

Harvesting the benefits of fruit nutrition science for a consumer driven future

By Nigel Swarts

Apple growers have a great story to tell when it comes to fruit nutrition. In the push for better fruit quality the nutritive properties of apple fruit have improved in a happy marriage with innovation in orchard nutrient management.

The Australian apple consumer eats around nine kilograms of apples each year, roughly one apple per week. They expect this apple to be visually attractive and provide them with a great eating experience every day of the year. In the supermarket the consumer's eyes scan for vibrant colour, round shaped apples. Next comes the touch, feel and sometimes even smell test – is this apple firm, does it have a great aroma? The cheeky ones might even take a bite for that all important crunch and flavour test. Consistency of experience, particularly flavour, drives the repeat purchase.

Yet the dynamics of what consumers purchase and then choose to include in their regular household shopping lists evolves continually. Now, many consumers want more than just high-quality fruit, they want fruit that is healthy and safe to eat with strong environmental and ethical credentials. Recent food safety scares have heightened consumers' need for assurance that the fruit they are consuming has been grown and packed safely. Consumers are increasingly looking for transparency of production – they want to know that farmers are looking after their employees. Consumers now and more so into the future are concerned about the environmental footprint of the food they are consuming and that the food is nutritionally rich and healthy for them. Growers must now appeal to consumers' deep-seated values to gain product loyalty and repeat purchase. Whilst this may be a niche purchasing trend now, will it be the future for Australia and high value export destinations?

There is now a desire to better understand the story behind what we eat including where it is farmed, how it is farmed, farming systems used and how it is processed. The ability to reach consumers with this information through digital technology is now more possible than ever, with all participants of the supply chain now able to engage directly with the consumer.

Nitrogen know-how has quality benefits

Orchard management of fruit nitrogen is fundamental to a consistently great apple eating experience for consumers and to the environmental credentials of our orchard production system. The benefits of fruit nutrition science, and how growers use this to produce a better

apple, is one of the stories we can tell to engage consumers more deeply.

Nitrogen is the most important nutrient when it comes to managing fruit quality. Fruit nitrogen status strongly influences the development of fruit colour and maturity at harvest. In addition, fruit nitrogen status impacts fruit firmness and texture – all of which affect the consumers' apple eating experience.

The challenge is to place fruit on the shelf for purchase when it reaches its maximum eating quality. Long periods of cool storage make this particularly challenging as fruit continues to ripen slowly, softening and changing flavour. Fruit nitrogen status is a critical component in the ripening process and influences how well apples retain quality through cool storage.



Anundkumar Ajudiya undertaking fruit quality assessments on fruit harvested from nitrogen research trials.

► Over the last five years, tree nutrition research by the team at Tasmanian Institute of Agriculture (TIA) and Plant and Food Research New Zealand has improved our understanding of how:

- an apple tree partitions nitrogen throughout the tree (Morris et al 2018)
- timing of nitrogen application influences fruit quality outcomes (Swarts et al 2016)
- nitrogen moves through the soil profile following fertigation and irrigation events (Hardie et al 2017), and
- the seasonal requirements of nitrogen and water for apple orcharding (Morris et al 2018).

The *Improved Productivity and Profitability for the apple and pear industry* project is part of the apple and pear levy-funded PIPS program, which focuses on providing research outcomes on productivity, irrigation, pests and soils for the apple and pear industry. Further information

on the PIPS program is available at <https://apal.org.au/industry-info/pips>.

We have learned that apple trees are very efficient users and storers of nitrogen. As a deciduous tree, apples have a mechanism where they remove nitrogen from their leaves in autumn just prior to leaf senescence. That nitrogen is stored in branches, trunk and larger roots and is remobilised from storage organs for early spring growth. Our research has demonstrated that almost half of the tree's nitrogen requirement comes from stored nitrogen and the other half comes from root uptake.

Apple trees use stored nitrogen up until a few weeks after bud burst and then switch to uptake from roots. Our research shows that from mid-November through to December, small regular applications of nitrogen up to 3-5kg N/ha (total 20-30 kg N/ha) drip fed through fertigation systems will supply the apple tree with enough nitrogen to drive spur leaf and

bourse shoot growth as well as set up the crop. Nitrogen is also taken from the soil through the process of mineralisation where nitrogen from decaying plant material and the soil organic matter are made available to trees through the activity of soil microbes. Up to 30kg N/ha can be made available through this process depending on soil type and orchard management practices, but it's an important nitrogen source to add to the overall nitrogen budget for the orchard.

Very little or no nitrogen needs to be applied from December until after harvest. This ensures that nitrogen in fruit tissue trends towards the deficiency range for premium quality fruit that will store for extended periods of time. Our research clearly demonstrates that increased nitrogen in Royal Gala fruit leads to a reduced overall red colour coverage and reduced red colour intensity. Similarly, fruit with a higher nitrogen content was less firm at harvest.

