XIII

INTERNATIONAL MANGO SYMPOSIUM

SEPTEMBER 29th to OCTOBER, 3rd, 2023 ▪ MÁLAGA, SPAIN

BOOK OF ABSTRACTS

IHSM La Mayora

Instituto de Hortofruticultura Subtropical y Mediterránea

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XIII INTERNATIONAL MANGO SYMPOSIUM
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Abstracts of Oral Presentations

Crossbreeding the diverse *Mangifera* genetic pool to create the mangoes of the future

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Mango consumption has been growing at a drastic rate. In order to keep up with demand and to enter new markets, there is a need for constant improvement of fruit taste, quality, disease resistance, and shelf life. There is also a responsibility to support growers with profitable new varieties in order to promote robust production and economic sustainability. So far, the commercial industry has relied exclusively on *Mangifera indica* and on breeding programs which count on open pollination and coincidental seedlings. However, greater genetic diversity is needed. The *Mangifera* wild species have a bank of genetic resources that can be used to develop superior cultivars. These cultivars will demonstrate higher disease resistance, thereby reducing the need for pesticide usage. They will show better color and taste, as well as contain higher nutritional values. In addition, some *Mangifera* wild species can be used as rootstocks to help produce more productive and efficient mango trees in a wider variety of soils. In our breeding research program, we work primarily with the commercial Keitt variety which is a leader in the global market. However, its green skin is relatively susceptible to diseases, and has a short shelf life. Therefore, we have been breeding the Keitt with *Mangifera casturi* and *Mangifera quadrifida*. Both are green during growth and change to a reddish-purple color to indicate they are ripe and ready to eat. This is a perfect characteristic to facilitate new market introduction and penetration. These two *Mangifera* species are also considerably resistant to diseases and offer new, exciting tastes and flavors. The cross-pollinated seedlings were grafted onto mature trees. The F1 generation fruit were screened for the desired traits such as color, taste, disease resistance, lack of fibers, etc. The selected F1 fruits were then cross-bred to create the F2 generation. The F2 generation is currently being evaluated. We aim to merge this program with another research protocol for optimal marker identification and superior fruit production in the future.

Crop load affects mango fruit mineral status and susceptibility to internal disorders

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Consistent mango fruit quality is pivotal to consumer confidence, repeat purchase, and profitability. If fruit are not inherently robust at harvest, then export related phytosanitary treatments; for example, vapour heat treatment (VHT), can induce physiological disorders such as flesh cavity with white patches (FCWP). Among other determinants, fruit robustness at harvest is linked to growth environment, mineral nutrition, and canopy management. A trial was conducted across two consecutive fruiting seasons on a 'B74' mango farm. Forty-five and 54 trees in years 1 and 2 respectively were assessed. Fruit number per tree was counted 3-days before harvest and assigned into four crop-load categories: very low (<50 fruit); low (50-100 fruit); medium (100-150 fruit); and, high (>150 fruit). Ten fruits were randomly sampled per tree and subjected to ± VHT treatment and then ripened and assessed for postharvest quality and mineral nutrient concentrations. A biennial bearing pattern was evident across the fruiting seasons. In season 1, 91% of the trees had very low (22%), low (47%), and medium (22%) crop-loads, while only 9% had high crop-load. In season 2,70% had high crop-load compared with 11%, 9%, and 9% with medium, low, and very low crop-loads, respectively. In pooled data across both seasons, FCWP incidence was lowest in high crop-load trees at 8.8% compared with medium (35.3%), low (59.2%), and very low (42.7%) crop-loads. Linear correlation coefficients indicated that crop-load was significantly ($p \leq 0.05$) positively correlated with fruit flesh Ca ($r = 0.66$), Mg ($r = 0.52$) and negatively correlated with FCWP incidence ($r = -0.68$) and K concentration ($r = -0.71$). Thus, seasonal tree variability within the orchard markedly affects fruit robustness, mineral status, and susceptibility to FCWP. Decisions on consigning fruit to export (viz., +VHT) versus domestic (viz., -VHT) markets can be informed by monitoring orchard conditions and crop-load across growing seasons.

Induction of stomatal opening following night-chilling event rescue mango trees from physiological damage

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Chilling events have become more frequent with climate change and are a significant abiotic factor that causes plant physiological damage and, consequently, reduces crop yield. Like other tropical and subtropical plants, Mango (*Mangifera indica* L.) is particularly sensitive to chilling events especially if they are followed by bright sunny days - 'Cold Night-Bright Day'. It was previously shown that stomatal opening in the following bright morning is restricted by the night-chilling process in Mango leaves. This impairment results in restraint of carbon assimilation and, subsequently, photoinhibition and ROS production, which leads to chlorosis, and in severe cases even cell death. Our detailed physiological analysis shows that foliar application of the guard cell H^+-ATPase activator, Fusicoccin, in the morning that follows the cold-night mitigates the physiological damage of 'Cold Night-Bright Day' abiotic stress. This

application restores stomatal opening, enabling gas exchange, releasing the photosynthetic machinery from detrimental excess-photon energy, and improve the plant's overall physiological state. The processes by which plants respond to this abiotic stress are investigated, and the use of foliar application of compounds that cause stomatal opening as a potential method of minimizing night-chilling physiological damage will be discussed.

Rethinking mango production systems, towards intensive high-density orchards

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Mango production systems and their management in Australia and Internationally have not changed substantially for decades, apart from some evolutionary changes associated with new genetics, and the mechanisation of pruning and harvesting. These changes have not kept up with the changing farm business environment of increasing competition, increasing costs of inputs such as materials, labour, water, and land values. For mango production to remain sustainable and profitable, we need to rethink and redesign how we produce mangoes. Future orchard production systems will need to be higher producing with lower cost per unit output, be more resilient to climate, be safer places to work in, require less labour and be able to adapt to future trends in technology, automation, and protected cropping. All this is not possible with our current low density orchard systems. We will need to rethink and transform mango production from the ground up. In Australia a team of researchers from the Queensland Department of Agriculture and Fisheries, universities and the mango industry have begun to redesign mango production systems, drawing inspiration from developments that transformed production in temperate tree fruits. This program of work, on mango orchard intensification towards higher productivity, now 10 years old, includes an extensive portfolio of allied projects that have made remarkable progress in tropical mango production. This presentation covers key elements that underpin production in mango orchards such as crop load, tree size and vigour, canopy architecture, light interception and distribution, harvest efficiency, economics, and genetics. Major, insights, and new approaches emerging from our research will be presented. By sharing our thoughts and understanding of mango production at this conference, we aim to engage with fellow researchers, foster collaborations, and inspire future breakthroughs among the scientific and mango growing community.

The Australian mango breeding program

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The Queensland Department of Agriculture has been introducing and evaluating mango varieties since the early 1960's and actively cross-breeding since 1994. The mango genetic improvement program has developed varieties suited to Australian conditions and consumer preferences with long-term success of varieties 'R2E2' and 'Calypso'. The focus is now on developing regular bearing, high yielding, low tree vigour mango varieties suited for high density intensive orchard systems. The breeding program is also identifying tolerance to the postharvest disease anthracnose (*Colletotrichum* spp.) and incorporating it into advanced breeding lines. The mango breeding program is underpinned by the National Mango Genebank, a living arboretum of mango varieties and related species from all over the tropical world. Molecular genetics has been used to improve our understand of genetic relatedness and identify markers for traits of interest. This presentation will introduce identified traits that impact on breeding methodologies and objectives and our progress towards incorporating these ideas into new varieties. The integration of breeding goals with current trends of orchard intensification is a key driver for this program.

Anatomical differences in floral organs between diploids and autotetraploids of Kensigton Pride mango

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The relationship between ploidy and cell size has been recently demonstrated for the vascular tissues of vegetative organs in *Mangifera indica* (Barceló-Anguiano et al., 2021). Yet, there is a lack of information on this relationship in reproductive organs. In this work, we explore the relationship between cell size of the vascular tissues in mango flowers and their possible effect during cross-pollinations between diploid and autotetraploid lines. During the spring of 2021, self and cross hand pollinations were performed using mango trees belonging to diploid and autotetraploid genotypes of 'Kensington Pride'. Pollen tube growth in both ploidies was monitored *in vitro* and *in vivo* through fluorescent microscopy methods. Additionally, we evaluated the size of the vascular elements of the xylem and the phloem in the female gynoecium, comparing the style and the ovary tissues. Our results revealed that flowers from autotetraploid genotypes were generally larger than those from diploids. Pollen grains and pollen tubes from autotetraploids were also wider, and the pollen walls thicker. However, pollen tube arrival to the ovary was similar in self and cross pollinations between ploidies. The vascular elements of the xylem and the phloem were also larger in tetraploids, and both ploidies showed larger vascular elements in the pistil compared with the ovary, with much shorter elements. The general size increase related with ploidy is consistent in autotetraploid genotypes of mango. This gigas size effect was maintained in the pollen tubes, which putatively contain haploid and diploid sperm cells in pollen from diploids and tetraploids, respectively. The pistil of mango does not discriminate between genotypes that only differ in chromosome numbers, allowing the arrival of pollen tubes to the ovule and therefore hybridization between ploidies. We discuss the possible relationship between vascular tissues and reproductive performance in individuals of different ploidies.

Characteristics and compatibility of rootstocks and grafts on native mango cultivars, Frutales Experimental Station, Peravia, Dominican Republic

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Se realizó un estudio con el objetivo de caracterizar y evaluar la compatibilidad de cuatro porta injertos en tres cultivares de exportación. Materiales biológico utilizados como porta injertos: 'Morado', 'Gota de Oro', 'Banilejo' y 'Largo', cultivares comerciales: 'Mingolo', 'Crema de Oro' y 'Banilejo'. Se utilizó un diseño completamente al azar en un arreglo factorial (A-porta injerto) y (B-cultivares) con seis repeticiones y 12 tratamientos. Los datos obtenidos fueron analizados usando el programa INFOSTAT versión 2020. Para la cantidad de embriones de los portainjertos, el cultivar 'Banilejo' y 'Largo' tienen 55 y 50% respectivamente poseen un solo embrión. El 'Gota de Oro' y 'Morado' tienen 40% con dos embriones. En medición del porcentaje de prendimiento hubo diferencia significativa ($p < 0.0001$) entre las combinaciones de porta injertos 'Banilejo x Largo' y ' Largo x Largo' ambas con una frecuencia de 83%. Los resultados mostraron que la longitud de plántula de a partir de punto de injerto hubo diferencias estadísticas significativas ($p < 0.0001$), siendo 'Largo x Gota de Oro', igual a 'Banilejo x Banilejo' con una media de 57.61 mm y 66.08 respectivamente. En la variable de la doble injertía hubo diferencia significativa ($p< 0.0001$) entre las combinaciones de portainjertos con cultivares comerciales, siendo 'Largo x Largo' x 'Mingolo' y 'Banilejo x Banilejo' x 'Crema de Oro' con un prendimiento de 91.20 y 46.70% respectivamente.

Molecular Events Involved in Fruitlet Abscission in Mango

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In mango (*Mangifera indica* L.), fruitlet abscission limits productivity. Fruitlet abscission initiates with a decrease in polar auxin transport through the abscission zone (AZ), triggered by ethylene. The secreted IDA (INFLORESCENCE DEFICIENT IN ABSCISSION) peptide acts as key component controlling abscission events in Arabidopsis. Recent reports suggest that IDA-like (IDL) peptides may assume similar roles in fruit trees. In a previous study we isolated two IDA/IDL-like encoding genes (termed *MiIDA1* and *MiIDA2*). We used mango fruitlet explants and fruitlet-bearing trees, in which fruitlet drop was induced by ethephon, and monitored *MiIDA1* and *MiIDA2* expression patterns, together with that of different ethylene-related and cell wall-modifying genes, in control and ethephon-treated fruitlet AZs. We also examined the ectopic expression of *MiIDA1*

and *MiIDA2* in Arabidopsis, and their capacity to repair the abscission deficiency of an Atida mutant. Our data provide different lines of evidences supporting the conserved functions of both *MiIDA1* and *MiIDA2* in regulating mango fruitlet drop. To further study the mechanisms regulating mango fruitlet abscission, we conducted a transcriptome analysis, using control and ethephon-treated fruitlet AZs. Among findings, we observed changes in the expression of genes encoding for hormones (ethylene, auxin and ABA), increased expression of *MiIDA1*, *MiIDA2* and of distinct cell wall degrading genes. We also detected upregulation of genes encoding for precursors of phytosulfokines (PSKs), in the treated AZs. PSKs are small peptide hormones, recently suggested to act as new players affecting drought-induced flower abscission in tomato. The possibility that different MiPSKs assume roles in regulating mango fruitlet abscission, will be discussed. Understanding of the mechanisms regulating mango fruitlet drop may assist in the development of methods to mitigate this problem, and provide candidate genes for biotechnological applications.

