Integrated Crop Protection
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Soil Wealth
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JUNE 2019

VEG & TECH: SCIENCE FICTION OR THE FUTURE OF FARMING?

GLOBAL SCAN AND REVIEW

How do you know if information is reliable? Tired of searching the internet to find the answer to that problem? Our global scan and review series provides leading, research-based information from around the world to Australian vegetable growers and advisors.

KEY MESSAGES

- ✓ **Technology will play an important role in improving efficiency**
- ✓ **Technologies that use smart phones and tablets (e.g. apps) are rapidly advancing and will develop quickly over the next five years (e.g. drones)**
- ✓ **Many innovative technologies are still considered 'concept stage'. For example:**

  - Artificial intelligence systems are at the beginning of their evolution, the important aspects are ability to deliver real value and data ownership

  - Blockchain technologies have an application in agriculture which could lead to increased transparency on the movement of commodities through the value chain
- ✓ **Internationally, ag tech is being made usable by start-up companies**
- ✓ **Growers and their advisors will still play a critical role on-farm in the future providing local understanding, expertise networks and industry knowledge.**

THE VEGETABLE FARM OF TOMORROW?

It's 9 am, and a Werribee farmer in Victoria sips coffee in front of a laptop. Real-time satellite images ricocheted from a wireless array of smart dust sensors sprinkled over the farm show nutrition problems in a north-west field and pest issues in the south. At 9:10 am, the farmer deploys a team of collaborative robots to exact locations to apply precise quantities of pesticide and fertiliser. At 9:20 am, after overlaying the input data from nodes linked to the local community's low-power wide-area network onto a digital twin of the entire system, with a click of a button the farmer initiates automated irrigation based on local weather data and on-farm diagnostics.[1]

Okay, so this may not be a farmer of tomorrow, or even of the near or distant future, but how can we know where and when science fiction might become reality? Or do we even want them to become reality? The above example might excite some, but horrify others – where is the sun on my face and dirt on my boots on this fictional futuristic farm? As agricultural systems forge toward a large-scale, complex, tech-savvy future, where should you look for these technologies and what questions should you be asking?

Hort Innovation ahr applied horticultural research RMCG

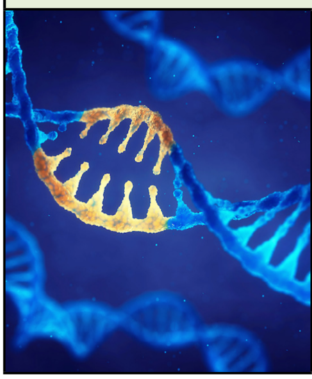
This project has been funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

WHAT ARE SOME OF THE NEWEST GLOBAL INNOVATIONS IN TECHNOLOGY?

Current technology megatrends in agriculture include use of the Internet of Things (or IoT), big data, artificial intelligence (AI) and advanced sensors.

A series of horizon scans by Agrifutures in 2018 [2] identified 24 technologies at the edge of current thinking that have the potential to impact on Australian rural industries. The Soil Wealth ICP team have taken a sample from this list most relevant to the vegetable industry, most of which are still considered 'concept stage' (Table 1).

Table 1: Examples from the watchlist of 24 emerging technologies detected by Agrifutures in 2018 [2]

TECH TYPE	EXAMPLES	DESCRIPTION & APPLICATIONS	STATUS
Data			
	Smart dust	Tiny wireless sensors could monitor vegetable crops at an unprecedented scale to accurately determine watering, fertilisation and pest control needs.	Concept
	Digital twins	Artificial intelligence that can virtually simulate, validate and optimise entire systems or processes. Constantly monitor the whole process from vegetable production to marketing and sales. AI systems are at the beginning of their evolution, the important aspects are ability to deliver real value and data ownership.[3]	Actual use
	LoRaWAN (Low-Power Wide-Area Networks)	Subscription-free wireless data networks set up by agricultural communities. A single gateway can collect data from thousands of nodes deployed kilometres away. Handy if you're growing vegetables across multiple farms.	Prototype
Genomics and biotech			
	CRISPR	Described as 'the future of gene editing', CRISPR is a rapid form of 'molecular scissors' that cut DNA at a specific location in the genome so that bits of DNA can be added or removed. CRISPR-edited products have been marketed as non-genetically modified, if only a few snippets of the plant's existing genes have been changed rather than inserting genes from animals or bacteria, although CRISPR can do that too. There is potential to create new traits in vegetable crops, such as pest resistance or drought tolerance.	Actual use

