Horticulture and Irrigated Agriculture

Overview

The combined direct and indirect contribution of horticulture and irrigated agriculture to the Western Australian economy is about $2.5 billion annually. Horticulture directly employs almost 7000 workers at the farm level, which represents almost 20 per cent of all employment in agriculture, forestry and fisheries.

Rohan Prince
DIRECTOR, HORTICULTURE AND IRRIGATED AGRICULTURE

HORTICULTURAL PRODUCTION OF FRUIT, vegetables, wine grapes, nursery plants, cut flowers and turf in WA is valued at over $1.1 billion annually. Irrigated agriculture in the state's north produces about $130 million worth of food, fibre and fodder each year.

Horticulture has the highest flow-on benefits among agriculture industries; in general, the value of horticulture increases three times from the farm until it reaches the end consumer. The wine industry has the highest flow-on benefits, where wine grapes worth $72 million at the farm gate are valued at $700 million as wine at the final selling point in WA.

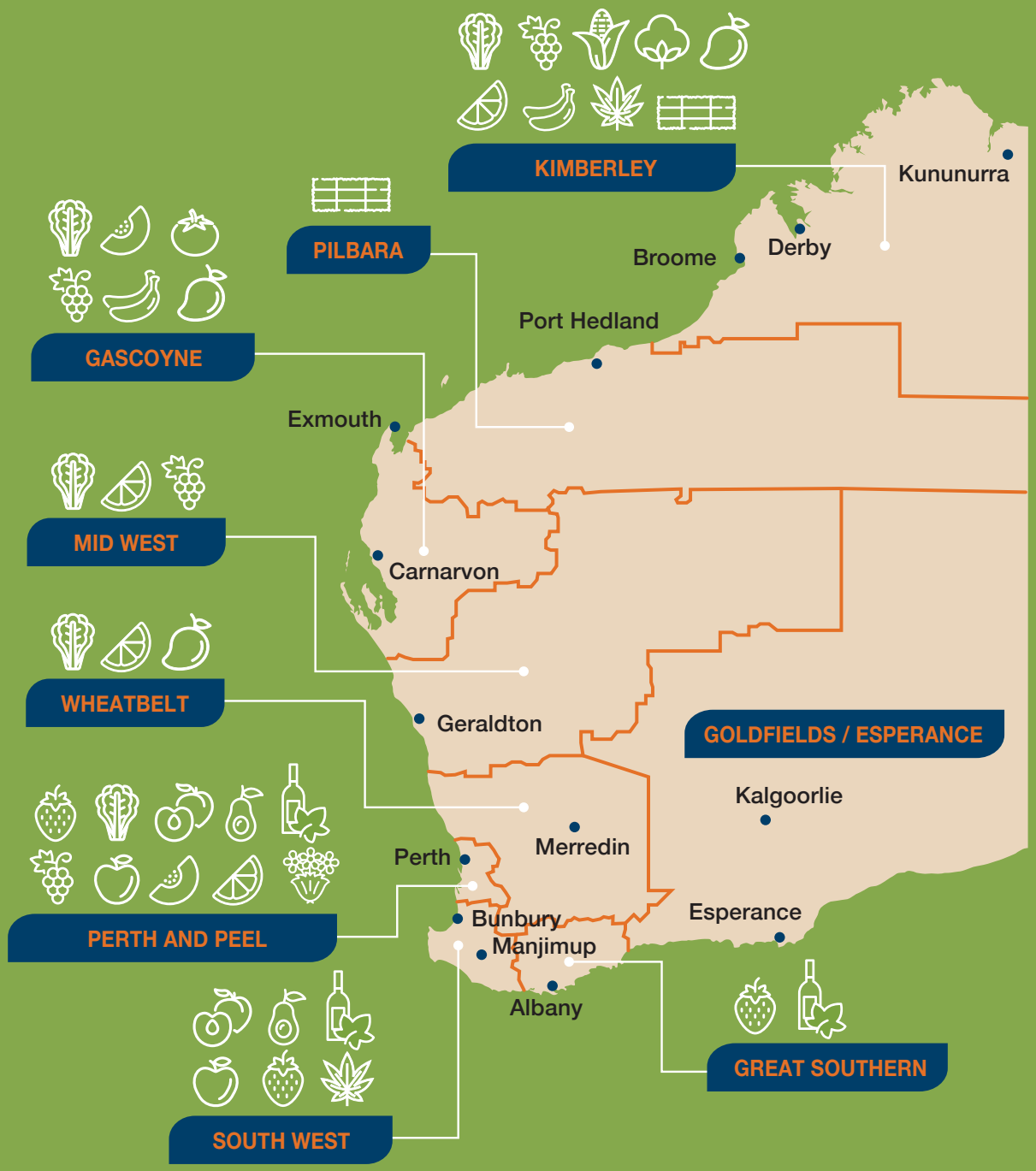
Exports in demand

Quality horticultural produce is in high demand in overseas markets. Between 2013 and 2019, exports of WA fruit increased nearly 400 per cent, from A$12.4 million to A$59.9 million, mainly from strawberries, avocados, table grapes, oranges and melons. In the same period, vegetable exports increased 14 per cent from A$103.6 million to A$117.9 million, mainly from carrots, truffles, potatoes, onions and celery.

WA's horticulture and irrigated agriculture industries have strong opportunities to grow exports into Asian markets if we can meet the expectations of the consumers in these markets. Crops with emerging export potential include melons, cauliflower, broccoli, pumpkins, apples, stone fruit and mangoes.

Growing quality produce in an environmentally responsible manner in a clean environment means WA producers can compete in highly competitive export markets.

Horticulture and Irrigated Agriculture



LEGEND

- Avocados
- Bananas
- Citrus
- Cotton
- Cut flowers, nursery plants and cultivated turf
- Fodder
- Hemp
- Maize
- Mangoes
- Melons
- Pome (apple/pear/nashi)
- Strawberries
- Stone fruit
- Table grapes
- Tomatoes
- Vegetables (includes potatoes, onions, carrots)
- Wine grapes

Horticulture and Irrigated Agriculture

Irrigation intensifies value

An estimated 90 000 hectares of land in WA is irrigated with almost 600 gigalitres of licensed water. The gross value of irrigated agriculture ranges from several thousand dollars per hectare for fodder or fibre crops to more than $200 000 for intensive fruit and vegetable crops. Intensive glasshouse systems can produce as much as 40 tonnes of produce per megalitre of water and generate gross values of more than $1.5 million per hectare each year.

"Horticulture and irrigated agriculture can diversify WA's economy and grow and support regional economies. The challenge is to produce export quality products while meeting consumer expectations around food provenance and environmental stewardship."

ROHAN PRINCE

WA's highest value horticultural crop is carrots, which was worth $126 million in 2018–19 (Figure 23). Carrot production across the Swan Coastal Plain is fully mechanised from seeding to harvest and scale-up has encouraged vertical integration of packing facilities. WA exports $80 million worth of carrots to Asia and the Middle East each year.

DPIRD's Australian National Apple Breeding Program (ANABP) has produced varieties ranked within the top 20 apple brands in the world – Pink Lady™ at number one and Joya®/Sundowner™ at number 17. The latest variety, ANABP 01, marketed as Bravo® branded apples, has created a new opportunity for Australian apple growers to play a more significant role in the world apple market.

Vast industry spread

WA's horticulture and irrigated agriculture sector spans nearly 3500 kilometres from Kununurra to Albany, with vastly different production environments, crops and pest and disease management challenges. The different environments support production at different times of the year.

DPIRD's Horticulture and Irrigated Agriculture team plays an important role in linking and coordinating responses to industry issues.

To build international competitiveness and grow the sector, the team undertakes research to increase the productivity, profitability and sustainability of horticultural and irrigated agricultural businesses across the state.

Research areas cover genetics, agronomy, production systems, environmental stewardship and the delivery of safe, quality produce to domestic and international consumers.

Field research spans temperate, subtropical and tropical crops at research facilities spread across WA from Manjimup and Perth to Carnarvon, Broome and Kununurra.

New technologies and innovation are sought from across Australia and the world and evaluated for their suitability to WA's environments and business operations.

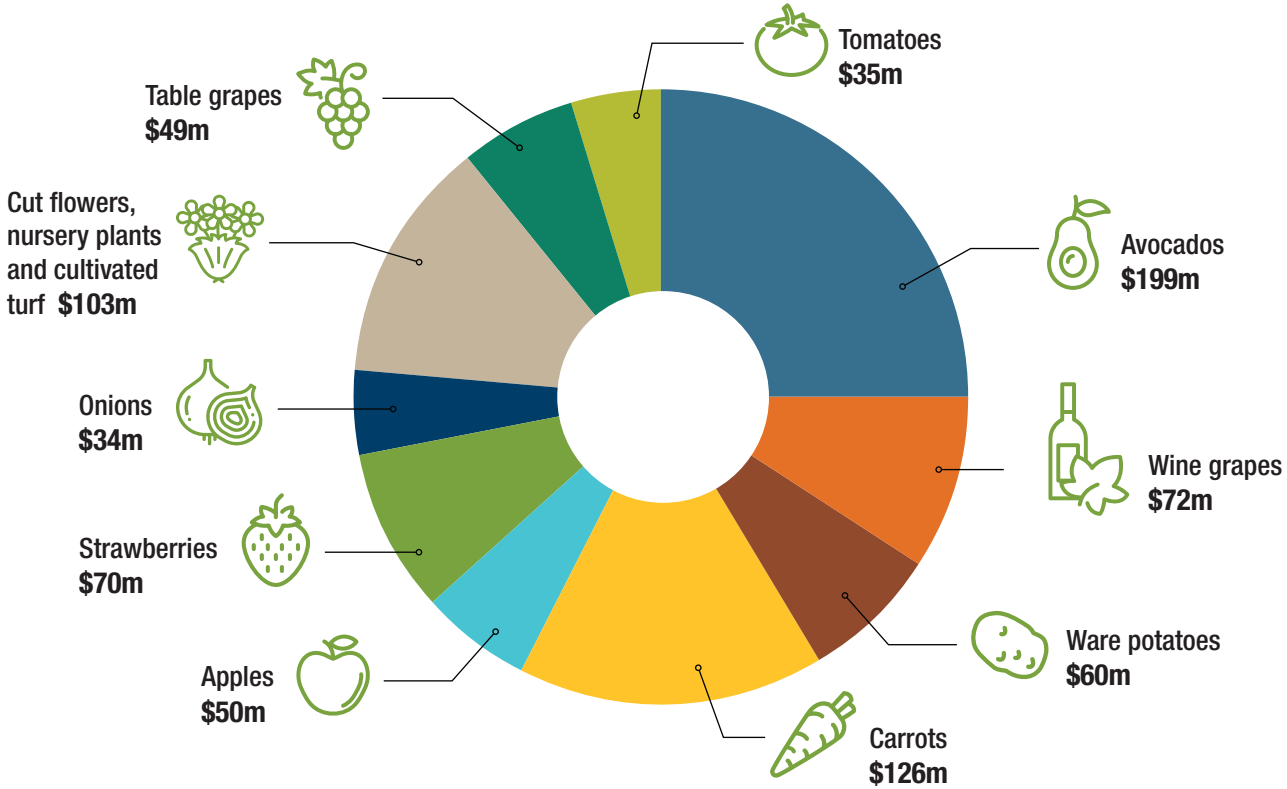


FIGURE 23. Gross value of agricultural production ($) of WA's top ten horticulture industries (2018–2019)

Note: 2017–2018 data for cut flowers, nurseries and cultivated turf.

Horticulture and Irrigated Agriculture

The team works closely with industry and government to:

- improve productivity through modern and efficient production systems and technology
- understand consumer and market drivers, trends and opportunities
- encourage sustainable growth through environmentally responsible production systems
- manage pests and diseases to increase product quality and meet market needs.

HORTICULTURE AND IRRIGATED AGRICULTURE

Purpose: increase the productivity, profitability and sustainability of Western Australia's $2.5 billion horticulture and irrigated agriculture sector.

FRUIT

VEGETABLES

INSECTS AND DISEASE

TROPICAL FOOD, FIBRE AND FODDER

RESEARCH

Develop production systems to increase yield and product quality in an environmentally responsible and cost-effective way.

ANALYSE

Understand consumer and market drivers and build industry capacity to take advantage of new opportunities.

ENGAGE

Engage with industry and government to deliver outcomes of research and analysis and develop coordinated responses to industry issues.

FRUIT AND PERENNIAL CROPS

FRUIT AND PERENNIAL CROPS

Western Australia produces a wide range of temperate and tropical fruit species, from Kununurra in the north to Albany in the south, for domestic consumption and export.

Dr Dario Stefanelli
TEAM LEADER,
(FRUIT AND PERENNIAL CROPS)

DPIRD'S TEAM OF FRUIT AND PERENNIAL crop researchers works with established and emerging fruit and perennial crop industries across WA to grow high-quality products and increase competitiveness in global markets.

