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Analysis of kiwifruit literature using HistCite and VOSviewer

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Rapid increase in the number of published papers in any research area makes it challenging to keep up with the trends and hot topics. A total of 4,664 kiwifruit-related papers were found in the Web of Science core collection between 1 January 1900 and 6 July 2023. Citation analysis using HistCite and VOSviewer software facilitated a meaningful overview of the literature from historical, geological, organizational, and scientific disciplinary aspects. The results revealed an accelerating increase in the number of annual publications in the field of kiwifruit since 1967. The research network is centred in New Zealand, China, and Italy, with The New Zealand Institute for Plant and Food Research Limited being a leading research and collaboration partner. The journals Postharvest Biology and Technology, Food Chemistry, The New Zealand Journal of Crop and Horticultural Science, and Scientia Horticulture are the top sources of high-impact publications on kiwifruit. Resent research topics have been focused on bioactive compounds, physiological and metabolic processes, bacterial canker, postharvest biology and technologies. There has been a shift from principles to a combination of principles and practical technologies. A recent increase in the number of studies on the utilization of kiwifruit as non-food resource, the extraction of bioactive substances, and the relationship of kiwifruit with human health, indicates emerging research directions. This analysis provides a useful reference for a comprehensive understanding of the overall research status, as well as trends in the field of kiwifruit research.

Poster 2.1 Breeding

Potential of *Actinidia arguta* var. *hypoleuca* endemic to Japan for utilization as kiwiberry

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Actinida arguta var. *hypoleuca* is endemically distributed in warmer, southern parts of Japan. So far, the resources have not been utilized for production or breeding. To evaluate the potential in its utilization, characteristics of the wild plants collected from different region were investigated. Flow cytometric analysis showed that all of 12 plants collected were diploid. The stem of young shoot was red or reddish green except one collection [Izu]. The leaf shape was elliptic, and the lower sides of leaves were glaucous and the conspicuous cluster of trichomes were observed at the branch points of the main and lateral veins showing typical morphological characteristic of var. *hypoleuca* . The inflorescences were cyme and the sepals and peduncles were reddish except [Izu] with green sepals and flower axils. [Izu] flowered mid-late May, 10 days later than [Myojogatake] and [Zushi]. Fruit skin was green with partly blush in [Myojogatake] and [Zushi], while green in [Izu]. Average fruits weight was about 5.7 and 6.3 g in [Myojogatake] and [Zushi], respectively, whereas those of [Izu] were larger, weighing 14.1g. The fruit of [Myojogatake] and [Zushi] gradually softened by early October on the vine and then dropped, whereas those of [Izu] kept hardness until mid-November. After suffering the first frost, fruit of [Izu] softened, but fruit were still left on the vine even after leaf fall. Total soluble solid contents of juice reached to 18.7% and 17.3% in [Zushi] and [Izu] respectively, but the taste was much better in the fruit of [Izu]. These results showed that [Izu] with the trait of late ripening and fruit with good size and taste could be a useful material for kiwiberry selection.

Poster 2.2 Breeding

Scanning Electron Microscopy: a useful tool for screening *Actinidia* pollenizers

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For *Actinidia*, interspecific hybridization and polyploidy have the potential to introduce novel characteristics and increase desirable qualities. However, for wide crosses, the selection of suitable male pollenizers is essential. Scanning Electron Microscope (SEM) screening of pollen grains obtained from male pollenizers is a useful approach to assess somatic-ploidy levels. For this investigation we used SEM to obtain high-resolution images of *Actinidia* pollen grains extracted from dried and frozen anthers derived from different species and interspecific hybrids. This included available male *A. chinensis* var. *chinensis* accessions from the USDA's Davis, California collection. For horizontally-positioned pollen grains we used ImageJ software to measure various parameters. Mean values were then plotted in Excel to reveal discrete clusters that correspond to different somatic-ploidy levels. We were able to distinguish between diploid, tetraploid and hexaploid and aneuploid pollenizers with high accuracy. SEM images were also used to evaluate various male interspecific hybrids for sterility based upon pollen-grain morphology. Collapsed and shrivelled grains were indicative of infertility in the F1. Excess exine ornamentation characterized by thick, lumpy textures in the F1 may suggest at least partial genetic imbalance in otherwise normally-shaped pollen grains when compared with the much smoother exine textures observed in respective parent species. Where non-even sex ratios are present in the F1, the SEM can be used to effectively screen large seedling populations of *Actinidia* pollenizers. Because dried and frozen, *Actinidia* pollen remains viable and suitable for crosses for 8 to 10 years; vials of SEM-vetted pollen samples can be placed in long-term storage for subsequent plant breeding. This enables successful cross combinations to be replicated even if the original male pollenizer is no longer available.

Poster 2.3 Breeding

Evaluation of fruit peeling characteristics of different kiwifruit varieties

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Fruit peeling is an important trait of fruit quality, which directly affects the storage and use convenience of the fruit, and then affects its commercial value. At present, the peelability of citrus and banana has been extensively studied, while research on the peelability of kiwifruit is relatively scarce. In this study, 25 kiwifruit varieties were used as materials to comprehensively evaluate and analyze the peeling characteristics of different varieties at the soft ripening stage. Firstly, the peels of different varieties of kiwifruit were manually torn and pulled, and the peeling characteristic was judged and evaluated by observing the two parameters of peeling number (number of peel fragments) and peeling degree (degree of flesh damage) during the process of flesh and peel separation. Then, the peeling force of different varieties was measured using a peeling device that was designed by ourselves and constructed based on mechanical measuring tools to objectively reflect the changes in the peeling characteristics of kiwifruit varieties. By comprehensively comparing the peeling number, peeling degree, and peeling force of 25 kiwifruit varieties, it was shown that the number of peeling, peeling degree, and peeling power of fruits in the soft ripening stage of different kiwifruit varieties were different. Among the 16 *Actinidia chinensis* varieties, 'Jinfeng' and 'Fenghuang 1' were more prone to peeling and had a lower degree of flesh damage compared to other varieties. Among the four *A. deliciosa* varieties, 'Miliang 1' was easier to peel than other varieties, and its flesh was less damaged. Among the five *A. eriantha* varieties, 'White' had the thickest peel and was peeling smoothly, but required a stronger peeling force. 'Ganlv 1' was easier to peel and effortless than other varieties, and 'Ganmi 6' had more peeling numbers and was more difficult to peel compared to other varieties. The peeling characteristics of different kiwifruit varieties varied greatly, among which the fruit of *A. eriantha* was the easiest to peel, and the peeling characteristics among different kiwifruit varieties within the same species would also be quite different. In conclusion, this study created a device based on a mechanical measuring device that can measure the peeling force of kiwifruit and a system that can objectively and comprehensively evaluate the peeling characteristics of kiwifruit was established by combing the peeling force, peeling number, and peeling degree.

Poster 2.4 Breeding

Investigation of kolomikta kiwi (*Actinidia kolomikta*) and selection of the new cultivars in Lithuania

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Investigations of new horticultural plants with high biological value and economic potential are the topical trend of modern horticulture. Nowadays, the plants of the *Actinidia* L. genus became more and more popular in Lithuania. Due to unfavourable climate conditions for the cultivation of kiwifruit (Chinese gooseberry) in Lithuania the species *Actinidia kolomikta* Maxim. seems to be one of the most perspective plants of this genus for cultivation. It distinguishes by the many flavors and nutritional qualities of berries which accumulate a complex of biologically active substances. The popularity of *A. kolomikta* is rising regarding the new productive cultivars created in recent years. The gene pool collection of *Actinidia* Lindl. was established at the Vytautas Magnus University Botanical Garden. It was the main precondition for comprehensive studies. Resistance to biotic and abiotic factors of the environment as well as growth and development and productivity of different cultivars and clones were evaluated. The aim of the investigation was to distinguish the informative morphological, biochemical, and fecundity peculiarities and to select clones of *A. kolomikta* perspective for creating new cultivars of local origin proper for cultivation on a large scale in the climate conditions of Lithuania. The result was a selection and approval after DUS test a new Lithuanian cultivar 'MILEMA'.

