. Gregory Lang (one of the authors) is a leader of the NC-140 stone fruit research group and leads cherry research projects in several states in the USA and provinces in Canada. His vast knowledge on the performance of each new rootstock under different climate conditions is well reflected in this book. The book also has numerous color-illustrations and pictures of training systems at different ages of cherry trees. I will strongly be recommending this book to my graduate students who take the "Advance Fruit Science," a graduate level class, with me. At the same time, the book is understandable for commercial fruit growers. Top-notch scientists such as Drs. Dennis and Gerry Neilsen, Tim Smith, Miljan Cvetkovic, David Granastein, and Eugeniu have effectively contributed to various portions of this book such as mineral nutrition, irrigation, root physiology, production, and pest and disease control. The step-by-step illustrations and pictures, meshed with the clarity of language used makes the book one of the most useful reference that researchers, fruit growers and packing houses, fruit hobbyists, and graduate students should have on their bookshelf.

Reviewed by Esmaeil "Essie" Fallahi, University of Idaho, USA



Tucker, A.O., and Janick, J. (2019). Flora of the Voynich Codex: An Exploration of Aztec Plants (Cham, Switzerland: Springer), pp.353. ISBN 978-3-030-19376-8 (hardcover) / 978-3-030-19379-9 (softcover) / 978-3-030-19377-5 (eBook). € 187.19 (hardcover) / € 135.19 (softcover) / € 106.99 (eBook). www.springer.com

Jules Janick, Professor Emeritus at Purdue University, and the late Arthur O. Tucker, Professor Emeritus and herbarium director from Delaware State University, published a groundbreaking book entitled *Unraveling the Voynich Codex* in 2018. The *Voynich Codex* contains fantastical art with unusual symbols, bathing nymphs, zodiac signs, cosmological images, a kabbalah-like map, and illustrations of 21 animals and 358 plants. Conventional wisdom considers the Codex to be a 15th century European manuscript. However, based on the identification of New World plants and animals, Janick and Tucker posited a 16th century Mesoamerican origin for the *Voynich Codex*.

Flora of the Voynich Codex: An Exploration of Aztec Plants expands the identification of phytomorphs in the *Voynich Codex*. It consists of five chapters: an introduction to the *Voynich Codex*; a review of Aztec botany, agriculture, trade and medicine; an iconography; a fourth chapter on phytomorph identification in the *Voynich Codex*, which makes up the bulk of the text; and an intriguing fifth chapter that reviews other 16th century Mesoamerican and European herbals. It expands the number of identified plants in the *Voynich Codex* to 169, which includes 131 images from the herbal section and 41 plants from the pharmaceutical section. All

but one are identified as indigenous to the New World. The book is dedicated to Dr. Hugh O'Neill, who in a 1944 paper first identified the two most famous examples of New World plants in the *Voynich Codex*. An appendix contains an extensive list of plants with their Nahuatl name and their identifications in the literature.

Despite the tremendous success in identifying plant species, not all identifications are definitive, and the authors indicate where questions remain. For example, Folio 24r presents a crudely drawn image that the authors suggest may be from the genus *Silene* in the *Caryophyllaceae*, but the species identification is not possible because of the lack of detail in the phytomorph. In this case, the leaves are hastate while a potential species match has attenuate leaves. The authors suggest a species identification based on possibilities but admit that an accurate match is not possible. Other phytomorphs present similar challenges. The authors suggest folio 88r may be *Lupinus montanus*, but the lack of detail makes accurate identification difficult. Other phytomorphs are easier to pin down, at least to the family level. Folio 94v displays a plant that is likely associated with the *Ericaceae*, *Macleania insignis*, even if the species identification may not be entirely precise.

Flora of the Voynich Codex is a comprehensive treatment of the botanical identification of plant images in the *Voynich Codex*. It provides additional evidence that the *Voynich Codex* may be a 16th century Meso-American manuscript, because, with one exception, the plants described are indigenous to the New World.

Reviewed by Irwin Goldman,
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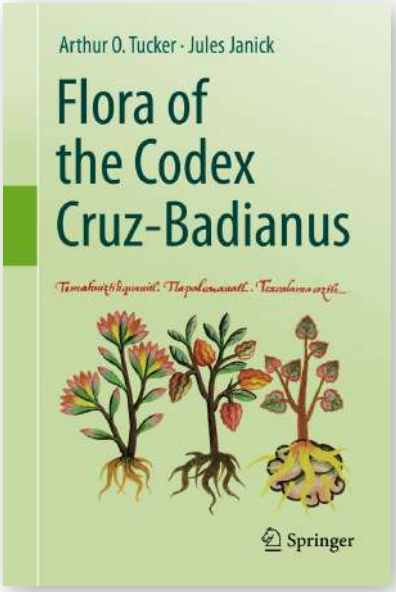

Tucker, A.O., and Janick, J. (2020). Flora of the Codex Cruz-Badianus (Cham, Switzerland: Springer), pp.321. ISBN 978-3-030-46958-0 (hardcover) / 978-3-030-46961-0 (softcover) / 978-3-030-46959-7 (eBook). € 176.79 (hardcover) / € 124.79 (softcover) / € 139.09 (eBook). www.springer.com

The 1552 text of *Libellus de Medicinalibus Indorum Herbis* (Little Book of Native People's Medicinal Herbs), now known as the *Codex Cruz-Badianus*, was authored by Martin de la Cruz, a physician in the Colegio de Santa Cruz de Tlatelcolco. The Colegio was an institution originally established to train Aztec boys for the priesthood in what is now Mexico City. The herbal was translated to Latin by Juan Badiano, a staff member and former student of the Colegio. Both Cruz and Badianus were indigenous Nahuans (Aztecs). The herbal contains 185 paintings of plants with their Nahuatl name with description of their value for mediating human ailments. The Codex is of tremendous significance to historians as the earliest substantial medical text in the New World.

Identification of the plant illustrations (referred to as phytomorphs) has been difficult in part because some of the images are not precisely illustrated, many do not contain flowers or fruits, and some of the Nahuatl names can refer to multiple species. Thus, authorities differ in their identifications. In the *Flora of the Codex Cruz-Badianus*, Tucker and Janick identify 183 of the 185 phytomorphs by family and genera, although some are admittedly speculative. For example, they note that the reflexed sepals of the actinomorphic flowers in folio 45v1 identify the phytomorph as matching a current cultivar of *Oenothera epilobiifolia* subsp. *cuprea*, which appears a much better match than two other species previously suggested by other authors. However, even in this case, the modern cultivar has a different array of colors than the phytomorph. The authors suggest Folio 38r8 is *Echeveria elegans* from the family *Crassulaceae*, possessing red and yellow funnelform flowers subtended by calyces with acute lobes and basal leaves. This phytomorph had previously been identified as either from the genus *Veronia* or the genus *Echeveria*, but the authors were able to rule out *Veronia* because of the basal leaves and the appearance of the non-*Asteraceae* flowers. They suggest that it is from the species *elegans*, but admit that it is not a precise species identification.

In the final chapter, the botanical identifications made by Arthur O. Tucker in Chapter 2 are compared with those of William E. Gates and Emily Walcott Emmart, both of whom produced their identifications in 1931, and a modern compilation by Martin Clayton, Luigi Guerrini, and Alejandro de Avila, in 2009. In addition, it lists families and genera that are congruent with the identifications by Janick and Tucker in *Unraveling the Voynich Codex*. An extensive botanical index is included. This flora provides what is arguably the most informative insights to date into the botanical identity of plants from the *Codex Cruz-Badianus*.

Reviewed by Irwin Goldman,
University of Wisconsin-Madison, USA

› V International Jujube Symposium

Division Horticulture for Human Health #ishs_dhea

› Participants of the symposium.

On 6-7 September 2021, the V International Jujube Symposium hosted by the Hebei Agricultural University was held in the library at its west campus in Baoding, People's Republic of China. In response to the national call for epidemic prevention and control of COVID-19, the symposium was held as a hybrid event with both virtual and in-person attendance. The symposium was organized by Hebei Agricultural University and co-organized by seven units, including Chinese Jujube Research Center (HAU), College of Horticulture (HAU), National Innovation Alliance of Jujube Industry (National Forestry and Grassland Administration), Section of Dry Fruits (Chinese Society for Horticultural Science), Section of Jujube (China Cash Forestry Association for Science and Technology), Jujube Industry Technology Innovation Strategic Alliance of Hebei Province, and Hebei Provincial Technology Research Institute of Jujube Industry. It was held under the aegis of the International Society for Horticultural Science (ISHS), Division Horticulture for Human Health, Working Group Jujube. The symposium was chaired by Prof. Zhao Zhihui, who is the new Chair of ISHS Working Group Jujube. Prof. Liu Mengjun, former Chair of ISHS Working Group Jujube and Convener of the V International Jujube Symposium, delivered an opening speech.

› Prof. Zhenhai Han awarded Prof. Mengjun Liu the ISHS Convener medal and certificate.

Prof. Shen Shuxing, President of Hebei Agricultural University, attended the opening ceremony and delivered a welcome speech. He pointed out that jujube research is the traditional strongpoint of Hebei Agricultural University. The success of this symposium would further promote the international exchange and cooperation in jujube and contribute to the healthy development of the world jujube industry. He honestly expected that the leaders and participants would keep support and care to Hebei Agricultural University and carry out deeper cooperation with us to promote the better development of the international jujube industry. Prof. Bhimanagouda Patil, Chair of ISHS Division Horticulture for Human Health, gave an online speech. He firstly expressed his warm congratulations to the online opening of the V International Jujube Symposium on time at this difficult time, and expressed his heart-

› Welcome address by Prof. Niaz Ali (Hazara University, Pakistan), Symposium Convener Prof. Florin Stanica (University of Agronomic Sciences and Veterinary Medicine, Romania), Prof. Shengrui Yao (New Mexico State University, USA), Prof. F. Cossio (Plant Breeder and Consultant, Verona, Italy), Prof. Guijun Yan (The University of Western Australia, Australia), Prof. Ping Liu (Hebei Agricultural University, China), and Prof. J.S. Bal (Punjab Agricultural University, India).

› Prof. Mengjun Liu, Symposium Convener, handing over the ISHS Young Minds Awards to A) Meng Xianwei for the best oral presentation, B) Zhao Zixuan for the best poster.

felt thanks to the experts and volunteers who served and contributed to this symposium. Then he gave a detailed introduction to the composition and development of ISHS. Prof. Han Zhenhai, Vice-Chairman of the Chinese Society for Horticultural Science and Council Representative of ISHS, delivered a speech and expressed congratulations to the symposium opening. Finally, under Prof. Patil's authority Prof. Han awarded the ISHS Medal to Prof. Liu Mengjun on behalf of ISHS.