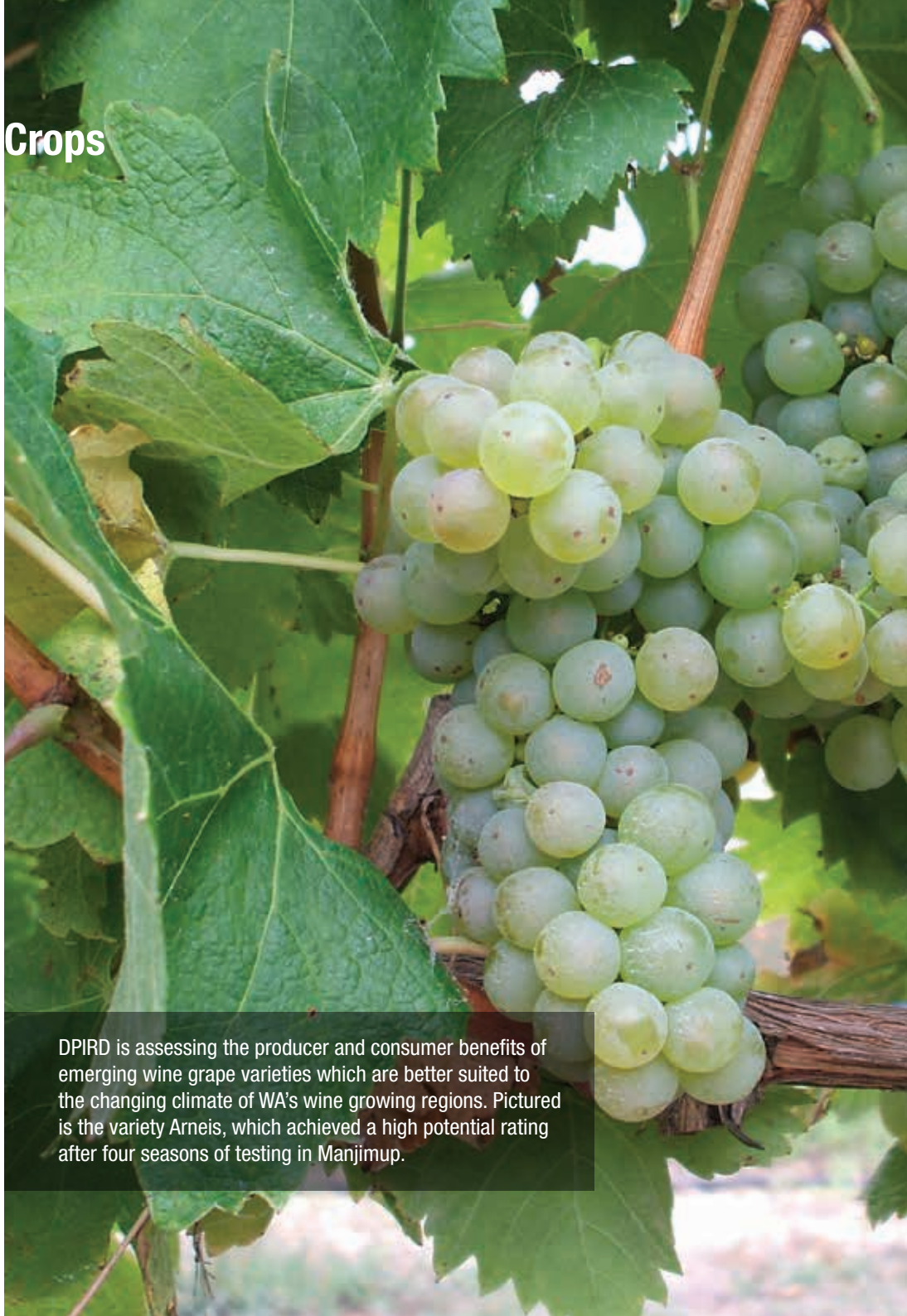
The team undertakes plant breeding and evaluation programs to develop new varieties that match changing market needs while yielding well on-farm and in a changing climate.

Production systems research is focused on optimising growing conditions to increase fruit yield and quality, integrating innovative sensing technologies to improve decision-making and reduce input costs.

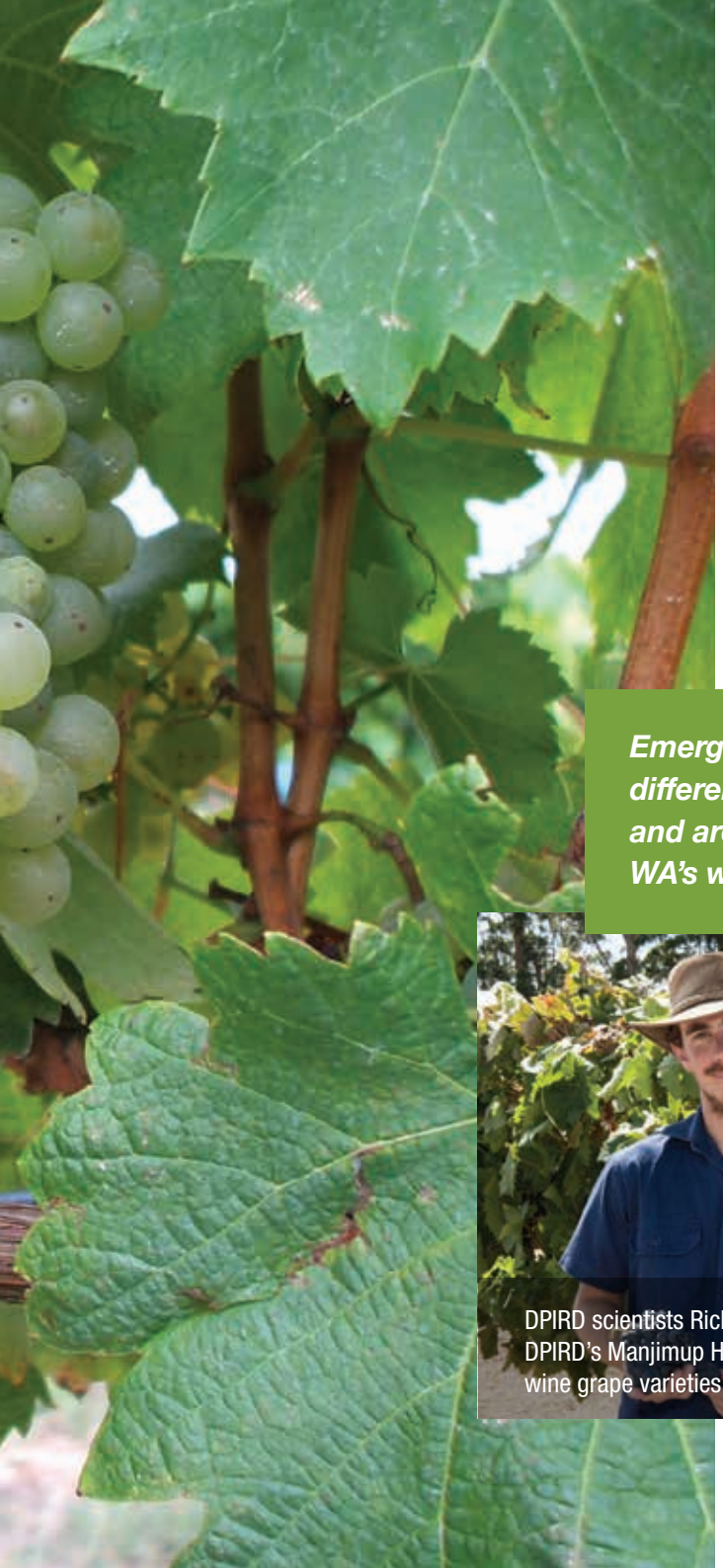
The team is also working to generate value-adding opportunities for the fruit and perennial crop industries and increase profitability along the value chain.

New wine grape varieties have novel appeal

Emerging wine grape varieties suited to Western Australian growing conditions will help WA wine producers mitigate the impacts of climate change while reducing input costs and meeting changing consumer preferences.



DPIRD is assessing the producer and consumer benefits of emerging wine grape varieties which are better suited to the changing climate of WA's wine growing regions. Pictured is the variety Arneis, which achieved a high potential rating after four seasons of testing in Manjimup.



ABOUT 80 PER CENT of WA's $700 million wine industry is based on just five 'noble' French varietals: Sauvignon Blanc, Cabernet Sauvignon, Chardonnay, Shiraz and Semillon.

Relying on such a small group of varietals could limit the profitability and sustainability of the WA wine industry in the face of market trends and climate change.

Emerging wine grape varieties offer consumers different aromas, flavours, textures and styles and are better suited to the changing climate of WA's wine growing regions.

Estimates from industry production data (2018) show only about 1.5 per cent of WA's production is from emerging varieties.

However, propagation orders received by the Western Australian Vine Improvement Association (WAVIA) show demand for emerging varieties has increased by 20 per cent in the past five years compared to the period between 2010 and 2015.

DPIRD research scientist Richard Fennessy has spent the past 12 years assessing the producer and consumer benefits of emerging wine grape varieties at DPIRD's Manjimup Horticulture Facility and the WA College of Agriculture—Harvey in the Geographe wine region.

DPIRD scientists Richard Fennessy and Dr Kristen Brodison at DPIRD's Manjimup Horticulture Facility. Richard is assessing emerging wine grape varieties to offer alternatives to the WA wine industry.

Richard showcased trial wines to industry and state government and opposition members at a State Parliament House event.

Fruit and Perennial Crops

Varieties were assessed for their timing of budburst, flowering, veraison and harvest, vine growth characteristics and wine attributes and quality.

After four consecutive seasons, the 18 varieties at the Manjimup site were categorised as having high, medium or low potential (Table 5) and the research findings were summarised in the bulletin *Evaluation of alternative wine grape varieties in Manjimup Western Australia*.

Over the past 10 years WAVIA has seen good demand, particularly for cuttings of Arneis and Vermentino.

Emerging wine grape varieties are also being assessed at the WA College of Agriculture in Harvey, where students are collecting production data for the small-lot trials.

Table 5. Potential of emerging wine grape varieties grown at Manjimup in WA

High potential	Medium potential	Low potential
Arneis	Brachetto	Furmint
Barbera	Durif	Gamay
Lagrein	Fer	Kadarka
Pinot Gris	Harslevelu	
Saperavi	Savagnin Blanc	
Tannat	Scheurebe	
	Tempranillo	
	Vermentino	
	Viognier	

The varieties from the Harvey site will be categorised once the results for 2020 are tallied.

DPIRD scientist Richard Fennessy has adapted commercial methods to tailor winemaking to small lots of emerging wine grapes. The new methods bring out the best of each wine style.

Innovative winemaking

Establishing the appeal of wines made from the emerging varieties was a central focus of the project.

In what is believed to be an Australian first for variety comparison, Richard used commercial winemaking techniques to produce small-lot trial wines (ranging from two litres to 20 litres), tailoring the winemaking to a wine style that best suited each of the varieties. Previously the practice had been to produce wines in a 'neutral' style using a standard process to compare all varieties.

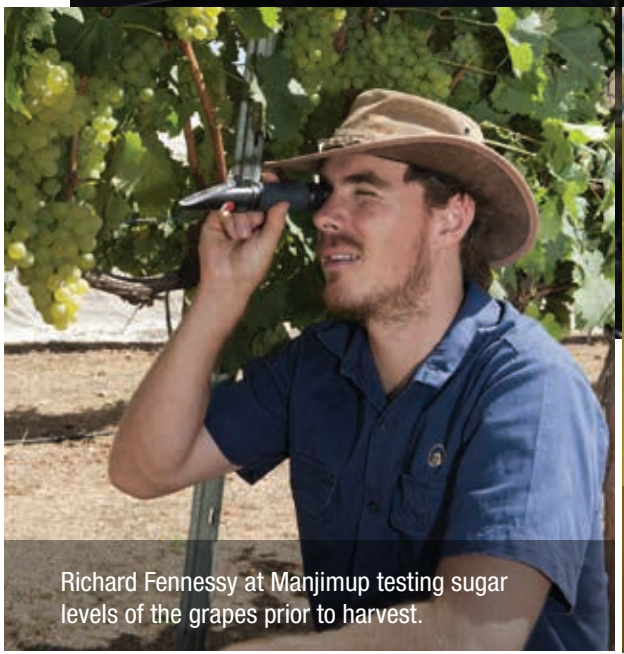
To successfully apply the commercial techniques, the project had to overcome challenges of scale and available resources. Small-lot wines are difficult to make soundly as they are highly susceptible to oxidation and the limited volume provides little opportunity to taste the wines during the process.

Richard validated the commercial approach when a panel of 16 winemakers overwhelmingly scored the wines made in the commercial style higher than the neutral wines made from the same varieties.