Poster 3.1 Genomics

Chromosomal duplication in *Actinidia chinensis* var. *rufopulpa*

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Kiwi is an edible berry produced by a variety of climbing lianas of the genus *Actinidia*, which belongs to the *Actinidiaceae* family. Among commercial species, 'Hayward' has become the market's dominant cultivar since the 1970s, owing to its appealing smaragd-green pulp, refined flavor, and good post-harvest performance. However, the genus *Actinidia* contains a large number of cultivars and selections with a wide range of shapes, sizes, volumes, sensory, and nutritional characteristics. After nearly four decades of almost mono-varietal production, today's market is looking for new types of fruit to expand and provide consumer diversity. So far, the required characteristics have been focused on taste (high dry matter content, low acidity, and new volatile components), color, nutritional characteristics (high vitamin C, quinic acid, and folic acid content), and convenience (i.e., long storage, edible or peelable peels). Recently, consumer interest has primarily been focused on fruits with a different color pulp, such as yellow or bicolor (yellow-red and green-red pulp). The latter, in particular, has become a novelty in the fruit and vegetable markets due to its distinct color and flavor characterized by tropical notes. *Actinidia chinensis* Planch. var. *rufopulpa* cultivars 'Hongyang' and 'Chuhong' are examples of red pulp kiwi cultivars that are commercially available. However, since the early 2000s, kiwi crops have been plagued by "bacterial canker," a pathology caused by the bacterium *Pseudomonas syringae* pv. *actinidiae* (PSA) that has resulted in significant economic losses in countries such as Italy and New Zealand. Several studies have shown that the various ploidy levels in *Actinidia* species are related to a greater or lesser susceptibility to this illness. Particularly, it was found that diploid varieties, like those with red pulp, are more prone to infection and display symptoms that are more severe. Two different diploid pulp genotypes were subjected to chromosomal duplication in order to create pre-breeding material for the creation of red pulp fruit varieties that are less susceptible to PSA. To produce the tetraploid plants, the in vitro petiole segments were incubated in an initiation substrate for four weeks before being treated with a 0.05% colchicine solution. The regenerated plants were examined to confirm the ploidy, and tetraploid lines were acclimatized and cultivated in the open field for upcoming phenotypic analyses.

Poster 3.2 Genomics

Tetraploid inter-specific cross population QTL mapping for resistance to *Pseudomonas syringae* pv. *actinidiae* (PSA)

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Kiwi is one of the most recently domesticated fruit crops. Starting in its native South China, kiwi was introduced to New Zealand, where it has been widely cultivated since the mid-20th century. To date, China, New Zealand, Italy, Chile, and Greece are the largest producers of this fruit crop, accounting for 75-80% of the world's annual commercial kiwi yield. For many years, the activity of kiwi (*Actinidia* spp.) genetic improvement has been focused on the identification of new selections with commercially valid phenological characteristics such as flower age, harvest age, pulp color, fruit preservability, taste and shape. In fact, kiwi was an "easy" plant to cultivate, as it was less demanding and susceptible to disease. Since the early 2000s, however, kiwi crops have been affected by "bacterial cancer", a pathology caused by the bacterium *Pseudomonas syringae* pv. *actinidiae* (PSA) that initially colonizes the surface of the plant without causing significant infections, but once penetrated inside it is able to colonize phloematic and xylematic vessels and cause serious damage, leading, in cases of advanced infection, to the death of plants within a few months. As a result, this bacteriosis has significantly reduced the world's variety landscape in some cases (see the eradication of the cultivar Hort-16A due to its high susceptibility to disease) and caused significant economic losses in nations like Italy and New Zealand. Because of few products available to treat them, bacterial diseases are notoriously challenging to manage. The actions are primarily preventive measures and involve prompt containment of the bacteria by removing the compromised plants. Therefore, the goal of the research is to create new commercial varieties of kiwifruit that are more resistant to PSA. About 50 species contribute to the whole genus *Actinidia*, some of which are found in the *Leiocarpae* division and seem to be less susceptible to the PSA. *A. arguta* in particular might be thought of as tolerable/resistant. In order to create a tetraploid genetic map and pinpoint the PSA resistance gene, an interspecific cross-population, created by crossing the susceptible parent 'Soreli' (*A. chinensis* var. *chinensis*) with the tolerant/resistant parent 'Cornell' (*A. arguta*), was used in this study. The cross-population was genotyped using the ddRAD sequencing technique and phenotyped after artificial infection. A tetraploid genetic map was created using the Polymap R package, and QTL analysis was carried out using the PolyQtl R package.

Poster 3.3 Genomics

Adaptive evolution and genetic structure of *Actinidia arguta*

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Climate change is the ultimate determinant of biological evolution. Landscape genomics have brought the way to identify environmental factors and adaptive loci that drive genome evolution. Mining and using environmental data for as long as possible would be a key to accurately identify the associations. Although the locally distributed East Asian plants have received a lot of attention, research on phylogeography of climbing woody plant widely distributed from Northeastern to Southwestern mountains across East Asia is still unavailable. *A. arguta* is distributed in almost all East Asian Mountain ranges from southwest China to the Russian Far East, including the islands of Japan, Taiwan and other peninsulas. Here, based on a de novo genome of a male *A. arguta* autotetraploid and the re-constructed paleoclimatic data since 22,000 B.C., we dissected the genetic basis of the adaptation of *A. arguta* to climate change using geological climate data with genome environment association and revealed evolutionary history of the species populations. The species could be clustered into three geographical groups, which first diverged 12.9 Mya. *A. arguta* underwent a strong population expansion from 0.1-0.2 Mya involving the warmest interglacial period during the late-Pleistocene. At least two gene-flow events occurred during in the process of population differentiation, one of which occurs between northern and southern geographical groups.

Poster 3.4 Genomics

A high-quality RNA extraction method from leaves and roots of kiwifruit plants

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High quality RNA extraction is an essential requirement for carry out molecular biology studies like qRT-PCR or next generation sequencing. RNA extraction in kiwifruit tissues is challenge due to the presence of polysaccharide-rich tissues, polyphenolics compounds and secondary metabolites. The main objective was to test four different methods for obtaining high quality RNA quickly to carry out molecular biology studies in roots and leaves from adult kiwifruit plants. Two kits protocols and two CTAB protocols were tested, 1) RNeasy Plant Mini Kit (Qiagen, CA, USA) and 2) Plant total RNA purification kit (Norgen Biotek Corp, ON, CA). For each kit, the corresponding lysis buffer was used. 3) CTAB method specifically design for kiwifruit cultivars and 4) a rapid CTAB method meant for grapevine and woody plants. A high-quality RNA resulted from protocol 4) the rapid CTAB method described for grapevine only in one day and three hours. The Nanodrop efficiency ratios in leaves and roots were A260 /A280 2.14, A260 / A230 2.20 and we obtain a concentration over 450µg/µL and 250µ/µL respectively. Furthermore, the Bioanalyzer RIN number was greater than 3.5, which is essential for next generation sequencing on plant species. In our conditions, we have successfully stablished an optimised and fast CTAB-based protocol for isolating high-quality RNA from kiwifruit leaves and roots suitable for downstream molecular biology studies.

***Young mind award**

Poster 4.1 Biology & Physiology

Differences in fruit and seed characteristics of some kiwifruit cultivars bred in Korea affected by pollen donors

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This study was conducted to evaluate fruit and seed characteristics pollinated by four pollen donors and to select the best pollen donor which is good at producing commercial fruits from some kiwifruit (*Actinidia chinensis*) cultivars bred in Korea. The experiment about 'Haeguem' and 'Redvita' was carried out from 2018 to 2019, and that of 'Garmhwang' and 'Sunfl' was from 2021 to 2022. The fruit setting rate of all cultivars, which were pollinated by four pollen donors, exceeded 90% for two years. In 'Haguem' and 'Redvita', the fruit weight was the heaviest with 'Chieftain' and was the lightest with 'Pohwa'. In 'Sunfl' and 'Garmhwang, the fruit weight with 'Deliwoong' and 'Chieftain' was heavier than that with 'Pohwa' and 'SKK2'. About the fruit characteristics of 'Haeguem', the dry matter content and soluble solids content were the highest with 'Pohwa' in 2019, and malic and quinic acid contents were the highest for two years with 'SKK2'. The total number of seeds was the highest with 'Chieftain' and the lowest with 'SKK2' for two years. In 'Redvita', dry matter content was high with 'SKK2' and 'Deliwoong' in 2019. Titratable acidity was the lowest for two years with 'SKK2'. The total number of seeds and the number of mature seeds in 'Redvita' were the highest with 'SKK2'. Dry matter content and soluble solids content of 'Sunfl' was the highest with 'SKK2' and 'chieftain' respectively only in 2022, but neither had significance in 2021. Titratable acidity was the lowest with 'Chieftain'. The total seed number was the most with 'Deliwoong' and 'Chieftain'. In 'Garmhwang', dry matter content with 'SKK2' was the highest. Soluble solids content with 'Deliwoong' was higher than with other pollen donors in 2021 but lower than with 'SKK2' and 'Pohwa'. The total seed number was the most with 'Deliwoong' and 'Chieftain'.