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► As soon as fruit is removed from the tree, nitrogen application can commence again. For early varieties such as Royal Gala this can be a very effective way of building nitrogen reserves for spring remobilisation in the following season. For later varieties such as Cripps Pink (marketed as Pink Lady®) harvested just prior to and during leaf yellowing, nitrogen uptake will be less efficient as the trees head into shut down mode preparing for winter dormancy. Management strategies for nitrogen use need to be variety specific.

A fresh apple weighing around 150g contains less than 1g of nitrogen. This means that for a 70t/ha crop just under 50kg N/ha is being removed from the orchard on an annual basis. As fruit is a very powerful nitrogen sink, a significant amount of nitrogen taken up by the tree during the pre-harvest period is removed during harvest. This can be restored by application of another 30-40kg N/ha post-harvest split into small doses, ensuring that leaf tissue nitrogen is restored to optimum levels ready for relocation to winter storage organs.

Our research has shown that pre-and post-harvest drip fertigation little and often, at the right time, has a two-fold benefit:

- Very little to no nitrogen leaches below the root zone so that uptake efficiency of over 75 per cent of fertiliser nitrogen can be achieved (Hardie et al 2017).
- Emissions of nitrous oxide, a potent greenhouse gas, from fertiliser nitrogen are kept to a bare minimum throughout the season (Swarts et al 2016). Apple growing will be among the lowest greenhouse gas emitters per tonne of produce for any agricultural crop.

This good news story around nitrogen management is a win-win, matching consumers' expectations for quality with their growing interest in provenance and good environmental stewardship.

Apples are so familiar to consumers that they are rarely given due recognition for both the nourishment they provide or the important story behind efficient nutrient management that produces the high-quality fruit consumers expect.

Nutrient management in the orchard not only produces fruit firm in texture and rich in colour – these same methods produce apples stacked with mineral nutrients, high in dietary fibre and vitamin C, a wide range of phenols and polyphenols that combine to give apples their renowned antioxidant capacity.

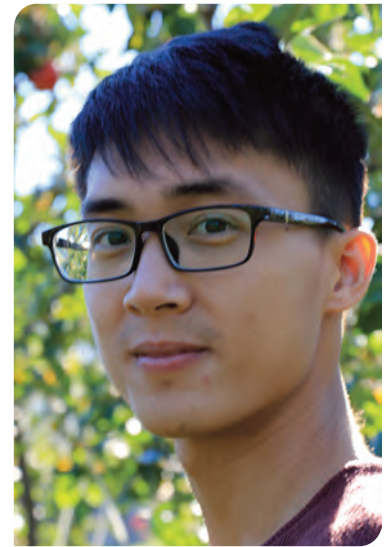
The sustainability (environmental) challenge for tree crop horticulture is to improve orchard management practices that preserve and promote functional biodiversity to reduce reliance on chemical inputs including insecticides, herbicides, fungicides and inorganic fertilisers. A future vision for fruit tree nutrition will see increasing efficiencies and more reliance on sustainable forms of nitrogen to fulfil the annual nutrient budget. Orchards will be more biodiverse containing a suite of inter-row species that:

- provide flowering plants for pollinator services in spring and attract predatory insects for biological pest control and disease resistance
- improve presence and function of advantageous mycorrhizal fungi and other soil microbes
- improve soil health and nutrient cycling and availability.

Consistently producing high quality fruit with a great story will see future consumers eat a lot more than one apple a week and will attract increasing interest from international markets. Studies have shown that almost half of all consumers decide what to buy when they are inside the supermarket. With the proliferation of information, the wide range of influences and influencers and the relative ease of delivering and accessing this information, a good news story to tell such as this one will become ever more important in the consumer-driven future.

Nigel will be speaking at Hort Connections on his research on tree crop nutrition with a specific focus on apples. :afg

PIPS researcher collaboration with WSU professor



Bi Zheng Tan

TIA PhD student Bi Zheng Tan, who works on the PIPS II apple nutrition project, will head to Washington in July to collaborate with Washington State University Professor Lee Kalcsits. Professor Kalcsits presented a key note address at last year's Hort Connection 2018 conference on bitter pit disorders in apple relating to calcium deficiencies. Bi will work with Professor Kalcsits to determine how apple calcium uptake is affected by nitrogen and potassium fertigation and its influence on fruit quality. Bi will use the synchrotron facility in Canada to obtain a complete picture of cell structure and cell wall strength in apple fruit following fertigation treatments. This will help determine impact of fruit chemistry composition on fruit quality attributes such as firmness or incidence of bitter pit in apples. Bi has submitted an abstract to present his research at the 16th American Society for Horticultural Science conference in Las Vegas in July.

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