The wines produced from the emerging varieties at the Manjimup and Harvey trial sites were assessed by expert panels of winemakers and at wine shows to establish their market appeal. In addition, in a consumer perceptions study, 40 educated wine consumers assessed the likeability of each of the varieties from the Manjimup site.

From 2017 to 2020, wines from the Harvey site have received seven gold, 13 silver and 23 bronze medals from four consecutive seasons.

Geographe wine producers tasting trial wines at the DPIRD Bunbury office.


Richard Fennessy at Manjimup testing sugar levels of the grapes prior to harvest.

Vermentino juice settling before fermentation. This emerging variety is one of 15 varieties showing promise in the small-lot wine trials at DPIRD's Manjimup site.

Persistence pays off for apple breeders

DPIRD's apple-breeding program is developing superior cultivars that are adapted to the local climate and suitable for export markets.

Fruit and Perennial Crops

The highly popular Cripps Red apple is one half of the cross that has produced the newly released ANABP 01 apple bred by DPIRD's Australian National Apple Breeding Program. Cripps Red is marketed as Sundowner™ in most places but Joya® in Europe.

Export of apples from WA has increased in both volume and value. From 2016 to 2020 apple export grew from over 11 tonnes, valued at about $32 000, to over 82 tonnes worth about $432 000.

AN APPLE-BREEDING PROGRAM in Western Australia is ensuring that local apple producers have access to climatically adapted cultivars that are suitable for domestic and export markets.

DPIRD's Australian National Apple Breeding Program (ANABP) aims to breed apple cultivars that add to the profitability and development of the WA apple industry. WA produced around 24 000 tonnes of apples in 2018–19 that had a wholesale value of $50.4 million.

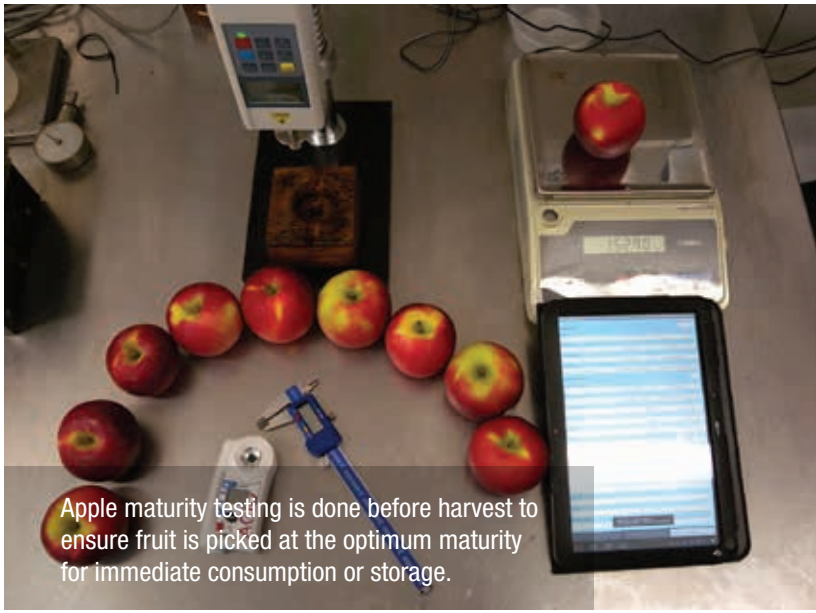
The ANABP is the only government-owned apple-breeding program in Australia and is highly regarded internationally. It has produced two apple cultivars that are in the current top 20 branded apples in the world – Pink Lady™ and Joya®. The program's most recent development, ANABP 01, is extremely popular with Australian consumers. ANABP 01 fruit that meets the required quality specifications is marketed as Bravo® (see next page).

The ANABP develops apple cultivars that are adapted to the long, hot, dry summers and mild winters of the south-west of WA. The most important climatic adaptation relates to winter chilling. Apple trees need a period of cold weather to break their winter dormancy. WA's mild winters provide less winter chilling compared to northern hemisphere winters.

The breeders also consider the qualities needed for a variable and warming climate to build a long-term sustainable apple industry.

The ANABP provides the WA industry with new apple cultivars that can be licensed to allow export to other countries. International trade of each apple cultivar is controlled by the breeding program that owns the cultivar and associated trademark. Apple cultivars from other breeding programs that are grown in Australia may be limited to domestic sales only.

By growing ANABP cultivars, WA apple producers can increase the volume of apples for the export market to grow the WA industry. Producers also benefit from international commercialisation of ANABP cultivars, which provides a competitive advantage in export markets which may potentially increase profits.



Apple maturity testing is done before harvest to ensure fruit is picked at the optimum maturity for immediate consumption or storage.

Burgundy Bravo® like no other

In 1992 a cross between the apple cultivars Royal Gala and Cripps Red created ANABP 01. After full evaluation and testing, ANABP 01 was released to apple growers for commercial production in 2014.

More than 80 growers now produce the crop across WA, New South Wales, Queensland, South Australia and Victoria, most of which is marketed as Bravo®. In 2020, about 1700 tonnes of Bravo® apples were marketed to Australian consumers.

Apples produced from ANABP 01 have a distinct sweetness, moderate to high crisp and crunch, and have a striking burgundy colour. They are like no other apples currently available in Australia, which helps consumers to identify them in the marketplace. ANABP 01 apple flesh is slow to brown, making it ideal as cut fruit. The fruit contains one of the highest levels of flavonoids among apple cultivars. Flavonoids are antioxidants that may improve heart health. The desirable qualities of the cultivar suggest it could be an acceptable and sought-after product in international markets.

International commercialisation of ANABP 01 is underway. Following the export success of Cripps Red and Cripps Pink, marketed as Joya® and Pink Lady™, there is excitement among growers of ANABP 01 that this apple from the WA-run program will be as successful.

Senior technical officers Steele Jacob (left) and John Sutton (right) with the new Bravo® apple.

BELOW RIGHT: Steele Jacob (DPIRD) and Jenny Mercer (WA Farm Direct) with the first major export of Bravo® apples to leave WA for Singapore.

New cultivars in the pipeline

Yellow skin, red flesh, a bell-shaped base and a long conical shape are just some of the unique apple characteristics currently undergoing evaluation by the ANABP.

The ANABP uses conventional plant breeding to create hybrid seed for new cultivars suitable for domestic and export markets. It can typically take 20 years to produce and test a new apple cultivar before release.

DPIRD apple breeders aim to deliver a new apple cultivar to consumers every 10 years.

Painting pollen for hand pollination of apple flowers.

LEFT AND MIDDLE IMAGE: Apple seedlings being grown in hothouses.

Newly grafted ANABP 01 apple trees.

The apple-breeding project team, led by Dr Kristen Brodison, grows thousands of hybrid apple seedlings every year.

About 20 suitable apple selections (one in 400 seedlings) progress through to the evaluation stage, which includes appearance, eating characteristics and profitability of production. Only about three selections progress to consumer testing.

Cultivars finally released to market are superior to existing cultivars or are unique. They should handle and store well; have consistently high yields; be easy to prune, train and manage; and have good resistance to pests, diseases and sun damage.

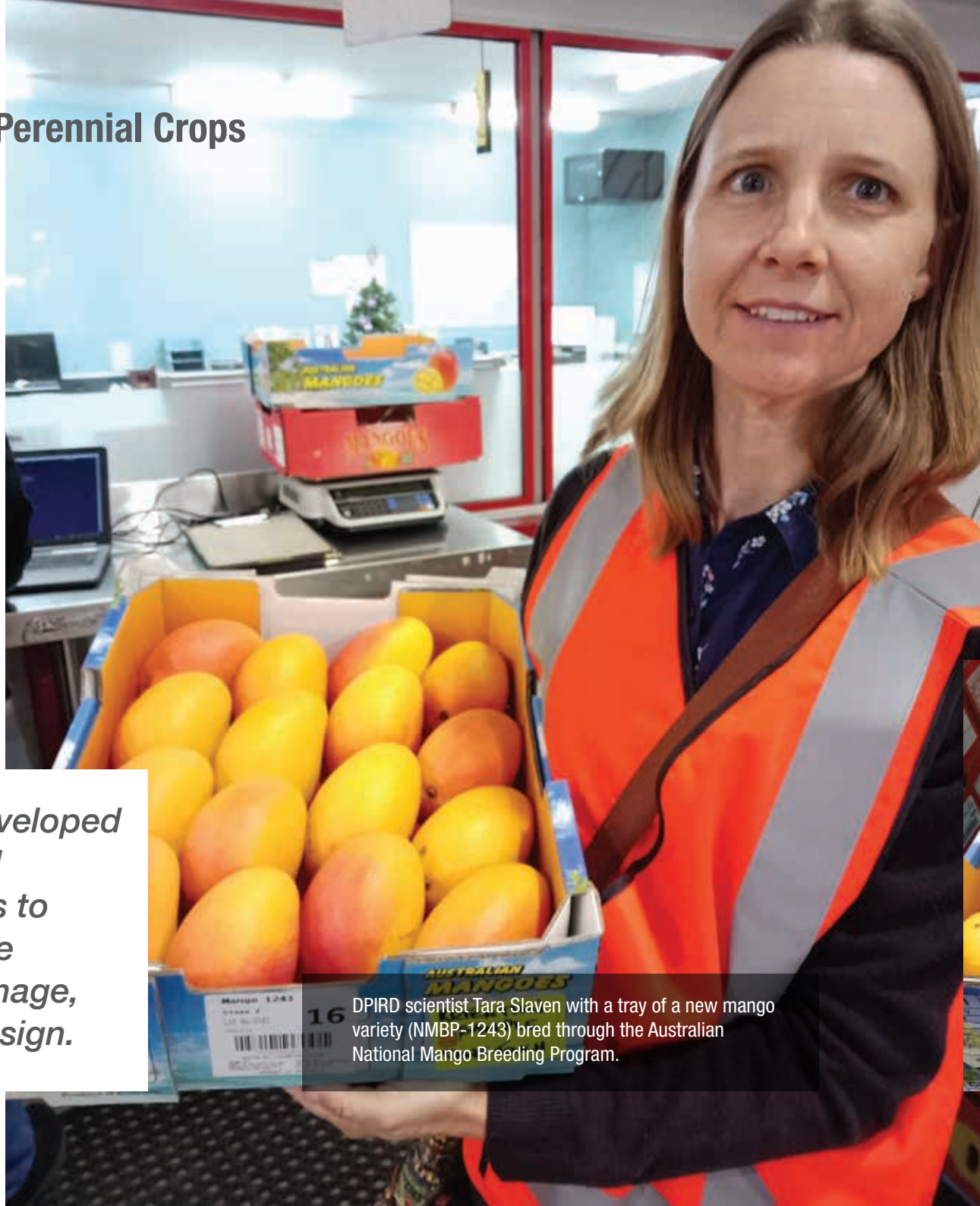
Consumers differ in their preferences for apples, typically based on flavour and texture characteristics. For example, some consumers like apples that are sweet (e.g. Golden Delicious) while others prefer apples with a higher fruit acid content (e.g. Pink Lady™).

ANABP selections are assessed for nutraceutical qualities including their potential to boost antioxidants in consumers' diets. Some ANABP cultivars including Cripps Pink and ANABP 01 contain some of the highest levels of flavonoids among apple cultivars.

Some selections may suit other uses such as processing, dried fruit or cider production. To improve crop utilisation, water efficiency and overall farm productivity, DPIRD is investigating whole-of-harvest solutions that could make WA apple growers more competitive and profitable.

New mango varieties a win for consumers and producers

DPIRD mango researchers have developed new mango varieties with improved attributes and are assisting growers to increase production and marketable yield through research into sun damage, protected cropping and orchard design.



DPIRD scientist Tara Slaven with a tray of a new mango variety (NMBP-1243) bred through the Australian National Mango Breeding Program.

Fruit and Perennial Crops

NEW MANGO VARIETIES that taste better, look better and are easier to grow than current commercial varieties have been successfully bred by the Australian National Mango Breeding Program (NMBP).

The NMBP has developed three new varieties (currently named NMBP-1201, 1243, and 4069) that are a significant improvement on the industry standard, Kensington Pride.

The NMBP was initiated in 1994 as a collaboration between DPIRD and agricultural agencies in the Northern Territory and Queensland and the CSIRO. The Australian Mango Industry Association, growers and a range of entities between production and marketing have joined the program since the production of the new varieties.

The three new varieties have improved agronomic performance and quality compared to Kensington Pride, making them more profitable for growers.

In an auction-style study, mango consumers said they would pay more for the new varieties, particularly NMBP-1243 (up by about 20 per cent). In contrast, willingness to pay for one of the present commercial varieties fell by 17 per cent after tasting.

New mango varieties (NMBP-1243 and NMBP-1201) have superior agronomic performance and quality compared to the industry standard, Kensington Pride.