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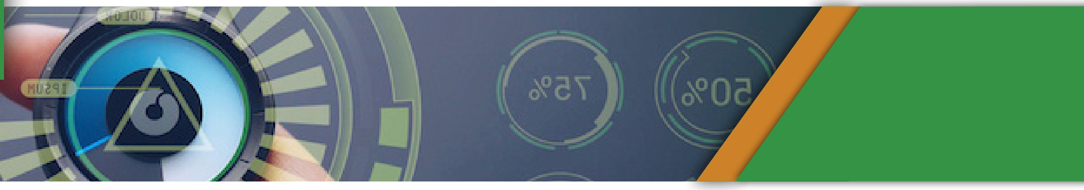
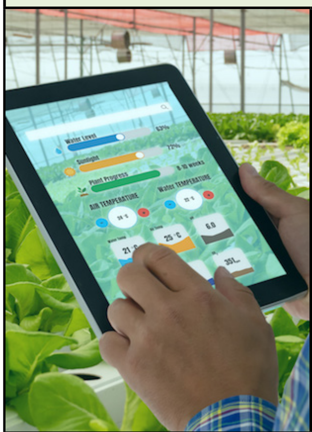


TECH TYPE	EXAMPLES	DESCRIPTION & APPLICATIONS	STATUS
Robotics and AI			
	Collaborative robots	Fleets of robots collaborate to accomplish one or several tasks. Potential for use in nursery planting, crop seeding, crop monitoring and analysis, fertilisation, irrigation, weeding and spraying, thinning and pruning, as well as autonomous harvesting. The vegetable industry has recently made significant gains through investing in robotic prototypes within universities.	Prototype
	Wearable user interfaces	Interfaces that allow unskilled workers to operate complex equipment and carry out complex tasks or hands-free and non-verbal communication between human and machine by wearable devices. This would be most applicable for some vegetable production tasks, as well as packing shed and logistics that are seeing ever-increasing levels of automation, complexity and efficiency.	Concept
Business models			
	Blockchain	A shared system of record-keeping that can be trusted by all involved parties – a chain of 'blocks' of digital information stored in a public database (the 'chain'). Improve traceability, therefore provenance or product origin. This could lead to increased transparency of the movement of commodities through the value chain. The potential for manufacturers to impose production specifications becomes an increasing probability with the take-up of this technology. This will become increasingly important for the industry as export of Australian vegetables continues to increase, coupled with consumer demand for connection to provenance.	Actual use/ prototype
Renewable energy			
	Sodium-ion batteries	Rechargeable metal-ion batteries that use sodium ions as charge carriers instead of lithium, which is expensive and requires large amounts of drinking water during extraction. These batteries have the potential to supply reliable energy to where it's needed most, such as packing and cool store facilities, coupled with renewable energy generation such as solar cells.	Concept

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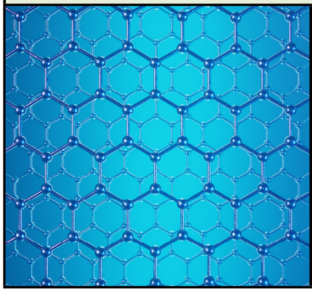
TECH TYPE	EXAMPLES	DESCRIPTION & APPLICATIONS	STATUS
Advanced materials			
	Compaction, membranes for water filtration, fuel storage	A single layer of carbon atoms arranged in a hexagonal lattice – graphene is the thinnest material in the known universe and the strongest material even measured (150 times stronger than steel). These properties could create super lightweight machinery to reduce compaction, to membranes for water filtration to fuel storage, energy networks, robust fertilisers with bonded nutrients tailored to crop needs and improved food packaging.	Concept

HOW ARE THESE NEW TECHNOLOGIES BEING APPLIED?

Many technologies with potential uses in agriculture are still effectively at the 'concept stage', that is, more or less still in the realm of science fiction. But beyond projected uses of these technologies, some actual examples are starting to be trialled in agricultural systems around the world. So, which are closer to being usable than others? And what are the sticking points to application? Here are some examples of different phases of development for several types of tech.

CONCEPT OR PROTOTYPE STAGE

Although we have been hearing about smart dust for many years, actual applicability of these tiny sensors in vegetable systems may not be that close. Although intended to shrink to the size of rice grains over the next few years, the current dust 'motes' are more like the size of bottle caps, and coordinating and managing these systems after they have been deployed presents a conundrum. Although sensors at the fine scale of smart dust might still be somewhat futuristic, arrays of remote monitoring sensors are already used in agricultural systems, such as soil moisture monitoring for precision irrigation.