Prof. Liu Mengjun from Hebei Agricultural University (China), Prof. Florin Stanica from the University of Agronomic Sciences and Veterinary Medicine of Bucharest (Romania), Prof. Yao Shengrui from New Mexico State University (USA), Prof. Noemi Tel-Zur from Ben-Gurion University of the Negev (Israel), Prof. J.S. Bal from SGGS World University (India), Dr. Ferdinando Cossio (Italy), Dr. Kamal Ghouth (Iran), Prof. Feng Jiancan from Henan Agricultural University (China), Prof. Huang Jian from Northwest A&F University (China), Prof. Pang Xiaoming from Beijing Forestry University (China), Prof. Wang Sen from Central South University of Forestry and Technology (China), Prof. Liu Ping from Hebei Agriculture University (China), 26 domestic and foreign experts, scholars, and postgraduates gave online or in-person special reports on the developmental status, latest technological progress and developmental direction of the world jujube industry. During the coffee breaks, the display of posters was conducted online through the Zoom software and live broadcast platform.

At the closing ceremony, Prof. Liu Mengjun expressed his desire to the participating experts to write the World Jujube Flora, which was fully affirmed by the participating experts and reached a preliminary consensus. Then PhD student Meng Xianwei and Master student Zhao Zixuan were awarded the ISHS Young Minds Award for best oral and poster presentation, respectively. Prof. Florin Stanica expressed his wish that University of Agronomic Sciences and Veterinary Medicine of Bucharest (Romania) will host the next jujube symposium. He showed the introduction video of his university. Finally, Prof. Zhao Jianjun, Director of the International Cooperation Office and Institute of Science and Technology of Hebei Agricultural University, expressed heartfelt congratulations on the success of this symposium. He pointed out that the academic presentations were of high level and rich in content. All the experts closely focused on and provided suggestions to the high-quality development of jujube industry, which clarified the future direction of the world's research for this crop.

In conclusion, during the V International Jujube Symposium, 26 domestic and foreign experts, scholars and postgraduates gave online or in-person reports, 13 graduates gave a poster presentation, and 61 abstracts were collected. The related manuscripts will be published in *Acta Horticulturae*.

The VI International Jujube Symposium will be organized by the University of Agronomic Sciences and Veterinary Medicine of Bucharest (Romania) and co-convened by Prof. Florin Stanica and Prof. Liu Mengjun.

Finally, more than 100 experts, scholars and postgraduates from the United States, Romania and eight other countries in the field of jujube science conducted online/in-person academic exchanges and discussion, and the number of online viewers reached more than 8,300.

The successful convening of the V International Jujube Symposium will strongly promote the development of the world's jujube industry and bring positive and far influence to Hebei Agricultural University's scientific and technological exchanges and cooperation with the world.

Lixin Wang, Zhihui Zhao, Florin Stanica and Mengjun Liu

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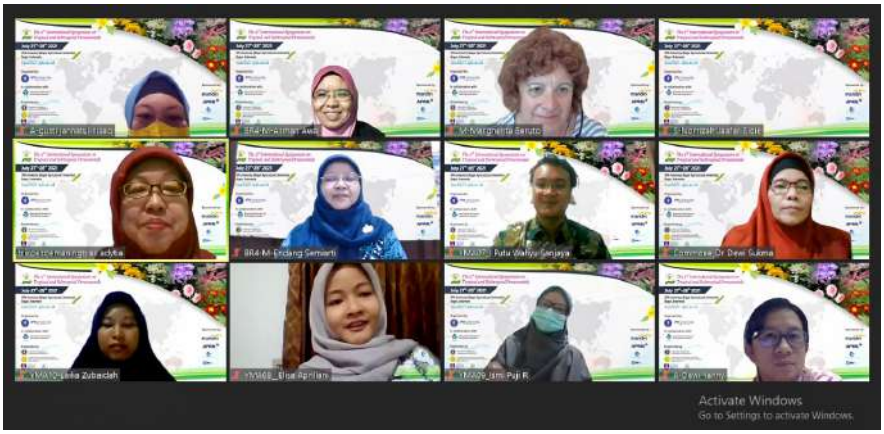
II International Symposium on Tropical and Subtropical Ornamentals

Division Ornamental Plants #ishs_dorn

Indonesia finally had the opportunity to host the II International Symposium on Tropical and Subtropical Ornamentals. This happened in Bogor, West Java, Indonesia, in a virtual event held on 27-28 July 2021, via Zoom due to the COVID-19 pandemic travel restrictions. This symposium was organized by the Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, under the auspices of the International Society for Horticultural Science (ISHS), and with the support of the International Ornamental Crop and Research Institute (Ministry of Agriculture, Indonesia), Bogor Botanical Garden, Indonesian Flower Association (ASBINDO), Indonesian Society of Horticulture (PERHORTI), and Universiti Teknologi MARA Cawangan Melaka, Malaysia.

The specific objectives of the event related to the topic of "Tropical and Subtropical Plants" included: 1) Discussing important developments in flower and ornamental plant research around the world, and 2) Exchanging information and promoting communication among international researchers, academics, and farmers, focusing on the introduction and domestication of native ornamental plants and flowers, and commercializing them to domestic and international markets.



› Some of the symposium participants.

The symposium consisted of keynote addresses, plenary sessions, parallel sessions, and Young Minds Award oral presentation competition activities organized by ISHS. In the plenary sessions, important issues regarding the development of floriculture around the world were discussed, while in the parallel sessions more specific topics were discussed. This was complemented by a poster session.

The symposium attracted more than 250 participants, including presenters, accompanying people, staff, researchers, students and government agents from 15 countries around the world (Algeria, China, Costa Rica, Finland, Indonesia, Japan, Malaysia, Philippines, Russia, South Korea, Sri Lanka, Sweden, Taiwan, Thailand, USA). They shared their knowledge and experiences on a wide range of topics in tropical and subtropical flowers and ornamental plants.

There were two days of scientific program, starting with keynote speaker, Dr. Ir. M. Taufiq Ratule, M.Si (Director of Indonesian Centre for Horticulture Research and Development, Ministry of Agriculture, Indonesia), and invited speakers, Prof. Fure-Chyi Chen (NPUST, Taiwan), Ir. Hesti Widayani, M.M (Indonesian Flower Association, Indonesia), Dr. Su-Chiung Fang (Academia Sinica Biotechnology Centre in Southern Taiwan (AS-BCST), Taiwan), Prof. Seiichi Fukai (Kagawa University, Japan), and Prof. Kanchit Thammasiri (Mahidol University, Thailand).

There were 79 presenters for oral presentations, which were divided into eight main topics: Plant breeding and genetics, Plant genetic resources, Plant protection, Micropropagation and biotechnology, Production and business, Postharvest technology, Ornamental and landscape, and Aquatic ornamental plants. In addition, 19 poster presentations were presented during both days.

Winners of the ISHS Young Minds Awards for the best oral presentation were Mr. I Putu Wahyu Sanjaya from IPB University, Indonesia, with the presentation entitled

› Professor Margherita Beruto, Chair of ISHS Division Ornamental Plants, virtually presenting the ISHS medal award to the Symposium Convener, Dr. Syarifah Iis Aisyah.

"Molecular characterization of soft-rot disease pathogen from *Phalaenopsis* and genotypes response differences to its infections," and Lailia Zubaidah from Universitas Gadjah Mada, Indonesia, with the presentation entitled "Establishment of CRISPR/Cas9 genome editing system in Indonesian orchid *Dendrobium lineale*."

Erik Mulyana

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› Winners of the ISHS Young Minds Awards for the best oral presentation: A) I Putu Wahyu Sanjaya, B) Lailia Zubaidah.

› IX International Symposium on Mineral Nutrition of Fruit Crops

Division Physiology and Plant-Environment Interactions of Horticultural Crops in Field Systems #ishs_dphy

The IX International Symposium on Mineral Nutrition of Fruit Crops was held from 28-30 June 2021 and was convened by Prof. Arnon Dag and Uri Yermiyahu from the Volcani Institute, Israel. Technology was at the forefront of oral and poster presentations, and in the background, because this was the first year this symposium was held virtually after being delayed for a year due to COVID-19 travel restrictions. Although the group missed the personal interaction, the conveners did a wonderful job in creating a high-quality program that was engaging and interactive. ISHS Working Group Mineral Nutrition of Fruit Crops continues to be an unbiased source for information on nutrient management of fruit crops. Nutrient management has been rapidly changing with increased diversity in amendments and constantly evolving environmental regulations to address issues associated with environmental degradation and climate change. Recent shifts towards organic production require a deeper understanding of the connection between horticultural strategies and nutrient management. These changes have been aided by advances in technology which provide researchers and the industry with increasing layers of high-resolution data that requires complex analysis and processing to identify actionable decisions by tree fruit producers.

› Symposium organizers in Israel managing symposium logistics from the control room.

This important symposium had presentations that highlighted the diversity in issues and advancements across many fruit cropping systems. Still, fruit crops share common threads of analogous nutrient-related issues, bottlenecks in technology, and availability of different fertilizers and amendments that require validation and testing. The symposium had 220 participants from 35 countries. It included 7 invited keynote lectures, 81 additional oral presentations and 39 posters, presented by people from 24 countries. There were 14 parallel sessions on diverse topics relating to fruit crop nutrition. Topics (Table 1) centered around:

- Nutrient uptake, agronomy, and fruit quality,
- Diagnostic and sensing methods,
- Organic nutrient management and sustainability,
- Genetics,
- Foliar nutrient management, and
- Interactions between soil biology and fruit crop nutrition.

This virtual format increased the participation of students and early career researchers in this symposium. We hope this will be

Table 1. Number of oral presentations and posters per topic.

	Oral presentation	Poster
Uptake, fruit quality, agronomy	37	19
Organic nutrition	11	3
Nutrient management regulations and sustainability	8	3
Genetics and nutrition	6	3
Foliar nutrition	5	5
Soil biology and nutrition	5	3
Nutrition diagnostics and methods	9	3

a continued trend since involvement of early-career scientists is important for the longevity of the working group. ISHS Young Minds Awards were granted for best presentations among 27 student and early career participants. The winners were Moshe Halpern for the best oral presentation titled "Nitrogen fertilization of tomatoes in an elevated CO_2 world", and Inmaculada Martos-García for the best poster presentation titled "Silicon effect on vegetative growth of young olive K-starved plants."

Three panel discussions addressed "hot" topics in the field in which perspectives of experts from different disciplines and different parts of the world helped to provide a more holistic view on the issues discussed.