Poster 4.2 Biology & Physiology

Effect of high day temperatures on red-fleshed *Actinidia chinensis* var. *chinensis* fruit

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Red-fleshed kiwifruit cultivars usually produce fruit with lower pigmentation in warmer climates. With climate change, increased daily temperatures will challenge red-fleshed kiwifruit cultivars even further. Anthocyanins are the pigments responsible for the red flesh colour, and their concentration correlates with the intensity of the flesh colour. Previous studies showed how carbon starvation hampered anthocyanin accumulation in kiwifruit flesh. We hypothesise that under elevated day temperatures plants become stressed and carbon starved, leading to repression of anthocyanin accumulation. To test this, rapid flowering *Actinidia chinensis* var. *chinensis* 'Zes006' plants were exposed to day temperatures of 24°C (control) and 32°C (high temperature treatment) for 8 weeks from the onset of anthocyanin accumulation. Experiments were conducted using Conviron cabinets, for uniformity of all other conditions (humidity, watering, soil). Changes in fruit physiology, transcriptome, and metabolite concentrations in 20-week-old fruit were analysed. Fruit physiological parameters and metabolite concentrations were not significantly altered in heat, however anthocyanin concentrations were lower in the high heat treatment. Principal component analysis was able to separate samples based on day temperature. The carbon starvation scenario in heat is unlikely to be as extreme as low leaf-to-fruit ratio treatment and therefore not the only driver of the observed phenotype. Several transcription factors were also upregulated, suggesting an involvement as repressors of anthocyanin. Heat shock protein genes were upregulated in response to heat treatment. This study provides us with a fundamental understanding to develop tools for the prediction of high temperature effects on future red cultivars suitable for climate changing regions.

Seed development in *Actinidia* species

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In the *Actinidia* genus, seed development influences fruit set, fruit size and fruit quality, yet our understanding of the physiological, metabolic, and molecular processes involved are limited. To further our understanding of seed development, we have monitored the timing of black seed development in fruit of six contrasting *Actinidia* species and observed that small-fruited, berry-type kiwifruit reaches 100% black seed at an earlier fruit age than standard large-fruited kiwifruit. Samples of fruit from one berry-type kiwifruit (*A. arguta*) and one standard-type kiwifruit (*A. chinensis* var. *chinensis*) were collected at weekly intervals from anthesis to fruit maturity. Fixed and light microscopy images of seeds were acquired. Observation of the seed sections stained with Toluidine Blue revealed that the timing of embryo development differed between the two species. Iodine staining for starch indicated that starch was not accumulated in the kiwifruit seeds of either species, contradicting the previous literature. This work expands our understanding of seed development in different kiwifruit species and underpins our knowledge of fruit set, fruit size and fruit quality.

Poster 5.1 Production

Comparative results of two grafting methods in kiwifruit

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The production of young plants, which are clean in terms of plant health and are the right starting material for true to name, is of great importance for a quality production all over the world. It is even more of a challenge for crops such as kiwifruit or any other plant, which are relatively new in the history of horticulture. Kiwifruit cultivation has a history of about 25 years in Albania. During this period, growers tried to meet the young plants they needed in different ways, but sometimes undesirable situations were encountered. This study has been planned in order to provide healthy material that can be a solution to these situations. In this study, we aimed to help growers and encourage them to propagate kiwifruit plants themselves instead of to buy uncontrolled, unknown quality and high-priced markets. Of course, although there are no large kiwifruit plantation and massive propagation in Albania, it was planned to propagate healthy plants with a good root system for home gardens. The seeds of the 'Hayward' cultivar were used in this study because the plants growing from seeds have a strong root system. 'Hayward Clone 8' were grafted with two different methods (chip budding and cleft grafting) onto these seedlings when they germinated and reached sufficient graft thickness in a three-year period (2020, 2021 and 2022). The seedlings obtained from planting kiwifruit seeds in orchards were planted in the open field after one year. After two years from planting in the orchard, kiwifruit plants were grafted. The results are encouraging for farmers: the occupancy in the case of grafting with chip budding, for the three years taken together, was 78.33 percent, while in the case of grafting with cleft grafting, the average of the three years was 58 percent. Propagating of kiwifruit seedlings with this method is long way, but in our opinion, it is better to lose a few years at the beginning than to have a weak plant during the entire life of the production period.

Kiwifruit research and production in Iran

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Kiwifruit is one of the main export crops from Iran. It is cultivated in the favourable climate around the Caspian Sea. Iran produced ~442,000 metric tons of kiwifruit from 14,836 ha in 2021, making it the world's fourth largest producer. Of this production, 210,000 metric tons were exported to more than 30 countries. The most common cultivar grown is *Actinidia chinensis* var. *deliciosa* 'Hayward', although recently red-fleshed kiwifruit orchards have been established and current interest lies in commercialising a new yellow-fleshed cultivar. Kiwifruit orchards are progressively increasing in both numbers and size. The Iranian kiwifruit industry is becoming increasingly technical, with new production and handling knowledge and industry extension coming largely from the University of Guilan and the Citrus & Subtropical Fruits Research Center. Graduate students' theses now tend to address practical aspects of kiwifruit production and handling. The average yield has increased from 30 to 40 t ha $^{-1}$ through changes to plant spacing, canopy management, fertilisation and plant growth regulator use. The potential demand for Iranian kiwifruit is large, with a large domestic market and proximity to major export markets, including Russia, Central Asia and the Middle East, all accessible by land. There is an opportunity to increase the revenue from exported fruit through an increased focus on new cultivars, fruit quality and supplying higher paying markets. These production and marketing opportunities are currently helped by government policies to assist economic diversification. However, to maintain the current momentum and fully commercialise the increasing production, the industry needs to focus on producing fruit for export and to develop further the technical systems required to provide customers with quality fruit.

Poster 5.3 Production

Accuracy assessment of a digital crop estimation system for kiwifruit count prediction

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Pre-harvest estimation is of utmost importance in modern horticulture industries. In recent years, Digital Crop Estimation (DCE) has emerged as a technological solution to replace the traditional manual estimation methods. In the kiwifruit industry, pre-harvest estimation has historically been performed based on manual counts of a small percentage of orchard area which has throughout the years evidenced faults and limitations. Fruitometry Limited was the first company to provide commercial DCE services for the kiwifruit industry in New Zealand, producing full orchard coverage density maps for all the stages of growth of kiwifruit: winter buds, shoots, flower buds, fruitlets and fruit. After its third commercial season, an accuracy study has been conducted to compare Fruitometry's fruit density estimations with the ultimate source of ground truth: the total amount of fruit harvested from the orchard. For that aim, complete data was extracted from official packout reports for all the orchards where full maturity areas had been scanned not more than 16 weeks prior to harvest. This study comprises data from 139 hectares distributed among 72 different Maturity Areas from 36 KPINs. Te comparison dataset consists of 21 data points for each variety, SunGold and Hayward. Overall, Fruitometry's fruit density estimations demonstrated strong performance with an average accuracy of 96% compared to packout results for 2023 harvest. The highest error encountered was less than 9%, and the bias resulted -0.17 fruit/m^2. The observed results validate the reliability and precision of Fruitometry's density estimations for harvest prediction.

Fruit quality response of ‘Sweet Gold’ and ‘Jecy Giold’ kiwifruits to trunk girdling

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Kiwifruit quality is very important to promote marketability nationally and internationally. Contrary to other kiwifruit-growing countries such as New Zealand and Italy, the trunk girdling practice to improve the fruit quality is not common in Korea. Then the girdling trials were evaluated with yellow-fleshed 'Sweet Gold' and 'Jecy Gold' bred by National Institute of Horticultural and Herbal Science, RDA, Korea for 2 years. These cultivars were grown with pergola training system under plastic film house. The trunk girdling was applied once at 45, 60, and 130 days after anthesis (DAA) and twice at 60 and 130 DAA. The response of two cultivars to trunk girdling was very similar for two years, but the yearly response was a little different. Fruit weight showed an increasing tendency in treatments of 45 DAA once or 45 and 130 DAA twice, which was accompanied by the increase in fruit length, not fruit width. Dry matter was increased by treatment of 130 DAA once or 45 and 130 DAA twice. The soluble solid content showed the tendency to increase in treatment of 130 DAA once or 60 and 130 DAA twice, which indicated that late trunk girdling might advance the fruit maturation. However, the other factors, such as fruit acidity, firmness, starch content change, and flesh coloration were not affected by trunk girdling regardless of the timing of the treatment. The results indicated that trunk girdling might affect fruit size and dry matter mainly compared to the other fruit quality factors, but these effects responded differently depending on the fruit developmental stage of fruit cell division and fruit early maturation in two different yellow-fleshed cultivars. Consequently, it requires two trunk girdling to improve fruit weight and dry matter, together in yellow-fleshed 'Sweet Gold' and 'Jecy Gold' kiwifruits.