Interaction of mango cultivar, ripening stage and processing techniques on sugar and organic acids

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Mango is the dominant tropical fruit variety produced worldwide; however, it is perishable quickly due to inadequate storage facilities after harvesting. In order to deal with these cross-cutting issues related to post-harvest and an increase in market demand, an appropriate mango processing technology should be introduced in fruit production and fast adopted to be an effective strategy. This study aimed to determine the effect of raw material (mango cultivar and ripening stage), and processing techniques (pasteurization, tray drying, and vacuum frying), on mango products' soluble sugars and organic acids content. Soluble sugars and organic acids content was well known as a crucial indicator, influencing mango products' quality and consumer perception. Mango fruit of Kent, Keo Romeat, and Keo Chen cultivars from Cambodia were selected and ripened into three different ripening stages: mature-green, mid-ripe, and ripe stages. A hot-water circulation system heated fresh mango puree to reach 85°C for 5 min, while tray drying was operated at 60°C for 150 min and vacuum frying at 100°C for 7 min with a slice thickness of 4 and 2 mm, respectively. It was found that processing did not impact the total sugar content expressed in mango product dry matter. The ratio of sucrose to hexose (glucose + fructose) of cv. Keo Chen and Kent increased with ripening, independently with processing. Drying and vacuum frying affected malic acid content in contrast tendency. The total sugar/total organic acids ratio increased with the ripening stage throughout the vacuum-fried and dried products of Cambodian cultivars. Based on these results, the concentration of sugars and organic acids are substantially different, suggesting that the impact of cultivar and ripening stage interacting with each process.

Development of out-of-season mango production under the extreme desert conditions of the Israeli Dead Sea and Arava regions

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The Israeli mango industry is mostly focused on cultivation under Mediterranean climate in the north of the country. The warm and dry desert conditions near the Dead Sea and the Arava valley provide an opportunity for early and out-of-season production in either open orchards or in green houses. Induction of flowering by external application of paclobutrazol (Cultar), or by drought is a common practice in tropical regions, but is not used in Israel due to the natural induction by the cool winter. We first monitored natural flowering of early season Israeli cultivars ('Shelly', 'Orli', 'Agam' and 'Tali' vs. 'Tommy Atkins') in the Arava valley. Variation in timing and intensity of natural flowering was detected between cultivars, especially in warmer seasons. We applied Paclobutrazol or drought treatments, in the summer, to induce early and more efficient flowering. Passive heating, by covering the trees in a polyethylene tunnel, or active heating in a greenhouse were also tested to improve fruit setting and enhance fruit development. Inflorescence counts, as well as morphological and histological analyses suggest that both Paclobutrazol and drought treatments induced early flowering. The effect of Paclobutrazol was stronger, inducing higher numbers and earlier inflorescences. Differential expression patterns of key flowering genes and earlier expression of *MiFT1* were associated with early flowering induction by Paclobutrazol. Overall, results emanating from this study, can be employed to produce out of season protocols for mangoes under warm desert conditions.

Mango breeding for quality traits

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Mango (*Mangifera indica* L.) is one of the most important fruit trees in tropical and subtropical regions. However, international trade of mangoes is based mainly on few cultivars that were mostly generated dozens of years ago. Only few research groups focus on mango breeding programs worldwide. Breeding combines the generation of new genetic combinations mainly through sexual reproduction and the selection of individual plants with desirable traits. Most breeding programs focus on fruit quality, appearance and taste. Vegetative traits, tree architecture and tolerance/resistance to diseases are also important. Until recently, mango was an orphan crop with very poor knowledge at the physiological, molecular and genetic levels. The lack of genetic and genomic resources for mango has limited the ability to integrate genetic approaches into mango breeding and the heritability of many of the important quality traits is still not known. Recent development of molecular tools for mango, including transcriptomes, genome sequence drafts and molecular variation, provides opportunities for enhancing mango breeding, enabling integration of molecular genetics and genomic approaches into mango breeding. We will discuss different aspects of mango breeding and the effects of the developed tools for improvement of mango breeding and selection.

Facilitating industry adoption of intensive mango practices and the use of agri-technologies in Australia

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The Australian mango industry is a high-value industry, widely distributed across Australia's remote, northern tropics. This industry faces challenges including long supply chains, variable climate, labour shortages, increasing input costs, and inconsistent fruit quality. The Mango Industry Strategic Plan (2022-26) identifies the adoption of intensive mango practices and the development of new ag-technology, as key solutions to increasing industry efficiency, profitability, and sustainability. This paper describes the extension and communication methods used to facilitate industry awareness and adoption of new practices and technologies, within two national Hort Innovation funded projects, 'National Tree Crop Intensification in Horticulture Program' (AS18000) and the 'Multi-scale Monitoring Tools for Managing Australian Tree crops' (ST19000). These cutting-edge projects incorporate an integrated research, development and extension structure, with objectives to 1) Investigate and progress the knowledge and understanding of increased mango orchard intensification methods and technologies, with goals to improve orchard efficiency, productivity and profitability and 2) Communicate, demonstrate and extend these latest findings and recommendations to support mango industry stakeholders

to make informed decisions which improve their management practices. Communications and extension associated with these projects involve a highly integrated approach using multiple techniques. The primary method has been the establishment of experimental research and best-bet practice demonstration sites on government research stations and on commercial growers' properties. These resources, developed, established, and managed in collaboration with industry experts and growers provide the factual results, information, and examples which are used to inform the wider mango industry. Several demonstration sites were established independently of these projects, with growers being approached and then agreeing to share this information with the wider mango industry. This strategy known as 'Farmer Participatory Research' harnesses the farmers practical experience and expertise, to improve the value of innovative technologies and improved practices, which then facilitates greater industry adoption.

Genetics of mango sensory preferences

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The Australian Mango Breeding Program is focused on developing and evaluating new mango hybrids that meet the demands of the Australian market and consumer preferences. This involves enhancing both production and consumer traits such as productivity, low tree vigour and fruit quality. Understanding the genetic complexity associated with consumer traits has been a challenge, but advancements in genomics have presented new opportunities to gain insight into the biological factors that link consumer preferences to the genetics and chemistry of fruit sensory qualities. We are exploring flavour profiles in mango and creating a molecular pathway for targeted flavour improvement. This will enable efficient incorporation of production and consumer-related traits into new superior varieties, potentially adding value to the industry, which is currently worth AUD $218 million per year. Additionally, we are investigating Australian consumer preferences and behaviours, including consumption and purchasing, regarding mangoes, examining sensory qualities like taste, smell, appearance, and texture that influence consumer needs, while promoting profitability and sustainability in the Australian mango industry. The success of the program in creating premium or niche mango varieties has the potential to make a significant impact on the industry's growth and success.
This work is part of the Genetics of Fruit Sensory Preferences project, funded by the Hort Frontiers Advanced Production Systems Fund (APS), part of the Hort Frontiers strategic

partnership initiative developed by Hort Innovation, with co-investment from the Department of Agriculture and Fisheries (DAF), the Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland (UQ), and Griffith University (GU) and contributions from the Australian Government.

MangoBase: bioinformatics tools for mango research

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Mangoes are delicious fruits with great nutritional value, and one of the main fruit crops worldwide in terms of production, being cultivated in more than 100 countries. Recently the genomes of several mango (*Mangifera indica*) varieties and *Mangifera* species, such as *M. altissima* and *M. odorata* have been sequenced. However, there were no bioinformatics platforms dedicated to mango genomics to access and study these data. Here, we present MangoBase (https://mangobase.org/), a web portal, which provides multiple interactive bioinformatics tools, sequences, and annotations to analyze, visualize, and download omics data related to mango. MangoBase includes bioinformatics tools such as BLAST, genome browser, annotation and gene ID search, gene list sequence downloading, gene list annotation extraction, gene set enrichment, and gene ID lookup. Additionally, a gene expression atlas with 12 datasets and 80 experiments representing some of the most significant mango RNA-seq experiments published to this date is available. These experiments study mango fruit ripening in several cultivars with different pulp firmness and sweetness or peel coloration, and other experiments also study hot water postharvest treatment, infection with *C. gloeosporioides*, and the main mango tree organ tissues.

Mango malformation: epidemiology, host-pathogen interaction and management of disease

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Mango malformation disease (MMD), affecting inflorescences and vegetative plant organs of *Mangifera indica* L., occurs in many mango-growing countries worldwide, and is considered one of the most important diseases of this crop. MMD results in serious yield losses since most of the malformed inflorescences do not bear fruit. MMD is primarily caused by the fungus *Fusarium mangiferae* although additional *Fusarium* species are responsible for disease. Symptoms of floral malformation include shortened, thickened and highly branched panicles, producing up to three times the normal number of flowers, that are either sterile or eventually abort, and can possess dwarfed and distorted leaves. Vegetative malformation includes hypertrophy of young shoots, shorter internodes, dwarfed malformed leaves and an overall tightly bunched appearance of shoots. Conidia are the primary source of inocula, dispersed from mature malformed panicles that disseminate passively in the air. Apical and lateral buds serve as the infection sites where conidia land, germinate and penetrate via host tissues. *F. mangiferae* interaction with mango tissue is mainly epiphytic. Mycelial growth occurs between protected buds and flower organs and usually does not survive in exposed organs. Specific interactions of mycelia with stamens, gynoecium and penetration into aborting carpels, allow survival of the pathogen on developing malformed panicles. Colonization and subsequent plant infection is not systemic as the pathogen was not detected within the vasculature between bud nodes, cannot infect roots or survive in soil. Due to the airborne nature of disease and local infection, a conceivable method for management suggests protection of buds from external conidia, disseminating from infected panicles. Fungicide dip-treatment of infected budwood reduced inoculum density but did not cure infected material. Timely application of selected fungicides in infected orchards demonstrated that disease severity can be reduced under field conditions. Furthermore, sanitation by removal of infected panicles is paramount for reducing inoculum density.

World mango production and trade

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The mango is commercially cultivated both in the tropics and subtropics in all continents from 37º North till 33º South latitude and it is actually produced in around 100 countries all over the world. Although the most important mango producing countries are located in the tropics, the cultivation of mango in the subtropics has grown much in the last decades. Due to a variety of cultivars, different climatic conditions and also to the development of cultural techniques allowing forcing flower induction outside of the natural flowering period it is possible to supply the growing demand of world markets all year around. Despite the number of mango producing countries has stabilised in the last decade, world mango production has increased considerably in this century from 25.0 x 10^6 t in 2000 till 57.0 x 10^6t in 2021. Mexico, Thailand, Brazil, Pakistan, Peru, and India are the leader exporting countries. Green or yellow cultivars are preferred in Asian continent (main producing mango continent with around 75% of total world production) where consumers favour taste rather than colour. With the main exception of the Mexican cultivar Ataulfo, especially in the US market, the Floridian cultivars, with 'Kent' followed by 'Keitt' being the favourites, dominate the Western markets. The segmentation of the fresh market of mango including the so called 'ready to eat' and 'fresh cut' as well as the increase of the market for frozen mangoes and processed mangoes, with organic mangoes more in demand, displays an optimistic view for the future of this crop.

Mango rootstock breeding project in Israel

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Although rootstocks have a significant effect on virtually all aspects of tree performance – resistance to diseases and pests, tolerance to limiting environmental conditions, tree vigor and architecture, fruit quality and yield– the diversity of rootstocks that are available to growers is highly limited compared to that of cultivars. To date, the Israeli mango industry has relied on a single rootstock, '13/1', which is preferred by the local growers due to relative tolerance to calcareous and saline soils. A rootstock breeding program was launched in 2016, with the objective of developing dwarfing and high-yielding rootstocks for Israeli conditions. Based on a screen of morphological parameters, 2,400 sexual progenies of the polyembryonic rootstock '13/1' were selected. The seedlings were grafted with 'Shelly' and planted in a breeding plot. Trunk circumference was measured every autumn, and growth rate was extracted. Large variation was observed. Thus, a range of 2.1-30.4 cm in growth between the years 2020 and 2022 was recorded in the seedling population, while average growth in the control '13/1' rootstocks was 12.5 cm. The first yield was harvested 4 years after planting, in 2022. Total fruit weight per seedling ranged between 0.5 and 42.1 kg. Average yield in the seedling population was similar to that of the control rootstock (19.1 kg and 18.5, respectively). However, yield level in 87 of the seedlings was higher than in the individual control rootstock with the heaviest yield (29.1 kg), and 12 of the seedlings had at least 20% more yield! Yield and growth rate data will be collected for 6 and 10 years, respectively, at the single-seedling level. Rootstocks will be rescued from outperforming seedlings, and will be tested on a large scale in commercial plots with diverse cultivars, soils and climate conditions.