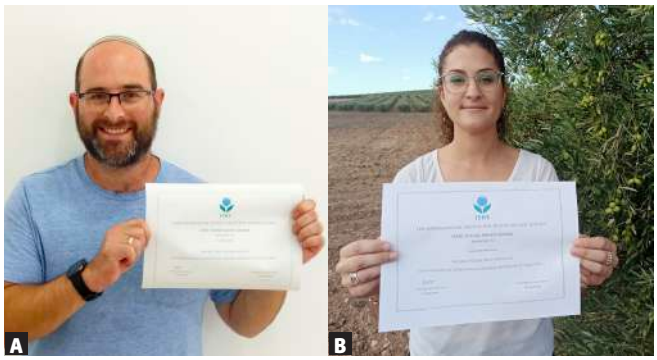
Dr. Patrick Brown and Anat Lowengart facilitated the discussion of management of N and P to meet regulatory requirements and environmental protection. Regulatory agencies and consumers are increasingly demanding sustainable nutrient management practices. These changes will continue to create opportunities for researchers to identify ways to fine tune management practices that enhance fruit quality while also reducing nutrient inputs and environmental impacts. Furthermore, to make changes in practice, extension and outreach will be important to clearly identify potential barriers to adoption of more sustainable nutrient strategies.

Drs. Lee Kalcsits and Victor Alchanati led a panel discussion on the second day focused on diagnostic and remote sensing of mineral nutrition of fruit crops. There has been an increase in methods available for plant nutrient status, either in the field or in the lab. These new methods provide opportunities for greater replication, higher resolution spatial data, and easier quantification of plant responses to nutrient management practices. With increasing tools for sensing spatial and temporal variability in plant and soil nutrient composition, there is an increasing need for validation and data processing to simplify the data-to-decision pathway for these new technologies.

Lastly, Drs. Ashar Bar-Tal and Carlo Leifert led discussions focused on organic fertilization of fruit crops. This remains a continued challenge for organic producers. Demand for organically produced fruit crops is increasing in all global markets. These global markets will increase the demand for organic fertilizers which can lack consistency in composition and availability compared to inorganic fertilizers.

The X International Symposium on Plant Nutrition of Fruit Crops will be hosted by Prof. Lee Kalcsits, in 2024, in Washington State in the USA. He will also serve as the next chair of ISHS Working Group Mineral Nutrition of Fruit Crops. Dr. Elmi Lötze is the outgoing chair, and the group thanks her for her service and strong leadership over the past four years.

Lee Kalcsits, Arnon Dag, Uri Yermiyahu and Elmi Lötze



› Winners of the ISHS Young Minds Awards: A) Moshe Halpern (best oral presentation), B) Inmaculada Martos-García (best poster).

› Virtual field tour: A) Visit to an avocado orchard, B) Visit to an olive grove to hear about nutrient-related research, C) Visit to nutrient and water-related research during the virtual field tour.

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› XII International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems

Division Physiology and Plant-Environment Interactions of Horticultural Crops in Field Systems #ishs_dphy
Division Precision Horticulture and Engineering #ishs_deng

The XII International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems is one of the oldest symposia held by the International Society for Horticultural Science (ISHS). The 2021 symposium marks the 45th anniversary of the first, held in 1976 by John Jackson (England) and Bob Wertheim (The Netherlands). Three Working Groups – Orchard and Plantation Systems, Rootstock Breeding and Evaluation, and Environmental Physiology and Developmental Biology – are sponsoring this year's event. Though initially scheduled for an in-person event in 2020, the symposium was postponed twice due to the worldwide health emergency and was finally hosted virtually from Wenatchee on July 26-30, 2021. Despite the virtual format over five days, the participants had the opportunity to listen to and see 76 oral and 53 poster presentations from 26 different countries.

During the opening session, convener Stefano Musacchi welcomed all the participants, and Greg Lang (Chair of ISHS Working Group Orchard and Plantation Systems) introduced the role of the International Society for Horticultural Science. Rich Koenig, Washington State University's Dean of the College of Agricultural, Human, and Natural Resource Science (CAHNRS), addressed the importance of the international connection among scientists and their relationship with the industry. Afterward, Luca Corelli-Grappadelli gave the opening keynote presentation entitled "Precise ecophysiology: how physiological studies can lead to innovative management practices on fruit crops."

The symposium hosted six other invited speakers that addressed specific research topics related to the three Working Groups. These speakers, listed in order of the agenda, were: Lailiang Chen ("Apple flower development and pollen tube growth in relation to sorbitol"), Terence Robinson ("A re-examination of the physiological basis of orchard system performance with respect to light interception and light conversion efficiency"), Stuart Tustin ("Orchard systems for the 21st century: perspectives, considerations and critique"), Gennaro Fazio ("Imagine rootstocks"), Ted DeJong ("How do dwarfing rootstocks control fruit tree vigor? Is it about hormones, nutrients, carbohydrates or water?"), and Lav Khot ("Precision orchard management in digital agriculture era: a review").

The primary research areas covered during the symposium were:

- Environmental physiology: Twenty-seven oral presentations and twelve posters were organized among five sessions. These sessions covered different topics ranging from ecophysiology and the effect of warmer temperatures on bud break to flower biology, crop load management, and thinning.
- Training systems: Twenty-three oral presentations and sixteen posters were organized among five sessions. New

› Participants of the symposium.

› Greg Lang, Chair of ISHS Working Group Orchard and Plantation Systems (left) and Stefano Musacchi, symposium convener (center) virtually handing over the ISHS Young Minds Award certificates to A) Giacomo Palai for the best oral presentation, B) Ahmed Ben Abdelkader for the best poster.

training systems with a 2-D canopy were proposed, and the application for different species was discussed. Fruit overcolor improvement by the use of mechanical defoliation or reflective mulches was analyzed in relation to orchard design and light interception, as was the efficient use of deficit irrigation and root population dynamics in response to irrigation and orchard management.

- Rootstocks: Fifteen oral presentations and eighteen posters were organized among three sessions. Results from multi-state trials like NC140 (USA) and Eufrin (Europe) were presented. Investigations on rootstocks physiology of apple, avocado, cherry, grape, and walnut were discussed.
- Precision farming and fruit quality: Eleven oral presentations and seven posters were organized among three sessions. A review on digital agriculture provided the most recent application of technology in the orchard. Further, an innovative spray system was tested to increase the sustainability of the different crops. Non-invasive detection of russet and metabolic signature for fruit quality of fruit in different canopy positions was discussed. Other subjects analyzed included the effect of aminoethoxyvinylglycine (AVG) and fruit position in the canopy on fruit quality.

All presentations were pre-recorded before the symposium, followed by a live discussion with the speakers. Recordings were available for registrants for thirty days after the event, helping to mitigate issues related to time zone differences. All the sessions started at 6 am Pacific Daylight Time (PDT), with time zones of speakers considered with respect to the order of presentations. For example, speakers from Europe that were nine hours ahead presented in the morning (PDT), which corresponded to mid-afternoon and evening in their respective countries, while speakers from Australia presented in the afternoon (PDT), which corresponded to the early morning of the following day. The fact that all presentations were pre-recorded and accessible optimized the possibility to watch them during the symposium.

A speed networking event was organized during coffee breaks to allow the participants to interact in one-to-one discussions for three minutes. After three minutes, a new discussion started offering the possibility to connect with a different person. Participants received this technology well because it allowed them to meet and mingle with many people, emulating an in-person setting. A 45-minute video about some of the main crops produced in Washington State (apple, pear, and cherry) was being played to provide the experience of a virtual field day.

The business meeting was held on July 28, and Stefano Musacchi was elected Chair of ISHS Working Group Rootstock Breeding and Evaluation. A presentation of the 45 years of history of the twelve symposia was given by Stefano Musacchi, utilizing pictures provided by the previous conveners and published in the *Acta Horticulturae* books. A new location for the next edition of the symposium has been identified: New Zealand will host the symposium in 2025. Michael Blanke presented a touching memory of Jens Wünsche, who recently passed away.

Four brown bag-style lunch round tables were organized by the three Working Group chairs to facilitate discussion among the participants. A group of panelists of the three Working Groups discussed the future of each research area. All participants were able to interact, writing questions for the panelists and making comments. The last round table discussion organized by Ted DeJong covered the sustainability of the several crops represented in this year's symposium. All four brown bag lunches were well received by the participants, expressing positive comments on the format.

During the closing ceremony, ISHS certificates and medals were given online by Greg Lang to the convener and the ISHS Young Minds Awards winners.

Giacomo Palai was awarded for the best oral presentation with his talk "Rootstock and irrigation induced different response in berry aromatic characteristics in 'Merlot' and 'Sangiovese' grapevines." Ahmed Ben Abdelkader won the best poster award with his research titled "Automatic irrigation scheduling in an apple orchard based on soil water potential thresholds continuously detected by digital tensiometers."

Overall, the XII International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems was a very successful event with high-level research presented in the different areas among the three Working Groups.

Stefano Musacchi

› Contact

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IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (physiological, biochemical, embryological, genetic and legal aspects)

Division Plant Genetic Resources and Biotechnology #ishs_dbio

The IX International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (physiological, biochemical, embryological, genetic and legal aspects) (Biotech 2021) was successfully held on 12-13 July 2021, in Bangkok, Thailand. The conference was organized as a virtual event due to the COVID-19 pandemic by the Department of Plant Science, Faculty of Science, Mahidol University, under the auspices of the International Society for Horticultural Science (ISHS) and with the support of the Department of Agriculture.

The conference attracted 108 participants, including presenters, staff, researchers, and government agents from 17 countries around the world (Belgium, Brazil, China, Germany, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, Portugal, Russia, Thailand, Turkey, United Kingdom and USA), who shared their knowledge and experiences on a wide range of topics in plant biodiversity conservation.

The conference participants were welcomed by Assoc. Prof. Dr. Kanchit Thammasiri, Biotech 2021 convener, and Assist. Prof. Dr. Unchera Viboonjun, Head of Department of Plant Science, and the conference was opened by Assoc. Prof. Dr. Palangpon Kongsaeree, Dean of Faculty of Science. Then, Professor Dr. Jorge Canhoto, Chair of ISHS Division Plant Genetic Resources and Biotechnology, gave a presentation on the ISHS, and presented an ISHS certificate and medal to the Biotech 2021 convener. The Dean presented souvenirs to the symposium sponsor, Department of Agriculture, and the opening ceremony ended with virtual group photographs.