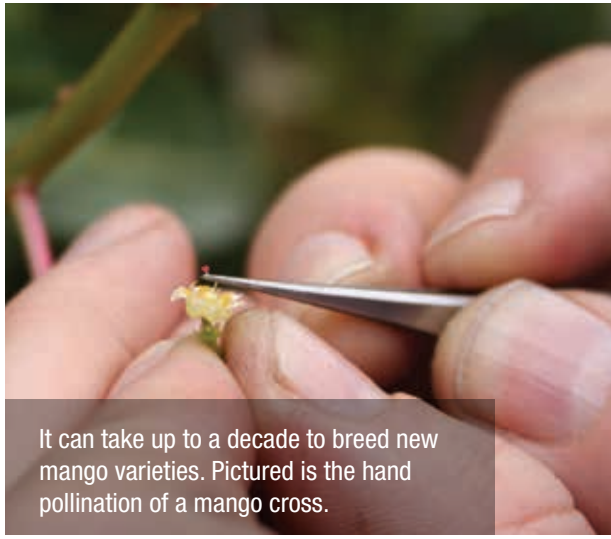
On average, WA produces 1260 tonnes — or 180 000 trays — of mangoes per year. This represents five to eight per cent of Australia's mango harvest and has an estimated value that varies from $7 to $16 million between seasons. The majority of WA production is consumed by the Perth market, although there is some opportunistic export, and some late-season mangoes are sent to eastern Australia.

DPIRD scientist Tara Slaven examines a flowering mango tree as part of the Australian National Mango Breeding Program. New mango varieties have been created by crossing the standard Australian variety, Kensington Pride, with a range of Floridian, Indian and Asian cultivars.

Fruit and Perennial Crops

Mangoes are propagated either by seed or by grafting (above). Grafting joins the parent tree to a rooted plant known as the rootstock.

Parent tree (budstock) shooting 24 days after having been grafted onto rootstock.



It can take up to a decade to breed new mango varieties. Pictured is the hand pollination of a mango cross.

DPIRD is part-owner of the three new hybrid mangoes bred through the Australian National Mango Breeding Program.

DPIRD is part-owner of the three new licensed hybrid varieties which are protected under Australian Plant Breeder's Rights legislation. They were created by crossing the standard Australian variety, Kensington Pride, with a range of Floridian, Indian and Asian cultivars. It can take more than 10 years to breed a new mango variety.

While small commercial quantities from Queensland plantings of the new varieties were available in eastern Australia in the 2020–21 season, it will still be a year or two before fruit from the more recent WA plantings is in the Perth market.

To support the establishment of full value chains for the new mangoes, DPIRD will continue the development of production and commercialisation. Research scientist Tara Slaven and her team of technical officer Helena O'Dwyer and research station operatives at the Frank Wise Tropical Agriculture Institute in Kununurra are conducting field screening such as sunburn management and budwood production. Market research has been conducted in partnership with Griffith University and the University of Adelaide.

Sun protection for mangoes

Sunburn is a major quality issue for WA mango growers. Up to 40 per cent of the crop can be lost to sunburn each year. Typically, all fruit on the western side of a tree can be affected. Growers could potentially earn an extra $2.8 to $6.4 million annually if they could market 40 per cent more fruit at current prices.

Caused by a combination of light and heat, sunburn ranges from mild bleaching to blackened depressions of the skin. It can also cause deformity of the fruit where the exposed side of the fruit does not fill out, creating a flat surface known as slabbing. The market will tolerate some bleaching up to about 25 per cent of the fruit; any more than that renders the fruit unmarketable.

DPIRD mango researchers are assessing modified pruning techniques, row orientation, stress reducers, and protected cropping to reduce the occurrence of sunburn and increase the volume of marketable fruit per tree.

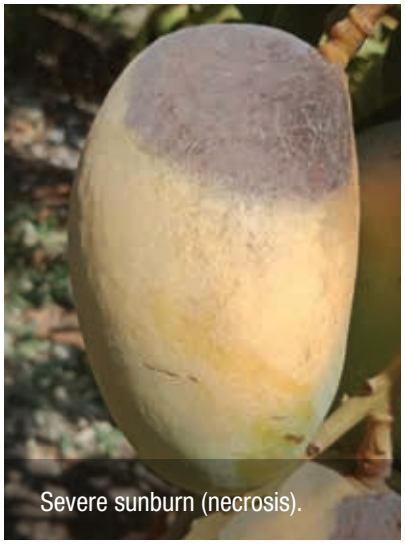
Novel shelter systems

At DPRID's Carnarvon Research Facility, senior research scientist Neil Lantzke is developing protected cropping systems to lift mango productivity and quality, as well as expand the production window for the fruit in WA.

Protected cropping controls the micro-climate of the orchard to reduce heat and light stress on the trees. It can also provide wind shelter, which reduces evaporation and fruit rubbing, thereby increasing marketable yield.

Mango with no sunburn.

Minor sunburn (bleaching).



Severe sunburn (necrosis).

DPIRD research is developing protected cropping systems to protect mangoes from heat and light stress and improve fruit productivity and quality.

The protected cropping structures can be opened and closed during the growing period to create shade during fruit production and control the amount of light and heat reaching the crop. This reduces evaporation, temperature and sunburn, thereby decreasing stress on the orchard and enabling a wider cropping window and potentially higher yields.

Fruit and Perennial Crops

Virtual orchards

LiDAR (light detection and ranging) is a remote sensing tool used in a range of applications including mapping, vegetation analysis, tree height measurement and terrain modelling. It can be used to map mango orchards to better visualise production issues such as sunburn.

LiDAR scans create digital twins of orchards, which can then be used to help make decisions from the micro-scale (individual leaves/branches) to the macro-scale (whole orchard management).

Management practices in the digital orchard can be modelled to predict how they will affect production issues such as light interception and spray efficiency.

DPIRD is using the remote sensing system to improve mango orchard design and management in a collaboration with the Department of Agriculture and Fisheries, Queensland, and the University of Queensland.

DPIRD is using remote sensing to create 'digital twins' of mango orchards and model how management decisions affect light interception and issues like sunburn.

Smoothing out seasonal avocado supply

Avocados are the largest and fastest growing fruit industry in WA. However annual yields can vary by as much as 70 per cent of total production from one year to the next.

DPIRD research scientist Declan McCauley is investigating how to even out annual avocado yields to make growing avocados more sustainable and competitive.

WA produces about 38 per cent of Australia's total avocado production. In 2019–20 total Australian avocado production was about 87 500 tonnes, with a value of $493 million.

Annual yields depend on the number of fruit set and retained on the trees until harvest, as well as the size of the harvested fruit. Fruit set can vary between seasons by up to 50 per cent.

Weather conditions during ripening can affect avocado yield. For example, stress-induced fruit drop of up to 20 per cent of yield has occurred in the Carabooda area due to hot and dry easterly winds in summer.

Declan is researching what causes avocado trees to divert energy (carbohydrates) into fruit rather than the leaves and stems. He is also investigating the factors that determine fruit set, especially environmental effects. The third part of his research is evaluating production practices such as the use of growth regulators to reduce tree growth and thereby increase fruit set.

In other research, DPIRD scientist David Rowe is examining how avocado tree density, protected cropping and irrigation systems influence fruit yield and water use efficiency.

DPIRD research scientist Declan McCauley measures avocado size as part of a trial investigating fruit load and yield.

Three-year-old flowering avocado orchard in the Manjimup area under observation for the carbohydrate distribution studies.

DPIRD development officer Jesse Bowman (left) and research scientist Elliot Howse (right) installing a lysimeter in a new avocado orchard to study water dynamics, use efficiency, fertigation efficiency and nutrient leaching.

VEGETABLE CROPS

VEGETABLE CROPS

DPIRD's vegetable research team carries out research and development, from Carnarvon in the north to Manjimup in the south, to increase vegetable quality and yield. A key focus of the research is assessing the yield and quality benefits of growing vegetables under protected cropping structures.

The team also identifies opportunities to expand market share for WA vegetables through economic analysis of domestic and export markets.

Western Australia produces about $500 million worth of vegetables each year, predominately at Wanneroo, West Gingin, Myalup, Carnarvon, Manjimup and Kununurra.

Neil Lantzke
TEAM LEADER, (VEGETABLE CROPS)

THE STATE'S MAJOR VEGETABLE CROP is carrots, which contributes about a quarter of the total production value, followed by tomatoes, potatoes, onions, broccoli and cauliflower.

Most of the vegetables produced are consumed locally or sold into Australia's eastern states.

Vegetable exports are worth about $118 million; the largest export is carrots at $80 million. The largest export destinations are the United Arab Emirates ($24 million), Singapore ($19 million) and Saudi Arabia ($18 million).

Crops go undercover to generate more profits

Horticultural profits are underpinned by yield and the proportion of the crop that reaches first-grade quality, a class that often receives twice the price of second-grade produce. DPIRD's vegetable production research and development team is investigating ways to lift product quality, increase the share of first-grade product and increase profitability on WA vegetable farms.

Eggplants growing under protected cropping, a system that can achieve higher yields per hectare and improve water use efficiency.

Vegetable Crops

PROTECTED CROPPING, OR SHELTERING crops with dedicated structures, protects against extremes of temperature, strong winds, rain and high pest pressures.

Vegetable crops worldwide are grown under protected cropping structures. Southern Spain has about 30 000 hectares of polyhouses, and screen and greenhouses are increasingly used in the Middle East, north-west Mexico and North Africa.

Tomatoes, capsicum, eggplant and cucurbit crops are commonly grown under protected cropping. In 2018 about 30 per cent of Australia's tomatoes were grown in greenhouses. Eighty-five per cent of Australia's continental cucumber production during the winter/spring period is grown in Geraldton in greenhouses.

Protected cropping can extend or modify the harvest season, achieve higher yields per hectare and improve water use efficiency. Lower pest pressures can enable insect control to be achieved with fewer chemical applications.

Yields per square metre can be four to 10 times higher than in field-grown crops, depending on crop type and the protective technology used.

About 30 per cent of Australia's tomatoes were grown in greenhouses in 2018.

Vegetable Crops

DPIRD's vegetable team, led by senior research scientist Neil Lantzke, is determining production guidelines and return on investment for a range of crops grown under protected cropping structures at the department's Carnarvon Research Facility. The structures include a net house that covers 1.3 hectares and an 800m^2 greenhouse with a retractable roof.

The research is part of a $1.4 million state government investment in new programs and upgrades at the Carnarvon Research Facility to support the diverse horticultural industry in the Gascoyne.

Higher pest pressures at Carnarvon over the last decade have led to an increased incidence of insect-borne viruses affecting high-value crops such as capsicum, which leads to a reduced growing window, reduced yield or total crop write-off. This has resulted in a higher reliance on chemical control options.

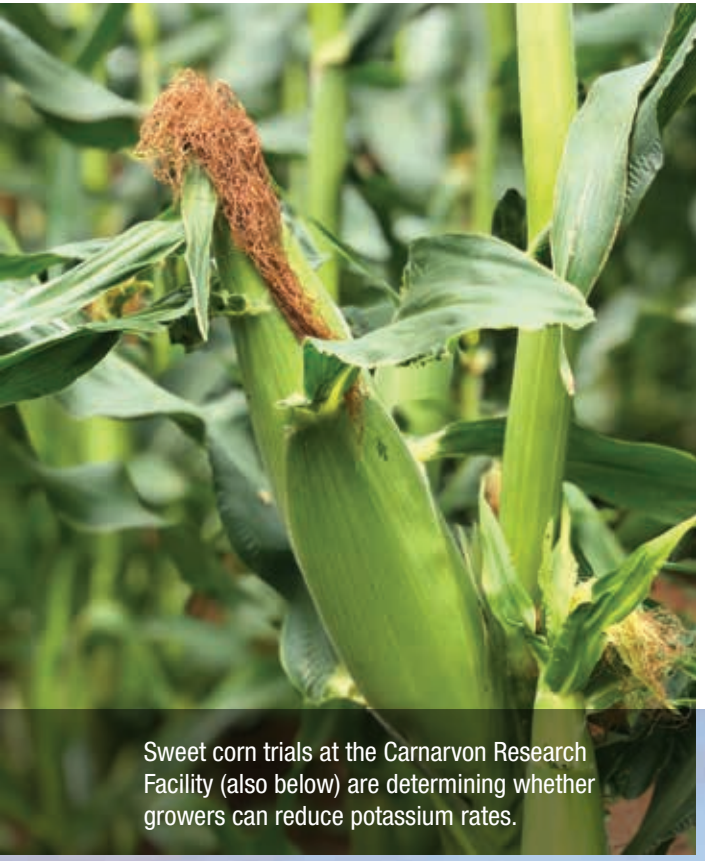
DPIRD is investigating cost-effective ways to build insect-exclusion structures and retrofit existing net houses in Carnarvon. Insect-exclusion netting around vulnerable crops could help growers reduce chemical usage and promote beneficial insect control options.

