International Citrus Congress 2024 – Report

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The 15th International Citrus Congress was held in the Jeju Special Self Governing Province, South Korea between November 10th and 15th 2024. Usually held every four years, the previous Congress was in Mersin, Turkey in 2022, following a delay from 2020 due to Covid restrictions. My attendance at this event was funded by Citrus NZ and First Fresh NZ Ltd.

Jeju Island is the main citrus growing region of Korea. Being a volcanic island, its has rich fertile soil, and a good growing climate. They receive around 1,800 mm of rain per year (similar to Gisborne). The main varieties grown are satsuma type mandarins, and newer types of mandarin and summer orange. There have been a lot of developments in growing techniques in Jeju, including ground covering, and growing under cover. There are government research blocks as well as private companies looking at new variety development and growing techniques on the island.

The Congress began with a Welcome Reception at the International Convention Centre on Sunday evening, which was a good opportunity to meet some new people and catch up with others.

Monday morning saw an opening ceremony with visiting dignitaries from the local area including the Jeju Governor.

The format was for Keynote Presentations during the first session (45 mins) and a further one after lunch (45 mins). In between were concurrent sessions looking at a range of subjects including industry, germplasm and genomics, cultivars and breeding, rootstocks, genetics and DNA markers, biotechnology, omics, plant physiology, climate change and abiotic stress, soil and water management, HLB, diseases, virus, pets, postharvest physiology, processing, engineering, Asian citrus initiative networks, blood oranges, cultivar protection and early commercialisation and nursery. Being on my own, I targeted presentations and topics that fit in with the interests of CNZ and First Fresh with relation to New Zealand conditions, and upcoming R&D work. The abstracts for *all* of the presentations are also available.

The following is a summary of a number of the presentations I attended. Not every presentation attended will be reported, rather ones that have relevant information to CNZ projects, NZ growers, and comparisons to other countries production. I have tried to keep to themes e.g. technology, or HLB, which incorporate information from several presentations into a summary.

Global Summit Round Table:

A round table discussion on Climate Change and HLB featuring Italy, Brazil, Australia, South Africa, India and the USA.

All agreed the ICC is a major conduit for global collaboration on citrus issues.

From Italy, Europe is co-operating and working together in the citrus growing regions to prevent HLB entering the area. Italy is the second largest producer of citrus after Spain, and a large producer of fresh blood oranges. Droughts across Italy have also reduced production recently.

In Brazil, climate change is now having as large an affect on citrus as HLB. Up to 20% fruit loss is occurring due to drought and high temperatures in the main growing regions.

Australia has a wide range of growing areas, and although they only produce about 1% of global citrus, they do have a lot of climate mitigation, simply from geography and a range of citrus growing regions. It may even be that some areas that currently suffer from frosts will actually benefit form some degree of climate change. However, some of the areas where rainfall is increasing are already suffering form more disease pressure.

South Africa also has a number of growing regions, from cool and coastal, to desert. There are always some areas suffering from some climatic event e.g.. drought, flood or heat stress. Shade netting has been adopted in some areas with high heat stress. Costing USD$8-10k per ha, it is providing some heat stress mitigation, as well as up to 30% water saving.

India has one of the fastest growing citrus sectors, and is the 3rd largest in the World, producing 14.7m tonnes which is 9% of global production. The main crop is loose skinned mandarins, but its low production – 13.5t/ha average, from low productivity and poor planting material. They have lived with HLB for over 70 years and continue to be a major issue. Couple that to climate change and unseasonable heat or rain, and it lowers productivity further.

Climate change could reduce the range of growing regions in California in particular. The San Joaquin Valley grows much of the state's citrus, but mandarin and navel production may become more difficult. Shade netting is being widely trialed in these areas, similar to SA.

With regards to HLB, responses depended on where the countries were at with their response, or efforts to keep it out. In Italy, its about keeping it out, so plenty of work going on with high quality production material for new trees, as well as looking at genome editing and precision agriculture.

Rootstocks are another focus. This is similar in South Africa and Australia too, where HLB is not yet present. It would have a massive impact in South Africa, where 140,000 jobs rely on citrus. They too are looking at technologies and rootstocks as are the Australians, where Citrus Australia has deemed it their highest priority, given that its close in PNG. They are also focusing on international collaboration in genetics.

In India, Brazil and California, where HLB is already present, technology also plays a part. In India they are using drones for spraying, sensors for plant health and yield mapping with GIS mapping technology. Rootstocks and technology are prevalent in Brazil as well, but so is moving parts of the industry to newer areas where there is less HLB. At this stage they have prevented the spread of HLB from Los Angeles backyards into commercial growing areas, but this may change soon. Massive education programme in California to help prevent the spread.

Someone from Israel added to the conversation that they have spent close to US$1bn in hi-tech Agriculture, but as yet the uptake hasn't been great. They are beginning to move to things like drone spraying for certain pests such as Mediterranean fruit fly.

Overall, it shows that across the World, there is a lot of time and investment going into technology, and growing systems to counter the effects of climate, and HLB. Over time this will become more widely available and be of benefit to the NZ industry as well.

South Korean Citrus:

An overview of the Korean citrus industry.

Korea grows around 22,000 ha of citrus, and produces 609,000 tonnes. This gives a pretty impressive average of almost 28t/ha, the majority of which is mandarins. They are 29th in overall World citrus production, but 9th globally for mandarin production. Its worth about US$846m to their economy.