› Opening ceremony with organizers. From left to right: Mrs. Kunyaporn Pipithsangchan, Director of Genebank Research and Development Group, Department of Agriculture; Staff from Faculty of Science, Mahidol University: Assist Prof. Dr. Sasivimon Swangpol, Deputy Dean for Physical Systems and Environment; Assoc. Prof. Dr. Kanchit Thammasiri, Biotech 2021 convener; Assist Prof. Dr. Unchera Viboonjun, Head of Department of Plant Science; and Assoc. Prof. Dr. Palangpon Kongsaeree, Dean.

There were two days (July 12 and 13) of scientific program, starting with the keynote speaker, Prof. Pei Shengji, Kunming Institute of Botany, China, and six invited speakers, namely Dr. Bart Panis, Bioversity International, Leuven, Belgium; Prof. Dr. Jorge Canhoto, University of Coimbra, Portugal; Prof. Dr. Hugh W. Pritchard, Royal Botanic Gardens, Kew, United Kingdom; Prof. Dr. Shaik Mohammad Khasim, Acharya Nagarjuna University, India; Dr. Manuela Nagel, IPK Gatersleben, Germany; and Dr. Gayle Volk, USDA-ARS National Laboratory for Genetic Resources Preservation, Colorado, USA. Then, 33 oral presentations were divided into seven sessions, namely Plant diversity conservation, Cryopreservation, Breeding, Micropropagation, Physiology and production, Plant molecular research, and Plant protection. In addition, 37 posters were presented over both days. All oral and poster presentations were of interest to participants, who

responded and shared knowledge and experiences with questions, suggestions, and discussion online.

At the end of the second day, an ISHS business meeting was arranged by Prof. Dr. Jorge Canhoto. Prof. Dr. Jorge Canhoto and Assoc. Prof. Dr. Kanchit Thammasiri announced the winners of the ISHS Young Minds Awards: João Martins, Ph.D. student at the Center for Functional Ecology, University of Coimbra, Portugal, for the best student oral presentation entitled "Chemotyping and in vitro conservation of strawberry tree *Arbutus unedo* L., *Ericaceae*" and Mr. Possathorn Nopun, Ph.D. student at the Department of Plant Science, Faculty of Science, Mahidol University, Thailand, for the best student poster presentation entitled "Micromorphology and histochemistry on lip of *Orchidantha foetida* (*Lowiaceae*)". Subsequently, it was decided to hold the X International Scientific and Practical Conference on Biotechnology as an Instrument for Plant Biodiversity Conservation (physiological, biochemical, embryological, genetic and legal aspects) in India by the ICAR-NBPGR, New Delhi, in February 2023. The convener of the next conference will be Dr. Anuradha Agrawal. At the end of the conference, Assist Prof. Dr. Unchera Viboonjun and Assoc. Prof. Dr. Kanchit Thammasiri expressed their appreciation to all participants, supporters, and to all members of the Organizing Committee for their efforts and contributions.

The book of abstracts and the review of the virtual conference were available for two months post conference, at the conference website: https://plantscience.sc.mahidol.ac.th/biotech2021. The proceedings of the conference will be published as a volume of *Acta Horticulturae* after editorial review.

Kanchit Thammasiri

› Virtual ISHS business meeting and closing ceremony.

› Winners of the ISHS Young Minds Awards: A) João Martins (best oral presentation); B) Possathorn Nopun (best poster).

› Contact

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› XIII International Controlled and Modified Atmosphere Research Conference – CAMA2021

Division Postharvest and Quality Assurance #ishs_dphq

With the theme "Fast Forward to a Fresh Future," the XIII International Controlled and Modified Atmosphere Research Conference, CAMA2021, created a unique forum to discuss recent scientific and industrial developments of controlled atmosphere (CA) and modified atmosphere (MA) technologies applied to fruits and vegetables. CAMA2021 was attended by 176 participants from 34 countries worldwide.

This event was hosted online from Leuven, Belgium, on 16-18 August 2021, through the digital Whova platform, combining live seminars with interactive discussion with poster authors. To promote participant interaction, round table discussions were organised next to scientific speed dating and networking sessions.

The convener, Bart Nicolaï, Katholieke Universiteit Leuven (KU Leuven), Belgium, opened CAMA2021, after which Gerard Govers (KU Leuven Vice-Rector of Science, Engineering and Technology), and Chris Watkins (Chair of ISHS Division Postharvest and Quality Assurance) welcomed the audience.

Mabel Gil, invited speaker from Consejo Superior de Investigaciones Científicas (CSIC), Spain, addressed the opportunities for CA and MA packaging of minimally processed foods. This was followed by contributions on MA packaging for mango export, its applications for fresh-cut artichokes and carrots. In addition, risks of temperature abuse leading to rapid quality decay in fresh-cut lettuce, and the possibilities of compostable bio-based packaging materials were discussed. Focussing on product physiology, the role of low oxygen in relation to chilling injury in tomatoes and the central carbon metabolism of pear fruit was explored. The last session of the day addressed the benefits of CA on storage of 'Galant' apple and mango and long-distance transport of table grapes. The impact of storage on 'Honeycrisp' apple volatile was shown stressing the influential factors temperature, season, and CA conditions. Also, the potential of a volatile signature for chilling injury was revealed.

Peter Ragaert, invited speaker from Ghent University, Belgium, started the second day by summarising novel developments in food packaging and discussing the potential of coatings. This was followed by contributions on technical innovations such as developments in respirometry and spectroscopy for non-invasive measurement of fruit internal oxygen levels and multi-species gas sensing. In addition, a technique to map oxygen diffusivity in fruit and vegetables was presented. Also, the potential of metal-organic frameworks in sorbing, storing and releasing ethylene and 1-MCP was shown. Further opportunities of CA storage and transport were explored for white pointed cabbage, blueberry, green asparagus and 'Hass' avocado. The second day ended with an online show by the Belgian mentalist Piet Kusters that made us realize nothing is simply coincidence, including the postal delivery of a red hot chili pepper to one of the participants…

› Organising Committee celebrating a successful CAMA2021.

The final day started with a session dedicated to the EC RoxyCOST action on "Oxygen sensing – a novel mean for biology and technology of fruit quality." Joost Van Dongen, invited speaker from RWTH Aachen University, Germany, gave an overview of adaptive metabolic responses of plants to low oxygen. This was followed by contributions on Group VII Ethylene Response factors in apple and the expression of specific genes of the primary metabolism in apple. More applied contributions addressed palliflex MA storage of fresh figs and CA storage of 'Ankara' pear with 1-MCP showing its seasonal dependency. Also, short-term controlled atmosphere storage of apple was discussed in relation to uneven ripening at commercial packinghouses. Finally, the environmental aspect of packaging was highlighted showing the potential of a high-barrier cellulose-based bioplastic with naringin. The last session covered dynamic controlled atmosphere (DCA) including a contribution on how computer simulations can help to optimize commercial respiratory quotient (RQ) based DCA storage of pears, and one on the positive impact of 1-MCP and DCA-CF on eating quality and superficial scald during transport and shelf life of apple.

The presentation by Robert Prange, invited speaker from Dalhousie University, Canada, reviewed current storage recommendations for apple and pear. Information was compiled from over 125 cultivars from 2000 onwards, revealing how these recommendations have evolved due to changes in cultivars, the removal of diphenylamine and the introduction of DCA, either in or not in combination with 1-MCP.

During the closure, the audience award for best poster presentation was presented to Angel Dizon, KU Leuven, Belgium, for her poster on "CA storage: beneficial or detrimental to aroma quality of pear (*Pyrus communis*)?", and the "passport contest" was won by Laia Torregrosa, Industrial Leridana del Frio SL, Spain. The ISHS Young Minds Award for best oral presentation went to Suzane Pols, KU Leuven, Belgium, for her presentation

on “It’s a RAP: identifying and characterizing Group VII Ethylene Response factors in *Malus* x *domestica*,” and for best poster to Namrata Pathak, The Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany, with her poster “Ethylene removal in fresh produce packaging: available products and their comparison.” Carolina Torres, Washington State University, took up the challenge to organise CAMA2025.

Ann Schenk and Maarten Hertog, on behalf of the KU Leuven organisation

› Contact

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› Winners of the ISHS Young Minds Awards: A) Suzane Pols (best oral presentation), B) Namrata Pathak (best poster).

› II International Symposium on Growing Media, Soilless Cultivation, and Compost Utilization in Horticulture

Division Protected Cultivation and Soilless Culture #ishs_dpro

› Policy-related workshop by the European Compost Network and Growing Media Europe: ‘EU Fertilising Products Regulation – Opportunities and Challenges to place Growing Media and Soil Improvers on the European Market’.

GrowingMedia2021, the II International Symposium on Growing Media, Soilless Cultivation, and Compost Utilization in Horticulture, was organized at the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), close to the historic university city of Ghent in Belgium, from 22 until 27 August 2021. GrowingMedia2021 was organized by ILVO, Ghent University and Hasselt University, under the aegis of the ISHS, as a hybrid symposium, and reached 180 participants from 28 countries. This event allowed for sharing expertise on: (a) growing media and sustainable use of resources, (b) the microbiome of growing media and integrated disease and pest control, (c) soilless cultivation: added value of innovations for water and nutrient use efficiency, and (d) biochar and compost in horticulture and carbon storage potential. The programme included 5 keynote speakers, 50 oral presentations, 32 poster presen-

› Field visit at Ornamental Plant Research (PCS): different vertical wall systems.

› Field visit at ILVO: on-farm composting.

tations, and 2 technical tours. In addition, we organized four interactive workshops: a Nomenclature workshop, a Peat-related workshop, a Policy-related workshop and a Next-Generation Sequencing Workshop on the microbiome of growing media. Posters were presented in three ways: a printed version was displayed at the symposium location, each presenter was asked to orally summarize their poster in a 3-minute pitch, and a digital interactive poster exhibition room was available during the symposium, with a special digital poster session on Tuesday 24 August 2021.

At the hybrid GrowingMedia2021 symposium, 2/3 of the participants were online participants. Half of the presentations at GrowingMedia2021 were given online, and 2/3 of the poster presenters were online participants. The hybrid formula thus allowed us to provide a full programme in this COVID-19 period. Although it was a complex set-up and the online interaction was an important challenge, hybrid symposia have several advantages for the number of participants and presenters, and the level of flexibility/planning for participants and the organisers. In comparison with earlier symposia in the same field, special attention was given to the microbiome of growing media and horticultural soils as affected by composition and management, balancing the sustainability and quality of mineral and organic materials in growing media, the role of biochar in growing media and in composting, and the use of organic fertilizers in horticulture and interaction with the microbiome. The symposium allowed for exchange of knowledge on how growing media and composts can help in adaptation to climate change, and how growing media can be helpful in the evolution towards more food security and quality of life. Growing media occupy a central place in the climate debate. In circular soilless cultivation systems, growing media play a crucial role in terms of water and nutrient use efficiency. Urban greening is nearly impossible without them, and growing media are also implicated in several other climate-related questions. The production and composition of growing media may imply different levels of energy use and affect carbon stocks, and over time, the use of growing media will become increasingly relevant for climate adaptation as well.