An 800m^2 greenhouse with retractable roof has been built at the DPIRD Carnarvon Research Facility as part of a large project investigating the yield and economic benefits of protective cropping systems for the horticulture industry.

Optimising fertiliser inputs

Vegetable growers in the Carnarvon area apply a range of nutrients, often at high rates, which may not be necessary and could be linked to poor vegetable quality.

DPIRD research scientist Dr Giao Nguyen will investigate the effect of potassium fertiliser application rates on produce yield and quality. Trials are underway on sweet corn and pumpkin at the Carnarvon Research Facility to determine whether growers can reduce potassium rates. This could save on fertiliser costs and reduce the chance of excess fertiliser getting into the environment.



Sweet corn trials at the Carnarvon Research Facility (also below) are determining whether growers can reduce potassium rates.

Rejuvenating the Carnarvon tomato industry

Tomatoes are worth about $35 million per year to WA. The crop accounts for about 30 per cent of the total horticultural production in WA's Gascoyne region.

Lifting the quality of tomatoes could open up market opportunities for Carnarvon growers.

Development officer Annie Van Blommestein is supporting the Carnarvon tomato industry by:

- discussing production practices and opportunities to improve fruit quality with local growers
- providing marketing and business education to growers
- reviewing suitable tomato varieties and fertiliser practices
- assessing tomato fruit quality and post-harvest shelf life
- demonstrating best-practice techniques for post-harvest handling.

Annie's work will identify potential focus areas for demonstration trials on growers' properties in 2022.

DPIRD is working with the Carnarvon tomato industry to lift fruit quality and open up new market opportunities.

Technology improves irrigation efficiency

Achieving high irrigation efficiencies is critical for WA vegetable producers who are dealing with an increasingly drier climate.

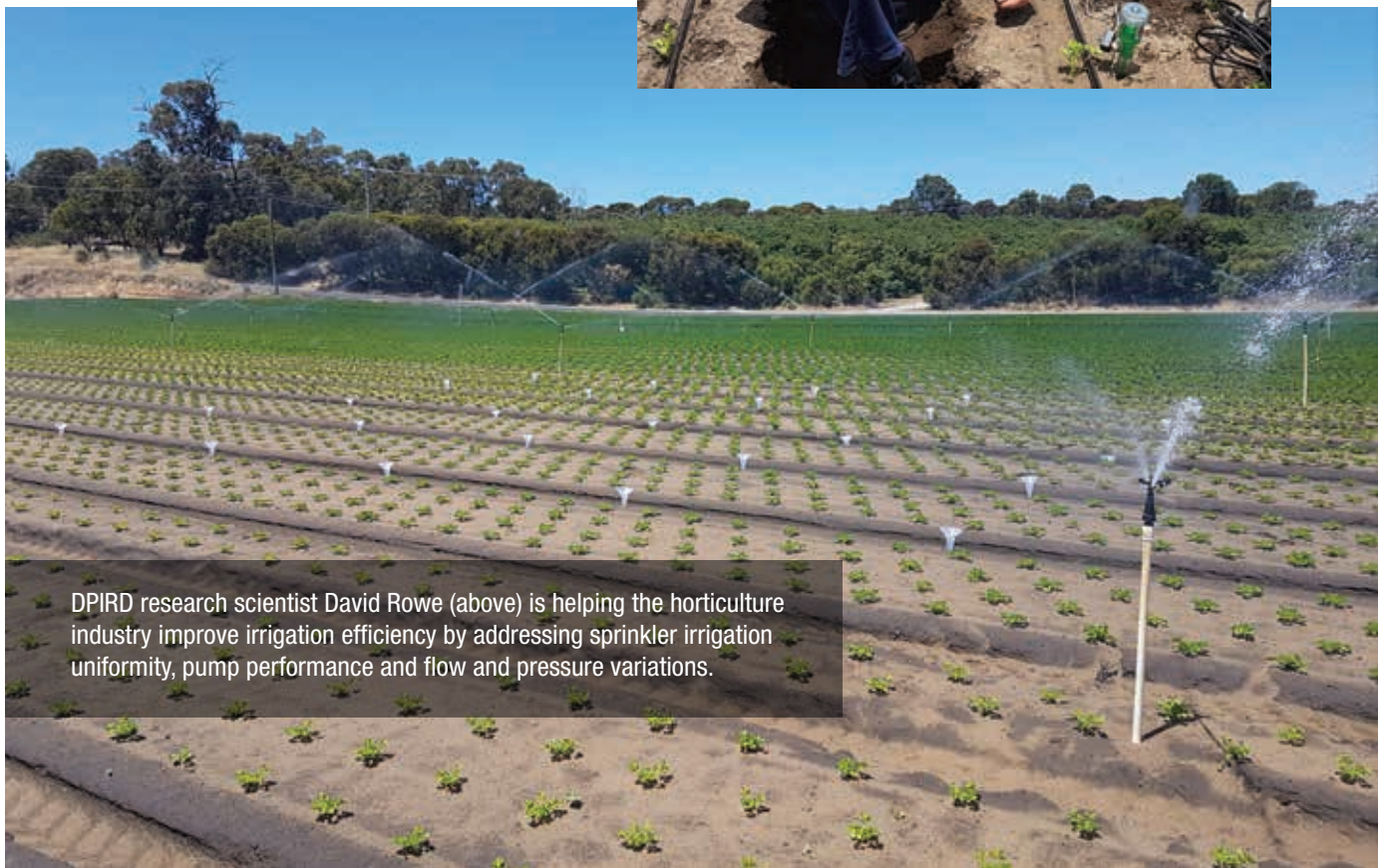
DPIRD researchers have found that the efficiency of commonly used vegetable sprinklers changes significantly depending on wind speed. In higher winds, sprinklers are less likely to give even water coverage, highlighting the need to space sprinklers more closely together in high wind speed areas such as the Swan Coastal Plain.

In one trial, an increase of wind speed from 4 km/hr to 20 km/hr caused a 10 per cent reduction in distribution uniformity for sprinklers spaced 12 metres apart. Distribution uniformity is a critical component of efficient irrigation. The same increase in wind speed saw a 20 per cent reduction in uniformity for sprinklers spaced 16 metres apart. This shows that closer-spaced sprinklers provide superior irrigation uniformity and are more resistant to the effects of wind.

Irrigation assessments in the north Wanneroo area by DPIRD research scientist David Rowe found that growers could improve irrigation efficiency by addressing sprinkler irrigation uniformity, pump performance and flow and pressure variations.

Soil moisture monitoring helps growers determine when to irrigate and how much water to apply. DPIRD researchers at Carnarvon are assessing several moisture sensors for their reliability and accuracy and will determine the soil moisture levels at which farmers should commence irrigation to prevent crop stress.

DPIRD has installed a Low Range Wide Area Network (LoRaWAN) system at the Carnarvon Research Facility. The team will investigate giving access to growers across the district to encourage the uptake of soil moisture sensors, water meters, water tank sensors and weather stations on their properties. The technology will allow growers to remotely monitor their irrigation systems and better manage irrigation of crops.



DPIRD research scientist David Rowe (above) is helping the horticulture industry improve irrigation efficiency by addressing sprinkler irrigation uniformity, pump performance and flow and pressure variations.

Vegetable Crops

New export markets

Demand for premium WA vegetables is increasing, in part due to increasing middle class incomes in Asia and the Middle East.

Between 2009 and 2019 the value of WA's export vegetable industry increased by 112 per cent to $118 million (Figure 24).

Carrots, potatoes, onions and truffles formed 91 per cent of total vegetable exports by value. DPIRD research officer Manju Radhakrishnan is investigating whether other WA industries with low or negligible exports can be added to the list of major exported vegetables. A preliminary multi-criteria analysis put asparagus, cauliflower, broccoli and sweet potato at the top for further analysis.

To assess export potential Manju is analysing selected export markets in terms of import value, price, quantity and trends over the past few years. She is determining the extent of market competition and analysing comparative tariff and distance advantage for Australia. The analysis will result in a list of markets that might have potential to absorb WA's premium products if there is capability to supply.

Manju is also exploring the potential for WA-grown crops to replace vegetable supplies from interstate and imports from overseas to Australia. For part of each year, WA receives supplies of vegetables including asparagus, capsicum, cucumber, garlic, mushroom, sweet potato and tomato from interstate. Garlic and asparagus are the major vegetables Australia imports from overseas.

Given the wide climatic variability across WA, further research may discover new WA production areas that will deliver produce out-of-season, reducing the need for imports.

For part of each year, WA receives supplies of capsicum from interstate.

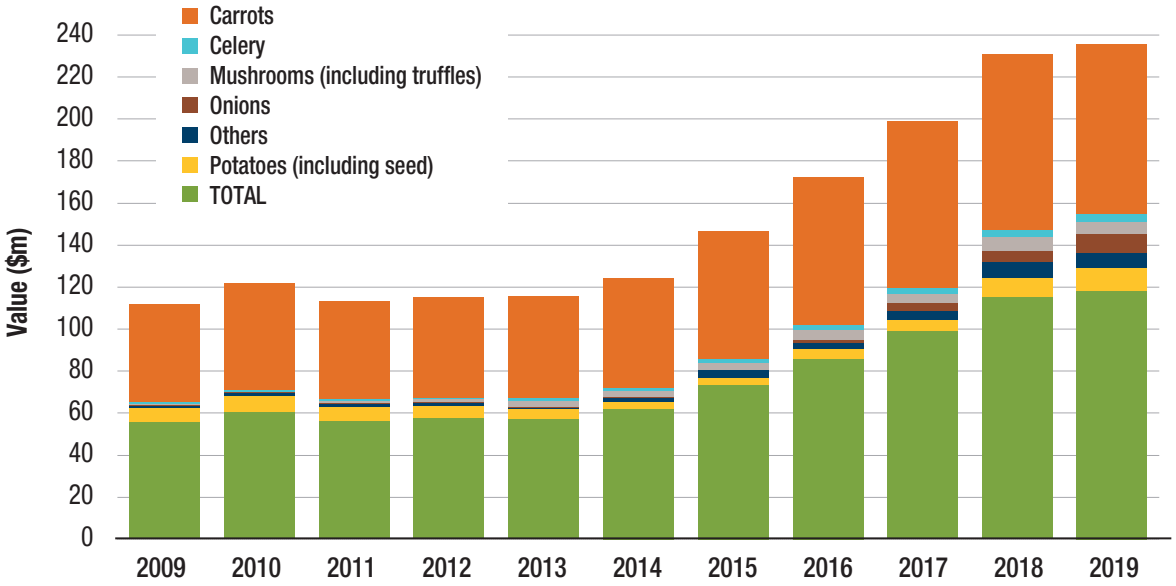


FIGURE 24. Vegetable export value trends (2009–2019)

Surveillance through citizen science and community trapping

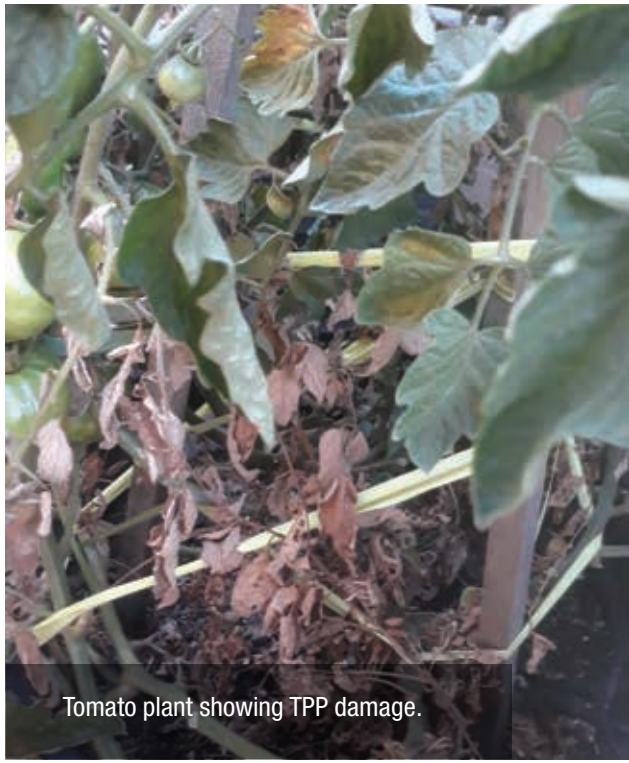
DPIRD project leader Don Telfer is leading surveillance efforts to detect a tiny sap-sucking insect known as the tomato potato psyllid (right), which can carry a destructive bacterial pathogen capable of significantly reducing vegetable yield and quality.

A citizen science project led by DPIRD is providing export markets with proof that Western Australia is free of a serious horticultural pathogen.

Vegetable Crops

Tomato potato psyllids are tiny sap-sucking insects first discovered in Perth in 2017. They pose a serious risk to the WA vegetable industry.