V-Mango, a functional structural plant model of mango tree growth, development and fruit production: from model design to applications

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Mango (*Mangifera indica* L.) is the fifth most produced fruit in the world, mainly in tropical and subtropical regions. Its cultivation raises a number of issues such as low yield, irregular fruit production across years, phenological asynchronisms resulting in long periods of susceptibility to pests and diseases, and heterogeneity of fruit quality at harvest. To address these issues, a functional-structural plant model, V-Mango, has been developed and implemented in the 'vmango-lab' virtual modelling environment. V-Mango has two objectives: to improve our understanding of tree functioning and to assist in the design of sustainable mango production systems. V-Mango, calibrated for the cultivar 'Cogshall' in Réunion Island, has been structured with modules representing interrelated processes of architectural development and fruit growth. Appearance of growth units and inflorescences was decomposed into elementary stochastic events conditioned by structural and temporal architectural factors. Daily growth and phenology of growth units and inflorescences were modelled using empirical distributions and thermal time. Fruit growth was determined by carbon- and water-related processes modeled at the fruiting branch scale and affected by climatic variables and source-sink factors. Currently, the vegetative and reproductive development of mango trees has been simulated over successive growing cycles and represented on dynamic 3D mock-up for unpruned mango trees. Integration into the model of other important processes (e.g. pest damages, mortality of growth units, light interception, light-related photomorphogenesis) is underway, as well as the effects of pruning. In this way, V-Mango will better account for and simulate the effects of cultivation practices on vegetative growth and fruit production (e.g., effects of pruning on light distribution and vegetative growth, effects of harvest time on fruit quality and fruit fly incidence). This advancement will enable the design of simulation-based management solutions to improve mango production.

Morphological and molecular characterization of fibrousness in mangoes

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Mango (*Mangifera indica* L.) is one of the most important fruit trees in tropical and subtropical regions. The fruit is a drupe with a fleshy edible mesocarp. The seed is covered with a hard fibrous endocarp. The fibers penetrate from the endocarp into the mesocarp. Fibers characterize all mango cultivars, but some are considered more fibrous then others. High quality cultivars have short and soft fibers, but in fibrous cultivars they are harder and may fill the entire mesocarp, negatively influencing customers' satisfaction. The aim of this study was the characterization of fiber formation in fibrous and non-fibrous accessions morphologically and histologically in ripened fruits. Two types of fibers were detected: thick and long fibers driven

from the fruit stalk, extending the entire length of the fruit just under the peal, and shorter fibers that emerge from the endocarp. Fibers developed in the mesocarp of fibrous accessions have larger cross section areas relative to those of non-fibrous cultivars. However, the main difference is probably the fiber's rigidity. Next generation sequencing performed during fruit development and seed hardening of some 'fibrous' and 'non-fibrous' accessions, the mesocarp and endocarp tissues revealed selective differential gene expression. Our work sheds light on the differences between fibrous and non-fibrous cultivars, enabling a better understanding of the processes leading to fiber formation in the mesocarp. This information is valuable for developing markers for breeding of non-fibrous cultivars and for future biotechnological approaches to generate fibrous-free cultivars.

How to increase efficiency of mango hybridisation and breeding - an experience

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Mango breeding suffers from several limitations beginning from making crosses to hybrid recovery and finally testing population in the field. Generating a large hybrid population in a short time is the objective of every mango breeding program, however achieving it is very difficult. We initiated a hybridisation program in 2015-16 cropping season and could generate 3245 hybrid seedlings in five cropping seasons which included 2312 seedlings in only two years. This was possible because we used several unique approaches to emasculate and pollinate thousands of flowers using a large number of plants under Ultra High Density Plantation and engaging 5-6 scientists/students during the flowering season. Meticulous emasculation and pollination at an appropriate time and selection of suitable female parents enhanced the success. Three female parents namely Alphonso, Ratna and Totapuri were used due to availability of a large number of small bearing trees. We employed a total of 12 male parents whose flowering synchronised with the flowering of female parents. High percentage of hybrid seedlings could be obtained even without bagging or capping by selecting the appropriate stage of flower panicle and controlling insect pollinators. Primary results of tree vigor and fruit quality indicated good genetic insights enabling a successful mango breeding programme. Results of five year hybridisation and hybrid evaluations will be discussed in this research presentation.

Genes associated with regulation of flowering in mango

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Irregular flowering and alternate bearing are the major issues in mango production and these affect mango production globally. Studies on environmental, biochemical, hormonal and agronomical factors associated with irregular flowering or alternate bearing have been well established. However, there is limited knowledge about the genetic and molecular control of flowering and their association with distinct behavior of different mango varieties. Our group has been working on the molecular and genetic aspects of mango flowering for the past 10 years and we have gathered good insights about molecular control of flowering in mango. FLOWERING LOCUS T (FT), TERMINAL FLOWER 1 (TFL1) and FLOWERING LOCUS D (FD) module is intact in mango and all these genes are involved in regulation of mango flowering. Genes upstream to FT namely GIGENTIA (GI), FLAVIN BINDING KELCH REPEAT F BOX 1 (FKF1), CYCLIC DOF FACTOR 1 LIKE (CDF1) and CONSTANS (CO) that are under circadian control seem to be functioning as a module. However, the function of CO in mango flowering needs to be further ascertained. The SUPRESSOR OF OVEREXPRESSION OF CONSTANS1 (SOC1), SHORT VEGETATIVE PHASE (SVP) are also involved in regulation of mango flowering. Besides these genes, micro RNA 172 is a positive regulator and micro RNA 156 is a negative regulator of flowering in mango. The diversity in the regulatory characteristics of flowering related genes in different genotypes probably permit flowering in both tropical as well as subtropical climate. Presence of multiple copies of the key regulatory genes may be conferring plasticity to different genotypes enabling them to adapt to different environmental conditions. The presentation will give a comprehensive understanding of regulation of mango flowering, based on the current knowledge.

Grafting and breeding *Mangifera* species and their potential for the future of mango cultivation

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In Southeast Asia there is a wide diversity of *Mangifera* species that bear edible fruit, with 69 taxonomically recognized (Kostermans and Bompard, 1993). Among these species, *Mangifera indica* is the most important commercial fruit crop, although *M. lalijiwa*, *M. odorata*, among others, are routinely cultivated or collected for sale from wild trees. Several *Mangifera* species has been breeding at Fairchild Tropical Botanic Garden in South Florida over the past 20 years (Ledesma et al. 2018). Pollen collection and storage tests of *Mangifera odorata*, *M. lalijiwa*, and *M. laurina* were evaluated to conserve genetic resources and aid in pollination (Ledesma et al. 2019). Suitable graft interstocks has been evaluated (Campbell 2007). Following research into *Mangifera* species in Florida, USA *M. casturi*, *M. lalijiwa*, *M. laurina*, *M. odorata*, *M. quadrifida*, *M. rubrapetala*, *M. aplanada*, *Mangifera himanalis, Mangifera pentandra*, *Mangifera gedebe* and *M. zeylanica*. Suitable rootstocks for their propagation and conservation has been tasted. These trials have been successfully grafted onto *Mangifera indica* 'Turpentine', *Mangifera rubrepatela*, and *Mangifera casture*.

Mango production in Saudi Arabia

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The mango is a major fruit crop in tropical and subtropical regions of the world. There are numerous mango cultivars being cultivated around the world, including the Arabian Peninsula. Mangos were introduced into the Kingdom of Saudi Arabia in the 1980s from India, Egypt, and Florida of the United States. In the Kingdom of Saudi Arabia, the Jazan region which is in the south-west of the country is the major producing zone for mangos. An overview of the performance and adaptation of the different mango cultivars in the Jazan province, including the environmental and growing conditions, regional distribution, rootstocks, and horticultural practices are addressed in this paper. The information has been collected by the process of visiting local farmers and researchers from the Research Center of Jazan Ministry of Environment, Water and Agriculture of Saudi Arabia.

Advances in orchard irrigation technology and theory and its application in mango orchard

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Globally, irrigation water is becoming increasingly scarce. As a result, efficient and suitable irrigation systems are becoming more and more necessary for all farms. Advanced farms are now using automatic irrigation systems. These systems are developed based on the actual water needs of trees and a deep understanding of the tree's water physiology and fruit growth and quality formation. They can better and more sustainably maintain fruit productivity and quality. New knowledge and technology have now been developed for orchard irrigation. One that I think has great promise is the automatic control of irrigation based on reliable measurements of micro-changes in twig diameter. Field data is recorded and transmitted by radio or mobile communication network to the farm office control system. This allows irrigation to be provided at the right time and with the right amount of water. I will discuss the prospects of adopting this new technology in mango farms. The physical part of the automation, including sensors and controlling systems, is developing rapidly and relatively easy, considering the development of the mobile electronic and AI industries. However, the paramount aspect of the success for any crop irrigation automation system is the need for a good understanding of the relationship between twig diameter variation (or any other indicator), level of water stress, and formation of good fruit yield and quality. This is where researchers are needed to advance such technology and turn it really useful for general tree crop farmers.

Mango cultivars evolution in Mexico

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Mango was introduced in Mexico from the Philippines in 1779 by the Spanish colonizers. However, it wasn't until the mid-20th century that mango cultivation became a significant industry in Mexico, with the introduction of the 'Tommy Atkins' cultivar, improved production techniques, and expanded markets. This cultivar was a game-changer for the industry due to its long shelf life, which allowed for extended transportation that opened export markets. In the following decades, other mango cultivars were introduced to Mexico, including 'Kent', 'Keitt', and 'Haden', which added variety to the industry and expanded the range of flavors and textures available to consumers. This led to a boom in mango production in the 1970s and 1980s. Ataulfo is the main cultivar planted since 2009, due to its greater acceptance in Mexico and for export because of its small size, rich flavor, and creamy texture. In 2021, it was cultivated in over 31% of the area with mango in Mexico. In recent years, there has been a growing trend towards organic and sustainable mango production in Mexico, as consumers and producers alike prioritize environmental and social responsibility. Perspectives on the Mango Industry include the introduction of new mango cultivars into Mexico based on superior traits across a range of climate zones.

Potencial de los recursos genéticos de mangos locales en la República Dominicana

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Con el objetivo de evaluar el potencial de los recursos genéticos de los mangos (*Mangifera indica* L.) locales, de la República Dominicana, a través del IDIAF se caracterizan y preservan ex-situ los diferentes cultivares debido a que la diversidad genética se encuentra en peligro de extinción. Por la siembra a gran escala del mango con variedades introducidas, descuidando las locales. El país cuenta con frutas de diversidad en colores, sabores, tamaños, tolerancia a plagas y enfermedades que satisfacen el gusto de los consumidores locales e internacionales, esa

variabilidad demanda nuevas investigaciones para la identificación y selección de nuevos cultivares comerciales. Julia Morton señala que el mango se introdujo a la isla en 1742, sin que a la fecha se conozca cuáles fueron los primeros mangos. Con avance de la biotecnología este puede ayudar mediante el uso de marcadores moleculares a determinar los progenitores que han dieron origen a los mangos dominicanos y propiciar futuros mejoramientos. En la década de los 80' se evaluaron 70 cultivares criollos diferentes con fines de industrialización, resultando que el Cv. 'Banilejo' ocupó el primer lugar. Después en el 1995 la Secretaría de Estado Agricultura con el apoyo de JICA, realizó un recorrido a nivel nacional caracterizando alrededor de 200 cultivares distintos, de los cuales existen innumerables cantidades de cultivares sin nombres, en otros casos igual nombre para distintos mangos y diferentes nombres al mismo fruto. Desde el 2020 se realizan evaluaciones al azar a nivel nacional para determinar la variabilidad en la diversidad existentes. Los resultados muestran cambios notables, observando que en la provincia Peravia se encuentran 200 cultivares distintos con haber muestreados el 10 % del perímetro en árboles dispersos. Hoy día existen cultivares locales que tienen uso extenso en la parcela.

Mango microbiota: from the orchard to the plate

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Microorganisms are an integral part of the composition of fruit. The structure and variation of microbial communities on the surface of fruits (epiphytes) can have dramatic consequences on the quality of fresh fruits, the shelf-life, and the safety of fruit-derived products. However, current knowledge of the structure and functions of the fruit microbiota is still limited. So far, exploring the microbiota on the surface of fruits mainly focused on detecting fruit and/or human pathogens, without considering the associated microbial communities and the underlying environmental factors. This study aims to explore the composition of microbial communities (bacteria and fungi) present on the surface of mangoes in Réunion Island, as well as their quantitative and qualitative evolution during the production-storage-processing continuum. A DNA metabarcoding approach (high-throughput sequencing) was used to study the structure and variations of the microbial communities monitored from the tree (in relation to biotic and abiotic factors), during storage to post-harvest processing (drying and minimally processed products). By integrating metabarcoding data, microbial counts, physicochemical parameters of mangoes, and climatic data, this approach identified key factors impacting mango-associated microbial communities and their variations in processed fruit products. The main spatial and temporal factors shaping microbial communities on the tree together with storage conditions and processing methods select certain microbial taxa and reduce the associated microbial diversity. The variations observed also depended on the ripening stage of the fruit at the time of harvest. The results obtained led to a better understanding of the structure and dynamics of Mango fruits microbial ecosystems from the tree to the plate. This integrated approach can be used to guide and adapt culture, storage and processing methods in order to limit losses and control post-harvest diseases of fruits.