The indicative polls on growing media terminology during the Nomenclature workshop clearly differentiated between definitions and important characteristics for reporting with a large consensus versus these that need further consultation and discussion. During the Industry and Policy day on 26 August 2021, the International Peat Society organised a session on environmental matters related to peatland extraction and the meaning of “Responsibly Produced Peat” in situations where peat is essential for growing media. Later that day, the European Compost Network (ECN) and Growing Media Europe (GME) discussed the EU Fertilising Products Regulation and the opportunities and challenges to place growing media and soil improvers on the European market.

Winners of the ISHS Young Minds Awards were:

- Thijs Van Gerrewey (Faculty of Bioscience Engineering at Ghent University, Belgium) for his oral presentation on “Microbe-plant-growing media interactions modulate the effectiveness of bacterial amendments on lettuce performance inside a plant factory with artificial lighting.”
- Daniel Hauck (Weihenstephan-Triesdorf University of Applied Sciences, Freising, Germany) for his poster presentation on “Plant availability of phosphorus in recycled fertilizers from wastewater treatment – effect of grain size.”

For research stimulating compost use in sustainable growing media, Vlaco (the Flemish compost and biogas organisation) also awarded one oral and one poster presentation. A special committee consisting of Vlaco, a composting facility, a growing media producer and the Public Waste Agency of Flanders, was responsible for selecting the awardees:

- Alev Kir (Olive Research Institute, Turkey) was awarded the best oral presentation

› Symposium Convener Bart Vandecasteele (right) handing over the ISHS Young Minds Award certificate for the best oral presentation to Thijs Van Gerrewey (left).

› Daniel Hauck, winner of the ISHS Young Minds Award for the best poster.

for her contribution on "Testing peat-free growing media based on olive wood residues for olive saplings."

- María Ángeles Bustamante (Department of Agrochemistry and Environment, Spain) was awarded the best poster: "Influence of the starting feedstock materials to obtain compost. Deeping on microbiological characteristics and the relationship with chemical composition."

Another major success for the symposium was the publication and distribution to registered people of the *Acta Horticulturae* 1317, collecting all scientific contributions presented at the symposium.

Bart Vandecasteele

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› XII International Symposium on Plum and Prune Genetics, Breeding and Pomology

Division Temperate Tree Fruits #ishs_dfru
Division Plant Genetic Resources and Biotechnology #ishs_dbio

The XII International Symposium on Plum and Prune Genetics, Breeding and Pomology was held in Zlatibor, Serbia, on 14-17 September 2021. The symposium was organized by the Fruit Research Institute, Čačak in a hybrid format. Scientists from 18 countries from Europe, Asia, and South and North America participated in the symposium.

The symposium was postponed from July 2020 due to the international health emergency (COVID-19) and the organizers decided to move to a hybrid format. The epidemiological situation allowed some of the participants to be physically present in the venue place at Hotel Palisad, and all others attended virtually in a live video conference. The organization of a symposium in a hybrid format was a great challenge for the organizer and according to the participants it was successful.

The symposium was opened with a welcome and greeting speech from the convener, Dr. Darko Jevremović. He remembered that the third Symposium on Plum Genetics, Breeding and Pomology was also organized by the Fruit Research Institute in Čačak, Serbia, in 1977. After 44 years, researchers working on plum and prune gathered again in Serbia to present their latest findings in this research area. The opening speech of the convener was followed by the online greetings from the ISHS representative, Prof. Dr. Theodore DeJong, UC Davis, CA, USA, Chair of ISHS Division Temperate Tree Fruits.

During four days of the symposium, lectures were given in the following sessions:

- Genetics and breeding. Eight oral and 15 poster presentations illustrated plum fruit breeding programs in numerous countries and several newly bred and released cultivars. Advances in plum breeding programs with different goals were presented and elaborated.
- Genetic resources and cultivar testing. Within this session, four oral presentations and six posters were presented. The main topic of the presentations was the evaluation of plum cultivars in European countries.
- Rootstocks. Five oral presentations and four posters presented evaluation of rootstocks for plums and other stone fruits in several geographical locations and their effect on fruit traits.
- Physiology and orchard management. Five oral presentations and nine posters were shown in this session. Different aspects within physiology and orchard management (training systems, technology of growing, pruning, in vitro multiplication, soil management) were the topics of a dozen research teams.
- Diseases and pests. Current research on *Plum pox virus*, *Phellinus tuberculosus*, *Alternaria alternata* and *Xanthomonas arboricola* pv. *pruni* has been presented in four oral and four poster presentations.
- Fruit quality, ripening and postharvest. This session included two oral presentations and five posters on the pre- and postharvest factors affecting fruit quality and shelf life of harvested plums.
- Fruit drying and processing of plum. Dried prunes and plum spirit/brandy were topics of three oral presentations and one poster.
- Only one poster was presented in session Marketing and economics.

Three eminent speakers were invited with great pleasure to give their plenary lectures. The symposium was opened with the introductory online lecture of Dr. Michael Neumuller from Bayerisches Obstzentrum, Hallbergmoos, Germany, on "Recent achievements and future challenges in breeding for European plum cultivars: finding the suitable genetic resources for important traits". Within session Diseases and pests, Dr. Sylvie Dallot from INRA, Montpellier, France, summarized "Improved knowledge on key epidemiological parameters to optimize sharka management strategies" in her online speech. At the last day of the symposium, Prof. Dr. Ninoslav Nikićević from the University of Belgrade, Faculty of Agriculture, Serbia, gave a lecture at the venue place on the "Production

of superior quality plum brandy in small domestic distilleries in Serbia".

The symposium also recognized young scientists through the ISHS Young Minds Awards. A special committee selected PhD student Aleksandra Korićanac, Fruit Research Institute, Serbia, for the best oral presentation entitled "The effect of foliar sprays containing calcium on quality and storability of 'Stanley' plum fruit", and PhD student Maria Nicolas-Almansa, CEBAS-CSIC, Spain, for the best poster presentation entitled "Developing new genomic resources for genetic mapping and QTL identification in Japanese plum (*Prunus salicina* Lindl.)".

The symposium was closed after the ISHS business meeting, during which the main topics were the initiative to merge/join Plum and Apricot Symposia, as well as the host of the next symposium. These issues will be discussed in the following period.

The symposium was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, City of Čačak, City of Užice, Dunav osiguranje, Gruža agrar, Agranela and Artevos GmbH.

Darko Jevremović

› Winners of the ISHS Young Minds Awards: A) Aleksandra Korićanac (best oral presentation), B) Maria Nicolas-Almansa (best poster).

› Contact

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› VII International Symposium on Persimmon

Division Temperate Tree Fruits #ishs_dfru

› Virtual technical tour in Nara scheduled on the last day of the symposium.

The VII International Symposium on Persimmon was held as a virtual symposium between September 20-26, 2021. This symposium was first scheduled between 11-15 October 2020, in Nara, Japan, but it was postponed for one year because of the COVID-19 pandemic. We believed that we could hold a regular symposium in Nara in 2021 with a 1-year postponement. Unfortunately, the circumstances didn't allow us to hold a face-to-face symposium, so the symposium was held completely virtually. Despite this, we had the sense that the host city of this symposium was Nara, ancient capital of Japan, and we tried to create the atmosphere of Nara during the symposium. We also planned to hold "welcome" and "farewell" events. This virtual symposium was jointly organized by the International Society for Horticultural Science (ISHS), the Japanese Society for Horticultural Science (JSHS), and

the Institute of Fruit Tree and Tea Science (IFTS) of the National Agriculture and Food Research Organization (NARO).

We had 47 oral and 44 poster presentations from China, Spain, Turkey, Australia, Korea, Italy, Russian Federation, and, of course, from Japan. More than 130 participants from 12 countries registered. In the symposium, we had seven sessions for the presentations: Current status of the persimmon industry (S1), Breeding and genetics (S2), Crop management (S3), Biotechnology and physiology (S4), Diseases and pest management (S5), Postharvest technology (S6), and Utilization (S7). We had keynote lectures and panel discussions based on the presentations in each session. In addition, a special session entitled "Perspectives from the basic to the field" was organized by NARO.

The oral and poster presentation files, including a keynote lecture at each session, were collected prior to the symposium and were made available from September 20. All participants could discuss with presenters by chat from this date.

The symposium started on 23 September with the opening remarks of Prof. Maria L. Badenes, Chair of ISHS Working Group Persimmon, and Mr. Shogo Arai, Governor of Nara Prefecture. Opening remarks continued with the speeches of Prof. Yüksel Tüzel, President of ISHS, Prof. Yoshinori Kanayama, President of JSHS, and Dr. Tomoyuki Yukawa, Director of IFTS, NARO. Then, we moved to S1-S3 for panel discussion on the first day. Panel discussion was held as a real-time event for creating the feeling of being at a live performance at a virtual symposium. Several panelists of each session were selected from oral presenters of each category. The panel discussion for S4 and odd number poster session were held on the second day. The special session by NARO and panel discussion of S5 were held on the third day with even number poster session. The special session by NARO was performed by three invited speakers for breeding, evaluation of phenology, and forecasting insecticides for persimmon. The poster session was carried out by "REMO" software. Then, finally, on the fourth day, panel discussions of S6 and S7 were carried out, followed by a virtual technical tour.

› Speakers of opening remarks and all Chairs, Co-chairs, and panelists from every session.

A virtual technical tour was provided for showing persimmon cultivation in Nara. Then a discussion between the remote audience and the growers and staff of the Nara Prefecture Agricultural Research and Development Center was held. I believe this session was quite interesting for all participants because we could show some special techniques of persimmon cultivation in Japan, including persimmon production in heated plastic houses.

The symposium ended with the ISHS business meeting, during which Yangling, China, was elected for hosting the next International Symposium on Persimmon in October 2024. In addition, the winners of the ISHS Young Minds Awards for the best oral and poster presentations were announced. The winner for the best oral presentation was Yang Xu, Research Institute of Subtropical Forestry, Chinese Academy of Forest, China, and his presentation title was "Research on mechanism of fruit top rot occurrence in persimmon." The winner for the best poster presentation was Yosuke Fujiwara, Graduate School of Agriculture,

› Winners of the ISHS Young Minds Awards: A) Yang Xu (best oral presentation), B) Yosuke Fujiwara (best poster).