Jeju Island was created about 25,000 years ago from a volcanic eruption, and now offers temperate to subtropical growing conditions, off the south coast of the Korean peninsula and South Korean Mainland.

The Citrus belt is on the south coast on deep volcanic ash soil. Records indicate citrus growing in the region from 476AD.

Satsumas were introduced from Japan in 1911, with modern citrus orchards under management being encouraged since the 1960's by the local government to enhance rural development.

In 1987, a protected growing system using plastic tunnels/houses was developed to extend the growing season, and in the 90's, Tyvek ground coverings were introduced to enhance outdoor production with yield and brix increases.

Local government support since the 2000's has seen the area in production decrease, as they aim to manage grower income and fruit supply.

All production in Jeju consists of Satsuma's and mandarin hybrids. With the combination of open field, heated and non-heated tunnels, mandarin production continues for 12 months of the year. All are grown on trifoliata rootstock.

Recent breeding in Korea has focused on a range of characteristics including flavour (high brix/low acid), timing (12 month supply), colour (deep orange/red), easy peel, seedless, and disease resistant. These newer varieties are slowly replacing older ones, to maintain the citrus status above that of other fruit where there is now more competition.

Ground covering using Tyvek is aimed at enhancing fruit quality and reducing water loss from blocks (see more in the Field Trip section).

Mites, scale, aphid, leaf miner and thrips are all common pest problems. Canker, scab and Melanose are the main disease issues, hence the requirement for disease resistance in new cultivars. Plastic tunnel houses can enhance the effect of any pest and disease, requiring careful management.

Packing is undertaken n a range of packhouses ranging from smaller scale (3,000 t/yr) to larger operations at 10,000 t/yr. NIR (Near Infra Red) camera technology is used on the lines to grade for brix, as well as standard cameras for blemish and size. Mainly packed for the domestic market.

Large emphasis on gifting culture, hence the brix cameras to attain the highest quality fruit for those markets. 60-70,000 tonnes per year is processed into frozen concentrate, with the citrus peel being processed into animal feed and solid fuel pellets.

Labour shortages are an issue. Technology is being developed to help reduce these shortages and reliance on labour. This includes automatic/robotic sprayers, unmanned machinery, AI and sensor technology for automation. It also includes early work on trellising (tree form modification) within plastic tunnel houses.

Altering the soil microbiome in Florida using cover crops

Of interest due to the comparable work with ALT and CNZ on cover cropping in citrus in NZ.

This project looked at the soil benefits of growing cover crops in Florida. The soil in Florida is vastly different to that of New Zealand, but the benefits to the soil, and the issues they are trying to resolve are very similar.

Floridian citrus is grown in “beach sand” type soil. This requires the application of 200kg/ha/yr (around double that of current NZ recommendations). The blocks are managed with herbicide and mowers. Growers are now beginning to look at trying to increase their organic matter content with the use of cover corps, compost applications, and humic & fulvic acids.

Cover crops were planted to increase Nitrogen fixation (using legumes), suppress weeds, reduce soil erosion and compaction, increase soil moisture retention and organic matter.

A range of crops were planted in both May and November. Summer crops included Sunhemp, cowpea, buckwheat, millet and wheat or sudangrass. Winter crops were sunhemp, cowpea, clover, radish, oats and rye. Sunhemp, cowpea and clovers are all legumes that fix nitrogen.

After 3 years of trials, there was a significant increase in organic matter content, as well as the bacterial and fungal content and composition in the soil. They also found changes in the nitrogen cycling genes, carbon, nitrogen and nitrous oxide emissions, changing the total complex of the soil and leading to changes in nutrient availability for the trees.

Further work will be completed overtime on long-term effects. I mentioned our work on the other side of the cover cropping work, which was about bringing in beneficial insect species and the

benefits they may have on controlling pest species. This is something they hope to extend the project into, as any assistance with controlling ACP in Florida would be beneficial.

Chilean Citrus Industry:

The Chilean industry has grown hugely over the last 25 years with developments in new varieties and new export market access. The USA is the main export customer for Chilean citrus, now representing 86% of their export market. 15 years ago, this was 43%. This has mainly been driven by mandarins, with a lot of growth over the last 10 years. 399,000 tonnes were exported in 2023, with a FOB value of US$ 460 million (Average FOB (delivered) wholesale selling price of NZ$ 2.05/kg across all varieties).

There are 28,000 ha of citrus in production in Chile (NZ - +/-1500 ha), in various regions which have helped extend the growing and therefore export seasons. Mandarins represent that largest area at almost 12,000 ha, followed by lemons at 9,000 ha, and oranges at 6,000 ha. Mandarin varieties include Murcott and Tango, Oranges are Fukumoto, Lane Late and Cara Cara, with lemons being mainly Eureka, Fino and Messina.

Export OGR's are around NZ$1.30 for mandarins, and NZ$0.70-0.90 for oranges and lemons. Note that the shipping costs between Chile and their main market of the USA are significantly lower than shipping fruit from NZ to Asia or the USA.

There are many challenges in the Chilean industry including. Climatic concerns from persistent droughts in northern areas. More competition entering the US market. Orchard maturity leading to stagnation of production. Competition for land and water from other horticultural crops, some with higher profit margins. As with everyone else – labour and a need to reduce input costs.

The local industry body has a Citrus Export Committee to support promotion and market access as well as research and development projects to improve competitiveness.