Increased accuracy of genomic predictions for tree vigour in mango (*Mangifera indica* L.) by utilizing preselected variants from a genome-wide association study using sequence data

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Genomic selection (GS) is expected to improve the efficiencies of perennial fruit tree breeding programmes by increasing the accuracy of breeding value estimates through use of genomic relationship matrices (GRM) instead of the traditional pedigree-based approaches. Robust GS models are helpful in enhancing genetic gain with the reduction of breeding cycle length through elimination of progeny tests and early selection of superior parents. The aim of this study was to carry out the first evaluation of GS in mango (*Mangifera indica* L.) in a gene pool collection focused on parental selection for low tree vigour. Our objective was to compare genomic predictive ability (PA) by using whole-genome sequencing (WGS) data against preselected SNPs from a genome-wide association study (GWAS), to determine if preselected variants can improve genomic PA for tree vigour. Phenotypic records for tree vigour (assessed as trunk circumference measured 10 cm below and above the graft) at ages nine (172 records) and twelve (178 records) were available to build multivariate genomic prediction models using the genomic best linear unbiased prediction (GBLUP). Plink was used to perform the GWAS analysis and the most significant (p-value based) SNPs were selected (n = 50,000) and GRMs were used to evaluate genomic PA in a GBLUP framework. Results from five-fold cross-validation indicated that genomic predictions for tree vigour in mango breeding would likely benefit in terms of higher prediction accuracy of candidate parents from using preselected variants from GWAS. Compared with using all WGS data, genomic prediction with preselected variants significantly increased predictive ability (15 to 23%), suggesting that GS accuracies could be improved by using preselected variants from GWAS.

Vegetative growth and development of the mango tree canopy: understanding and practical applications

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Vegetative growth is of essential importance for mango tree growth and fruit production. It shapes the tree structure, provides pathways for water and metabolites transport, supports leaves, inflorescences and fruits. It generates canopy growth and contributes to the increase of potential tree production. On the other hand, excessive vegetative growth may be detrimental to flowering and fruiting, to orchard yield and orchard intensification. Hence the importance of understanding the mechanisms of vegetative growth and the factors affecting it. Vegetative growth results from complex interactions between endogenous factors, environmental factors and cultivation practices. The base element of vegetative growth is the growth unit, a leafy axis originating from a bud in terminal position in the woody structure. The morphological, topological, temporal and reproductive characteristics of the growth unit affect its ability to produce descendent growth units and/or inflorescences and fruit. This results in marked interactions between vegetative growth and reproduction at different scales, from the growth unit to the whole tree, that are cultivar-dependent and contribute to irregular bearing. Temperature, light and water availability have an effect on vegetative growth by promoting bud burst and affecting the morphology of new growth units. In a given environment, the cultivar, the rootstock and pruning have the greatest impact on vegetative growth. The rootstock promotes or impedes tree growth from the first years after planting and its choice is crucial for orchard management. Pruning allows maintaining tree dimensions. It is a trigger of immediate vegetative growth in the mango tree and it must be used properly in order to favor, and not limit, fruit production. Fertilization and irrigation also stimulate vegetative growth. These different points and the interactions between them are presented, with a focus on the understanding of the underlying processes and the practical implications for a sustainable mango production.

MangoViz, an open-source interactive web interface to view and explore data of long-term agronomic experiments on mango

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Long-term agronomic experiments provide interesting data and enable various analyses such as yield regularity over years or effects of climate on tree productivity. However, the visual exploration of these large datasets, that precedes statistical analyses, can be a long and tricky task with several angles of approach: by variable, by factor level, by year, by specific set of years, etc. To simplify and speed up this exploration, we developed MangoViz, to view and explore data of long-term agronomic experiments on mango. MangoViz was developed with the R-Shiny technology that provides interactive web interfaces, so that it can be used from any device with internet access. It can handle data from different experiments that are processed separately. Data of a 15-year pruning experiment and a 12-year cultivar evaluation are currently uploaded in the interface. Three variables can be explored: fruit mass per tree, number of fruit per tree and individual fruit mass. For each variable, three interactive graphs are provided. The first graph shows the distribution of the selected variable for each level of the tested factor (e.g., pruning modality or cultivar) and for a selection of years. The second graph shows the changes of the selected variable, per factor level and/or per tree, across years. The third graph is the spatial distribution of the selected variable, per factor level and per year or averaged over years, on a map of the experiment. Tabs next to the graphs allow to quickly select the desired years and factor levels, and graphs are adjusted instantly. Tabs are also available to provide useful information and documentation on the experiments. Long-term trends could be detected in the two current datasets, enabling specific statistical analyses. MangoViz code is open-source. It can be adapted to fit users' datasets and specific requirements.

The effect of cold storage on the biochemistry and physiology in mango (*Mangifera indica*) fruit ripening

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Cold storage is widely used to extend shelf life of mango fruit during transport to non-tropical markets, however, the effect on plant growth regulators remains unknown. Abscisic acid (ABA) has been implicated in both ripening and cold stress responses, and may influence firmness and colour changes. This study examined the effect of cold storage on the concentrations of ABA and individual sugars during ripening, and how low temperature storage impacts fruit physiology (including objective colour and firmness). Imported 'Kent' mango fruits were ripened according to industry specifications (20ºC) either immediately upon arrival (control), or after 21 days of simulated transport conditions (9ºC; cold stored). Fruit remained firmer for longer during ripening after cold storage, but had a duller colour (lower chroma values) than control fruit. Additionally, ABA levels doubled during ripening in control fruit but decreased by 90% in cold stored mangoes. Since ABA is known to promote ripening, the lower levels after cold storage may be the cause of the slower firmness losses. Sucrose levels followed a similar pattern to ABA, increasing 1.5-fold in control fruit but showed a 14% decrease in the cold stored, suggesting there is a metabolic shift from starch breakdown to sucrose breakdown after cold storage. These findings contribute to a better understanding of the effect of low temperature storage on mango ripening, which can then be used to optimise cold storage practices, and hence improve fruit quality and reduce nutritional and economic losses.

The U.S. mango market trends and the National Mango Board

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The National Mango Board (NMB) is an agriculture promotion organization focused on increasing awareness and consumption of fresh mangos in the U.S.A. Since 2005, its mission has been to inspire consumers to purchase and consume more mangos. The NMB accomplishes its mission through Marketing & Communication and Research & Industry Relations programs. A question asked often by the industry is, “Has the NMB been successful in getting consumers to eat more mangos? The short answer is “Yes.” Since 2005 to 2022, the per capita availability of mangos in the U.S.A. increased from 1.88 to 3.76 lb. per person and the overall import volume of fresh mangos in the U.S.A. increased from 260,842 to 574,783 metric tons, representing an increase of 120%. Mango retail sales have increased from $109 to $302 per store per week; and the weekly volume per store increased from 132 to 251 units of whole mangos. From 2013 to 2022, the average percentage of households aware of advertising and promotions increased from 6.7% to 17.3%, market penetration (percentage of *households buying)* increased from 14.1% to 27.7%, and market intensity (*mangos per buying occasion*) increased from 2.88 to 4.25 whole mangos per household in a two-week period. The groups more likely to buy mangos were found to be Asian and Black, and younger consumers (age<34). The main reasons for purchasing mangos are “quality”, “ripeness”, and “price”, and for not purchasing mangos are “nobody in my household likes the taste”, “not thinking about them”, and “they are too expensive”. The main source of information for awareness of mango advertising and promotion is the In-store promotions. The latest analysis conducted from 2013 to 2022 indicates that the NMB programs are responsible for 14.11% increase in sales at the FOB level with a return on investment of 14.88 to1. Impacts of major demand drivers including promotions were measured using household tracker data and probit and ordered probit statistical models.

La madurez a cosecha y el acondicionamiento con etileno facilitan el proceso de mango para cachetes congelados

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Acorde al National Mango Board y a las empresas procesadoras, el principal problema para la producción de mango congelado es la desuniformidad del grado de madurez de los frutos a cosecha y arribo a planta, lo cual está directamente correlacionado con el cómo manejar la fruta en elárbol y el cómo hacer el proceso de maduración después de la cosecha. Por lo anterior, se estableció este proyecto con la finalidad de generar un protocolo para el óptimo manejo del fruto de mango para congelado al determinar el grado óptimo de madurez a cosecha en 'Tommy Atkins', 'Tommy-Kent', 'Kent' y 'Keitt', así como establecer las temperaturas y tiempos de acondicionamiento de aplicación del etileno exógeno para lograr el máximo de eficiencia en la obtención de la materia prima. Para ello, se seleccionaron huertos comerciales de cada una de las variedades evaluadas. Se siguió desarrollo y crecimiento para cosechar a dos estados de madurez (sazón y tres cuartos). En cada variedad se cosecharon 240 frutos en los estados de madurez indicados y se sometieron al acondicionamiento con etileno al ambiente o en cuarto frío (22-24 ºC). Se encontró que las diferencias más notables fueron para grado de madurez a cosecha y acondicionamiento con etileno. Para firmeza, la tasa más rápida de ablandamiento se observó para frutos tratados con etileno al ambiente, en tanto que los conservados en refrigeración tardaron 24 h más para alcanzar dicho estado. El color de pulpa fue menos intenso para frutos mantenidos en refrigeración, inclusive con la aplicación de etileno. Por otro lado, los frutos tres cuartos mostraron mayor intensidad que aquellos cosechados en estado sazón. Respecto al contenido de sólidos solubles totales (SST), los valores más altos se observaron en los frutos testigo o en frutos aplicados con etileno al ambiente. Los frutos acondicionados con etileno bajo refrigeración mostraron menor contenido de SST. Se sugiere a los procesadores de mango congelado que cosechen en madurez tres cuartos y acondicionen el fruto con etileno a 100 ppm por 24 h en cuarto frío y no al ambiente como se hace tradicionalmente.

The climate of mango producing areas: a case study on three islands

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Cultivation of mango (*Mangifera indica* L.) spread in the last 30 years to wider latitudes than the species' native area. This raises numerous questions regarding the species adaptation capacity, physiology and productivity. We described the climate of three different mango producing areas located in distant islands: La Réunion (21ºS, France), located in the Mascarene archipelago in the Indian ocean; Tenerife (28ºN, Spain), in the Canary archipelago in the Atlantic Ocean; and Sicily (38ºN, Italy), at the centre of the Mediterranean Sea. Air temperature, rainfall, evapotranspiration, solar radiation, wind speed and direction were collected from weather stations located as close as possible to experimental mango orchards for the period 2018-2022. The climate of each orchard was characterized and they were compared across the three islands. The orchards fell into micro-climatic areas that differed from each island's macro-climatic area as they are described in the literature. The three orchards differed greatly on the basis of several parameters. The absolute highest (43ºC) and lowest (2.5ºC) temperatures were recorded in Sicily. Temperatures showed little variability, both during the day and along the year, in La Réunion and in Tenerife, where the daily average temperatures ranged between 18ºC and 27ºC. Also the annual distributions of rainfall and potential evapotranspiration varied greatly: the cumulated pluviometric deficit was negative during half of the year in La Réunion, during two thirds of the year in Sicily, while it was constantly negative in Tenerife, which was characterized by a nearly arid climate. Rainfall and high temperatures occurred at different periods of the mango phenological cycle among the islands, probably affecting this cycle and the potential productivity. The results show that mango could be cultivated in a broad range of climatic conditions, if appropriate crop management is implemented to ensure sustainable fruit production.

Identification of the gene that causes polyembryony in mango

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In mango, like in citrus, sporophytic apomixes result in polyembryony, where seeds contain multiple embryos, one of which is sexually originated, and the others are vegetative clones of the mother tree. Polyembryony is common in mangoes that originated from Southeast Asia and is frequently used for clonal propagation of rootstocks. Utilizing the mango genome and genetic analysis of a diverse germplasm collection, we identified the gene, *MiRWP*, that causes polyembryony in mango. To our understanding, it is the first case of cloning a gene based on genetic and genomic data in mango. The *MiRWP* gene is an ortholog of *CitRW*P that causes polyembryony in citrus. A specific insertion in the gene's promoter region alters its expression in flowers and developing fruitlets, leading to the induction of nucellar embryos. Implications for mango breeding, and especially for the development of new rootstocks will be discussed. With an improved understanding of the biological basis of sporophytic apomixes, polyembryony may also become a useful biotechnology tool for the clonal production of other crops.