Kyoto University, Japan, and his presentation title was "Candidate gene analysis for the *ASTRINGENCY* locus controlling fruit astringency in *Diospyros kaki* using mRNA-seq and small RNA-seq data."
Particularly because this symposium was held completely virtually, we could easily discuss topics with growers and researchers from different countries. This symposium was very helpful to share updated information on persimmon. We obtained improved knowledge through our "fruitful" discussions. We hope that we can see all of our participants again at the next symposium in Yangling, China, in 2024.

Keizo Yonemori

› Contact

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› VIII South-Eastern Europe Symposium on Vegetables and Potatoes

Division Vegetables, Roots and Tubers #ishs_dveg
Division Protected Cultivation and Soilless Culture #ishs_dpro

In 2017, in Maribor, Slovenia, it was decided that the following VIII South-Eastern Europe Symposium on Vegetables and Potatoes would be held in Ohrid, North Macedonia, from 24 to 26 September, 2020. It was organized by two countries, Kosovo and North Macedonia, with two conveners: Professor Gordana Popsimonova from the Faculty of Agricultural Sciences and Food at the University Saints Cyril and Methodius from Skopje, North Macedonia, and Professor Skender Kaciu from the Faculty of Agriculture and Veterinary at the University of Prishtina "Hasan Prishtina" from Kosovo.
Initially, the idea was to make a contemporary concept with 10 thematic areas: Innovative plant production and modern technologies, Crop modelling and management, Cover materials, tunnels, and greenhouses, Plant protection and food safety, Product quality, Energy used in horticulture, Fertigation, water and growing medium, Sensors, automation and robotics, Organic horticulture, and Environmental impact and sustainable production. After summarizing the final contributions, it became obvious that the initial concept was too ambitious, and that almost half of the thematic areas would have to be adjusted into more generic categories. On the other hand, there was an important thematic group added: Agro biodiversity. This region has a very rich diversity of vegetables and a very good, previously established, regional research network. Organic horticulture and environmental impact and sustainable production were observed to be the most important topics from the symposium and as such to be elaborated on the third day, during the FAO workshop on climate-smart agriculture and organic production of vegetables in protected cultivation.
Another ambitious step in the organization of this symposium was the intention to welcome the participants in Ohrid with a hard copy of *Acta Horticulturae*. At the end of 2019, during the time of abstracts collection, we were pleasantly surprised by the interest expressed from scientists from a huge geographic scope, from the United States to Japan. There were 122 titles received. It can be well understood that some of the authors were discouraged from submitting the full paper with the uncertainty that was imposed on all of us with the COVID-19 outbreak. For the same reason, the symposium was postponed for one year (24-26 September 2021), in hope that the situation would be

› Professor Daniel Leskovar, Chair of ISHS Division Vegetables, Roots and Tubers, delivering the ISHS medal to symposium convener, Professor Gordana Popsimonova.

› Working session Plant Nutrition.

› Opening session. Welcome message by A) Professor Dr. Vjekoslav Tanaskovic, Dean of Faculty for Agricultural Science and Food, University Saints Cyril and Methodius, North Macedonia, B) Professor Dr. Naser Sahiti, Rector of University of Prishtina "Hasan Prishtina", Kosovo.

› Iva Bažon, winner of the ISHS Young Minds Award for the best oral presentation.

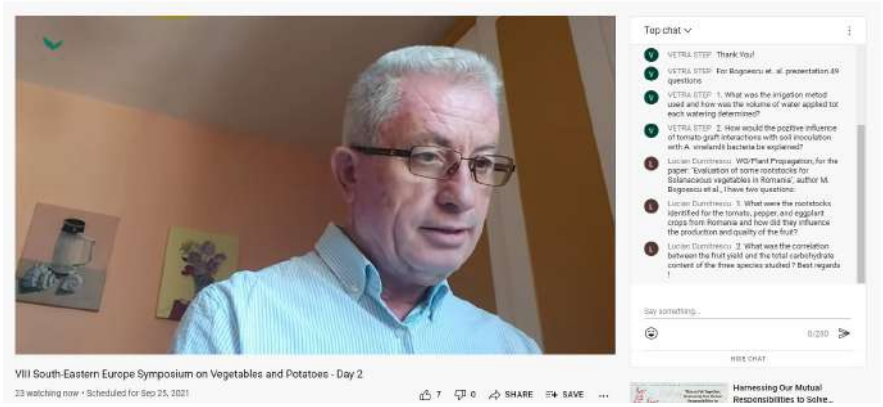
resolved and that it could be safely held in person. Finally, *Acta Horticulturae* 1320 was issued, as planned, on 8 September 2021, and distributed with 57 papers and 182 authors. Editors are Professor Dr. Nazim Gruda from Germany, Professor Dr. Stefania De Pascale from Italy, and Professor Dr. Constantinos Kittas from Greece.

The symposium was held virtually, with pre-recorded presentations, both oral and posters. The discussions were organized in separate Zoom meetings for each working session, followed by conclusions that were streamed live via YouTube. The links for both symposium days are: https://youtu.be/c9M0FwTi2jE and https://youtu.be/8DFDya-jDO0c. There is still room for improvement and adoption of this new modus operandi that will probably stay as a possibility for the following symposia. The advantage is that it enables wider inclusion of authors that normally might not be able to cover the travelling and accommodation expenses. However, the absence of feedback and live communication among the participants is very discouraging. A hybrid model, with in person events and the possibility for virtual participation might be the best solution.

The low number of young researcher participation in the symposium reveals yet another burning issue in this region, a serious lack of young researchers and brain-drain. The winner of the ISHS Young Minds Award was Ms. Iva Bažon from the Institute of Agriculture and Tourism, Poreč, Croatia, for the best oral presentation entitled "Bolting garlic quality and morphological traits are influenced by scape removal".

The core of the attendants of these symposia, starting from 2001, is composed of researchers that participated in the working session on greenhouse technologies. Their participation on the symposia and the interim activities are supported by FAO Regional Office for Europe and Central Asia. It is expected that colleagues from Central Asia will join in future the ISHS Working Group South-Eastern Europe Vegetable and Potato Production. Taking into consideration that all the activities for successful completion of the symposium, including the preparation of the proceedings, had to be executed before the symposium, the timely support by the Ministry of Agriculture, Forestry and Water Economy of North Macedonia was of utmost importance.

Gordana Popsimonova



› Astrit Balliu answering questions live on YouTube.

› Contact

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From the Secretariat

› New ISHS members

ISHS is pleased to welcome the following new members:

New Individual Members

Australia: Dr. Ido Bar, Dr. James Brinkhoff, Mark Cleal, Mr. Jim Fah, Mr. Richard Goehner, Assoc. Prof. Stephen Harper, Ms. Denoline Jolivet, Mr. Stephane Kern, Mr. Amit Khanal, Dr. Andrew Miles, Mr. Craig Shephard, Dr. Priyakant Sinha, Dr. Luz Angelica Suarez Cadavid, Mr. Michael Tatlock, Mr. Tony Tremlett, Ms. Emma Walters, Mr. Angus Whittaker, Mengdi Wu, Dr. Zeyu Xiao, Mr. Yuxin Xue, Ms. Ziwei Zhou; **Austria:** Dr. Markus Eitle, Dr. Heinrich Hildebrand, Martin Mehofer, Dr. Sophie Schaffernicht; **Azerbaijan:** Mr. Rahib Mammadov; **Belgium:** Ms. Amina Benchennouf, Mr. Angelo Castro, Dr. Francisco Davila, Ms. Paulien De Clercq, Ms. Brechtje de Haas, Jonathan De Mey, Mr. Bart Dequeker, Ms. Clara Gambart, Kris Kunnen, Mr. Simon Lauwers, Wim Mahieu, Dr. Ine Pertry, Mr. Wito Plas, Mr. Toma Rixen, Mr. Jakub Salagovic, Mr. Hans Van Cauteren, Tomas Van de Sande, Ms. Ellen Van de Velde, Mr. Ewout Van Oost, Massimiliano Virgilio, Ms. Hui Xiao; **Benin:** Yasmine Godonou; **Bulgaria:** Prof. Dr. Daniela Ganeva, Assoc. 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Year 2022

- February 15-17, 2022, Stellenbosch (South Africa): **V International Symposium on Pomegranate and Minor Mediterranean Fruits.** Info: Prof. Dr. Olaniyi Fawole, Postharvest and Agroprocessing Research Lab, Department of Botany & Plant Biotechnology, University of Johannesburg, APK Campus, South Africa. E-mail: olaniyi@sun.ac.za E-mail symposium: info@ishsstellenbosch.org Web: https://ishsstellenbosch.org
- February 16 - April 16, 2022, Riva del Garda, Trento (Italy): **XIV International Symposium on Plant Bioregulators in Fruit Production.** Info: Dr. Fabrizio Costa, Via Mach 1, 38010 San Michele all'Adige, Trento, Italy. Phone: (39)0461615563, E-mail: fabrizio.costa@fmach.it Web: https://eventi.fmach.it/ISHS-2021
- March 13-18, 2022, Brena Baja (La Palma) & La Laguna (Tenerife) (Spain): **XIV International Protea Research Symposium.** Info: Prof. Dr. Juan Alberto Rodríguez Pérez, Àrea de Producción Vegetal, Universidad de La Laguna, Calle Dinamarca 29, 38300 La Orotava, Tenerife, Spain. Phone: (34)666695267, E-mail: jarodrip@ull.es Web: https://proteas2020.asocan.net

NEW

- March 14-16, 2022, Abu Dhabi (United Arab Emirates): **VII International Date Palm Conference.** Info: Prof. Dr. Abdelouahhab Zaid, Date Palm Research & Dev. Programme, UAE University, PO Box 81908, Al Ain, United Arab Emirates. Phone: (971)3 7832334, Fax: (971)3 7832472, E-mail: szaid@rams.colostate.edu or Prof. Dr. Ghaleb Ali Alhadrami, College of Food and Agriculture, UAE University, PO Box 17555, Al Ain, United Arab Emirates. Phone: (971)37635647, Fax: (971)37632384, E-mail: hadrami@uaeu.ac.ae E-mail symposium: info@idpc.ae Web: https://idpc.ae/en