Healthy tomato plant.



Tomato plant showing TPP damage.

A DPIRD SURVEILLANCE PROGRAM has demonstrated the absence of significant pathogen from WA, with the help of Perth-based citizen scientists.

The pathogen, known as *Candidatus liberibacter solanacearum* (CLso), is spread by the tomato potato psyllid (TPP – a tiny sap-sucking insect that feeds on, and reduces crop yield in, tomato, potato, capsicum, chilli, goji berry, tamarillo, eggplant and sweet potato as well as some weeds such as nightshade.

CLso is also known for causing the tuber symptom 'zebra chip' where potato tubers take on a dark stain upon cooking, causing significant downgrading of potatoes.

Volunteers in the Perth metropolitan and peri-urban areas trap the tiny TPP insects using sticky traps and send the samples to DPIRD for pathogen analysis.

The program outcome has been critical to maintaining key WA horticultural export markets, particularly seed potatoes, through demonstrating the absence of the companion organism CLso.

Cooked potatoes showing 'zebra chip' symptoms.

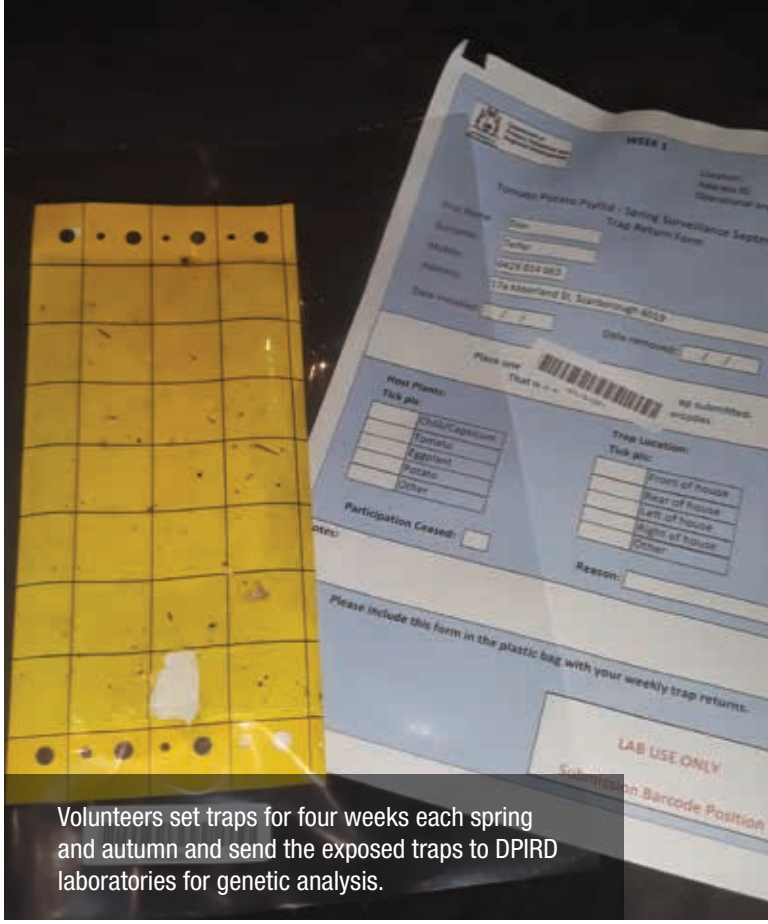
Vegetable Crops

Up to 250 volunteers in and around the Perth metropolitan area trap the tiny tomato potato psyllids using sticky traps and send the samples to DPIRD to determine if they are carrying the bacterial pathogen.

Continuing to demonstrate WA's CLso-free status will ensure that interstate and overseas seed potato markets valued at about $10 million per year are not disrupted and have the opportunity to grow further.

DPIRD project leader Don Telfer is leading the surveillance team to monitor for CLso with the help of the volunteer public.

TPP was discovered in a backyard in Perth in 2017. It is now well-established from Esperance to Carnarvon. Surveillance has not detected TPP on horticulture properties in the Ord River Irrigation District.

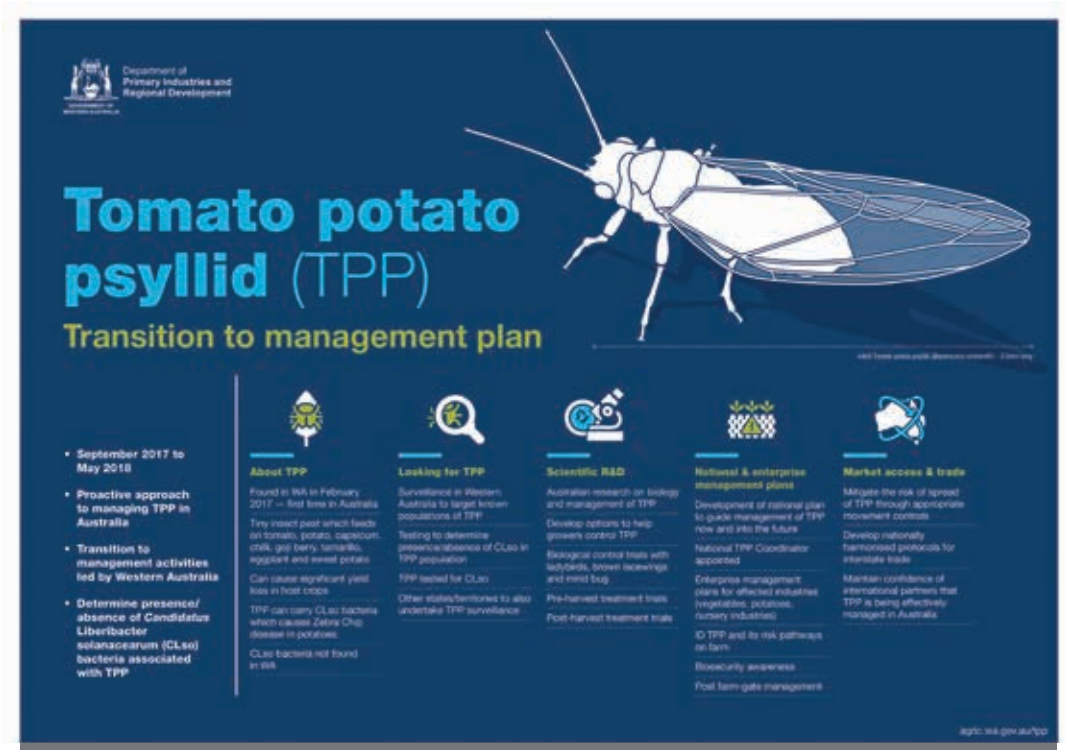


Volunteers set traps for four weeks each spring and autumn and send the exposed traps to DPIRD laboratories for genetic analysis.

Backyard surveillance

To prove to interstate and overseas markets that CLso is not present in WA, more than 1000 TPP are caught each year in metropolitan backyards and then genetically tested for the presence of the pathogen.

Over four weeks each spring and autumn the surveillance team enlists up to 250 volunteers to take home a set of sticky traps. The volunteers are also given tomato seedlings to grow to lure the TPP to the nearby sticky traps. The sticky traps are changed weekly and the exposed traps sent to DPIRD's laboratories for analysis.



The Transition to Management Plan was developed following national agreement that TPP cannot be eradicated and that efforts should focus instead on managing the pest.

For the surveillance of CLso in the greater Perth metropolitan area to be effective, DPIRD needs sufficient volunteers with traps spread in a rough matrix across the surveillance area.

Don and his team identify and recruit residents with backyards across the surveyed shires to work with the surveillance team. Trappers come from local and state government organisations as well as the general public.

About 80 per cent of volunteer trappers return each season to be part of the surveillance project.

As part of continuous improvement, Don is working with DPIRD entomologist Dr Melinda Moir to engage volunteers in a nationally funded research project led by DPIRD. The research is investigating whether TPP traps can be used to monitor other pests without affecting the catching of TPP and whether an alternative TPP trap from the USA is more effective for monitoring in WA.

INSECT AND DISEASE MANAGEMENT

INSECT AND DISEASE MANAGEMENT

Insect pests and diseases challenge most horticultural and irrigated agricultural production. Sustainable management requires an understanding of the organisms, their natural enemies and the production systems.

Dr Helen Spafford

TEAM LEADER, (INSECT AND DISEASE MANAGEMENT)

DPIRD'S INSECT AND DISEASE MANAGEMENT team members are found throughout the state in paddocks, fields, vineyards and orchards collecting data on the dynamic set of insect pests, diseases and weeds that challenge production. Even new products like truffles have pests that require management.

New pest incursions, like fall armyworm and apple scab, require rapid responses to assess impacts and develop management approaches.

External drivers – such as changes in market regulations and requirements at the local, national and international level, and consumer requirements for clean, green and aesthetically pleasing commodities – create increasing pressure for horticultural industries to continually innovate. For example, one DPIRD project is exploring a systems approach for fruit fly pests and moths to help secure markets for WA growers.

The insect and disease management team is providing evidence-based solutions to some of the most challenging issues facing WA producers.

Not all insects are pests. Biological control is an important aspect of an integrated pest management program and is an area the team is investigating. The use of natural enemies helps to reduce the number of pesticide applications. Understanding the biology of the pests and their natural enemies is crucial for the biological control of pests of crops like avocados and apples.

Many crops require insect pollination and there is concern about the worldwide decline of colonies of the domesticated honey bee. Research is underway to study flies as alternative insect pollinators and develop ways to manage them to supplement honey bee activities.

Yield and market access expanded with integrated pest control

From Ord Valley sweet corn and mangoes in the north to Manjimup apples, grapes and truffles in the south, Western Australia produces a diverse range of horticultural crops. Equally diverse are the pests and diseases attracted to these horticultural crops, the control of which presents a constant challenge to growers.

Fall armyworm damage on maize.

Insect and Disease Management

RESEARCH SCIENTISTS in the insect and disease management team are focused on developing management systems for new and established pests that enable growers to reduce chemical use and costs while producing higher-quality fruit and vegetables.

Natural predators replace chemical control

Using natural predators to control mites and other pests is a central focus of the integrated pest management systems being developed by DPIRD horticultural researchers. Pest mites have a global reputation for their capacity to overcome chemical control, so developing non-chemical ways to control them is critical for their ongoing management.

Predatory mites are natural enemies that attack and eat pest mites.

The European red mite, *Panonychus ulmi*, was first detected in WA in 2005 and quickly spread through the state's major apple growing regions. It is the major pest mite of cooler climate growing areas such as Manjimup and Pemberton.

Avocado tree defoliation due to six-spotted mite infestation.

Predatory mite attacking a six-spotted mite.

The local predatory mites that are present in WA apple orchards do not successfully control the European red mite so the DPIRD research team is investigating the control potential of the predatory mite *Typlodromus pyri* which is known to attack the European red mite in orchards overseas and in the eastern states.

A population of *Typlodromus pyri* is currently being cultured for DPIRD in a biological control facility in South Australia. The predatory mites have been mass produced and a portion of the colony has already been imported into WA where they were released directly into selected orchards infested with European red mites during the 2020–21 season.

DPIRD researchers will be monitoring how well the predatory mite is becoming established and how well it controls the European red mite. If the predators establish themselves successfully they will be introduced into other infested orchards in WA.

DPIRD scientist Alison Mathews examines apple leaves for European red mites.

Integrated approach for mite control

Avocados are one of the highest value horticultural crops grown in WA with an estimated annual value of about $200 million. Although production is seasonally variable, a new record of 25 617 tonnes was achieved in 2018–19, which represented about 30 per cent of Australian production.

Six-spotted mite is a pest of avocado production in the lower south-west of WA. It feeds on the leaves of avocado trees, leading to defoliation and reduced fruit quality. Tree health and fruit set for the next season may also be affected.

DPIRD scientist Alison Mathews examines an avocado leaf for predatory mites.

Six-spotted mite with egg.

Research scientist Alison Mathews is investigating integrated pest management options for six-spotted mite. Naturally occurring predatory mites, mass-reared predatory mites, tree health and miticide applications may be used or adapted to sustainably manage this pest. A user-friendly monitoring strategy for the mite will also be developed.

The findings will give growers confidence in their pest monitoring program and ensure management strategies are applied only if and when needed.

Truffle troubles

Producers of black truffles need to be aware of pests and diseases to protect their valuable dark harvest. DPIRD led the first major national truffle research project into pests and diseases of truffles and their host trees.

The WA industry is the fourth largest production region globally. In 2019 truffle production from the fungus, *Tuber melanosporum*, in WA was estimated to be about 10 tonnes of saleable truffles of which about 80 per cent was exported. Truffle is a premium product; export-quality truffle is worth about $800 per kilogram.

Slugs and slaters are the most significant pests of truffles, being both widespread and most prevalent in orchards. They feed on unripe and ripe truffles reducing harvest quality and yield which reduces the return to the producer.