Graphene is another much-hyped tech still at the 'potential' use stage.

Although it may have numerous hypothetical uses in future, such as integration with controlled-release fertilisers, the potentially exciting material is still under development. The current cost of graphene ($200 per gram) is still prohibitive for most applications.

Nothing says 'science fiction' like robots. Indeed, robotics is a burgeoning field within agricultural technology. Prototype robot pickers are currently being developed for various horticultural crops around the world. Hoped to ease difficulties in sourcing cheap labour, models such as Harvey the capsicum picker (Australia) and Harvest CROO the strawberry picker (USA) are not far from actual usage. Whether the economics will stack up may be the next big question.

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ACTUAL USE STAGE

Since its 2013 demonstration in Arabidopsis and tobacco, rapid uptake of genome-editing tool CRISPR has seen road-testing in numerous plant types.[3] For example, in only 2014, Chinese scientists reported creating a strain of wheat that is resistant to powdery mildew.[5]

The concept of digital twins may bring to mind space-age virtual reality holograms. However, the technology has already been applied in real-world agricultural settings. For example, in Portugal, a system called OpenPD has been developed by Espiralpixel in which farmers provide pictures and descriptions of plant pests and diseases and experts analyse data of the model then provide rapid solutions via a mobile app.[6]

WHAT SHOULD WE BE LOOKING FOR?

As in other countries, the trajectory of tech growth usage in Australia may be linked with development of intuitive and easy-to-use software or equipment. Apps seem to be a natural conduit between technology and the farmer. Therefore, keeping a lookout for companies or start-ups offering user-friendly digital apps will be more valuable to the individual grower than understanding the raw technologies. This includes data integration and 'inter-operability' between different pieces of software you may operate on your farm.

Exciting and potentially alluring to a new labour market for the ag sector, tech has boundless potential to improve efficiency.

However, there may also be risks involved, such as unexpected negative effects or further reduction of human presence on farms. Indeed, the Australian Farm Institute Digital Farmers conference in 2018 explored the role that people play in digital agriculture, and the impact of digital agriculture on people.

Does all tech equate to improvement? For instance, does engineering plants resistant to agrochemicals rate as sustainable agriculture? Is scattering fields with smart dust truly beneficial, or just adding to the detritus we're leaving for future generations?

To assist your decision making - here are some key questions to answer about agricultural technology and how they fit with your vegetable business[3]:

1. **Does it increase productivity or decrease costs in a meaningful way today?**
2. **Does it fit with your long-term strategy of information creating valuable partnerships with customers, suppliers and researchers?**
3. **Is enough of the technology that enables the overall technology approach at an industrialised or utility level (i.e. beyond actual use stage)?**
4. **Is the technology built on top of other major business or consumer products so that most components will receive lots of ongoing investment and attention?**
5. **Do you have the capabilities/can easily source the capabilities in your area in order to keep the technology running/innovate?**
6. **Is the technology sufficiently 'hardened' to run in a commercial farm environment?[3]**

Precision ag practices are already widespread in many countries including Australia – including variable rate and application of fertilisers, pesticides and water – however large economic benefit is not guaranteed. For instance, although they may reach for 'optimal' levels of production, the economic benefits of precision farming technologies to adjust input levels are often low, as profit margins tend to plateau rapidly.

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WHERE ARE WE HEADED AND WHAT ARE THE POSSIBILITIES?

Within 30 years the world's population is estimated to grow ahead of what our food supply can support. In Australia, technology could help drive efficiency and productivity, and support the aging workforce.

While Australian agriculture has a track record of successful and timely adoption of technology, tech expansion is likely to be exponential over the coming decades.

Indeed, technology use in agriculture is on the rise globally, with numbers of tech patent registrations growing, particularly in the US, Asia and Europe. The market for agricultural robots and drones is predicted to reach $35 billion within the next 20 years.[8]

Tech could help meet market and consumer demands such as ethical and/or sustainably produced food (improved energy, efficiency, organics), health and nutrition (fresh food, healthy food), and provenance (product origin).

Fifty years ago, farmers would have been gob-smacked by the farming methods commonly used today. We can only imagine what farming may look like 50 years from now.

FURTHER INFORMATION

For further information, the following resources may be of interest.

- Sydney Uni ag-robotics video
- Queensland University of Technology 'Harvey' the capsicum harvester
- The Yield water balance and irrigation scheduling app
- Various strawberry harvesters overseas – e.g. Harvest Croo
- SwarmFarm's SwarmBots in broadacre applications
- Driverless tractors

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