New Varieties – commercialisation.

Lots of presentations from various countries with regards to their breeding programmes. A lot of breeding is focusing on mandarins, and in particular colour traits (red) and seedless fruit. As Citrus

NZ is involved in evaluating and potentially commercialising some new varieties in the future, it was interesting to see how some other countries go about this.

CREA in Italy for example is working on crosses between Clementine and Tarocco Blood Orange. They also have a fast track system to get varieties into production faster. This involves granting licences to growers to evaluate between 30 and 200 plants of each new selection. If a selection progresses, the grower can get 5 years of priority growing and a discount on royalties. The growers are also able (at their own risk) to take advantage of good selections, by planting before the end of the evaluation period.

In Uruguay the National Institute of Agricultural Research (INIA) has a process to certify new technologies, which includes new varieties. The process aims to "certify that the knowledge an technologies are applied, solve problems, exploit opportunities and create economic, environmental and social value".

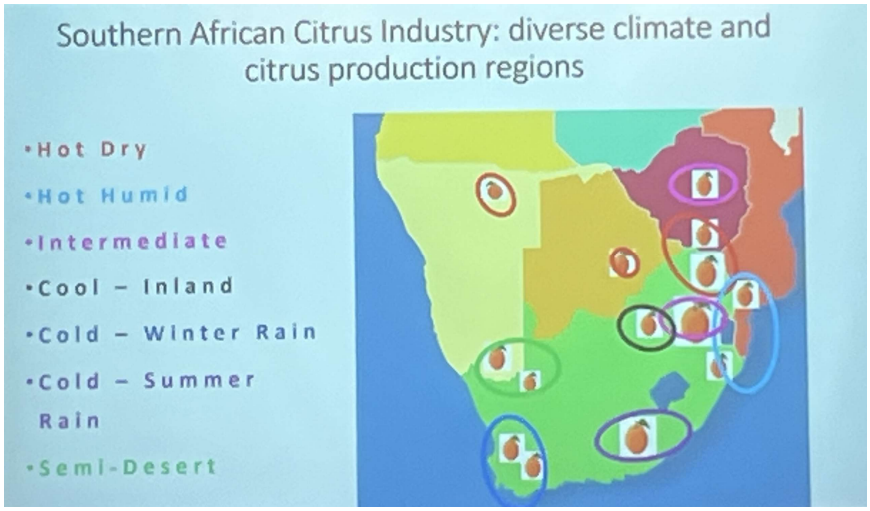
A grower committee decides what to commercialise. The initial process goes through an internal committee who approve or deny the proposal. If approved, it goes through to the external committee where it is discussed and then certified. Stage3 then puts the selections into evaluation to look at yield, alternate bearing, post harvest and customer testing. At that point it gets approved by the "Certec Agro" and then set for release.

Once released domestically, EOI's are then sent out for partners to licence the variety for the northern and southern hemispheres. Licences are then granted, and they are sent to different territories to clear quarantine.

To gain new varieties, pare million tonnes of citrus, of which cntal lines have been generated, irradiation is used, natural mutations are collected and tissue cuture established. New varieties are tested in the local market before going through the international process as above.

Southern Africa (Inc South Africa, Zimbabwe, Eswatini, Botswana, Namibia and Mozambique).

Southern Africa produces 3.95 million tons, 2.25 million tons of which is exported, primarily to the northern hemisphere for counter-seasonal supply (Asia, Europe, USA). There are 99,700 ha registered, with a huge climatic variation across all areas, and the full range of citrus being grown. Sea voyages are 25 days on average from port to customer.



CRI (Citrus Research International) is a grower funded and owned R&D company to provide practical solutions to citrus growers to sustain production and export. The cultivar and rootstock evaluation program focusses on field evaluations in all climatic zones and reports the results independently. CRI is not involved in breeding and commercialisation. CRI collaborates with private companies that source international varieties, as well as sourcing local varietal mutations. CRI then establishes evaluation blocks where comparison can be made with long term standard varieties. Enough fruit is required so that it can undergo post-harvest testing including cold treatment.

Evaluations concentrate on commercial export viability above all else. Also describing characteristics – fruit size and distribution, shape, colour, seed, brix/acid/juice, tree growth and habit, yield, production efficiency, chilling sensitivity. Climatic suitability and commercial potential are also key.

Reporting to the industry includes trueness to type and stability of the variety, characteristics (informed in fact sheets), information on the owner/breeder/manager of the variety, publishing in the SA fruit journal, and on the web based platform – CRIPS (Cultivar and Rootstock Information Platform).

HLB/ACP– various:

Again, there were many presentations on HLB. The following is a selection of the more practical aspects of control and prevention as well as some general information on the disease.

- What is HLB – HLB (Huanlongbing) is a citrus disease caused by a bacterium Candidatus Liberibacter asiaticus (Clas). Clas is transmitted by the Asian Citrus Psyllid (ACP). An ACP may be “hot” (infected with Clas) or “cold” (not infected). Only “hot” psyllids can transmit the bacteria and cause the disease. They are born uninfected, and only become “hot” once they have fed on a HLB infected tree. At that point they can then pass the disease on to other trees.
- Clas initiates an immune response in the tree which affects the phloem, and causes HLB symptoms. The infection triggers to production of ROS (Reactive Oxygen Species), which causes iron leakage in the plant, leading to yellowing.
- Clas is not affected by the gut bacteria in ACP, which is how it manages to survive to be transferred from tree to tree via the psyllid.
- Ongoing breeding work with Microcitrus (Australian Finger Lime), as it appears to be more resistant/tolerant to HLB. Aiming to breed the resistance trait into a “standard” type of citrus e.g. mandarin.
- Work is being done on GA applications to help strengthen the fruit of HLB infected trees. Also work on thinning fruit numbers, and also increasing the leaf area through nutrition, to help reduce HLB induced fruit drop.