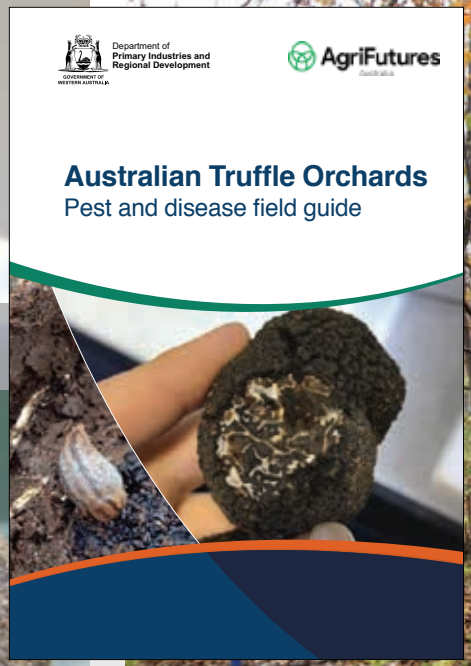
Slug feeding on truffle.

Insect and Disease Management

Research scientist Alison Mathews coordinated the production of an integrated pest and disease management manual and a field guide for the truffle industry. The documents provide growers with a comprehensive list of the pests and diseases they might find in their truffle orchards, and how to monitor and manage them.

Damaged truffle, possibly caused by springtails.

Extensive feeding damage caused by slugs and/or slaters.



Truffle orchard, Manjimup.

Scientists a step ahead of fungal pathogens

Fungicide resistance reduces control options for fungal diseases. DPIRD research scientist Dr Andrew Taylor is working with the WA apple and table grape industries to identify pathogens of high risk for fungicide resistance.

Apple scab, caused by the fungus *Venturia inaequalis*, is considered the most economically important disease of apples worldwide and is known to rapidly develop resistance to a range of fungicide groups. Under favourable conditions, uncontrolled apple scab can affect nearly all the fruit in an orchard, reducing fruit quality and may cause tree defoliation and reduced tree vigour.

The disease is relatively new to WA, and until Andrew's study its baseline fungicide resistance was unknown.

Without effective fungicides, high infection rates would be likely and the industry would need to shift to apple varieties with resistance to the pathogen.

Apple scab, caused by the fungus *Venturia inaequalis*, is considered the most economically important disease of apples worldwide.

Samples collected by Andrew from orchards in WA during the 2018–19 production season indicated that all fungicides registered for control of apple scab in WA were still effective. This means that if growers follow resistance prevention guidelines they can be confident of maintaining good disease control into the future.

Insect and Disease Management

Late season powdery mildew on grapes causing splitting of the berry.

Powdery mildew is a common disease caused by various fungal species and affects many crops and native hosts in WA. In seasons with regular warm and humid conditions, powdery mildew can cause significant yield losses and increase management costs.

Accurate identification of powdery mildew pathogens in WA is needed to develop management plans that delay the development of fungicide resistance. Andrew is currently updating the catalogue of powdery mildew species and their associated hosts in WA, using DNA sequencing techniques to categorise powdery mildew species with the correct taxonomy.

Powdery mildew of grapevines is caused by the fungus *Erysiphe necator*. With the support of the WA table grape industry, Andrew is trialling disease models developed in California and Europe that he has adapted for WA vineyards.

If successful, the models could improve management of powdery mildew in grapevines leading to fewer fungicide applications each season.

Early powdery mildew infection of a leaf.

Powdery mildew renders grapes unmarketable. DPIRD scientist Dr Andrew Taylor is developing a disease model to improve the management of the disease.

Insect and Disease Management

Fall armyworm moths can travel long distances by flying and using wind currents.

Fall armyworm

WA growers are now dealing with a new invader, fall armyworm. It is a significant pest that has been a challenge to manage wherever it is found. In the US and Brazil, where they have been managing fall armyworm for decades, losses and significant management costs are estimated at US$300 million annually.

Senior research scientist Dr Helen Spafford and a team of DPIRD officers around the state are monitoring the spread and establishment of fall armyworm. They are studying its impact and host range in WA, and surveys are underway to discover its natural enemies.

Fall armyworm became established in Australia early in 2020 at the tip of Cape York in Queensland and was confirmed in WA on 1 April 2020.

Fall armyworm caterpillars will feed on many different parts of corn plants. This larva was found in the tassel.

An integrated pest management approach to its control will be particularly important due to the propensity of fall armyworm to evolve resistance to insecticides.

DPIRD is actively seeking to monitor the resistance profile in collaboration with other agencies in Australia.

In the Americas, fall armyworm is known to be resistant to 29 active ingredients in insecticides found in six mode-of-action groups. It has also developed resistance to some of the *Bacillus thuringiensis* proteins produced by genetically modified crops.

In WA, it is now well-established in the northern production areas and is causing problems, particularly in corn and other grass crops, for growers in Kununurra, Broome and Carnarvon. The wide host range and dispersal capabilities of fall armyworm mean that it can spread throughout the state and potentially damage other crops.

Male Mediterranean fruit fly.

Developing a national systems approach to access key Asian markets

Verifying that horticultural products are free of pests like Mediterranean fruit fly through a systems approach could maintain market access and open up new markets for WA growers while reducing the need for end-point treatments.

Trading partners usually require an end-point treatment (such as cold disinfestation or fumigation) to be satisfied that imported products are free of pests of quarantine concern. But these end-point treatments can be costly or have environmental concerns; for example fumigation can leave residues and some of the older fumigants are ozone-depleting.

A systems approach is accepted by some trading partners as an alternative to end-point treatment. The systems approach uses two or more measures to provide the appropriate level of protection from a specific pest or disease. For each measure, evidence must be provided to demonstrate to the trading partner that the exported commodity is free of specified pests and diseases.

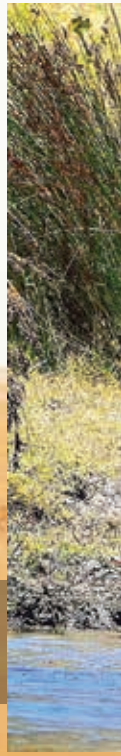
Project manager Kim James is leading a four-year project to realise market access opportunities for WA apples using a systems approach. The project assesses and models phytosanitary datasets to satisfy trading partners.

A case study for WA apples is being evaluated to determine whether a systems approach could be used to help access new Asian markets. WA does not currently have market access to Japan, China and Taiwan, and access to Indonesia is subject to treatment of the apples.

To prove the absence of fruit flies or moths, the case study will use data from several years of in-field trapping for pests across apple-production areas as the first measure for a systems approach. The second measure will be the results from harvesting and testing for pests of thousands of apples from those orchards.

Keeping a lid on stable flies

Stable flies breed in the plant residues remaining after vegetable crops are harvested and can be a major pest for neighbouring livestock. DPIRD researchers have found that compacting the soil above buried residues controls emergence of new adult flies without the need for insecticides.



Adult stable flies blood-feed several times a day on any nearby livestock causing distress and appetite loss.

Insect and Disease Management

DPIRD ENTOMOLOGIST Dr David Cook has developed a simple, chemical-free method to control the costly livestock pest stable fly, which in some years can reduce cattle growth rates by 25 per cent and milk production by about 50 per cent.

Outbreaks of this declared pest can occur in horticulture areas after harvest because larvae of the fly thrive in rotting plant material. Up to 1000 stable flies can develop in a square metre of vegetable residues left on the soil surface.

Adult stable flies are a pest of livestock operations, blood-feeding several times a day on any nearby livestock. Painful bites from the flies distress the animals, causing appetite loss and increased heat stress in summer when animals bunch together to avoid the flies.

Vegetable operations in areas where there is also a high volume of livestock, such as the Swan Coastal Plain, are obliged under the Biosecurity and Agriculture Management (Stable Fly) Management Plan 2019 to manage stable fly numbers as part of their post-harvest activities.

While as few as 20 flies on one animal will begin to affect production gains, it is common to find several hundred stable flies per animal on livestock close to major vegetable producers who are not controlling this pest.

Stable flies will also attack humans and domestic pets.

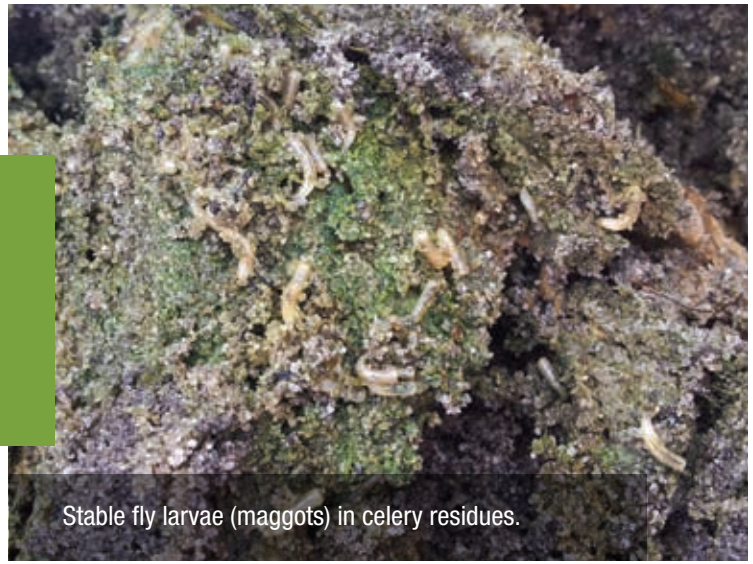
More than 50 flies per cow can reduce weight gain by 25 per cent and milk production by about 50 per cent. It is estimated that stable flies cost WA livestock industries up to $3 million in lost productivity in some years.

As few as 20 stable flies on one animal will begin to affect production gains.

Stable fly infestation on a newly born calf.

Insect and Disease Management

Stable fly outbreaks that affect livestock producers and residents could cause local shires to consider limiting future expansion of horticulture operations.



Stable fly larvae (maggots) in celery residues.

Burying is best

David undertook a combination of laboratory and field trials over several properties and a variety of crop residues to assess ways to control stable fly.

He found that the most effective method was a simple two-step process. Seven days after harvest, crop residues are buried using a mouldboard plough, stone burier or a deep, slow rotary hoe. This is followed by compacting the soil using a fixed landroller.

Example of crop residues left after harvest.

Stable fly eggs in carrot residues. Burying and compacting vegetable residues traps developing flies, reducing numbers by more than 95 per cent.

A newly emerged stable fly.

Insect and Disease Management

Compacting the soil with a fixed landroller after burying vegetable crop residues.

Burying and compacting residues builds soil organic matter and reduces wind erosion.

In the week between harvest and burial, adult flies are attracted to the residues rather than going to other laying material. Their eggs are buried with the residues, removing stable flies from the population.

Stable fly larvae developing in the residue are trapped beneath the compacted soil, which prevents the adults from emerging to feed on livestock.

While compaction does not eliminate stable flies altogether, trials have shown that it can reduce stable fly numbers by more than 95 per cent – from 1000 per square metre (if left totally untreated) to just 10 to 50 flies per square metre.

This method retains all the organic matter from the residues in the soil, there is minimal soil tillage, less use of machinery, no need to use any pesticides, and the compact, moist sand is less prone to soil wind erosion.

Native flies help crop pollination

Native flies could help pollinate key horticultural crops that are currently dependent on honey bees. DPIRD researchers are testing the ability of two native fly species to pollinate avocados as part of a national project to address the risk to horticulture industries of declining bee health worldwide.

DPIRD scientist Dr David Cook is examining the performance of native flies as pollinators, as a supplement to bees, in avocado orchards and blueberry crops.

Native flies actively visiting and feeding on blueberry flowers.

Insect and Disease Management

Western golden haired fly.

NATIVE FLIES MAY HAVE THE POTENTIAL to supplement honey bees as pollinators of key WA horticultural crops.

Crop pollination is an international issue due to pressures affecting the health of honey bee populations around the globe.

In Australia, pollination-dependent crops are worth nearly $6 billion per year.

Lesser brown or western blue-bodied fly.

DPIRD is leading a national project to investigate fly species as pollinators of avocado, berries (blueberry, raspberry and strawberry), hybrid carrot seed crops, hybrid brassica seed crops, mango and lychee.

DPIRD's research component is examining the performance of native flies as pollinators in avocado orchards. Avocados are the highest-value tree fruit crop in WA and are worth nearly $200 million annually to the state's horticultural sector.

A sarcophagid fly feeding on an open avocado flower.

Small hover flies are found in high numbers in the south-west of WA.

Western golden haired fly adult on an avocado fruit.

Flies make ideal pollinators as they regularly visit flowers for nectar and pick up pollen on their hairy bodies. They operate at cooler temperatures than bees and are present all year round in most growing regions.

DPIRD research scientist Dr David Cook has tested two fly species as pollinators in blueberry glasshouse trials and in large enclosures around whole avocado trees. The western golden haired fly is endemic to south-west WA and the western blue-bodied fly is present across mainland Australia.