Poster 5.5 Production

Effect of thinning methods and bioregulator application on flower drop in *Actinidia chinensis* var. *chinensis*

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In recent years, flower drop has become a rising phenomenon is different *A. chinensis* var. *chinensis* varieties and it can lead to 50% losses in fruit production. Flower drop generally occurs after thinning of later flower. The physiological mechanisms underlying flower drop are still unclear, but they seem related to a hormonal imbalance. The aim of this work was to verify the possible presence of fungal and bacterial pathogens associated to this syndrome and to investigate the role of different thinning strategies and bioregulator application on its incidence. The following thinning strategies were compared: standard thinning (8 shoots of 5 flowers per cane), thinning of later flowers only, no thinning. Concerning bioregulators, in plants subjected to standard thinning, Sitofex® (forchlorfenuron) and Sprintex® (alpha-naphthaleneacetic acid + AA) were applied. No specific pathogen was found associated to dropped flower, moreover, in standard thinning plants, fruit drop incidence was 33.17%. Sprintex® significantly reduced fruit drop, while Sitofex showed a minor reduction of incidence, but increased the final size of fruit and not a consequence of flower competition for nutrients. Interestingly, in no thinned plants fruit drop was ten times lower than in standard thinning, suggesting that the fruit drop probably a consequence of the ethylene production induce during thinning.

Poster 5.6 Production

I9Kiwi – a decision support system for agriculture 4.0

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The i9Kiwi platform is an innovative Decision Support System that helps kiwifruit growers to monitor and manage their orchards in real-time. Data collected from sensor networks and other external sources such as meteorological stations provide the farmers with valuable information such as soil temperature, environmental humidity and temperature, soil humidity at different soil depths, wind speed and direction, rainfall, and solar radiation, among others. The platform allows farmers to set alerts for specific actions to be taken in the field or to configure warnings associated with the collected data. These warnings can also be easily configured to inform the farmer if a particular disease is likely to occur under the conditions being monitored. On the management side, the platform allows the farmer to estimate the costs associated with the interventions, and for a given production. As the farmer can divide the logs by campaigns, the platform allows him to compare the productivity between them and identify the interventions/products that have given the best results. By registering all the interventions in the platform, i9Kiwi allows the farmer to easily create the Field Logbook, a mandatory document that must be submitted to the authorities every year.

Poster 5.7 Production

I9Kiwi - Development of strategies for the sustainability of the kiwifrui industry through the creation of a value-added product

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Kiwifruit (*Actinidia* spp.) production is an important economic activity worldwide, particularly in Portugal where it is the fastest-growing agri-food sector. Despite continuous investment, productivity has not met expectations due to problems related to plant resistance, plant health and pollination. The lack of technical knowledge among producers and the absence of smart, tailored and competitive precision agriculture solutions, limit the economic, environmental and social sustainability of the sector. The EIP-AGRI Operational Group i9Kiwi (https://i9kiwi.pt/) was created in response to these constraints and was developed by a partnership of scientific and technological institutions, supported by a relevant network of stakeholders. I9kiwi aimed to improve competitiveness and promote sector literacy in sustainability, resilience and agri-environmental practices by developing innovative and tailored solutions to the challenges and constraints faced by stakeholders. Overall, i9kiwi has produced tangible results and facilitated the transfer of innovation to the sector, with an impact on productivity and production costs. Briefly, an increase in production and a reduction in costs have been achieved by adapting cultural practices related to plant protection (hygienic pruning, disinfection of material, certification of propagating material, analyses of soil and irrigation water, etc.). The information obtained on the severity and incidence of diseases makes it possible to advise producers on the best planting areas, pre-planting measures and the most suitable varieties, thus optimising the use of resources. Promoting the adoption of agroecological and more sustainable practices reduced water and fertiliser use, increased pollinator diversity and improved soil and plant health. The i9Kiwi platform is an innovative decision support system that helps kiwifruit growers to monitor and manage their orchards in real-time contributing to the digitalisation of the sector. This commitment has helped to consolidate approaches, knowledge and best practice in the pursuit of financial, environmental and social sustainability in the sector.

Poster 5.8 Production

Kiwifruit industry in Greece: current trends and future perspectives

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In recent years, Greece has become the world's third-largest exporter of kiwifruit, following New Zealand and Italy. Herein, information regarding the kiwifruit industry in Greece is presented. The kiwifruit commercial cultivation in Greece started during the early 70s, when the first private plantation was established in the Katerini and Larissa districts. Since then, and especially after the 80s, kiwifruits are produced also in other regions of North Greece, where climatic conditions favor its growth. Most of Greek kiwifruit production comes mainly from Macedonia (Pieria, Imathia, Pella, Kavala) in North Greece region followed by Arta (Epirus region, West Greece) and Thessalia (central Greece). Currently, Greek kiwifruit total production amounts to 320,000 tons, twice that of seven years ago, while the production for the next years is expected to increase due to the high number of new plantations. The green-fleshed 'Hayward' is the most widely planted kiwifruit cultivar, however several yellow-fleshed and a few red-fleshed kiwifruits have been also recently introduced in a small scale in different areas. The kiwifruit production system in Greece has recently characterized by the establishment of some Consortia and clubs, such as Zespri and Jingold, that are mainly promote specific, yellow-fleshed kiwifruits to a limited number of growers. In addition to this, new yellow-fleshed kiwifruits, like AC 501 022® and AC 497 076® are being evaluated. In Greece, the T-bar and the pergola are the training systems mostly used, depending on the cultivation area. In terms of pathogens, the bacterial canker of kiwifruit caused by *Pseudomonas syringae* (pv. *actinidiae*, Psa) is regarded a minor problem for the kiwifruit production in Greece. Modern cultivation systems are widely used, whereas there is a continuous application of new on-orchard management and postharvest practices. The current production challenges for the Greece's kiwifruit industry include the improvement of refrigerators infrastructure, the fruit quality control and the climate change-adaptation strategies.

Poster 5.9 Production

The impact of chemically thinning flowers and fruits on kiwifruit cultivar Jinshi 1

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Fruit trees that have their blossoms and fruits properly thinned so the tree can support a suitable load produce reliable, high-quality yields each year. For certain fruit trees, chemical fruit and bloom thinning can lessen orchard production expenses by saving labor and time. The right chemical reagent for kiwifruit flower and fruit thinning has not received much attention in the production, and it is still unclear how to apply concentration and what effect the chemical reagent will have on the quality of the fruit. In the present study, the chemical reagent and concentration that were appropriate for Jinshi 1 fruit control and floral thinning were screened. The results showed that when Jinshi 1 was treated with a 3000-fold dilution of 40% ethethylene, the single blooming rate and vitamin C content increased by 1.97 and 1.15 times, respectively, whereas the double flowering rate decreased by 51.3%. After treating Jinshi 1 with a 100-fold dilution of 2% 6-BA, the single fruit rate and Vc increased by 1.33 and 1.42 times, respectively, and the double fruit rate dropped to 75.4%. A 150-fold dilution of 10% tenlobuzole and 5% calcium tunecyclate, as well as a 150-fold dilution of 40% ethethylene, could significantly suppress the growth of spring shoots without compromising the fruit's vitamin C content. The overall fruit setting rate was unchanged by any of the treatments.