HLB - Florida:

When planting new orchards, Floridian growers are using individual tree covers to maintain a psyllid free environment when trees are young. Lots of work going on with new therapeutics, resistant cultivars, sterile psyllid use. There is also work being done with using finger lime interstocks, as it is believed they are more resistant to HLB.

CUPS (Citrus Under Protective Structures) is a relatively new development and being trialed (was also mentioned by Nate and Anna Jameson when they were in NZ). This is a fully covered, psyllid proof structure. High costs, so good for higher value, fresh fruit crops (rather than juice). The structures also create a warmer atmosphere and therefore often have larger fruit. Currently there is a 75 acre trial in Florida, with a range of different rootstock and scion combinations.

HLB - Brazil:

Most citrus production is in the Sao Paulo region. Climatic change including warming and drought have been reducing yield and fruit size, couple with HLB. Currently, climate is a bigger concern for Brazilian growers than HLB.

Brazil grows almost 464,00 hao f citrus, with the majority (400,000 ha – 86%) being Oranges. 11% (51,000 ha) is lemons and lime, with the remainder (3% - 13,900 ha) in mandarins.

HLB was first detected in 2004, and is now also found in Argentina and Paraguay (neighbours). It isn't present in the North and North-Eastern regions of Brazil.

Up to 2022, the infection rate stayed around 17-22% of all orchards. In 2023, it climbed to 38% and in 2024, was 44%. This rapid increase was associated with the incidence of ACP increasing, with large population spikes that corresponded with the weather condition changes. There are now 32,000 ACP traps throughout the citrus belt to monitor progression.

ACP are attracted to new, soft growth, so areas where growth is constant throughout the year have greater chances of infection. It is though that the opportunity for infection in the north of Brazil will be much lower due to more seasonal growth.

ACP and HLB continue to spread faster where the problem aren't well managed. Diseased tree management can be poor, with slow tree removal and destruction. Poorly managed trees are more difficult to spray and get good coverage therefore ACP control isn't as effective. Some resistance has also been found to chemical controls. Milder weather brings around more tree flushes, which increases the likelihood of ACP transferring HLB to clean trees.

HLB impact is lower where growers are doing a good job of managing their orchards from planting, irrigation, groundwork and husbandry. The removal of Murraya (mock orange – ornamental garden plant) plants from areas where citrus is grown commercially has also helped. Production areas are

also beginning to move North, along with the infrastructure required e.g. packhouses and juice factories.

Orchard management is key, replanting with certified healthy trees, regular pesticide applications at growth flushes, monitoring and tree eradication, best management of nutrition etc, and maintaining natural enemies all help citrus thrive and manage the HLB problem.

HLB – Indonesia

Indonesia has small family farms, typically less than 0.5ha, however the total citrus production area is 57,000ha growing 2.5 million tonnes. Murraya is a common plant for gardens and hedges and harbours ACP.

The reduction in yield due to HLB infection is being offset by also growing cash crops in the same area as the citrus. It has also been found that some of the cash crops grown can help repel ACP.

Australia – Rootstock work for HLB:

27 HLB tolerant rootstocks have been planted in October 2024 to evaluate their suitability for the Australian conditions.

California – Work undertaken at UC Lindcove:

At this stage there is no HLB in commercial production areas in the Central Valley of California. UCL are conducting surveys for ACP and HLB, as well as working on a cure for the disease.

69 varieties that have shown some resistance or tolerance to HLB have been introduced to California, and are undergoing trial work to see their suitability for the growing conditions.

A CUPS (Citrus Under Protective Structure) trial is underway at Lindcove. This is the first structure of its kind in California (see below), and is a 4.5 acre (1.82ha) screenhouse to exclude ACP.

The aim is to look at whether they can grow under CUPS in California, and the performance of the varieties, as well as if there are any other benefits e.g. water saving.

At this stage, tree inside the structure are larger than their outdoor counterparts at the same stage. This is likely similar to what is seen with Afourer under net in Australia, where they grow longer, faster toward the light.

Juice production:

In 2023, 69.7 billion litres of orange juice was produced with a value of 140.2 billion Euros. Orange juice is currently four times more expensive than it was 12 months ago (As at November 2024).

Trends for 2024/5 include smaller pack sizes, to reduce costs of production and maintain retail pricing. NFC (Not from concentrate) juice continues to be popular as people want natural, less processed options. HLB and climate impacts are still having a major effect on juice availability and pricing.

Blood Oranges:

Although not widespread in New Zealand, they are becoming more popular overseas as the health benefits of the anthocyanin compounds, and the deep red colour attract customers.

Italy is the home of blood oranges, with 40,000 ha being grown, the majority in Sicily. China grows around 33,000 ha and the USA around 730 ha. Smaller areas are also being grown in Spain, Tunisia, South Africa, Australia and Japan.