He found that while the western golden haired fly could pollinate blueberries successfully, the western blue-bodied fly produced even better results. In blueberries it increased total yield by 36 per cent and increased the average berry size by five per cent compared with the western golden haired fly.

In avocados, David found that the western blue-bodied fly visited avocado flowers around three times more often than the western golden haired fly. Avocado trees that were enclosed with the western blue-bodied fly produced nearly 50 per cent more fruitlets than trees enclosed with the western golden haired fly.

Inside the large fly-proof enclosure over Hass avocado trees at a field trial site in Busselton, WA.

Adult flies ready for release into one of the fly enclosures in a Pemberton avocado orchard for the native flies pollination trial.

Insect and Disease Management

Overhead view of the paired-tree, fly-proof enclosures first used in an avocado orchard to record pollination by flies.

Pairs of Hass and Ettinger avocado cultivars with fly-proof enclosures during flowering helped understand the pollination ability of two native blowfly species.

David and his pollination team, research scientist Dr Sue Jaggar and technical officer Lachie Perry, monitored the avocado enclosures during the flowering period as well as trees outside in the orchard to record fly visitations and flower feeding. Future work will focus on ways to keep released flies within an orchard environment, such as protein lures.

Larger enclosures covering 21 avocado trees each tested the pollinating ability of the two species of fly. Pollination exclusively by native flies produced yields two-thirds of that achieved in open-pollinated trees that were visited by bees and other insects. This showed that the flies could be a viable pollinator alternative to bees.

To identify other fly species with potential as pollinators, orchards at Gingin, north of Perth, were monitored during 2020 for insects that visit avocado flowers.

Flies make ideal pollinators as they regularly visit flowers for nectar and pick up pollen on their hairy bodies.

The project will also develop rearing techniques for mass production of the best pollinating fly species so that they can be developed and distributed commercially in the horticulture sector. X-ray radiation will be trialled to stop cultivated flies from reproducing and increasing the natural fly populations.

TROPICAL FOOD, FIBRE AND FODDER

TROPICAL FOOD, FIBRE AND FODDER

DPIRD's tropical food, fibre and fodder team collaborates with national and international research and industry partners to expand, improve and better understand the productivity of Western Australia's tropical irrigated crop production systems.

Dr David McNeil and Christopher Ham

TEAM LEADERS, (TROPICAL FOOD, FIBRE AND FODDER)

THE TEAM INVESTIGATES food, fibre and fodder crops that have potential for profitable production in the north of WA.

DPIRD has developed strong working relationships with producers throughout the pastoral and horticultural industries and with the region's traditional owners. These relationships are crucial networks that interact with DPIRD in many ways, ranging from regional development issues, development and assessment of private proposals, industry specific issues, to research and extension of crops and cropping systems.

Research to stimulate the development of cropping systems is underway for hemp, mango, psyllium, cotton and quinoa in the Ord River Irrigation Area.

Fodder production systems are being developed for pastoral areas in conjunction with DPIRD's livestock team.

Specific research and development areas include:

- hydrology
- soils
- crop and economic modelling
- supply chains and market access
- policy
- irrigation.

New industry goes gluten-free with international backing

DPIRD is working with an Italian-based nutrition company to develop a new industry based on the functional food psyllium husk. The project is working across the supply chain from agronomic and plant breeding research through to product processing and market development.

Psyllium is produced from the husk of *Plantago ovata* seeds (inset), a medicinal plant native to southern and western Asia.

Tropical Food, Fibre and Fodder

A NEW INDUSTRY BASED on the highly valued dietary fibre psyllium husk is being developed in Kununurra in a project headed by DPIRD research scientist Dr David McNeil.

Psyllium is produced from the husk of *Plantago ovata* seeds, a medicinal plant native to southern and western Asia.

Used as a replacement for gluten in foods made for consumers with celiac disease, global demand for psyllium husk is on the rise. Global exports of the product were worth $330 million in 2018 and high-quality husk attracts strong prices of about $6.60 to $10.50 per kilogram.

Most of the world's psyllium currently comes from India where production systems are disaggregated, low-yielding and deliver variable product quality.

DPIRD is working with the Italian-based nutrition company Dr Schär Pty Ltd to develop a reliable supply of psyllium from the Ord River Irrigation Area in the Kimberley, an area with proven capacity for production of plantago.

Working across the entire value chain from paddock to plate, the research team is developing agronomy packages for plantago and assessing the processing, marketing and logistics components of the new industry.

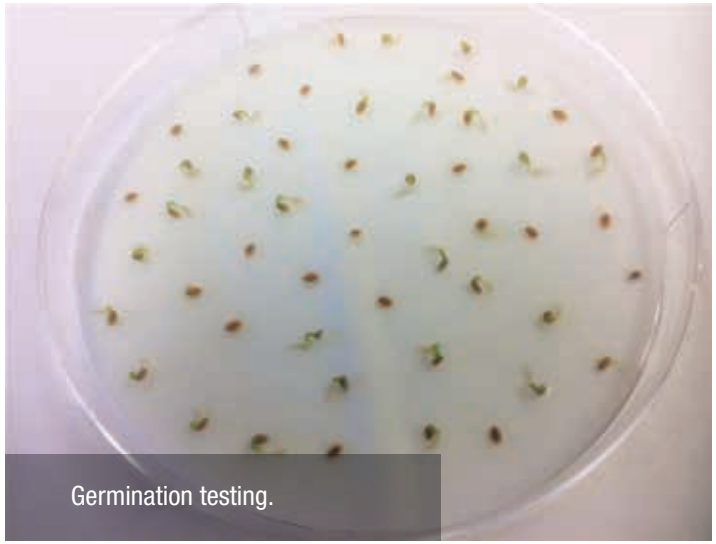
Seed quality and husk yield trials indicate that Kununurra-grown plantago is as good as, or better quality than, competing husk sources.

A new industry based on the highly valued dietary fibre psyllium husk is being developed in Kununurra. Pictured are the project team Silvano Ciani, Dr Siva Sivapalan, Dr David McNeil and Ombretta Polenghi in a trial plantago (psyllium) crop.

Commercially dehusked seed.

David McNeil checking breeding selections.

Tropical Food, Fibre and Fodder



Germination testing.

Newly germinated plantago crop.

Processing

Dr Schär has completed an economics and logistics plan based on processing the crop in Kununurra and negotiations to construct a processing plant are underway. Depending on the final scale of production, five to 10 direct full-time jobs could be created.

Dr Schär has also developed an improved processing system that increases the yield of premium quality husk, which will increase the competitive advantage of the industry. The local processing development has been based initially on a small industry of about $10 million turnover per year, although expansion will be possible.

The psyllium husk produced will be intended for export with an ultimate production goal of 10 000 hectares or 20 000 tonnes of seed producing 5000 tonnes of husk.

Agronomy

David is working with research scientist Dr Siva Sivapalan at the Frank Wise Tropical Agricultural Research Institute to develop agronomic guidelines for growing plantago in Kununurra. DPIRD senior research scientist Dr Helen Spafford is assisting with the development of an integrated pest management system.

Three years of trials to evaluate 14 existing plantago lines from India concluded in 2020 and seed of the most promising lines will be sown in semi-commercial plantings in 2021.

DPIRD, Dr Schär and the University of Adelaide are collaborating to breed new lines of plantago and screen seed and husk quality. Dr Schär will evaluate samples for processing through commercial equipment.

Harvesting trial plots of plantago (psyllium). The DPIRD trials have evaluated 14 plantago lines from India. The most promising seed will be sown in semi-commercial plantings in 2021.

Oasis Farms semi-commercial crop field day 2020.

Hand threshing plantago samples.

Irrigated fodder in WA's North West

DPIRD is helping cattle producers in the West Kimberley and Pilbara take advantage of irrigation opportunities for fodder production.

Tropical Food, Fibre and Fodder

Baling forage sorghum grown using irrigation to lift productivity of northern WA pastoral land.

DPIRD researchers are identifying the strengths and weaknesses of perennial grass species most suited to the semi-arid tropics of WA.

Northern WA cattle grazing irrigated pastures, which have been established to even out the annual feed supply.

A NEW DPIRD RESEARCH SITE in northern Western Australia is helping pastoral irrigators in the West Kimberley and Pilbara regions produce better quality cattle feed.

DPIRD has developed the Skuthorpe site near Broome to investigate irrigated farming systems and lift productivity of pastoral land and the northern cattle herd.

Northern producers graze their cattle on extensive areas of native grasses. However, the highly variable rainfall means good quality native grass is only available for between three and five months of the year during the wet season. This creates challenges for both grazing management and preparation of cattle for sale.

Because cattle can only be sold during the dry season when mustering is possible, there is a high degree of variance in the quality, weight and age, which in turn limits market options and on-farm profitability.

Cattle production systems in the Kimberley and Pilbara regions remain focused on the export trade to Israel, the United Arab Emirates and South-East Asia, with key markets being Vietnam and Indonesia.These markets have strict specifications. If cattle are not within the specifications, they are either sold to lower value markets or turned back out to pasture.

The northern pastoral industry contributes more than $300 million each year to the state's gross value of agricultural product and represents almost half of the Western Australian beef herd.

Tropical Food, Fibre and Fodder

DPIRD research is investigating irrigated farming systems to lift the productivity of pastoral land and the northern cattle herd.

Pastoralists with access to irrigation can use irrigated fodder to increase productivity by improving the quantity and quality of fodder available to cattle.

Kimberley cattle producers and agribusiness staff participate in a pastures field walk at a DPIRD fodder variety trial near Broome.

Pastoralists with access to irrigation can use irrigated fodder to increase productivity by improving the quantity and quality of fodder available to cattle. This would improve preparation of sale cattle to better meet market specifications.

Pastoral-based irrigated farming systems can reliably grow fodder for 12 months of the year using introduced pasture species irrigated by centre pivot irrigation systems. Small areas of irrigated pasture integrated within areas of extensive grazing is termed mosaic agriculture.

Since 2000 there has been increased investment in irrigation on pastoral lands to produce fodder for cattle destined for domestic and export markets. In 2020 more than 4000 hectares was under irrigation across the Pilbara and West Kimberley. Irrigation developments require significant investment and an understanding of irrigated farming systems.

In response to producer interest in mosaic agriculture, DPIRD has previously undertaken research to assess the potential for irrigated fodder production. The Mosaic Agriculture project found that quality irrigated fodder could potentially increase daily weight gains of cattle by 50 per cent compared to good quality native grass.

[see *Irrigation delivers year-round cattle feed*, Livestock section]

Tropical Food, Fibre and Fodder

Pastoral-based irrigated farming systems can reliably grow fodder for 12 months of the year using introduced pasture species irrigated by centre pivot irrigation systems.

The Skuthorpe research site is a partnership between DPIRD's Tropical Food, Fibre and Fodder team and Skuthorpe property owner Graeme Rogers. Senior development officer Chris Ham led the development and management of the five-hectare site, overseeing installation of an 88-metre centre pivot irrigator to irrigate almost 80 per cent of the site (3.8 hectares) using water from the Broome Sandstone aquifer.

The site will host the Pastoral Agriculture project – a research project involving both the Tropical Food, Fibre and Fodder team and the Livestock directorate – to research northern fodder crops for DPIRD's Northern Beef Development Program.

[see *More northern beef through land, labour and livestock efficiencies*, Livestock section]

The project will benchmark current knowledge of pastoral-based irrigated farming systems, focusing on variety choice, fertiliser management and irrigation monitoring and scheduling.

DPIRD researchers Geoff Moore and Samuel Crouch are leading the first two research trials of the Pastoral Agriculture project.

The first trial is quantifying the characteristics, strengths and weaknesses of perennial grass species most suited to the semi-arid tropics of WA and their suitability for fodder production systems under a controlled environment. Northern pastoralists with access to irrigation will use the data to choose the right species of grass to suit their production system and location.

Senior development officer Chris Ham downloads soil moisture data from an automatic soil water probe at Wallal Station.

Sorghum cut and wilting prior to baling at the Skulthorpe site.

The second trial is refining profitable fodder production systems for perennial and annual fodder species grown under the unique constraints of the north-west regions. The trial will focus on annual rotations of silage and legume hay crops to create a feedlot-quality ration. This will increase competitiveness of production and provide evidence-based information for pastoralists who are interested in more intensive feeding systems such as feed yards or feedlots.

To ensure that irrigation research is in line with industry needs, DPIRD has involved the Kimberley Pilbara Cattlemen's Association (KPCA) and key industry stakeholders in early planning phases.

DPIRD and KPCA produced the *KPCA Irrigated Fodder and Grazing Animals Production Systems Analysis for the Northern Beef Industry* booklet. It summarised agricultural developments on pastoral leases, indicated some key opportunities and provided information and management tips on key research issues identified through industry consultation.