Research on the water demand regularity of Xuxiang kiwifruit in the northern Qinling mountain

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This paper aims to provide an irrigation schedule during fruit phenological period (sprout, flowering, young fruit, fruit swelling and maturity) of Xuxiang kiwi, based on the effects of irrigation amount during the whole stages on growth, grain yield and quality of the kiwi. Results showed that with the increase of soil water content, both germination rate and setting rate increased first and then decreased. The growth of new shoots decreased with the decrease of soil water content, but the water gradient had no significant effect on the size of new shoots. With the increase of water capacity, hundred-grain weight of bell flower increased. The fruit size and fruit weight increased with the increase of soil water content in the young fruit stage and the fruit swelling stage. The field water capacity of kiwifruit orchard in mature stage was positively proportional to individual fruit weight and yield, but inversely proportional to dry matter, soluble sugar and titratable acid. The content of soluble solids, hardness and vitamin C were higher in the middle and lower in both sides. The water demand of Xuxiang kiwifruit in northern Qinling mountain was 516.29mm, among which the appropriate soil water contents of the sprout, flowering, young fruit, fruit swelling and maturity were 80.77%, 81.17%, 83.95%, 84.7% and 75% of the field water capacity, respectively. Overall, high irrigation amount during fruit expansion stage coupled with a moderate irrigation amount during the fruit maturity stage can considerably improve water use efficiency, with only a slight compromise in yield.

Poster 6.2 Irrigation & Soil

Implementation of agronomic solutions to control kiwifruit decline in South West of France

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Since 2020, kiwifruit decline (KD) has emerged as the major issue facing the crop. In 2022, a survey of 50 French kiwifruit growers, in line with Italian and New Zealand studies, showed that soil conditions, in particular compaction and waterlogging, are major factors explaining this phenomenon. We hypothesize that improving soil physical condition would slow the evolution before plants complete decline. For 3 years, we are monitoring a network of five orchards located in SW of France and affected by KD with increasing symptom severity: We are studying the combination of 3 factors promoting soil aeration and porosity. Factors are the establishment of permanent and temporary cover crops, the massive addition (100 $t.ha^{-1}$) of compost and mechanical soil decompaction. By crossing the factors, a total of 8 modalities are studied on each orchard, with at least two replicates. At the beginning of experiment, we observed difference in tree sanitary health status within the orchards. Soil bulk density was 20% higher at 25 cm depth than at 5 cm (in the Adour orchards) with no difference between the trampled zone and T-bar plumb line. Soil penetration resistance was highly related with vine sanitary health status and moisture, with greater pressure to dig into the soil for healthier vines. Finally, 80% of fibrous roots were found in the 20 first centimeters of soil. By creating soil porosity and improving its structure, we aim to (i) directly reduce anoxic conditions, (ii) promote root system development, and so plant resilience, and (iii) decrease or at least limit the vine health degradation.

Physiological response of *Actinidia deliciosa* cv. Hayward to prolonged and controlled humid conditions in the root

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Soil flooding is a major abiotic stress generally related to poor soil drainage combined with excessive rainfall or irrigation and negatively impacts many agricultural crops leading to significant economic losses. In addition, kiwifruit orchards in the Mediterranean basin suffers from a syndrome of un-known origin associated to long-time humid conditions which causes plant collapse and death in few months. This work studies the response at physiological level to prolonged and controlled humid conditions (Hd) in the root system for 8 weeks of *Actinidia deliciosa* cv. Hayward (HAY) plants, one of the most widely used in kiwifruit industry worldwide. Water content percentage, gas exchange parameters and water relations in leaves were determined. Moreover, some indicators of abiotic stress, like membrane permeability from leaf cells, proline and malonaldehyde (MDA) concentrations in this organ were also assessed. Plants cultivated under humid conditions (Hd) increased their percentage of water in the leaf at the beginning of the experiment, but decreased progressively, and no differences were found between Hd and Ct plants at the end of the treatment. The net CO_2 assimilation rate (An), stomatal conductance (gs) and the transpiration rate (E) lowered significantly due to Hd conditions, while no effect was observed in the internal CO_2 (Ci). Leaf water potential was 2.4-fold higher in Hd than Ct plants. Ion leakage, MDA and proline concentration were also increased by 62.7%, 88.2% and 140.9%, respectively, under Hd treatment. From this study, we conclude that HAY cultivar shows some sensitive responses to humid conditions in the root, as 1) An rate is reduced in spite of the stomata closure to prevent water loss, 2) membrane permeability and lipid peroxidation are increased indicating cell damage and, 3) the amino acid proline is accumulated to cope with the stress damage in this cultivar.

How does kiwifruit response to boron toxicity? A physiological study

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Soils with toxic levels of boron (B) are frequent in some agricultural areas throughout the world, limiting plant growth and crop productivity, related with loss of vigour, shorter biomass and even twig dieback when severe disorders. However, cultivars of the same species can show adaptative physiological responses to B excess, which confers tolerance to this abiotic stress. The effect of B toxicity in kiwifruit plants has been studied in a trial of *Actinidia deliciosa* cv. Hayward conducted in greenhouse. Two different treatments (0 and 250 µM B) in nutrient solutions were applied for 2 months. Plant growth, B and proline concentrations and gas exchange parameters were measured. At the end of the experiment, B concentration increased both in leaves and roots although no effect was observed in plant growth. Photosynthesis and stomatal conductance decreased but no effect was observed in transpiration rate. The synthesis of proline, an osmolyte which protects against salt toxicity, was also enhanced in plants grown under B excess. This study summarizes some important physiological responses in Hayward plants exposed to B toxicity, as initial work of screening plant material tolerant to this abiotic stress.

Poster 6.5 Irrigation & Soil

Roots Regeneration potential in kiwifruit after roots pruning under KVDS conditions

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In recent years, several Italian kiwifruit orchards have been threatened by a physiological decline, commonly known as Kiwifruit Vine Decline Syndrome (KVDS), leading to a reduction of the Italian kiwifruit growing areas of approx. 25%. Despite being considered a phenomenon with a multifactorial origin, a linkage has been found with soil waterlogging conditions, which can be promoted by intense rainfall and improper irrigation management. The accumulation of water along the soil profile, the alteration of its physico-hydrological, chemical and biological properties and the establishment of anoxic conditions represent factors negatively affecting the kiwifruit root system, which shows a complete absence of new roots and starts to decay due to a rotting process. The aim of the present study was to investigate the potential of root pruning in regenerating kiwifruit root system severely damaged by soil waterlogging conditions. A three-year experimental trial was carried out in a yellow-fleshed commercial and mature kiwifruit orchard (*A. chinensis*, cv. Zesy 002 grafted onto Hayward rootstock) located in Latina (Italy) severely affected by KVDS. Root pruning was carried out during the 2021 season through a deep vertical cut at approx. 70 cm from the trunk and the root system was monitored through trench excavation and soil profile observation. Sustainable soil management (e.g., compost application and cover crops) together with optimized irrigation management were carried out during the experimental trial to reduce water stagnation, soil compaction, root asphyxia, promoting soil oxygenation and the establishment of optimal conditions for the growth and development of the regenerated kiwifruit root system. A trench excavation was performed during the 2022 winter season and roots were sampled following the soil profile method and through the use of a grid up to a soil depth of 60 cm to compare two pruning treatments (root pruning - RP and no-root pruning vines - NRP) and evaluate the root system growth and development after one vegetative season. Root length density (RLD) and distribution per diameter class, projected and surface root area were evaluated with the use of a root image analysis software. Results showed that vines subjected to root pruning are characterized by increased root density and area, mainly concentrated in the smaller diameter classes, compared to NRP vines, proving that the pruning intervention together with the creation of favorable soil conditions contribute to the regeneration of the kiwifruit root system of vines severely affected by KVDS. The present study demonstrates the regeneration capacity of the kiwifruit root system after root pruning. Considering the relevance of the kiwifruit physiological decline and its severe effects on vines, results achieved could represent an important contribution to the implementation of innovative strategies to restore orchards affected by KVDS syndrome.