NEW

- March 20-24, 2022, San Juan (Argentina): **XVI International Symposium on Processing Tomato - XIV World Processing Tomato Congress.** Info: Dr. Luca Sandei, SSICA, Tomato Department, Viale f.Tanara 31/a, 43121 Parma (PR), Italy. Phone: (39) 0521795257, Fax: (39) 0521771829, E-mail: luca.sandei@ssica.it or Dr. Cosme A. Argerich, Instit. Nac. de Tecnol. Agro., C.C. Nro. 8, La Consulta, 5567 Mendoza, Argentina. Phone: (54)2622470304, Fax: (54)2622470753, E-mail: argerich.cosme@inta.gob.ar E-mail symposium: symposium@worldtomatocongress.com Web: http://www.worldtomatocongress.com
- March 28-31, 2022, João Pessoa, Paraíba (Brazil): **X International Congress on Cactus Pear and Cochineal.** Info: Mr. Mário Borba, 1571 Rio Grande do Sul Avenue, 58030021 João Pessoa-Paraíba, Brazil. E-mail: presidente@faepapb.com.br E-mail symposium: cactuscongress2022@faepapb.com.br Web: http://www.cactuscongress2022.com
- May 23-26, 2022, Pula (Croatia): **VIII International Symposium on Edible Alliums.** Info: Smiljana Goreta Ban, Institute of Agriculture and Tourism, Department of Agriculture and Nutrition, Karla Huguesa 8, 52440 Porec, Croatia. E-mail: smilja@iptpo.hr
- May 29 - June 2, 2022, Limassol/Lemesos (Cyprus): **VI International Symposium on Postharvest Pathology: Innovation and Advanced Technologies for Managing Postharvest Pathogens.** Info: Assist. Prof. Nikolaos Tzortzakis, Dept. Agricultural Sciences, Biotechnology, Food Science, Cyprus University of Technology, 3036, Lemesos, Cyprus. Phone: (35)7 25002280, Fax: (35)7 25002838, E-mail: nikolaos.tzortzakis@cut.ac.cy Web: http://web.cut.ac.cy/postharvestpathology2021/
- May 30 - June 3, 2022, Naoussa (Greece): **X International Peach Symposium.** Info: Prof. George Manganaris, Anexartisias 57, PAREAS Building, P.O. Box 50329, 3603 Lemesos, Cyprus. Phone: (357)25002307, Fax: (357)25002804, E-mail: george.manganaris@cut.ac.cy or Dr. Athanassios Molassiotis, Pomology lab, Faculty of Agriculture, AUTH, 54 124 Thessaloniki, Greece. Phone: (30)2310 998882, Fax: (30)2310 998882, E-mail: amolasio@agro.auth.gr Web: https://www.fruitsciences.eu/peach2021
- June 12-15, 2022, Cordoba (Spain): **XV International Asparagus Symposium.** Info: Juan Gil, Plaza de la oca, 1, 2-1, Córdoba, Spain. E-mail: juan.gil@uco.es or Dr. Roberto Moreno, Universidad de Córdoba. Genetics Department, Campus de Rabanales. Edificio C5. 2ª planta, 14071, Córdoba, Spain. E-mail: g12mopir@uco.es or Dr. Patricia Castro, Universidad de Cordoba. Genetics Department, Campus de Rabanales Edificio C5 2 planta, 14071 Cordoba, Spain. E-mail: patricia.castro@uco.es Web: https://www.ias2022.com/
- June 19-24, 2022, Davis, CA (United States of America): **VIII International Symposium on Almonds and Pistachios.** Info: Dr. Louise Ferguson, 2037 Wickson Hall, Plant Sciences Department Mail Stop II, UC Davis 1 Shields Ave. Davis CA 95616, United States of America. Phone: (1) 559 737 3061, Fax: (1) 530 752 8502, E-mail: lferguson@ucdavis.edu or Dr. Thomas M. Gradziel, Department of Pomology, University of California, 1 Shields Avenue, Davis, CA 95616-8683, United States of America. E-mail: tmgradziel@ucdavis.edu or Bruce Lampinen, Dept of Plant Sciences, University of California, 1 Shields Avenue, Davis, CA 95616, United States of America. E-mail: bdlampinen@ucdavis.edu Web: https://ucanr.edu/sites/Almond_Pistachio_2021/
- August 14-20, 2022, Angers (France): **XXXI International Horticultural Congress: IHC2022.** Info: Dr. François Laurens, INRAE, Centre d'Angers, 49071 Beaucouzé, France. Phone: (33)2 41 22 57 63, Fax: (33)2 41 22 57 55, E-mail: francois.laurens@inrae.fr E-mail symposium: info@ihc2022.org Web: https://www.ihc2022.org/

Symposia at IHC2022:

- August 14-20, 2022, Angers (France): **International Symposium on Breeding and Effective Use of Biotechnology and Molecular Tools in Horticultural Crops.** Info: Dr. Vincent Gerardus Maria Bus, Plant and Food Research, Private Bag 1401, Havelock North 4157, New Zealand. Phone: (64)69758946, Fax: (64)69758881, E-mail: vincent.bus@plantandfood.co.nz or Dr. Mathilde Causse, INRA-GAFL, BP 94, 84143 Montfavet Cedex, France. E-mail: mathilde.causse@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s1-breeding-and-effective-use-of-biotechnology-and-molecular-tools-in-horticultural-crops/
- August 14-20, 2022, Angers (France): **International Symposium on Conservation and Sustainable Use of Horticultural Genetic Resources.** Info: Dr. Tiziana Ulian, Royal Botanic Gardens, Kew, Wellcome Trust Millennium Building, Wakehurst, RH17 6TN

West Sussex Ardingly, United Kingdom. E-mail: t.ulian@kew.org or Dr. Raphael Morillon, Station CIRAD de Roujol, Petit Bourg, 97170 Guadeloupe, Guadeloupe. Phone: (33)590386162, E-mail: raphael.morillon@cirad.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s2-conservation-and-sustainable-use-of-horticultural-genetic-resources/

- August 14-20, 2022, Angers (France): **International Symposium on Quality Seeds and Transplants for Horticultural Crops and Restorative Species.** Info: Prof. Dr. Daniel Leskovar, 1619 Garner Field Rd., Texas A&M AgriLife Research, Texas A&M University, Uvalde Texas 78801, United States of America. Phone: (1)830-278-9151, Fax: (1)830-278-1570, E-mail: daniel.leskovar@agnet.tamu.edu or Prof. Dr. Olivier Leprince, 42 rue Georges Morel, 49070 Beaucouzé, France. E-mail: olivier.leprince@agrocampus-ouest.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s3-quality-seeds-and-transplants-for-horticultural-crops/
- August 14-20, 2022, Angers (France): **International Symposium on In Vitro Technology and Micropropagated Plants.** Info: Dr. Sandra Correia, Department of Life Sciences, University of Coimbra, Calcada Martim de Freitas, 3000-456 Coimbra, Portugal. Phone: (351)239240700, Fax: (351)239240701, E-mail: sandraimc@uc.pt or Prof. Dr. Stefaan Werbrouck, University Gent, Department Applied Biosciences, Valentin Vaerwyckweg 1, 9000 Gent, Belgium. Phone: (32)9 244 88 59, Fax: (32)9 242 42 79, E-mail: stefaan.werbrouck@ugent.be E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s4-in-vitro-techniques-and-micropropagated-plants/
- August 14-20, 2022, Angers (France): **International Symposium on Innovations in Ornamentals: from Breeding to Market.** Info: Dr. Johan Van Huylenbroeck, ILVO- Plant Sciences Unit, Applied genetics & breeding, Caritasstraat 39, 9090 Melle, Belgium. Phone: (32) 9-2722862, Fax: (32) 9-2722901, E-mail: johan.vanhuylenbroeck@ilvo.vlaanderen.be or Dr. Fabrice Foucher, UMR IRHS, Centre INRA, BP 60057, 49071 Beaucouze, France. E-mail: fabrice.foucher@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s5-innovations-in-ornamentals-from-breeding-to-market/
- August 14-20, 2022, Angers (France): **International Symposium on Innovative Technologies and Production Strategies for Sustainable Controlled Environment Horticulture.** Info: Assoc. Prof. Youssef Rouphael, University of Naples, Via Università 100, 80055 Portici(Napoli), Italy. E-mail: youssef.rouphael@unina.it or Dr. Jean-Charles Michel, L'Institut Agro - Agrocampus Ouest, 2 rue Le Notre, 49045 Angers, France. Phone: (33)241225422, Fax: (33)241225553, E-mail: jean-charles.michel@agrocampus-ouest.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s6-innovative-technologies-and-production-strategies-for-sustainable-controlled-environment/
- August 14-20, 2022, Angers (France): **II International Symposium on Greener Cities: Improving Ecosystem Services in a Climate-Changing World (GreenCities2022).** Info: Dr. Vivian Loges, Univ.Federal Rural de Pernambuco, Rua José Bezerra de Albuquerque 38a, Recife, 54315-580, Brazil. Phone: (51)8134624552, Fax: (51)8133206250, E-mail: vloges@yahoo.com or Mr. Philippe Faucon, 22 rue de l'Arsenal, 17300 ROCHEFORT, France. Phone: (33)546991701, E-mail: p.faucon@critt-horticole.comE-mailsymposium:sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s7-greencities2022/
- August 14-20, 2022, Angers (France): **International Symposium on Advances in Vertical Farming.** Info: Eri Hayashi, 6-2-1 Kashiwanoha, Kashiwa 277-088, Japan. E-mail: ehayashi@npoplantfactory.org or Prof. Dr. Leo F. M. Marcelis, Wageningen University, Horticulture & Product Physiology, Droevendaalsesteeg 1, 6708 PB Wageningen, Netherlands. Phone: (31)317485675, E-mail: leo.marcelis@wur.nl E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s8-advances-in-vertical-farming/
- August 14-20, 2022, Angers (France): **International Symposium on Urban Horticulture for Sustainable Food Security (UrbanFood2022).** Info: Dr. Kathrin Specht, Arndtstrasse 15, 10965 Berlin, Germany. E-mail: kathrin.specht@ils-forschung.de or Dr. Kevin Morel, 16, rue Claude Bernard, 75231 Paris, France. E-mail: kevin.morel@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s9-urban-horticulture-for-sustainable-food-security/
- August 14-20, 2022, Angers (France): **International Symposium on Value Adding and Innovation Management in the Horticultural Sector.** Info: Dr. David Neven, FAOB605, Viale delle Terme di Caracalla, 00153 Rome, Italy. E-mail: david.neven@fao.org or Dr. Syndhia Mathé, CIRAD-UMR Innovation / CSIR-STEPRI, P.O Box CT 519, Cantonments, Accra, Ghana. E-mail: syndhia.mathe@cirad.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s10-value-adding-and-innovation-management-in-the-horticultural-sector/
- August 14-20, 2022, Angers (France): **International Symposium on Adaptation of Horticultural Plants to Abiotic Stresses.** Info: Dr. Fulai Liu, Department of Plant & Environmental Science, University of Copenhagen, Hoeibakkegaard Alle 13, 2630 Taastrup, Denmark. Phone: (45)3533 3392, Fax: (45)35333478, E-mail: fl@plen.ku.dk or Dr. Bénédicte Wenden, INRA - UMR BFP - 71 avenue Edouard Bourlaux, 33882 Villenave d'Ornon Cedex, France. Phone: (33)557122549, E-mail: benedicte.wenden@inrae.frE-mailsymposium:sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s11-adaptation-of-horticultural-plants-to-abiotic-stresses/
- August 14-20, 2022, Angers (France): **International Symposium on Water: a Worldwide Challenge for Horticulture!.** Info: Brunella Morandi, Università di Bologna, Viale Fanin 44, 40127 Bologna, Italy. E-mail: brunella.morandi@unibo.it or Dr. Marcel Kuper, 361 rue Jean-François Breton, 34196 Montpellier, France. E-mail: kuper@cirad.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s12-water-a-worldwide-challenge-for-horticulture/
- August 14-20, 2022, Angers (France): **International Symposium on Plant Nutrition, Fertilization, Soil Management.** Info: Assoc. Prof. Lee Kalcsits, Washington State University, WSU-TFREC, Wenatchee, WA 98801, United States of America. Phone: (1)5096638181, E-mail: lee.kalcsits@wsu.edu or Prof. Patrice Cannavo, Agrocampus Ouest, Unité de Recherche EPHor, 2 rue André Le Notre, 49045 Angers, France. E-mail: patrice.cannavo@agrocampus-ouest.fr E-mail symposium: sciences@ihc2022.orgWeb:https://www.ihc2022.org/symposia/s13-plant-nutrition-fertilization-soil-management/
- August 14-20, 2022, Angers (France): **International Symposium on Sustainable Control of Pests and Diseases.** Info: Prof. Lucia Zappala, viale tirreno, 31, 95123 Catania, Italy. E-mail: lzappala@unict.it or Dr. Michel Peterschmitt, Campus International de Baillarguet, CIRAD, TA A-120K, 34398 Montpellier Cedex 5, France. E-mail: michel.peterschmitt@cirad.fr E-mail symposium: sciences@ihc2022.orgWeb:https://www.ihc2022.org/symposia/s14-sustainable-control-of-pests-and-diseases/
- August 14-20, 2022, Angers (France): **International Symposium on Agroecology and System Approach for Sustainable and Resilient Horticultural Production.** Info: Prof. Dr. Maria Claudia Dussi, Universidad Nacional del Comahue, Facultad de Ciencias Agrarias, CC 85 (8303) Cinco Saltos, Rio