Identifying key genes controlling flesh colour in mangoes using genome-wide association studies (GWAS)

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Mango flesh colour can vary depending on the variety of the mango, ranging from pale-yellow to dark orange. Consumer preference for mango flesh colour tends to vary according to geographic region and culture, and with such differences, there is a need to develop molecular markers for breeders to produce cultivars with desired colours at an efficient rate. It is widely known that carotenoids (orange and yellow pigments) are the largest contributor towards this colour, with the wide variation of pigmentation resulting from different concentrations and compositions. In this study, 201 varieties of *Mangifera indica* were used to conduct a genome-wide association study (GWAS) to identify genes contributing to the flesh colour of mangoes. We removed single nucleotide polymorphisms (SNPs) in tight linkage and performed a GWAS with 871,835 variants across all 20 chromosomes. We found that many loci across the genome are associated to flesh colour, which is indicative of a polygenic trait. The relationship between several of the loci and genes within the carotenoid pathway will also be investigated. The identification of molecular markers associated with flesh colour will be essential in employing marker assisted selection that could drive the production of new cultivars with desired flesh colours.

Determination of species identity and genetic diversity in genus *Mangifera* based on chloroplast and nuclear genome sequences

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Mango, which belongs to the genus *Mangifera* is a dicotyledonous angiosperm often referred to as the "king of fruits" for its flavor, color, and taste. Although the accepted classification describes 69 species within the genus, at present, a few species have been proposed to be hybrids. Molecular markers targeting chloroplast and/or nuclear genome-wide sequence data have been used to assess the genetic diversity of cultivated mango (*Mangifera indica* L.) and the identity of mango accessions, but very few studies have used the complete chloroplast genomes or multiple nuclear genes. Here, whole chloroplast genomes and 47 single-copy nuclear gene sequences were analyzed for 43 commercial cultivars and 21 mango accessions to evaluate the diversity and to confirm the identity of species respectively. Phylogenetic analysis of chloroplast genomes revealed low genetic diversity clustering all commercial cultivars into a single clade. However, nuclear gene phylogeny clustered commercial cultivars into distinct clades with a clustering pattern that did not strongly relate to their geographical origin except for the Indochinese cultivars. Phylogenetic analysis of 21 accessions together with 14 *Mangifera* species confirmed the species identity of the accessions Odorata and Pelipisan. However, the identity of some accessions was different from the proposed species, and some were suggested as hybrids.

Furthermore, the identity of a few accessions could not be confirmed due to the absence of sequence data for the respective wild species. More wild species will be sampled and added to the phylogenetic analysis to further confirm/validate the identity of the species. Comparative analysis of chloroplast and nuclear gene sequences exhibiting maternal and paternal inheritance respectively was found to be a reliable approach for analyzing diversity and species identity.

Updates on the mango's wild relatives: taxonomy, phylogeny, hybridization, and field explorations

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The mango genus contains some 69 species, including 26 that are edible and consumed in their native range of South and Southeast Asia. However, these wild species are poorly known, underutilized in breeding programs, and not well conserved either *in situ* or *ex situ*. Here, I provide an overview of our current taxonomic and phylogenetic understanding of this genus and insight into the composition and formation of hybrid *Mangifera* species. The evolutionary relationships between *Mangifera* species have previously been examined through morphological and phylogenetic lenses. Here, I present the results of our most recent phylogenetic analysis of the group, based on genome wide single nucleotide polymorphism (SNP) data of 30 species. Based on these results, we propose the recircumscription of the genus *Mangifera* and description of a new genus. We also investigate the occurrence and consequences of hybridization between mango and two congeneric species in Southeast Asia. We sampled the known hybrid species, *Mangifera odorata* and the newly proposed hybrid *M. casturi* along with their putative parental taxa. Analysis of population structure, admixture, and indices of genetic diversity support the hybrid origin of these taxa but showed no evidence of ongoing gene flow between parental species. Additionally, hybrids showed low levels of intraspecific diversity, consistent with lineages that have formed only a few times. We suggest the ability of *M. odorata* and *M. casturi* to reproduce clonally through nucellar polyembryony may have allowed these hybrids to persist. Finally, I share the results of recent field excursions to explore wild mangoes in Northern Thailand and Sabah, Malaysia, and the next steps for this work to explore and conserve mango's wild relatives.

Wholesale mango price dynamics in Vietnam during the COVID-19 pandemic

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The traditional food supply chain has a dominant role in the Vietnam urban markets. Most fresh food sold to the urban consumer still goes through a wholesale market. For example, almost

93% of fruit retailers in Ho Chi Minh City (HCMC) purchased fruit from the wholesale markets. The increase in supermarkets, convenience stores, safe food stores, and e-commerce channels in urban areas has led to a rapid transformation in fruits and vegetables (F&V) distribution in Vietnam. However, the traditional supply chain - with the presence of wholesale markets and traditional wet markets - still plays a vital role in the Vietnamese food system (especially in Hanoi and Ho Chi Minh City). This study captures and analyses mango price information in Hanoi and Ho Chi Minh City (HCMC) wholesale markets from March 2020 to June 2021. The specific research objectives are 1) to map out the general mango trade information at the wholesale markets; 2) to track wholesale mango prices spatially and temporally; 3) to estimate the price differences of mangoes of different varieties, grades, locations and seasons; and 4) to identify the impact of the COVID-19 pandemic on wholesale mango prices in Vietnam. We collected weekly mango prices from 20 wholesalers. Five wholesalers are from Long Bien market in Hanoi. Ten wholesalers are from Thu Duc market, the largest fruits & vegetables wholesale market of HCMC. And five wholesalers are from Binh Dien market of HCMC. We designed two checklists to collect general information on wholesale markets and weekly wholesale price data. Both face-to-face interviews and phone calls were used for data collection. This study finds that collectors are the main mango suppliers in the wholesale markets and vendors and stalls in wet markets are the primary buyers of wholesale markets. Mango prices, in general, reach peaks in December and January, and the lowest price is observed in March. Single fruit weight is the main criterion used for grading, while wholesalers also grade mangoes by other criteria such as shape, skin color, and ripeness. Cat Hoa Loc mango is the premium variety sold at the highest price and is most popular in the southern wholesale markets. The effects of the COVID-19 pandemic are more prominent and longer on Cat Chu and Cambodian Keo prices than on Cat Hoa Loc price. Compared to other varieties, Cat Hoa Loc mango has vast potential for further development in the domestic market in the future. However, given that Cat Hoa Loc mango was not sold at the Long Bien market, it is necessary for further research to examine the demand, willingness to pay, post-harvest storage, and transportation of this variety in the northern markets in order to develop southern Vietnam mango production further. The price information from our study could be used in cost and benefit analysis to evaluate the revenue gain from interventions that improve mango quality, change variety, or manipulate flowering time. The spatial and temporal dynamics of mango prices may also help the stakeholders in the value chain to make informed decisions.

Abstract of Posters

Computer visualization of branch structure and canopy of mango trees grown under different training systems

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The branching structure of a tree is defined as the connection of its branches and their arrangement in space. Representations of branching structures have been extensively used in studies to characterize growth habits of different species and cultivars, as well as to demonstrate differences in tree training systems and pruning strategies. These representations fit deciduous trees well, because they are typically pruned after leaf fall and before budbreak, when tree branch structure is clearly visible. However, in evergreen species it is usually difficult to observe branch structure without defoliating the tree and altering its normal growth. This disadvantage might be one of the reasons why tree-level mango studies have often been based on tree height and width measurements to estimate canopy volume, instead of focusing on more detailed measurements of mango branch structure that could provide a better understanding of tree growth and physiology. Our aim is to create computer aided 3D visualizations of branch structures of leafy mango trees from data manually recorded in the field in 4-year-old plants grown under three different training systems. We used a modeling platform to complete missing angle and width data, and reconstruct tree branch structures in silico. Subsequently, leaves were added at individual nodes to generate the leafy canopy. Pictures of branch structures and canopies were produced for comparison with photographs of the original trees. The visualizations made the differences between training systems apparent, and enabled the structural details and the canopy to be observed simultaneously. In conclusion, manual field measurements can be used to reconstruct and visualize mango branch structure and canopy in the computer to compare tree training systems. These visualizations could also have application for demonstration and extension purposes.

Flowering and yield with alternative gibberellin inhibitors to paclobutrazol in 'Tommy Atkins' mango

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'Tommy Atkins' is the second most important mango cultivar in Nayarit, but It shows irregular flowering affecting the yield up to 50%. Paclobutrazol (PBZ) has been used in order to alleviate this problem, however, continuous usage of these product could have a potential risk to human health. Our objective was to evaluate some gibberellin inhibitors other than PBZ on flowering and yield of 'Tommy Atkins' mango. The study was done during 2020 and 2021 in commercial orchards. Treatments: 1. Calcium prohexadione [(P-Ca, 500 mg L^{-1} three times (3X)]; 2. P-Ca [1500 mg L^{-1}, one application (1X)]; 3. P-Ca + uniconazole [(UCZ) 750 + 250 mg L^{-1} (3X)]; 4. UCZ [1000 mg L^{-1} (3X)]; 5. Cycocel (1000 mg L^{-1} , 3X) 6. PBZ [2500 mg L^{-1} ;(1X)], and 7. Control. Variables: percentage of differentiated flower buds and differentiation status; percentage of bud breaking, fruit fresh weight, and yield. The experimental design was completely randomized with six replications and a tree as experimental unit. In year 1, the percentage of differentiated buds was greater (P=0.0001) in P-Ca, Cycocel and PBZ treatments compared with UCZ treatments and control. In Year 2, there were not differences between treatments with GA inhibitors, except with respect to control. The percentage of flowering in all treatments with GA inhibitors was higher in both years (P=0.0023 and 0.0001 for 2020 and 2021, respectively) compared to the control. Fruit fresh weight was higher in P-Ca 500 (3X) and P-Ca 1500 (1X) treatments (year 1 and year 2, respectively). An increase in yield was observed with P-Ca treatments in both dosis (year 1), while PBZ and control had a decrease in yield of 16% y 40%, respectively. In year 2, there were no differences between treatments. These results implicate P-Ca as a potential substitute to PBZ.

Deciphering the spatial and temporal patterns of flowering within the mango tree crown

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The quantity and quality of light are both involved in a wide range of physiological and developmental processes in trees. The permanently and highly contrasted light environment

within the crown of evergreen trees may affect the spatialization of reproductive bud burst. The objective of this study was to characterize the effects of light environment and architectural traits of terminal growth units on their reproductive bud burst in the mango tree. In July 2020, 440 terminal growth units were sampled on four mango trees, cv. Cogshall. Some architectural traits of the growth units (Diameter, Position, Localization within the crown) and their light environment (quantity: relative transmitted PPFD, or TrPPFD; and quality: red/far red ratio, or ζ) were measured at sampling. The date of reproductive bud burst was recorded on each growth unit twice a week until September 2020. The effects of the studied factors on the occurrence and timing of bud burst were assessed using generalized linear mixed models. The occurrence of reproductive bud burst was higher at the periphery than within the crown. It increased moreover with ζ; and diameter values, and on apical growth units. Reproductive bud burst occurred in two flushes, bringing together one and two thirds of the growth units, respectively. The probability for a growth unit to burst during the first or the second flush was only affected by light environment, with opposite effects of light between the two flushes. For growth units that burst during the second flush, Position and Localization within the crown affected the delay of burst. The complex interplay between external and internal signals leading to the observed spatial and temporal patterns of mango flowering is discussed. Integrating this knowledge into a functional-structural model of mango tree could greatly improve the accuracy of simulations.

Expression Profiling of Four Mango *FT/TFL1*-Encoding Genes under Different Fruit Load Conditions, and Their Involvement in Flowering Regulation

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Plant flowering is antagonistically modulated by similar FLOWERING LOCUS T (FT) and TERMINAL FLOWER 1 (TFL1) proteins. In mango (*Mangifera indica* L.), flowering is induced by cold temperatures, unless the tree is juvenile or the adult tree had a high fruit load (HFL) in the summer. We studied the effects of juvenility and fruit load on the expression of four *MiFT/TFL1* genes cloned from the mango 'Shelly' cultivar. Ectopic expression of *MiFT1* in *Arabidopsis* resulted in early flowering, whereas over-expression of *MiFT2* and the two cloned MiTFL1 genes repressed flowering. Moreover, juvenility was positively correlated with higher transcript levels of *MiFT2* and both *MiTFL1*s. In trees with a low fruit load, leaf *MiFT1* expression increased in winter, whereas HFL delayed its upregulation. *MiFT2* expression was upregulated in both leaves and buds under both fruit load conditions. Downregulation of both *MITFL1*s in buds was associated with a decrease in regional temperatures under both conditions; nevertheless, HFL delayed the decrease in their accumulation. Based on our results, we propose that in the mango 'Shelly' cultivar, a decrease in ambient temperature induces both an increase in MiFT1 levels in the leaves, and a decrease in *MiTFL1* accumulation in the buds. On the other hand, HFL also affects *MiFT/MiTFL1* gene expression by suppressing *MiFT1* upregulation and delaying *MiTFL1*

downregulation. As a result, flowering is repressed, but not abolished. *MiFT2* might operate together with the *MiTFL1*s to regulate juvenility, whereas in the adult phase, *MiFT2* activity might not be related to flowering induction.