Dynamic management of roots zones for precision irrigation scheduling of kiwifruit orchard

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Kiwifruit could be considered a model fruit crop for irrigation management due to its high water requirement and, at the same time, susceptibility to both water excess and shortage conditions, which requires a precise and accurate application of water in the soil volume interested by root uptake. The present study aims to evaluate an innovative irrigation method characterized by four independent drip lines (4DL) placed at a distance of 0.5 and 1 m from the trunk respectively for each side. The experimental field was located in Metaponto (South Italy) and cultivated with a yellow-fleshed kiwifruit variety (*Actinidia chinensis*, Zesy 002) grafted onto D1 rootstock. The 4DL irrigation method allowed the control of both vertical and horizontal water movement and the distribution in different soil volumes, preventing the establishment of asphyxiating soil conditions which can severely affect kiwifruit root growth. During the irrigation season, two irrigation strategies were developed and applied to satisfy vine water requirements according to phenological stages and environmental conditions. In particular, one irrigation strategy was based on the alternate use of the two inner and two outer drip lines, while the second irrigation strategy was based on the alternate use of an inner and an outer dripline for opposite sides. Irrigation volumes were distributed in three/four daily interventions in order to more effectively assist plant water needs during the day. Soil water content was continuously monitored through soil moisture probes installed at different soil depths (10-60 cm) to control soil water content depletion and root uptake dynamics from each soil volume. Dynamic management of roots zones allowed to keep optimal vine water status during the season showing midday stem water potentials between -0.6 and -0.7 MPa. The 4DL irrigation system allowed to irrigate a double soil volume explored by roots, compared to the conventional two drip line irrigation system, applying the same seasonal irrigation volume. Innovative irrigation strategies developed with the 4DL could be important to implement precision irrigation in kiwifruit orchards as they effectively help to increase irrigation efficiency and ensure the best soil oxygenation conditions for root development, by wetting a larger soil volume, managing the soil water content at different distances from the trunk and controlling the water movement along the soil profile.

Poster 6.7 Irrigation & Soil

Water status and root growth of kiwi plants with rootstock under water deficit conditions

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For the renewal of kiwi orchards in Chile, it is proposed to use kiwi plants with rootstocks, which give them greater tolerance to water stress conditions. Therefore, the objective of this work was to evaluate the water status and root growth of kiwi plants with rootstock under water deficit conditions. A completely randomized experimental design with four treatments was established. T1 corresponded to kiwi plants without rootstock and without water deficit, T2 corresponded to kiwi plants with rootstock and without water deficit, T3 corresponded to kiwi plants without rootstock and with water deficit, T4 were kiwi plants with rootstock and with water deficit. The study was carried out on a 2-year-old orchard of cv Clone 8 and the rootstock used was cv Tomuri. The results show that the xylem water potential and stomatal conductance were not statistically influenced by the treatments. However, the root growth of the plants was statistically higher in T1 and T2 compared to T3 and T4. In conclusion, it can be pointed out that the water restriction did not influence the water status of the plants, but it did influence root growth.

Poster 6.8 Irrigation & Soil

An innovative and multidisciplinary approach to face kiwifruit vine decline syndrome (KVDS)

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In the last three years, the diffusion of the so called Kiwifruit Vine Decline Syndrome (KVDS), in Italy, involved also the *Actinidia chinensis* 'Zesy002' commonly known as SunGold. Preliminary indications from the research financed by Zespri pointed out water excess, stagnation, soil compaction or soil structure disruption associated with hypoxia or hyper oxidation as a potential cause in the emergence of KVDS. To face and contain the spreading of the problem, Zespri is coordinating five projects, considering plants as an integrated system with soil and atmosphere, and where microbial communities play a key role in modulating and translating environmental factors, with a "one health" approach. The approach of these new projects is clearly oriented, other than on research, toward the extension and communication. Thanks to the wide network of Zespri teams, technicians and growers that Zespri is involving in this "Task Force" approach, we are supporting growers and the rest of the industry with the "learning by doing" strategy. Using the soil paedology as the base for the agronomic management, we're investigating and validating processes capable of creating stable soil biological porosity, decreasing soil compaction and hypoxia, increasing soil microbiome diversity, improve water and nutrient management and consequently increasing fruit yield and quality. We believe that implementing novel management and monitoring strategies can improve kiwifruit growth and vine productivity, also reducing KVDS symptoms in impacted vineyards, contributing to the socio-economic sustainability of farms, and increasing the ecosystem services, according to a sustainable, integrated, modern and multifactorial concept of kiwifruit growing. We are going to present this new and involving approach as an example of the kiwifruit Industry resilience in this climate change time.

Poster 7.1 Pest and Disease

Kiwifruit Vine Decline Syndrome in central Italy: differences in microbial community structure in asymptomatic and symptomatic orchards

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In Italy, Actinidia chinensis is affected since 2012 by the Kiwifruit Vine Decline Syndrome (KVDS), which causes severe plant and production losses. In order to study the aetiology of KVDS, root and rhizosphere soil samples were collected in 2022 from 5 kiwifruit orchards in Lazio, both from asymptomatic and symptomatic trees, in two different seasons: spring and autumn. In this study, both conventional and molecular approaches were used to assess the impact of KVDS on soil health and microbial biodiversity. In particular, were assessed physicochemical characteristics (pH, electrical conductivity, total nitrogen, total organic carbon, elemental contents, water-soluble carbon); enzyme activities (urease, phosphatase, and β-glucosidase); microbial activity (basal soil respiration). Microbiome biomass and structure characterization was performed by using both phospholipid fatty acid (PLFAs) analysis and metabarcoding of the ITS2 and 16S regions. In addition, isolation of fungi and oomycetes was attempted both on artificial solid media from symptomatic root, and by baiting technique from rhizosphere samples. Pathogenicity tests of the most representative isolates are in progress at CREA-DC of Rome. Preliminary results showed a significant diversity between the asymptomatic and symptomatic rhizosphere in terms of soil physicochemical parameters and microbial living biomass. Pathogenicity test will shed light on the role of the different fungal and oomycetes species involved in the development of the diseases PhD Project co-funded by Programma Operativo Nazionale (PON) "Ricerca e Innovazione" 2014-2020 - Azione IV.5 "Dottorati su tematiche green" and by Zespri Fresh Produce Srl, Italy.

Poster 7.2 Pest and Disease

Comparison of traps for monitoring *Halyomorpha halys* in kiwifruit orchards

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The spread of invasive pest species, such as *Halyomorpha halys*, the brown marmorated stink bug (BMSB), is a major threat to global agricultural production. It is native to Asia but has spread throughout North America and continental Europe and has recently been reported in several islands of the Mediterranean Sea. The pest is also a major biosecurity threat to New Zealand and live BMSB are frequently intercepted at the border. Monitoring and detection are challenging due to the pests cryptic nocturnal activity and excellent mobility. Orchard monitoring for BMSB is critical during the spring and summer. Large populations can rapidly move to a different crop type as an existing food source is harvested, or as a preferential one ripens. The various trapping systems commercially available have a number of shortcomings including low detection precision, high cost and poor bug retention. In 2021 a large-scale trial was conducted in Latina province (Italy) to assess the effectiveness of a new prototype trap "Tunnel trap". Preliminary results presented here show that the designed trap has been proven to be more effective than other commercially available traps. The new prototype may have tremendous potential for both improved pre-border surveillance and for guiding the timing and frequency of pesticides applications, improving the existing integrated pest management systems (IPM).

Poster 7.3 Pest and Disease

Isolation and characterization of pathogenic fungi of kiwifruit die-back in Sichuan, China

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Kiwifruit, as an important economic fruit crop, is expanding its cultivation area in Sichuan Province, China. However, the occurrence of branch die-back affects the kiwifruit industry. The disease is initially manifested as drying of the branch at the onset, and the tissue at the junction of disease and health becomes reddish brown. With the rapid expansion of lesions along the branches, the later stages of the disease show that the entire branch wilts, more surface cracks, and xylem necrosis. In severe cases, the disease can lead to cane death. In order to explore the pathogenic species of kiwifruit die-back in Sichuan, we isolated and purified the pathogenic bacteria and fungi from branch die-back samples from the main planting areas of kiwifruit in Sichuan by tissue isolation, according to the morphological characteristics and pathogenicity, and combined with the analysis of molecular biology methods. The results showed that no Psa was detected, however, two strains of pathogenic fungi, strains 76 and 78, were successfully isolated. Their colony edges grew irregularly and their aerial mycelium was short, dense and showed a felted appearance. The aerial mycelium changed from white at the initial stage to gray at the later stage, and they turned black after 7 d of incubation on PDA culture. The two strains were analyzed by constructing phylogenetic trees with ITS, EF1-α, GAPDH, and CHS1, and the results showed that the two strains were *Botryosphaeria dothidea* and *Neofusicoccum parvum*, respectively. Two strains of the fungus were inoculated on healthy kiwifruit branches by both knife-cutting and needling, respectively. After 7 d, they both caused branch disease with normal surface phloem and infected xylem. The pathogenic areas showed reddish-brown spots. Knife cut inoculation sites were sunken and darkened to the sides. Needle-punctured inoculation sites had protrusions. Blank control branches did not show disease. We reisolated the diseased branches. The resulting pathogens had the same morphological characteristics and rDNA-ITS sequences as the original inoculation of the two fungal strains, fulfilling Koch's postulates. Therefore, *Botryosphaeria dothidea* and *Neofusicoccum parvum* were the pathogenic bacteria causing kiwifruit die-back in Sichuan, China.