They were first referenced in Italy in 1646, when they were introduced by a missionary returning from the Philippines. By 1935, there were 10 varieties in Sicily, eventually isolating Tarocco selections, then later also using Moro and Sanguinello to extend the season forwards and back. These three varieties allow harvesting from late November to March.

New selections based on these original varieties are developed through limb sport mutations being found, or selective breeding e.g. modern Tarocco varieties now include Tarocco Rosso, Ippolito, Meli and Lempo.

In the USA, there have been discoveries such as the Smith Red Valencia, discovered in a LA backyard in 1988. It was originally thought to be a spontaneous mutation of a Valencia, but that parentage has been questioned more recently. The Shahani Red was discovered as a mutation of a Washington Navel in 2008 and has been commercialised in California.

Blood oranges are rich in beta-carotene, which strengthens the immune system and converts to vitamin A as the body needs it. They are also rich in anthocyanins and flavonoids, these are the pigments that colour the blood oranges and help trap free radicals in the body, helping prevent things like cardiovascular disorders.

Blood oranges are dependent on temperature to develop their colour. In warm winters, colour development is poor. Moro, for example, requires chilling units of 450 hours at 0-7.2 degrees from the start of colouration to harvest.

Citrus Industry in Gannan Province – China

An interesting look at this industry in a single region of China. The area was highlighted as the area best suited for navel oranges in the “Development Plan for Citrus Advantageous Regions (2003)”, with the ability to grow high quality, fresh navel oranges.

Since then, 130,000 ha have been planted, over 35% of the total area of Navels in Chuna, and over 16% of Global Navel production!

This produces 18 million tonnes of navels per year – almost 13% of Global production (39% of production from China)

They also have a National Navel Orange Engineering Research Centre, which specializes in navel orange research. This includes breeding and cultivation, disease and pest control, commercialisation, equipment development, and post-harvest.

Tree Physiology – pruning, tree density and trellising.

Not included – the information from the March 2024 report on the visit to Australia was more comprehensive, and some was repeated e.g. from our visit to the DPI at Dareton, which was also presented here.

Nutrition:

In Brazil, growers are adapting to new technologies and have managed to increase their yields from an average of 17t/ha in the 1980's to over 40t/ha in the 2020's. This is all against a backdrop of abiotic and biotic stresses in the orchards including extreme temperatures and radiation, heavy metals, nutrition and bacteria (Clas/)HLB). All of these have an impact on fruit yield. To counter any of these issues, effective nutrient management is required by growers to maintain quality and yield.

Getting the balance right between ammonium and nitrate applications is one key. Solely using ammonium based nitrogen (Urea, sulphate of ammonia etc) will, over time, increase the acidity in the soil and affect the uptake of other nutrients. Nitrate is more readily available to the plant. In NZ we have options such as Calcium Nitrate, or a mix of ammonium and nitrate in the form of CAN (Calcium Ammonium nitrate).

Balancing Calcium and Nitrogen applications is also crucial for promoting cell wall integrity an disease resistance in flowers, leaves and fruit. Increased calcium supply has been shown to help reduce post bloom fruit drop. In Brazil, extreme heat and radiation has caused up to 30% higher fruit drop compared to the year before, so any nutritional assistance to reduce this should be used.

Nitrogen and magnesium also play an important role,, maintaining photosynthesis under stress conditions due to maintenance and enhancement of chlorophyll. Brazilian trials over 4 years have shown that increasing the soil applied magnesium from 0 to 100 kg/ha/yr increased the yield by 4t/ha. Similarly, regular foliar magnesium sprays increased yield by 3t/ha. An average of 65-8% increase in productivity.

Most micronutrients are best applied through foliar applications. Molybdenum improves nitrogen usage and efficiency, especially where orchards are fertigated. Other micronutrients such as boron, copper, zinc and manganese are vital for cell membranes and antioxidant enzyme activity. Which all help the plants be resilient in stressful conditions. Boron is better applied by the soil, but care must be taken to apply the correct amount as boron can become toxic to citrus.

Different rootstocks can also have quite different nutritional requirements, and so must be taken into account when designing a nutritional programme.

Technology:

At IVIA (the Valencian Institute for Agricultural Investigation) in Spain, there has been ongoing work on robotics, working with Pellenc since 1997 on harvesting technology.