An interactive gene expression atlas for mango

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Mango (*Mangifera indica*) is a fruit of high nutritional value and great economic importance, which is widely distributed around the world. However, despite the wide variety of omic analyses published in mango, no platforms for gene expression data were available. Here, we present a gene expression atlas for mango with 12 datasets and a total of 80 experiments. These experiments include gene expression data of fruits in different ripening stages of several cultivars, cold stress, hot water treatment, and infection by pathogens. Furthermore, one dataset provides a representation of the main tissues of the plant such as root, bark, leaf, flower, and seed. The mango expression atlas analyses are based on a high-quality genome reference, facilitating to easily identify in which tissues, stages, and experimental conditions are genes expressed, which is of great utility for experimental design and results discussion. Multiple interactive tools allow users to visualize and compare the gene expression data of multiple genes simultaneously and download them in different formats. Other features allow the visualization of gene expression values together with pictures of the plant phenotype, check the replicates of each gene, or compare the gene expression of samples from any dataset, allowing relative normalization based on a reference gene. The expression atlas is integrated into MangoBase (https://mangobase.org), a genomic portal dedicated to mango, with multiple interactive bioinformatic tools, and its results are connected with the different tools of MangoBase and functional annotations from multiple databases.

Phenotypic characterization of floral and reproductive differentiation in mango `Ataulfo´ in Nayarit, Mexico

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Knowledge of physiological changes in mango tree is key to achieving the productivity and competitiveness of orchards with this fruity. The objective was to characterize floral and reproductive differentiation phenotypically process, in a mango 'Ataulfo' orchard in Nayarit, Mexico. Two buds per tree were labeled, and weekly photographic monitoring was given from November 2019 to April 2020, from vegetative buds to fruits. Photographic phenotypic changes were complemented with stylized graphic designs. Four stages were identified: E1 closed bud, E2 swelling bud, irreversibly determined at flowering (IDF), E3 development of floral structures, and E4 formation and development of the fruit. In addition to 14 substages: deployment of filaments and scales, beginning of bud swelling, visibility of differentiated apices, elongation of the IDF bud, differentiation and succulence of scales, emergence and elongation of panicles, inflorescences still in elongation with visible flowers, anthesis, flower fading - majority of petals fallen or dry and pinhead fruits set, cerrillo fruits set, fruit drop, end of physiological fruit drop, growth and development of the fruit. The graphic design of the phenological stages served as a basis for comparison with the photographs and to facilitate the knowledge and understanding for producers and technicians of the physical changes in the field, from bud to fruit formation, to make decisions on the appropriate agronomic management to regulate the periods of flowering and harvest.

Digital Database of the ICIA Mango Germplasm Collection: FRUTTMAC Project

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Within the framework of the FRUTTMAC project, a database has been developed to boost mango germplasm banks and other tropical and subtropical fruit trees present in the Macaronesian region. This database is accessible to research centers, companies and producers. The first step was the preparation of specific forms for the characterization of mango and other tropical and subtropical species of agronomic interest such as avocado, custard apple, passion fruit, pineapple, dragon fruit, banana and prickly pear. These species have different accessions, conserved in germplasm banks of partners who participate in the MAC2/1.1b/310 project, 'Transfer of R+D+i for the sustainable development of tropical fruit trees in Macaronesia', with the acronym FRUTTMAC. Studies of description, characterization and evaluation of the accessions present in the different germplasm collections of the Canary Islands, Madeira and Azores have been carried out using the international descriptors elaborated by the International Institute of Plant Genetic Resources (IPGRI-Biodiversity) and by The International Union for the Protection of New Varieties of Plants (UPOV). This morphological characterization has been complemented with molecular genotyping studies, e.g., microsatellite markers, expandable to

the use of other molecular markers in the future. In addition, it should be noted that information was obtained regarding the behavior and agronomic adaptation of the plant material studied in the different environmental conditions of the Macaronesia region. The next step is to enable the information to interested agents such as cooperatives, agricultural associations, farmers, researchers, etc. on a digital platform through another: MediaWiki, that allows to navigate and consult the tropical and subtropical fruit species studied. This computer software was developed for the project by a team from the University Institute of Intelligent Systems and Numerical Applications in Engineering (SIANI) and was designed to add other interesting species in the future and the information regarding the accessions by the curators of the germplasm collections.

Management of fruit fly damage via mango harvest timing optimization: a modelling approach

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Fruit flies (Diptera: Tephritidae) are considered major pests of mango (*Mangifera indica*) worldwide. Their management, with an increasing focus on replacing synthetic pesticides with alternative environmentally friendly methods, is a challenging issue. A new fruit fly species, the oriental fruit fly, *Bactrocera dorsalis* (Hendel), recently invaded Reunion Island, further increasing fruit fly incidence on mango crops, which were so far mainly infested by the peach fruit fly *Bactrocera zonata* (Saunders). Field studies have shown that fruit fly damages can be reduced by adjusting the harvest date, as fruit fly infestation increases with fruit maturity. At the same time, the harvest date is an important factor in determining the shelf life and quality of fully ripened fruit, when it is ready for consumption. For example, harvesting mangoes too early can reduce their quality. A modelling approach was developed to optimize harvest timing with the dual objective of improving fruit quality and reducing fruit fly damages. A fruit fly-mango interaction model, which predicts the probability of a fruit being infested by fruit flies as a function of fruit maturity, was developed for both *B. zonata* and *B. dorsalis*, and coupled with an ecophysiological model that predicts fruit growth and quality by simulating carbon- and water-related processes at the fruiting branch level. Using the model, we virtually investigated i) the effect of light environment and leaf-to-fruit ratio, which alter fruit carbon availability, and ii) the effect of harvest date and frequency, which alter fruit maturity at harvest, on fruit growth, fruit quality and fruit fly infestation. The simulation results show that by harvesting the fruit at an earlier stage of maturity, such as the green mature stage, it is possible to greatly reduce the risk of mango infestations while ensuring that fruit quality is only minimally affected.

Application of plant growth regulator affects flowering characteristics of \`Irwin´ mango

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In Korea, 'Irwin' mango is the most popular mango cultivar with its attractive red blush peel color, and mango trees are cultivated in greenhouse due to low temperature during winter season. One of the problems of mango production is the excessive vegetative growth that inhibits reproductive growth. In this study, the application of 1-Naphthaleneacetic acid (NAA) at different concentrations of 30, 70 mg L^{-1} on the shoot apices of 'Irwin' mango at the BBCH scale of 011 was investigated. The results showed that mango trees treated with 30 and 70 mg L^{-1} NAA increased emergence rate of panicles up to 92.6% and 89.8%, respectively, compared to control group with 85.4%. In the percentage of panicle malformation, mango trees with 70 mg L^{-1} NAA had the highest value with 45.3%. Additionally, NAA treatment induced changes of the pattern of flowering. The application of 70 mg L^{-1} NAA showed only one peak in the pattern of flowering distribution. In contrast, distribution of flowering bloom in the group treated with 30 mg L^{-1} NAA increased with three peaks. Therefore, it is suggested that NAA treatment can be used for enhancing development of flowering, furthermore increasing the yield of mango crops under greenhouse conditions. (This study was carried out with the "Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ01666601)" Rural Development Administration, Republic of Korea.)

Isolation and expression analysis of *glutathione S-transferase* (*GST*)-like genes involved in anthocyanin accumulation in mango peel

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Recently, genes involved in anthocyanin synthesis in mango peel have been isolated. Expression analysis of these genes during red coloration in 'Irwin' peel showed that the expression of *MiCHS*, *MiANS*, *MiUFGT1*, and *MiUFGT3* is deeply involved in mango peel coloration and is regulated by the transcription factor *MiMYB1*. However, factors involved in anthocyanin transport and accumulation in mango peel have not been analyzed. It has been reported that glutathione S-transferase (GST) is involved in anthocyanin transport and accumulation in some plants. In this study, we isolated *GST*-like genes from the peel of 'Irwin' and investigated their relationship with anthocyanin accumulation. We identified four *GST*-like genes from transcriptome data obtained from the 'Irwin' peel using Blast searches and named them *MiGST1-4*. In *MiGST1*, eight of the nine conserved amino acid residues that are present in known GST proteins involved in anthocyanin transport were conserved, but these residues were not conserved in *MiGST2-4*. Analysis of the expression of these genes in mango peel showed that *MiGST1* was not expressed in fruit in which anthocyanin accumulation was suppressed by bagging (shading), but only in de-bagged fruit in which anthocyanin accumulation was observed.

On the other hand, the relationship between the expression of *MiGST2-4* and anthocyanin accumulation was not clear. These results suggest that *MiGST1* is a GST protein responsible for anthocyanin transport in mango peel.

Herbarium specimens and botanical characterization of *Mangifera* species

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Mangifera spp. belongs to the Anacardiaceae family. Twenty-two members of this genus have been collected at different living collections in Florida, including USDA Chapman Field - Subtropical Horticulture Research Station, The Tropical Research Center at the University of Florida, Fruit and Spice Park, and private collections. Individual plants, or parts of plants have been preserved and cared at the Forestry Herbarium of the Distrital University Francisco Jose de Caldas, Bogota, Colombia UDBC and Fairchild Tropical Botanical Garden Herbarium in Miami Florida. These materials may include pressed and mounted plants, seeds, pollen, frozen DNA extractions, and fluid-preserved flowers. This research is aimed to preserve the samples for over time so that current and future generations can identify the *Mangifera* spp. and study its biodiversity, and use the collection in support of conservation, ecology, and sustainable development.

A review of Kasturi (*Mangifera casturi*)

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The mango, *Mangifera indica* L. (Anacardiaceae), is the best known and most widely cultivated species in the genus *Mangifera*. There are over 69 *Mangifera* species currently recognized in Southeast Asia (Kostermans and Bompard, 1993), with many species locally rare and/or included on the IUCN Red List of Threatened Species. *M. casturi* is reported as extinct in the wild, although fruit of *Mangifera casturi* are sold at fruit markets in south of Kalimatan. Local agricultural services are conducting a survey of trees and there is an effort for their preservation being made by propagating trees for the local community. A general review of this species is presented in this paper, including an update of accessions existing in the United States and the South of Kalimantan, Indonesia.

Mycorrhizae in presence of *Ascophyllum nodosum* and vermicompost in mango 'Ataulfo' in Nayarit, Mexico

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Arbuscular mycorrhizae and tree root mango form a specialized interface over which bi-directional water and nutrient transference occurs. But this symbiosis is affected by farm management practices, weather, soil microorganisms, phenological stage. The objective was to quantified the infectivity (ability of fungal propagules to colonize host plant) by these native fungi, during mango tree stage flowering, in two orchard (6 & 20 productive age years) in Nayarit, Mexico. Three treatments were evaluated: vermicompost, *A. nodosum* and control. In each plot, soil and roots were randomly collected from 5 trees per treatment. The samples were processed in Laboratory and analyzed using a microscope and stereoscope. Test for differences in the percentage of colonization (PC) by fungal structures of hyphae and vesicles were statistically similar ($p \leq 0.05$), by mango orchard and treatments. But the trees showed differences in PC by arbuscules between orchards ($p \leq 0.038$). Arbuscules fungal structures of mango orchard of 20 productive age years, were exceeded 356 % by 6 age years mango orchard. However, treatments did not affect arbuscules structures. Is reported that in flowering stage of the mango tree is quantified less AMF colonization. However, contrary to expectations, results showed vermicompost y *A. nodosum* did not show synergy with this fungal intraradical structures for a best colonization.

Cell wall components during female germline development of Mango

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The formation of the male and female gametes are key developmental processes in the flowering plant life cycle. While the male germline develops in the anther, the formation of female gametes takes place within the nucellus of the ovule. During both developmental processes, the composition of the cell wall of the germline is essential for proper development. However, little is known about the composition of the cell wall of the germlines of mango, especially during female germline development. Thus, in this work, we evaluate the main components of the cell wall of the female germline by a specific immunohistochemical study on pectins, arabinogalactan proteins, and callose. The results show that cell wall components of the female germline differentiate among the neighboring somatic cells, similarly to the observed during the male germline development. The cell wall differentiation of the germlines may reflect a highly controlled developmental process by restricted crosstalk between the sporophyte and the germline.