Poster 7.4 Pest and Disease

Testing the susceptibility of cultivar ‘Hongyang’ ‘Hayward’ ‘Hort16A’ to white peach scale (*Pseudaulacaspis pentagona*)

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Kiwifruit is a common and popular fruit around the world. However, white peach scale (*Pseudaulacaspis pentagona* [Targioni-Tozzetti]), a scale insect with a wide range of hosts, seriously affects the yield and quality of kiwifruit. Stem assays were used to test the differences in susceptibility of 'Hongyang' 'Hayward' 'Hort16A' cultivars to *P. pentagona*. The total longevity of female individuals on three cultivars are 58.4 days at 23°C, with no significant difference. The first instar survival was not significantly different between 'Hongyang' and 'Hort16A', ranged from 17.86-36%; however, significantly different to 'Hayward' (11.49-22.77%). Adult survival on 'Hayward' reached 57.1%, which was significantly different from that on 'Hongyang' (31.6%). Adult size is no significant difference, ranged from 2.68 mm2-2.99 mm2.The fecundity on 'Hayward' (65.1 eggs per female) was significantly different to 'Hongyang' (139 eggs per female).

Poster 7.5 Pest and Disease

Effect of green light on *Actinidia chinensis* var. *deliciosa* Hayward performance and on infection by *Pseudomonas syringae* pv. *actinidiae*

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Light spectrum manipulation is emerging in modern agriculture both by the use of LED light in closed systems, and by the use of photoselective nets in open field. This spectral manipulation can be specifically designed to induce physiological responses, and/or control diseases and pests. Most studies have focused on the effects of red, far-red and blue light, and much less on green light, traditionally considered of no/minimal relevance. However, recent data support that green light plays non negligible roles in plants despite the differences in the species response, the experimental conditions and in the green light selected wavelengths make it difficult to draw general conclusions on its effects. We have investigated the effect We have investigated the effect of green-enriched white light on the growth and photosynthesis of *Actinidia chinensis* var. *deliciosa* 'Hayward' and how it influences the development of kiwifruit bacterial canker (*Pseudomonas syringae* pv. *actinidiae*). Our study showed that the increase in green light content led to a decrease of almost all parameters evaluated, especially of transpiration and ΦPSII. On the contrary, stem length and specific leaf area were increased by this light treatment showing a typical "shade avoidance syndrome" response. Disease development by *P. syringae* pv. *actinidiae* was little affected by the increase in green light content. Infection, on the other hand, led to a significant increase of gas-exchange-related parameters. Our results show that green-enriched light influences plant physiology and photosynthesis more than plant infection by *P. syringae* pv. *actinidiae* .

Poster 7.6 Pest and Disease

Two novel *Pseudomonas* species isolated from kiwifruit leaves

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Pseudomonas syringae pv. *actinidiae* , *P. syringae* pv. *syringae* and *P. viridiflava* affect *Actinidia* sp. to different extents, compromising production, so the coexistence of phylogenetically close but phenotypically drastically different strains is a critical diagnostic challenge. In this context, the phyllosphere of kiwifruit plants may act as a melting pot where pathogens and other species can coexist in the plant, promoting the evolution of highly adapted strains and/or the occurrence of coevolutionary phenomena associated with the spread and emergence of new diseases. To study the structural diversity of the genus *Pseudomonas* in the phyllosphere of diseased and healthy kiwifruit plants, a culture collection containing dozens of putative isolates from Portuguese orchards was established, typed by BOX-PCR and identified by 16S rRNA gene phylogeny. As a result of detailed morphological, physiological, chemotaxonomic and phylogenetic analyses, two new *Pseudomonas* species were proposed to science. Briefly, one set of strains clustered separately with the *P. sivasensis* type strain and the OrthoANI and digital DDH values were lower than 89% and 55% respectively. In parallel, another set of strains clustered with *P. savastanoi* and *P. ficuserectae* . The OrthoANI and DDH values against them were close to 96% and 65% respectively. The characteristic fatty acid methyl ester profiles present in all strains confirmed the assignment of the novel species to the genus *Pseudomonas*. Based on comparative genomics studies, a detailed search for pathogenicity islands, genes encoding virulence factors, antibiotic resistance and siderophore production was performed. Pathogenicity studies are ongoing to determine the ability of the new species to induce hypersensitivity and cause disease in *Actinidia*. These results, together with the other data collected in this study, confirmed that the strains represent two new Pseudomonas species.

Poster 7.7 Pest and Disease

Four novel bacterial taxa isolated from kiwifruit leaves

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Pseudomonas syringae pv. *actinidiae* (Psa), the causal agent of bacterial canker of kiwifruit, can lead to plant death, threatening the sustainability of the sector with significant economic losses. To understand the impact of Psa on the microbial community and to identify microorganisms with biotechnological applications in disease modulation or plant health, the microbiota of healthy and diseased plants was characterized using a culture-dependent methods. In this context, a collection of more than 1000 bacterial strains was established, typed by RAPD analysis and the representative strains were identified by 16S rRNA gene phylogeny. As result of a detailed morphological, physiological, chemotaxonomic and phylogenetic analyses, four new bacterial species were proposed to science. The KWT182 T and KWT1480 T strains represent two new species within the genus *Acerihabitans*, proposed as *Acerihabitans actinidiae* and *Acerihabitans deliciosae* species, respectively. The KWT128 T strain is a novel species within the genus *Symbiopectobacterium* , proposed as *Symbiopectobacterium verdissimus*. KWT595 T is a novel species within the genus *Frondihabitans* , proposed as *Frondihabitans actinidiae*. In terms of plant health effects, none of the strains, even those that have been isolated from diseased kiwi leaves, showed any phytopathogenic potential or antagonistic effect against Psa when inoculated on the fruits or leaves of *A. deliciosa*.

Effect of NAA, AVG, and 1-MCP on pre-harvest fruit drop, fruit maturity and quality of 'AU Golden Sunshine' kiwifruit

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‘AU Golden Sunshine' often exhibits a pre-harvest fruit drop that occurs just before harvest that could cause economic hardship to growers if not curtailed. A two-year study was conducted to determine the effectiveness of 88mg/L NAA (Fruitone®), 264mg/L AVG (ReTain®), and 158mg/L 1-MCP (Harvista®) at preventing pre-harvest fruit drop of this kiwifruit cultivar. Treatments consisted of each chemical alone, AVG + NAA, and 1-MCP + NAA applied at approximately 7, 14, and 21 days before anticipated harvest. During year one of the study, pre-harvest fruit drop ranged from 5.6-13.6% on average with no conclusive efficacy of the treatments to deter fruit drop. During year two, the incidence of pre-harvest fruit drop was substantially higher than the previous year, likely due to insufficient irrigation, with averages ranging from 32-66%. No differences were observed between treatments. Fruit maturity and quality were largely unaffected by treatment applications throughout the entire study. Further research is required to better understand the causes of the pre-harvest fruit drop behavior that 'AU Golden Sunshine' displays as recommendations cannot be made at this time.

Kiwifruit sensory properties: collecting data using a 'check all that apply' (CATA) methodology

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The Sensory and Consumer Science Team at Plant & Food Research have been measuring the sensory properties of kiwifruit as part of research on fruit production systems, storage treatments and development of new cultivars, for over 40 years. The sensory properties that have been a focus in this research include texture, flavour (both taste and aromatic components) and appearance. While starting out using both trained and expert panels to measure sensory properties of kiwifruit, we have now swapped to the use of consumer panels for which we employ CATA (check all that apply) methodology. This process involves providing consumers with a list of sensory attributes, and each relevant attribute is ticked. The order in which sensory attributes appear varies according to a randomised complete block design to avoid order of appearance effects. While the data are binary, our research has demonstrated that the number of times a particular sensory attribute is checked is related to the perceived intensity. Among the advantages of this methodology is that there is no need to train participants, and measurements of flavour and texture can be collected alongside consumer liking n in other approaches, asking about liking can bias the information on flavour. In this presentation we discuss the methodology, the facilities used to collect sensory data, and provide information on the typical sensory attributes used by consumers to describe kiwifruit.