Negro-Patagonia, Argentina. Phone: (54) 299 9 5719365, E-mail: mcdussi@yahoo.com or Dr. Sylvaine Simon, INRAE Gotheron, 460 Chemin de Gotheron, 26320 Saint-Marcel-lès-Valence, France. Phone: (33)432722206, Fax: (33)475588626, E-mail: sylvaine.simon@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s15-agroecology-and-system-approach-for-sustainable-and-resilient-horticultural-production/

- August 14-20, 2022, Angers (France): **International Symposium on Innovative Perennial Crops Management.** Info: Dr. Sara Serra, Washington State University, Department of Horticulture, Pullman, WA 99164, United States of America. E-mail: sara.serra@wsu.edu or Dr. Pierre-Eric Lauri, UMR SYSTEM, INRA, Place Pierre Viala, 34060 Montpellier, France. Phone: (33)499613054, E-mail: pierre-eric.lauri@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s16-innovative-perennial-crops-management/
- August 14-20, 2022, Angers (France): **International Symposium on Integrative Approaches to Product Quality in Fruits and Vegetables.** Info: Alyson Mitchell, Department of Food Science Technology, UC Davis, 1 Shields Ave, Davis CA 95616, United States of America. Phone: (1)5303046618, E-mail: aemitchell@ucdavis.edu or Dr. Nadia Bertin, UR 1115 PSH, INRA, Domaine St Paul, 228 route de l'aérodrome, Site Agroparc, 84914 Avignon, France. Phone: (33)0432722324, E-mail: nadia.bertin@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s17-integrative-approaches-to-product-quality-in-fruits-and-vegetables/
- August 14-20, 2022, Angers (France): **III International Symposium on Mechanization, Precision Horticulture, and Robotics: Precision and Digital Horticulture in Field Environments.** Info: Dr. Sindhuja Sankaran, Washington State University, P.O. Box 641020, Pullman Washington 99164, United States of America. Phone: (1)5093358828, E-mail: sindhuja.sankaran@wsu.edu or Prof. David Rousseau, Université d'Angers, 62 Avenue Notre Dame du Lac, 49000 Angers, France. Phone: (33)638291612, E-mail: david.rousseau@univ-angers.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s18-precision-and-digital-horticulture-in-field-environments/
- August 14-20, 2022, Angers (France): **International Symposium on Advances in Berry Crops.** Info: Dr. Susan McCallum, The James Hutton Institute, Errol Road, Invergowrie, DD2 5DA Dundee, Scotland, United Kingdom. E-mail: susan.mccallum@hutton.ac.uk or Dr. Béatrice Denoyes, 71 avenue Edouard Bourlaux, 33882 Villenave d'Ornon, France. E-mail: beatrice.denoyes@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s19-advances-in-berry-crops/
- August 14-20, 2022, Angers (France): **International Symposium on the Vitivinicultural Sector: Which Tools to Face Current Challenges.** Info: Prof. Dr. Ahmet Altindisli, Ege University Faculty of Agriculture, Department of Horticulture, 35100 BornovaIzmir, Turkey. Phone: (90)2323882622, Fax: (90)2323881865, E-mail: ahmet.altindisli@gmail.com or Assoc. Prof. Benjamin Bois, CRC - UMR Biogeosciences, 6 Boulevard Gabriel, 21000 DIJON, France. Phone: (33)662605225, E-mail: benjamin.bois@u-bourgogne.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s20-the-vitivinicultural-sector-which-tools-to-face-current-challenges/ NEW
- August 14-20, 2022, Angers (France): **XII International Symposium on Banana: Celebrating Banana Organic Production.** Info: Mr. Walter Ocimati, Bioversity International, Plot 106, Katalima Road, P. O. Box 24384, 256 Kampala, Uganda. Phone: (256)414286213, Fax: (256)414286949, E-mail: w.ocimati@cgiar.org or Dr. Thierry Lescot, CIRAD, RU GECO, Persyst Department, Boulevard de la Lironde, TA B26/PS4, 34398 Montpellier, France. Phone: (33)467615666, Fax: (33)467615821, E-mail: thierry.lescot@cirad.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s21-international-symposium-on-banana-celebrating-banana-organic-production/
- August 14-20, 2022, Angers (France): **International Symposium on Natural Colorants from Plants.** Info: Dr. Riikka Räisänen, Craft Studies P.O. Box 8, 00014 University of Helsinki, Finland. E-mail: riikka.raisanen@helsinki.fi or Ms. Anne de la Sayette, 22 rue de l'Arsenal, 17300 ROCHEFORT, France. Phone: (33)54699170, E-mail: arrdhor@wanadoo.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s22-natural-colorants-from-plants/
- August 14-20, 2022, Angers (France): **International Symposium on Postharvest Technologies to Reduce Food Losses.** Info: Gustavo Teixeira, Av. José Adriano Arrobas Martins, 210, 14.883-298 Jaboticabal São Paulo, Brazil. E-mail: teixeiragha@yahoo.com.br or Dr. Florence Charles, Universite d'Avignon, 301 rue Baruch de Spinoza, BP 21239, cedex 9, 84916 Avignon, France. Phone: (33)4.90.84.22.08, E-mail: florence.charles@univ-avignon.fr E-mail symposium: sciences@ihc2022.orgWeb:https://www.ihc2022.org/symposia/s23-post-harvest-technologies-to-reduce-food-losses/
- August 14-20, 2022, Angers (France): **IX International Symposium on Human Health Effects of Fruits and Vegetables - FAVHEALTH2022.** Info: Assoc. Prof. Kaleab Baye, Bole Sub-city, Addis Ababa, Ethiopia. E-mail: kaleab.baye@aau.edu.et or Dr. Marie-Josèphe Amiot Carlin, INRAE, 2 place Pierre Viala, Campus La Gaillarde, 34060 Montpellier, France. E-mail: marie-josephe.amiot-carlin@inrae.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s24-horticulture-for-nutrition-and-food-security-health-and-well-being/
- August 14-20, 2022, Angers (France): **International Symposium on Medicinal and Aromatic Plants: Domestication, Breeding, Cultivation and New Perspectives.** Info: Dr. Christoph Carlen, Agroscope, Route des Eterpys 18, 1964 Conthey, Switzerland. Phone: (41) 58 481 35 13, E-mail: christoph.carlen@agroscope.admin.ch or Mr. Guillaume Frémondière, Impasse de la Vesc, 26740 Montboucher sur Jabron, France. Phone: (33)475918146, E-mail: guillaume.fremondiere@iteipmai.fr E-mail symposium: sciences@ihc2022.org Web: https://www.ihc2022.org/symposia/s25-medicinal-and-aromatic-plants-domestication-breeding-cultivation-and-new-perspectives/
- September 5-9, 2022, Corvallis, OR (United States of America): **X International Congress on Hazelnut.** Info: Prof. Shawn A. Mehlenbacher, Department of Horticulture, 4017 ALS Bldg., Oregon State University, Corvallis, OR 97331-7304, United States of America. Phone: (1)5417375467, Fax: (1)5417373479, E-mail: mehlenbs@hort.oregonstate.edu Web: https://hazelnut2021.org/
- November 6-11, 2022, Mersin (Turkey): **XIV International Citrus Congress.** Info: Prof. Dr. Turgut Yesiloglu, Cukurova Ünivesitesi, Ziraat Fakültesi, Adana, Turkey. E-mail: tyesil@cu.edu.tr Web: https://www.citruscongressturkey.org/
- December 15-18, 2022, Guangzhou (China): **IV International Orchid Symposium.** Info: Prof. Dr. Genfa Zhu, Enviromental Horticulture Research Inst., Guangdong Academy of Agricultural Sciences, No. 1 East Jinying Street 1, Wushan Road, Tianhe district, 510640 Guangzhou, China. E-mail: genfazhu@163.com Web: http://www.ios2022.cn/

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