Evaluation of some introduced cultivars of mango (*Mangifera indica* L.) under arid conditions of Jordan

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Mango (*Mangifera indica* L.) is one of the most popular tropical fruits in the world. Recently, we have started cultivating mango trees in Jordan on organized plantations. This research experiment was carried out during two seasons (2018-2019) to evaluate some physical and chemical characteristics of three mango cultivars (Keitt, Tommy Atkins and Maya) at ripening stage. This experiment was arranged in Randomized Complete Block Design (RCBD) with three replicates. Mango cultivars investigated had statistical effects on yield and fruit characteristics. Keitt cultivar recorded the highest yield per tree during both seasons, followed by Tommy Atkins. There were significant differences of average fruit weight, width and length among the studied mango cultivars. Keitt cultivar had the highest fruit weight followed by Tommy Atkins whereas Maya recorded the lowest fruit weight. As per fruit ripening indication, Maya cultivar had the highest total soluble solid percent (TSS%) among the investigated three cultivars, whereas Keitt cultivar had the lowest TSS%.

Differences in metabolite content in a core collection of mango cultivars

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Mango (*Mangifera indica* L.) is a tropical fruit crop with a high economic impact worldwide. Mango is a climacteric fruit that with a myriad of metabolites involved in its nutritive value, delicate flavour, taste, and nutritional characteristics. This study aims to assess metabolites differences via comparative profiling of 23 cultivars from the mango germplasm collection maintained at the IHSM 'La Mayora'-UMA-CSIC. To achieve this goal, we used a combination of gas chromatography-mass spectrometry (GC-TOF-MS), ultra-performance liquid chromatography-mass spectrometry (LC-MS) to identify and semi-quantify 49 primary metabolites (sugars, amino and organic acids), and 132 polar secondary metabolites in two fruit ripening stages. Multivariate statistical approaches, including hierarchical cluster analysis, partial least squares discriminant analyses and k-means clustering, were used to characterize the variation in metabolite content between genotypes and to identify the biochemical pathways which are most affected during ripening. These results are useful not only to compare the metabolic profile among varieties, but also to identify differentially regulated metabolic

fluxes through different pathways demonstrating possible mechanisms of key metabolite formation and regulation in mango fruits.

Uso de técnicas no destructivas para determinar madurez óptima de cosecha en frutos de mango

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El mango es un fruto tropical que se cosecha en estado verde maduro cuando se exporta a mercados distantes, lo que provoca que no siempre llegue con la calidad y sabor requeridos por el consumidor. Los productores en México utilizan el color de pulpa y el contenido de sólidos solubles totales (ºBx) como criterios de cosecha, sin embargo, ambos son destructivos generando pérdidas considerables. Algunos países utilizan el criterio de contenido de materia seca (MS) que puede determinarse de manera no destructiva, pero que aún no se utiliza por no existir estándares propios. Por lo tanto, el objetivo fue construir y validar un modelo único para predecir de manera no destructiva la madurez óptima de cosecha de las principales variedades para exportación. En 2019 se cosecharon cinco grupos de 40 frutos cada uno (desde tiernos hasta ya coloreados) de las variedades Tommy Atkins, Ataulfo, Kent y Keitt. Los 200 frutos se escanearon en ambos cachetes con un espectrómetro F-750® para obtener los valores de MS. Los valores de referencia se obtuvieron mediante horno de aire forzado a 60 ºC por 72 h. El modelo se construyó mediante la aplicación Artificial Neural Network y se validó durante 2020 y 2021 en huertos comerciales ubicados en Nayarit y Sinaloa, México. La MS se estimó utilizando el modelo generado en 2019 y cargado en un espectrómetro F-751®. El modelo único considerando las cuatro variedades y los dos estados de maduración del fruto fue promisorio ya que presentó una R^2 = 0.84. En cuanto a la validación, los valores obtenidos en las cuatro variedades y estados de madurez a cosecha fueron de 15.6% para el espectrómetro y de 15.2% para el método convencional, sólo 0.4 puntos porcentuales de diferencia, lo que indica la factibilidad técnica del F-751® para determinar de manera no destructiva el contenido de MS de cualquiera de las variedades, aunque se detectaron diferencias entre éstas. Ataulfo mostró el mejor ajuste del modelo de predicción con diferencia de sólo 0.3 puntos porcentuales, en tanto que Keitt tuvo la peor, con una diferencia de 0.6 puntos porcentuales.

Exploring genes whose expression fluctuates with floral induction and MiFT expression in mango leaves

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It is believed that mango flowering is controlled by the balance between flowering promoter (FP) and vegetative promoter (VP) factors. FP is produced in the leaves and moves to the apex to exert its effect, as shown by grafting experiments. It has been demonstrated that *MiFT*, which is the orthologous gene of *FLOWERING LOCUS T* in mango, functions as FP. In recent years, isolation and functional analysis of mango flowering-related genes such as *MiCO*, *MiCOL*, and *MiSVP* genes have advanced, suggesting that they regulate the expression of *MiFT*, but the actual role of these genes in the floral induction of mango is yet to be clarified. In this study, we conducted experiments using two cultivars, 'Irwin' and 'Aiko'. For 'Irwin', a low-temperature treatment (floral inductive condition) and a high-temperature treatment (non-inductive condition) were applied, and for 'Aiko', a no-thinning treatment (heavy fruit load and weak floral induction for the next season) and a full-thinning treatment (no fruit set and strong floral induction for the next season) were applied. RNA-Seq analysis was conducted to investigate the expression pattern of floral-related genes in mature leaves under these floral inductive and non-inductive conditions. As a result, it was found that the expression patterns of *MiCO*, *MiCO-like*, and *MiSVP* genes did not appear to be associated with floral induction and/or *MiFT* expression. On the other hand, some transcription factors were suggested to be new *FP* candidate genes and involved in the control of mango flowering.

Increase in the production of pollinated fruits with application of boron and calcium in mango \`Ataulfo´ in Nayarit, México

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In Nayarit, Mexico, critical temperatures (<15 º C;> 30 º C) during the flowering period, cause high production of parthenocarpic fruits (PRT). These fruits are smaller in size and less nutrient than pollinated fruits. The objective of this study was to evaluate the effect of Ca, B and N on the incidence and size of PRT fruits in 'Ataulfo' mango. The study was conducted 2018 and 2019, in Nayarit, Mexico in an 'Ataulfo' mango orchard with high presence of PRT fruits (80%). Treatments based on calcium, boron and nitrogen were applied to improve pollination, fertilization and set fruit. Forty-five days after full flowering, the number of PRT and fruits with seed retained by inflorescence varied between treatments. There were no significant differences among treatments in PRT fruits, but in fruits with seeds, the T4 and T5 treatments stood out with 2.5 and 2.4 fruits/inflorescence, respectively. The yield of fruits with seeds of treatments T5, T3 and T2 was 105, 95 and 89 kg/tree, respectively, which exceeded the control trees (45 kg / tree); T5 produced more than double that of T6 (control trees). The results indicate

the positive effect of nutrition by increasing yield of fruits with seeds, increasing the size of both types of fruits, and showing a tendency to decrease the incidence of PRT fruits.

Flowering and harvest modification with intensity and time pruning in mango `Ataulfo’ in Nayarit, Mexico

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The annual phenological behavior of mango in various producing areas of Mexico has varied with climate change over the past 12 years. Fresh autumns with low humidity, results in abundant blooms and a large harvest, which causes that the production intensify, the offer increases, low demand and the price of the fruit is reduced in the market. The objective was to evaluate the effect of the period and intensity of pruning in the bloom process of mango 'Ataulfo'. The study was conducted in 2018 and 2019, in a mango orchard of Nayarit, Mexico, different treatments were applied combining period and pruning. The effect on floral differentiation was evaluated, bloom, fruit set, harvest time and yield. A high percentage (> 90%) of buds differ in the first half of January and a low percentage differed between the end of February and the beginning of March, resulting in two flows bloom. The first results obtained show the importance of the period and intensity of pruning; undoubtedly severe pruning affects the differentiation, bloom and fruit production. Abundant and early blooms are obtained with light pruning at an early period, while light and intermediate pruning (August September) stimulate less bloom and fruit production, but late pruning reduce the yield significantly as a result of inhibiting the bloom differentiation of high percentage of buds.

Thidiazuron stimulates in vitro shoot regeneration from cotyledonary node explants in mango

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In terms of production, mango ranks as the fifth-most important fruit crop worldwide. Mango vegetative propagation is slow and only allows the production of a relatively small amount of plant material when compared to other fruit tree crops. High explant phenolic exudation and necrosis, media browning or slow in vitro growth makes mango a recalcitrant species. Currently, no efficient methods for mango in vitro establishment, micropropagation, or shoot regeneration are available. Previous studies in our group revealed the cotyledonary node (CN) in mango as a

reactive explant. CN consists of the embryo axis where cotyledons, main stem and root are inserted. In this study, mature seeds of the polyembryonic cultivar 'Ataulfo' and the monoembryonic cultivar 'Irwin' were used. Seeds were placed onto germination medium supplemented with 0, 1, 2 or 3 mg L^{-1} of thidiazuron (TDZ). After 3 weeks of culture the percentage of CN showing adventitious shoot regeneration and the number of buds/shoots per regenerating explant were significantly higher ($p \leq 0.05$) in the TDZ treatments compared with the treatment without TDZ. No statistical differences were found among the three TDZ concentrations for any of the parameters assessed. For the two genotypes studied, regeneration rates reached approximately 90% when TDZ was applied. Furthermore, TDZ treatments induced high-frequency of regeneration patterns, up to more than 6 buds/shoots per regenerating explant. Taking into account mango recalcitrance, our results represent a significant improvement for in vitro plant regeneration/mass propagation of this species.

Climate change multi-risk assessment for mango cultivation in Sicily, Italy by using bayesian network

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Ensuring food security poses a significant challenge for organizations and consultant companies involved in the agriculture industry or responsible for food programs. This challenge is particularly relevant in Sicily, Italy, which has a semi-tropical climate. Given the favorable weather conditions for mango cultivation and other tropical crops, it becomes crucial to consider measures for safeguarding against potential climate change impacts in the future. Climate change is expected to bring changes and increased risks in terms of temperature, extreme events, soil salinity, and irregular rainfall. Amidst this looming threat, there is a growing demand for a fresh approach and supportive tools to manage risks and mitigate potential damages in policy-making and decision-making circles. In this study, we employ a robust method known as Bayesian Network (BN) to effectively capture and model multiple risks under various future scenarios. By exploring 'what-if' situations, such as the maximum levels of climate-related variables, the projected BN model is trained and validated using spatially-resolved data from the Messina region in Sicily. This approach enables us to understand the dynamic variations in local-scale temperature and precipitation, as well as the underlying driving forces, within the timeframe of 2009-2022. The outputs of the Bayesian Network aid in predicting future trends in temperature and precipitation levels, thereby supporting the prioritization of mango

cultivation and conservation efforts. In general, the findings derived from the BN analysis provide valuable support for disaster risk management and mitigation strategies in the face of climate change and extreme events. This tool can further enhance decision-making processes by integrating the spatial results of the developed model into a user-friendly interface such as Geographic Information System (GIS), thereby assisting policymakers and decision-makers in prioritizing Disaster Risk Management and Climate Change Adaptation plans.

MISAR in agricultural area by developing machine learning models (Case Study: Mango Farms in Sicily, Italy)

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Agriculture plays a crucial role in the economy of Italy, particularly in the region of Sicily where it serves as a primary source of income. To ensure high yields, it is essential to enhance farmers' knowledge and awareness, especially in mitigating potential risks and damages caused by climate change and managing farming processes such as soil and water preparation, fertilizer, and pesticide management. To follow the MISAR (Climate Change Risk Management by Improving the Individual and Social Awareness of Risk in Sicily) targets, this paper focuses on the importance of Information and communication technologies (ICT) in the "Mango Farms Risk Management Plan" to foster stronger connections between stakeholders and farmers in Messina. Climate change poses various hazards such as temperature fluctuations, extreme events, soil salinity, and irregular rainfall, which are expected to increase in the future. Effective decision-making for stakeholders and farmers requires efficient analytical tools, particularly for handling large datasets. The paper introduces a new architecture called ADM, which combines Decision Support Systems (DSS), Agent-Based Modeling (ABM), and Machine Learning (ML) methods to develop a comprehensive risk plan for future agricultural challenges. The ADM model in MISAR incorporates empirical information collected during the ML phase, including the reactions of Mango plants to risks and determining factors like extreme temperature changes. To promote and safeguard mango cultivation and production, changes in temperature are estimated using advanced techniques such as Random Forest and Feed-Forward Neural Networks. Weather stations equipped with meteorological sensors are strategically placed within farms, providing direct measurements of hazards. Each station has its own credentials, allowing farmers access to the data. Furthermore, historical data analysis considers data from

municipal meteorological stations and satellite sources. The model facilitates mutual communication between decision-makers and farmers, enabling farmers to monitor forecasts and report unexpected events in their respective farm areas.