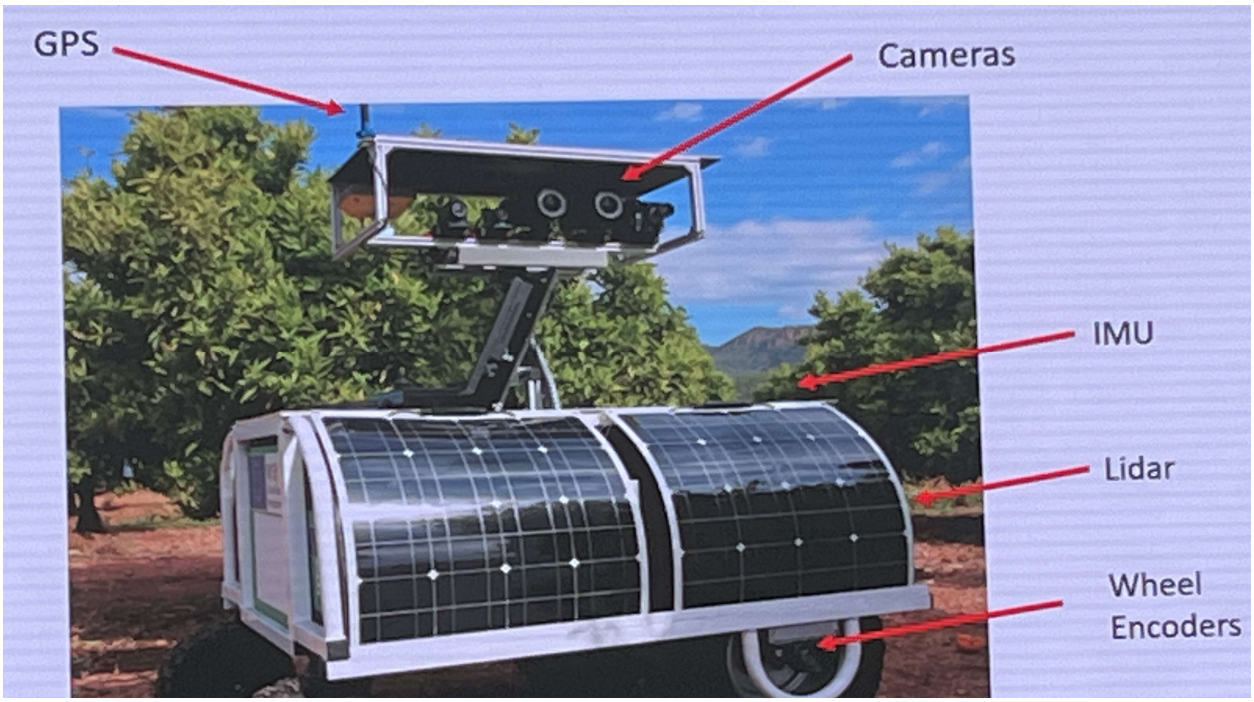
Sensors are now a big part of the research, with the data collected enabling growers to make better decisions around crop management and production, optimizing irrigation, nutrition, and harvesting using real time data. This can improve sustainability, using water and fertiliser when and when required, reducing usage, as well as maximizing yields and reducing losses.

Optical sensors work by turning light, into electronic signals. The changes in energy absorbed and reflected by plants can be measured by optical (spectral) and thermal cameras. The sensors measure electromagnetic radiation at different wavelengths, both visible and NIR (near infra red) for things that aren't visible. Sensor types include colour cameras, multi and hyperspectral cameras, thermal cameras and LIDAR. LIDAR creates a 3D picture of the structure of a plant via a laser scanner that emits a beam an measures the reflection time to calculate distance. It produces a 3D structure of biomass and growth and can also detect fruit through shape analysis.

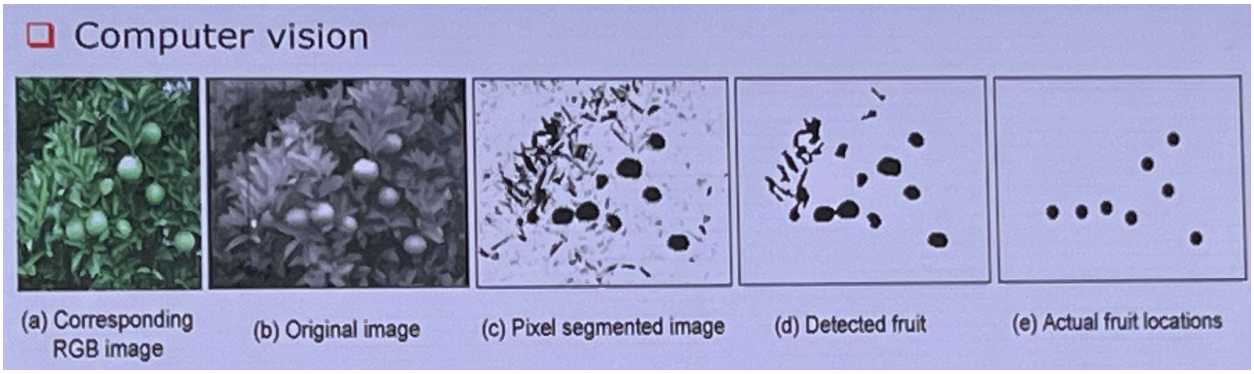
Visible information that can be captured and used includes pigmentation, chlorophyll, and photosynthetic activity, infra-red information captured includes cell structures, water content, evapotranspiration, temperature and stresses.

There are multiple platforms on which these sensors can be attached. Satellites can get land information. Planes can get land, orchard (plot) and plant data. Drones, hand held and UAV rovers can get plot and plant information.

Yield prediction is still challenging. We know its important for planning, harvesting and marketing but there are challenges with the way that citrus trees are traditionally grown, with lighting, hidden fruit, occlusions, clustering, maturity and size all compounding issues.



The robot above (built by Robotnik) has been fitted with cameras to look at fruit counting and yield estimation, analysing what it sees and turning it into fruit locations in the tree, as below.



The technology requires “teaching” using thousands of images, from which an algorithm can then be trained to take over and analyse the data.

Another technological advancement is that of insect identification using smart traps. These capture images of trapped insects in the field and send them directly to the manager/agronomist using the mobile 5G network and geolocation. Software can be sued to track the evolution and spread of pests in an area and correlate that with climatic data.