Poster 8.3 Postharvest & Sensory

Volatile profiling of ‘Hort16A’, ‘Zesy002’ and ‘Zes008’ kiwifruit

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With the loss of *Actinidia chinensis* var. *chinensis* 'Hort16A' fruit since Psa-V disease arrived in New Zealand, *A. chinensis* var. *chinensis* 'Zesy002' (brand: Zespri™SunGold™ Kiwifruit) and *A. chinensis* (Planch.) var. *chinensis* 'Zes008' (brand: Zespri RubyRed™ Kiwifruit), with better Psa-V resistance, were developed as key replacement cultivars for the industry. 'Zesy002' is a juicy, fruity, tropical sweet-tasting fruit with a hint of sour flavour, similar to that of 'Hort16A'. 'Zes008', with its radiating red-fleshed colour, has refreshing raspberry flavour (consumer description). Previous studies showed 'Hort16A' fruit contained much higher proportions of butanoates, relatively low aldehyde concentrations and 2 impact compounds, 1,8-cineole and DMS. This distinctive volatile chemistry contributed to its highly tropical flavours, compared with the high-aldehyde, higher-acetate ester *A. chinensis* var. *deliciosa* cultivar 'Hayward', which has greener, grassy flavour. This study focused on volatile profiling of 'Zesy002' and 'Zes008' fruit in comparison with 'Hort16A'. Fruit harvested at optimal ripeness from three orchards across New Zealand over two seasons were monitored. After one month of cool storage (1°C), the volatile profiles of eating-ripe fruit were analysed by gas chromatography-mass spectrometry (GC-MS). Samples were extracted by both headspace solid phase microextraction (SPME) and diethyl ether solvent methods. Highly volatile, low molecular weight flavour compounds and less volatile, higher molecular weight compounds were analysed. Volatile profiles for the different cultivars from different orchards and seasons were evaluated for similarities and differences. Key compounds with high odour activity values (OAV) probably contribute to aroma and in-mouth flavour; relative abundances of these were compared between cultivars. Information generated by this project, combined with sensory and molecular biology, will help advance our understanding of cultivar flavour variability due to environmental and seasonal factors. Understanding and controlling this variability will be key to ensuring new cultivars are as successful as 'Hort16A' for the New Zealand industry.

Use of LED lighting in post-harvest and its effect on kiwifruit quality

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The use of LED illumination, which substantially reduce the energy cost, opens new possibilities for its use to increase fruit quality. Post-harvest treatments with LED light, including White, monochromatic treatments of Red, Blue, Green, UVA, Far-Red, and a combination of red and blue (with R:B=1) where performed on A. chinensis var. chinensis fruit of during cold storage for 144 hours. R:B treatment was also performed for half of the duration (72 h). As control treatment, fruit were maintained in the dark. Average light intensity was set between 105 and 120 m mol m^{-2} sec^{-1}. Fruit were stored for 90 days and analyzed every 25 days. Effect of post-harvest disease (i.e. *Botrytis cinerea*) and disorders (i.e. storage break down, softening) were assessed. Fruit quality parameters and water loss were also measured. All light treatments caused an increase of weight loss in comparison to control ranging from 0.7 to 3% accompanied with an increase of flesh dry matter. The effect of light treatments on fruit quality parameters decreased over time and at 90 days no significant differences were observed. UVA, White and FR tended to slow down fruit softening. The light treatments did not reduce physiological disorders, but influenced the incidence of microbial spoilage.

***Young mind award**

Implementation of an automatic system for determining the red pigmentation in red-fleshed kiwifruit 'Oriental Red'

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Red-fleshed *Actinidia chinensis* fruit are new to the market; the pigmentation and the reports, that outline their benefits for human health, attract the attention of consumers. The development of a consistent red flesh pigmentation is linked to consumers acceptance. In order to provide to the market a high-quality product, the intensity and the percentage of red pigmentation are the colorimetric parameters used to classify commercially the product and evaluate the quality. Currently, the determination of the colorimetric parameters is carried out by expert operators who visually assess the quality, making the evaluation subjective and time-consuming. This work aimed to develop an automatic method to determine the intensity and percentage of red pigmentation on *Actinidia chinensis* 'Oriental Red'. The acquisition system consists of a box (80x80x80 cm) equipped with four led lamps, a 4K camera with a resolution of 3840x2160 and a lens from 2.8 to 12 mm of zoom, and a blue stand characterized by a grid for placing at least 35 kiwi slices. A Python script was developed to automatically analyze the image and provide the intensity and percentage of red pigmentation of each slice. The automatic image analysis follows four steps: 1) color space conversion from RGB to HSV; 2) spatial segmentation of each slice; 3) for each slice, calculation of the pixel number with H values typically of red and yellow/green (the H threshold values can be easily modified); 4) calculation of the ratio between the pixel number of the red and yellow/green pulp. The data elaboration is fast and accurate; it provides the percentage of red pigmentation, mean, standard deviation and the image with the pigmented areas highlighted. The developed method was tested on several lots of *Actinidia chinensis* 'Oriental Red'; and the results obtained by the image analysis and by the expert operators were compared, reporting a very good agreement.

Poster 8.6 Postharvest & Sensory

The antifungal activity and mechanism of silver nanoparticles, natamycin and *Meyerozyma guilliermondii* 37 against pathogens causing kiwifruit post-harvest rot

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Post-harvest rot causes enormous economic loss to the global kiwifruit industry, which considered as the primary fungal disease during the storage, transportation and sales. Currently, there are no effective fungicides to combat the disease. Our results indicated that 75 ppm AgNPs effectively inhibited the mycelial growth and spore germination of four kiwifruit rot pathogens: *Alternaria alternata*, *Pestalotiopsis microspora*, *Diaporthe actinidiae*, and *Botryosphaeria dothidea*. Additionally, AgNPs increased the permeability of mycelium's cell membrane, indicating the leakage of intracellular substance. SEM and TEM observations revealed that AgNPs induced pathogen hypha shrinkage and distortion, as well as vacuolation in hypha cells. The transcriptome sequencing of mycelium treated with AgNPs (24h/48 h) verified that "carbohydrate metabolism," "amino acid metabolism," "energy metabolism," and "xenobiotics biodegradation and metabolism" of "metabolism processes" were the most highly enriched pathways for these DEGs. AgNPs could significantly reduce the symptoms of kiwifruit rot without leaving any Ag + residue on the peel and flesh of kiwifruit. Natamycin is a natural antimicrobial preservative that effectively prevents postharvest decay and preserves fruit quality. The results indicated that 2 mg L^{-1} natamycin effectively inhibited mycelial growth and spore germination of *B. dothidea* in vitro. Natamycin caused *B. dothidea* hypha to shrink and deform, along with vacuolation and plasmolysis in hypha cells, as observed by SEM and TEM. Likewise, natamycin stimulated the accumulation of reactive oxygen species (ROS) in the hypha. The inhibition effect of natamycin on *B. dothidea* inoculated in kiwifruit was dose-dependent, with 500 mg L^{-1} natamycin significantly decreasing the incidence of soft rot to 35%. Furthermore, natamycin induced disease resistance in kiwifruit tissue by activating the antioxidant enzymes superoxide dismutase (SOD) and catalase (CAT), maintaining a low level of malondialdehyde (MDA), and repressing the activity of four cell wall degrading enzymes, as well as gene expression of β-galactosidase (β -Gal) and polygalacturonase (PG). Further field research revealed that pre-harvest treatment combined with the postharvest natamycin application significantly reduced the natural decay incidence of kiwifruit while having no negative effect on soft-ripe quality. Our results showed that *M. guilliermondii* 37 effectively reduced pathogen spore germination rate to 28.52% and decay incidence of inoculated kiwifruit to 42.11% maximumly, whereas cell-free supernatant lacked antifungal activity, implying that *M. guilliermondii* 37 didn't produce direct antifungal compounds against the two pathogens, *B. dothidea* and *D. actinidiae*. In addition, *M. guilliermondii* 37 adhered tenaciously to the pathogens' mycelium and colonized rapidly in kiwifruit flesh. Moreover, yeast strain 37 induced kiwifruit resistance by elevating the defense-related enzyme activity, increasing the antioxidant substances content, and suppressing the cell wall-degrading enzyme activity. Gene expression was consistent with the corresponding enzyme activity. Further postharvest yeast immersion treatment significantly reduced natural decay to 35.69% while maintaining soft-ripe quality. In conclusion, our findings proved that silver nanoparticles, natamycin,

M. guilliermondii 37 has an antifungal effect on the pathogens of kiwifruit rot disease and may be applied as a safe preservative to reduce soft rot.