Comparative analysis of morphoanatomical characteristics in mango trees (*Mangifera indica* L.) with different ploidy levels

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Polyploidy is a common phenomenon in plants, including mango. It refers to the presence of more than two sets of chromosomes in a cell. Polyploids can arise naturally through chromosomal duplication events during cell division or can be created artificially. In the case of mango, natural autoploid cultivars have been observed that contain four sets of chromosomes. Several autotetraploid cultivars were developed by our research group in some of the polyembrionic mango cultivars. In the study a leaf morphoanatomical characterization comparing the diploid and autotetraploid mango cultivars Kensington, Torbert, Manga Blanca and Turpentine have been carried out. Adult well-irrigated trees from each cultivar and ploidy were chosen for sampling purposes. From each tree, three mature leaves were randomly sampled. The selected leaves were in the third position from the apex to the base of a branch without vegetative growth or floral development. Macroscopic measurements of leaf morphology were taken, and a histological protocol was carried out that includes fixation, dehydration, paraffin embedding, microtome section, rehydration, staining and permanent mounting. Photomicrographs were taken and analyzed with ImageJ software. It has been observed that the petiole of the leaves of the tetraploid varieties tend to be longer and thicker. In the same way, the width and thickness of the leaf blade tend also to be larger and thicker. However, no clear difference in leaf length for all studied cultivars was found. Anatomically, a trend towards a cell diameter increase was observed in different tissues, such as the epidermis, parenchyma and vascular bundle. The area occupied by the xylem and the phloem was greater in tetraploids, as well as the diameter of the stomatal cells. Accordingly, these autotetraploid cultivars can exhibit different characteristics from diploid ones, which can be related with resistance to diseases or environmental stresses. Therefore, polyploidy is a topic of interest in research and selection of mango varieties for commercial production.

Mango production in Sicily, Italy: state of the art and future perspectives

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The cultivation of mango has moved to further latitudes from the equator in the last decades, gaining ground in new producing countries. In Italy, the largest surfaces dedicated to mango are found in the island of Sicily. The pedo-climatic conditions of some parts of the island proved favourable to the growth of the species and the product is appreciated by the European markets due to its advanced ripening degree at harvest and to the smaller environmental cost of the supply process. Mango in Sicily encounters climatic conditions that are suitable for the reproductive process during the Mediterranean summer but is limited by the often unpredictable winter weather events. Here, we present a summary of the results of studies that were conducted over a three-year period on plants of cvs. Kensington Pride, Nam Dok Mai, Tommy Atkins, Keitt, Osteen, Maya, grown in the open field or under shading nets. The phenology of the plants in the open field turned out to be significantly different than the one observed in the tropical regions, with vegetative development limited by the fact that harvest happens just before the onset of the cold season. Flowering-inductive temperatures occur for as long as three months: however, fruit set percentages, as a consequence of the effect of temperature on the pollen germination and viability were found to be smaller than in the tropical producing areas. The limited vegetative development of the mango plants allows for an easier management of the canopy and for the cultivation in protection systems: these are a valid help in protecting the plants from endemic diseases such as the Bacterial Apical Necrosis, whose spread was reduced by the presence of shading nets and windshields.

Can exogenous application of Zn, B, Ca and NAA on mango trees obstruct fruitlets´ abscission?

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Mango is one of the most important fruit crops in the tropics and subtropics, due to its pleasant aroma and unique flavor. Low fruit set and fruit drop is a limiting factor for mango yield. For the experiment, solutions with 16 amino acids, in addition with Zn 0.2 %, B 0.125 %, Ca 0.4 % and NAA 0.005 % was used, applied through three treatments (Control, AMINO16-Zn-B, AMINO16-Zn-B-Ca-NAA) on Kent, Tommy Atkins, Palmer, Irwin mango varieties. The parameters measured were Initial fruit number per inflorescence, Initial fruit number per tree, Fruit retained percentage per tree after 15, 30, 45 days of the solution application and at harvest (Final fruit retained percentage per tree), Final fruit number per inflorescence, Total fruit drop percentage per tree and Fruit weight at harvest. In Kent and Tommy Atkins varieties no statistical differences were observed. In Palmer variety, fruit weight was higher in AMINO16-Zn-B treatment (471.7 g), in comparison to the other two treatments. The other parameters did not differ statistically.

Irwin variety had a higher Initial fruit number per inflorescence in Control (9.3), than in AMINO solution treatments. Fruit weight was higher than the Control when AMINO16-Zn-B was sprayed onto Irwin trees (563.3 g). The other parameters in Irwin variety had not statistical differences. At harvest, 35.6% (mean value of the three treatments) of fruits retained on Palmer mango trees, 34.65% on Kent, 27.8% on Tommy Atkins and 12.6% on Irwin. However no significant differences were recorded among the treatments. Additional research should be done to investigate whether higher quantities of macro- and micro-nutrients are more effective to obstruct fruitlets' abscission on Kent, Tommy Atkins, Palmer and Irwin mango trees.

Testing the performance of exogenous ethylene application on ripening of hot water treated imported mangos (*Mangifera indica*)

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Ripening protocols have been developed to deliver 'ready to eat' climacteric fruits such as avocados, kiwifruit, and stone fruit. The biological roles of ethylene and temperature on ripening changes including softening are the basis for the design of successful commercial 'ready to eat' protocols. These protocols, when well executed, allow fruit to ripen evenly and express their maximum flavor at retail stores and increase consumption. Recent detailed observations on imported mangos arriving to the Netherlands and United States, mostly hot water-treated, suggested that exogenous ethylene may not be required. Our hypothesis was that the role of exogenous ethylene on imported mango ripening varies depending on mango ripening stages. Thus, imported mangos are either producing endogenous ethylene (physiologically mature), and/or have been exposed to exogenous ethylene from other mangos, during handling and transportation from production to consumption areas, and undergoing different stages of ripening. We discovered that exogenous ethylene treatment was not necessary to ripen imported hot water treated mangos because the ripening process was triggered by the increase of temperature during the hot water treatment allowing 'ready to transfer or buy' and/or 'ready eat' stages to be reached within one to three days upon store arrival. The use of ethylene application during the ripening protocol requires extra facilities, equipment, and handling costs. In addition, ethylene application triggers softening of immature mangos that can affect consumer acceptance. We propose enforcing maturity quality standards to assure consumer quality, proper packaging to avoid bruising, and sorting to segregate mangos into different ripening stages prior to ripening and fruit delivery to retail stores.

Imported mango quality survey at arrival to stores across USA

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Mango (Mangifera indica L) is a climacteric tropical fruit that has become popular around the world. US is the largest importer of mango in America, importing mangos from Mexico, Guatemala, Peru, Ecuador, Brazil, Haiti, and Puerto Rico. Over the years, US Mango consumption has increased from 0.8 to 1.6 kilos per capita during the last two decades. However, the US mango per capita consumption is still lower than other commodities available in similar yearly cycles. In 2020, bananas, apples, pineapples, and table grapes had a 12.4, 8.0, 3.3, and 3.8 per capita respectively. There are limited postharvest studies of imported mangos to the US available and most of them were carried out using non hot water treated (NHWT) mangos while 85 to 90% of imported mangos to the US are treated with hot water (HWT). To investigate the potential obstacles to increase mango consumption in the US, we surveyed mango quality at arrival to stores in the US West, and East coasts for one season in which we measured skin damage, chilling injury, flesh firmness and color, soluble solids concentration and dry matter percentages that led us to propose the following main barriers to increase US mango consumption. The main barrier to satisfy consumers is the large firmness variability within the 'ready to eat' lots that interferes with consumer acceptance and increase handlers' losses We recommend enforcing harvest maturity indexes and improve ripening protocols performance for the 'ready to eat' programs. We propose that to reduce firmness variability in the lots, a firmness segregation online should be investigated and validated to assist performance of ripening technologies and increase consumption.

A mango phylogeny: future directions and implications

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Mango (*Mangifera indica*, Anacardiaceae) is a member of a large genus that contains 68 other species that evolved in South to Southeast Asia. The current taxonomic understanding of *Mangifera* is based on morphology and breaks it into two subgenera, *Mangifera* and *Limus*, and includes some species of unknown positions. In addition, for cultivated mango, multiple domestication events have been proposed and interspecific hybridization is known to occur. A phylogenetic understanding of the group will help us better understand these processes and their consequences. Here, we examine our current understanding of the evolutionary relationships within *Mangifera* and propose future work to build a more robust phylogeny. We first provide an overview of our current phylogenetic understanding of *Mangifera*, based on previously generated genome wide single nucleotide polymorphism (SNP) data from 30 *Mangifera* species. Next, we present the results of a global survey of *Mangifera* biodiversity collections (living and herbarium). Finally, we propose to select a subset of these samples for target enrichment sequencing using Angiosperm353, a method that performs well with low quality DNA samples commonly obtained from herbarium specimens. An improved phylogeny

of *Mangifera* will contribute to a taxonomic revision of the clades and anchor future studies on hybridization and the evolution of important traits in the genus. This study will also contribute valuable information for the in situ and ex situ conservation of Mango and its wild relatives and provide foundational knowledge for plant breeding approaches.

Evaluation of physicochemical characteristics of ëIrwiní mango grown in the plastic house with heating at general and different storage conditions

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The 'Irwin' mango is one of the most popular mango cultivars, exists in South Korea. Identifying fruit characteristics is essential for improving the quality after harvest because they vary with different environmental conditions. In this study, the physicochemical parameters of 'Irwin' mangoes were studied under general conditions in a plastic house with heating and two different storage conditions. The fruits were kept under room temperature storage at 20ºC and cold storage at 7ºC for 14 days. They were then exposed to room temperature conditions. The physicochemical properties, such as chromaticity in the front and back sides, soluble solids content (SSC), titratable acidity (TA), firmness, ethylene production, and respiration rate, were measured. The data were analyzed using JMP Pro statistical software, and the mean separation was performed by Tukey's HSD test at $P < 0.05$. The 'Irwin' mangoes were divided into five different skin colors (maturity): S1 (Green > 50%), S2 (Green 30-50%), S3 (Green 20-30%), S4 (Green 10-20%), and S5 (Green 0%). Consequently, in general conditions, fruit firmness, and TA values were dramatically decreased, and the SSC content increased with the maturation. The highest respiration rate and ethylene production can be obtained in S4 and S5, respectively. Moreover, under storage conditions, the physicochemical parameters were varied in the usual pattern except for SSC in room temperature storage. Under other conditions, physicochemical characteristics were retained during the cold storage, and the characteristics were changed moderately after being exposed to room temperature. Considering the chromaticity, an apparent variation in every color value between the front and back sides of the fruit could not be observed, and there are significant differences among stages. These results showed that the 'Irwin' mango fruit quality relates to the physicochemical parameters. The outer environmental

conditions are affected by its changes, and how they influence the postharvest shelf life can be identified by evaluating these characteristics periodically.

Identification and pathogenicity of Botryosphaeria species associated with mango dieback disease in Egypt and Israel

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Mango is affected by several fungal diseases including dieback and fruit stem end rot, caused by members of the Botryosphaeriaceae family, recently recorded from multiple locations in Egypt and Israel. In August 2022, approximately 40% of mango trees showing symptoms of twig and branch dieback, leaf necrosis, leaf fall, internal tissue necrosis, and darkening within the vasculature, were detected in 20 farms located in Sharkya and Behera Governorates, Egypt. Sections from diseased branches were plated on PDA at 25ºC and after 3-5 days, fungal cultures were observed, with mycelia initially grayish-white in color eventually turning dark grey to black. After 21 days, the colonies produced dense aerial mycelia with dark-colored pycnidia containing conidia. Morphological characteristics were consistent with *Lasiodiplodia theobromae*, *L. pseudotheobromae* and *L. egyptica*. Similarly, in Israel, *L. theobromae*, *L. pseudotheobromae*, and *Neoscytalidium dimidiatum* were identified as causal agents of mango dieback based on morphology and phylogenetic inference (using ITS and *tef1-α* gene sequences). In Egypt, pathogenicity was carried out on healthy two-year-old mango cultivar 'Eweis' seedlings, using representative isolates, by inoculating wounded apical buds with a 5-mm PDA plug colonized with the aforementioned *Lasiodiplodia* species and non-colonized control plugs. All seedlings, five replicate plants per treatment, were maintained under greenhouse conditions (27ºC, 16/8-h day/night; 70% relative humidity) and monitored for disease development. After 28 days, all inoculated plants displayed similar symptoms to those observed in the field, whereas control plants remained healthy. Koch's postulates were fulfilled when typical colonies of *L.*

theobromae, *L. pseudotheobromae* and *L. egyptica* were successfully re-isolated from symptomatic tissues. Similarly, in Israel, representative isolates of *L. theobromae* and *N. dimidiatum* caused dieback symptoms on detached mango stems under controlled and outdoor shade-net conditions. The pathogens were re-isolated from inoculated stems successfully completing Koch postulates. Future studies will characterize diversity of *Botryosphaeria* in each country as well as development of effective management strategies.

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