It appears from most presentations that technology is advancing, and in some cases, such as sensors, and smart traps, there are some practical solutions forthcoming in the near future. We are still a long way off from any type of robotic harvesting and even yield assessment whilst citrus is still grown in the traditional manner. Growers need to understand their needs before adopting expensive technology, and keep expectations low at the start! There are certainly no universal solutions and the tech will only be as good as the initial information that is entered – all needs valid ground truth from traditional methods first.

Dwarfing Viroids:

Although not yet available in New Zealand, these are being used in Australia, and could be beneficial options for higher density, or trellis plantings.

In a long term trial in Australia, Bellamy navel oranges on trifoliata were inoculated with various different viroid’s in 1989. They were planted at their “standard” spacing of 6.7m x 3.3m, along with uninoculated control’s. Inoculation occurs around 12 months after planting. Trees grow normally for a number of years after inoculation, so timing is critical to enable to get the tree canopy developed, before the dwarfing effect takes over.

LiDAR has been used to map the tree canopy volume, height, light interception fruit production (size and quality) for 3 season from 2022. 35 years since inoculation, the canopy volume and height of the tree was significantly less than the control, but the light interception rates, fruit size, quality and yield were the same as the control.

This has shown that the viroid is persistent over the life of a tree and could be used to plan future orchards. Knowing the viroid type and its overall effect is critical, however it could lead to the ability to increase tree density, therefore optimizing yield. It also can help management efficiency with spraying, harvesting and pruning.

Future work for the DPI is going to look at the effects on other varieties e.g. mandarins, as well as the suitability for using them to grow on trellis structures.

Rootstocks

Some interesting work is going on in rootstock development. This concentrates on developments in California and Australia.

UC Riverside (California) are working on developing new rootstocks for California conditions. The state grows mainly fresh fruit for export and the domestic market primarily across oranges, lemons and mandarins. Like Southern Africa, there is a diverse range of soil types and climates, and can be subject to freezes. CTV, phytophthora and dry root rot are all common current issues. HLB is not yet present in commercial areas but is in Southern California, so is a primary concern for breeding new rootstocks (and scions).

In one trial, of M7 navels planted at “high density” – 800 trees/ha, the range of yield and brix from the various rootstocks was stark. From 160 kgs per tree (brix 12.9) down to 43 kgs per tree (brix 13.4).

At the DPI NSW in Dareton, there has been work on rootstock trials since 1993 when 47 trifoliate rootstocks were brought in from China. All of the ones that succumbed to diseases e.g. phytophthora were removed. Six of these were commercialised in 2020 and available through Auscitrus.

There is also work trialing other rootstocks including one with salt tolerance, and a dwarfing rootstock. A further 3 have been imported from Italy, and 6 Spanish ones are expected to be

imported soon. On top of this and as mentioned earlier, there are 27 HLB tolerant/resistant rootstocks also in trial.

Field Trip:

The middle day of the conference was a field trip, taking in an orchard, packhouse, the Jeju International Citrus Expo, and the UNESCO World Heritage Site – Seongsan Ilchualbong Peak.

The orchard consisted of Gungcheon Early satsumas with 30-40 year old trees. The total orchard was 1.98 ha, with 0.825ha under cover. The rest had Tyvek ground cover (Fig 1.) to help with ripening and ground conditions.

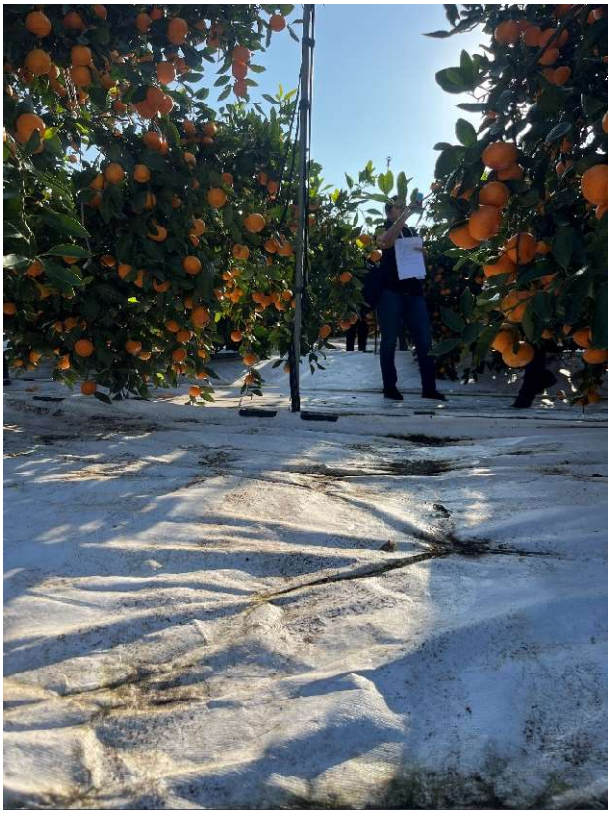


Fig 1 – Tyvek ground covering

Fig 2. Each tree is identified.

Each tree has a unique identification number. At harvest, a portable refractometer is used to test the brix levels. I believe this was a portable non-destructive unit which is held up against the fruit to get the result. Trees that have a brix level over 13 have baskets place underneath. Pickers then pick those trees only. The others wait until the brix levels have been achieved. This method of

harvest ensures that the growers maintains a strict quality standard and gets a premium for that fruit.

A pole is erected through each tree, where strings and clips can then be used to hold branches up, and take the strain of the fruit load – Figures 3 and 4.

Fig 3 – Pole and string system

Fig 4. High fruit loads on branches.

Fertiliser is applied in the spring for flowering and tree growth, with many of the liquid fertilisers being bespoke mixtures produced on site. Fruit quality was excellent, as was the flavour.

Fig 5 – Quality fruit

The grower had extended the season by covering an area in greenhouse, which enabled earlier fruit harvesting.

Harye Citrus Hub Packhouse

This packhouse was a 3.3 ha site with a 1.15 ha packhouse processing about 20,000 tons of citrus an employing 80 people.

The peak packing time for open field citrus is from October to February, and was at the peak when we visited. It was a standard packhouse configuration, with washing, waxing and drying before the grading. It just happened on two different floors! As with many modern packhouses, all of the fruit was sorted by camera graders. NIR cameras also graded the fruit on brix levels, and coupled with the optical sorters, graded fruit by size *and* brix.

The premium brand from this packhouse guarantees a brix level of 12 and acid below 1.0. The NIR cameras, coupled with the brix based picking from orchards ensures the quality of the product, and this is recognized as one of the premium Korean brands.

Fig 6 – Premium packagaing

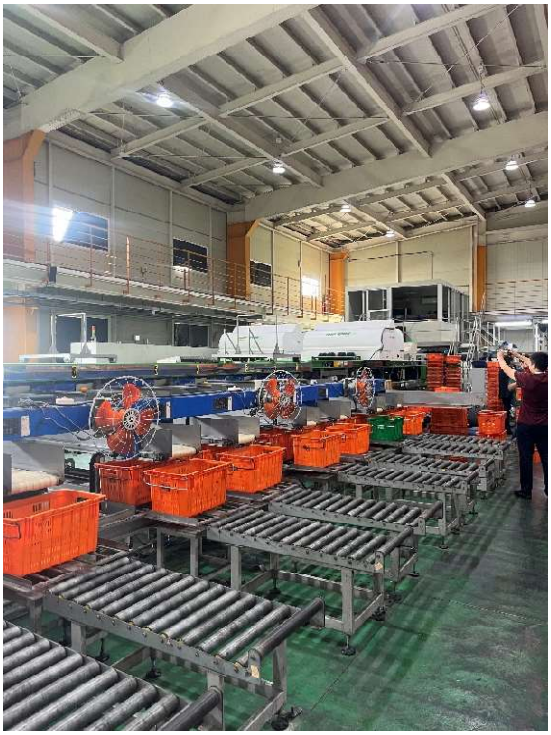


Fig 7 – Optical sorting (Maf Roda)

Jeju International Citrus Expo

The Citrus expo is an annual event organised by the lcoal government for the citrus industry. Its basically an A&P Show for citrus, with events, talks, shows, food, exhibitions and all manner of trade dsipalays all relating to citrus growing, packing, processing and marketing. It also has well-being workshops for local growers and health promotion of citrus for everyone.

We arrived for the opening cermeony on the first day and had some time to have a look around the trade shows. The show is held at the Agricultural Technology Centre, and aslo contains a greenhouse featuring many of the variteis available in Jeju (a little like the Germplasm block that PFR have in Kerikeri).

The trade shows were interesting, featuring much of the small scale machinery used in the Jeju orchards.

Fig 8 – Jeju International Citrus expo

Fig 9 – Okitsu in the greenhouse

Fig 10 – Small scale spray unit

Fig 11 – Remote controlled mulcher and sprayer

Summary:

Once again, it was very worthwhile having New Zealand represented at this International event. It is noticed by delegates from other countries that NZ is represented, many of whom don't realise that we grow citrus!

It is good to get an insight into various countries citrus industries, size, mix, export markets and have a feel of the trends that are affecting global markets and customer preferences e.g. seedless and colour (red). New breeding is taking advantage of this, as well as trying to breed in HLB resistance.

HLB is still a huge focus worldwide, and the information included here shows some of the progress that is being made. NZ can take advantage of contacts we have made, and current research if the need ever arises and HLB/ACP arrives.

New technology is progressing in the form of data collection and analysis, developing good management tools. These tools will help growers become more effcicient and sustainable over

time. Automation of irrigation, spraying and packing technology also continue, but there is slow progress on harvesting.

Hearing about various ways to commercialise citrus varieties was interesting and pertinent to the work we have ongoing with PFR and the mandarin vaiety trials. There are some aspects we can potentially incorpoate into our ongoing discussions and trial work.

Looking at sustainable growing methods that incorpoate activities such as cover cropping and the use of biological compounds are gaining momentum, compared to previous Congress's.

The ability to meet new people and gain new connections within the industry is one of the key aspects for me. I was able to renew connections with people from South Africa, Brazil and Australia, as well as make new connections with delegates from the USA, Argentina, Portugal, Australia and South Africa. Having been invited onto the ISC organising committee, I was also introduced to all of the people in that organisation, giving us further contacts across the World, which will aid us in exchanging infomration in particualar for research projects. There is interest from many of these people as to what we are doing in the New Zealand citrus industry, and how there may be some reciprocal areas of research, collaboration or infomration sharing.

A number of the research projects that have been undertaken by CNZ would be worthy of presentation at this event in the future and be of interest to a wider audience. There is interest in what we were doing and the results we were getting in a range of areas e.g. the ALT Cover Cropping, the Navel Orange Maturity and customer acceptance progarmme, and the mandarin variety trial work currently being undertaken, as well as future projects from the Future orchards workplan.