2019-2020

THE INNOVATION REPORT

vineland
RESEARCH & INNOVATION CENTRE

Introducing Vineland's new CEO

Ian Potter, Vineland's CEO

It was Vineland's long and successful history of innovation, from its early days in 1906 as the Horticultural Experiment Station, "Jordan Harbour" to address problems facing fruit growers, to Vineland's rebirth and transformation in 2007 into a world-class research and innovation centre and its continued success that persuaded me to take the position of CEO in April 2019.

Over the last few months, it has been both personally and professionally liberating to hear and see the wide range of innovation that Vineland's scientific, engineering, technical and business teams, with world-class facilities, have supported the Canadian and world horticultural sector.

Much has been written in academic and business literature on how research and development can lead to effective innovation in a sector. What is clear from the literature and my own experience is that for innovation to happen effectively, there is a variety of demands and inputs that need to come together, such as policy direction, market understanding, leadership, teamwork, technology/product focus, ability to fail, market understanding and many others. In my experience, for research and technology organizations (RTOs) such as Vineland to be successful, one of the main areas that have always resonated with me in discussing innovation programs with clients is risk management.

There are obviously different types and levels of risk, such as corporate risk, program risk, project risk, management risk and market risk, but most RTOs such as Vineland have become experts in managing the technology/product risk for and with clients, understanding the questions, possessing the skills to interrogate the issue and be nimble and agile to move towards the required outcomes, or as is sometimes the case, understand why something won't work in a quick fashion and shut it down, or park it, to effectively manage the investment.

To manage the technology/product risk, RTOs also have to understand market risk in terms of the present and possible future. As such, we conduct consumer and market assessments, get involved in road mapping and foresight studies, we also have horizontal and vertical relationships in the supply chain to understand market realities and the ability to help connect companies within these chains, from local small-to-medium enterprises (SMEs) to national and multinational enterprises (MNEs).

Hence, while a research and innovation centre, Vineland is also a tool for economic development. So for those leaders that had the foresight to form the Horticultural Experiment Station in 1906, I say thank you on behalf of the current Vineland Board, employees and the horticultural sector in Canada; as you will see in this report, innovation in horticulture is flourishing as a result of your foundational efforts and the ongoing support of the Ontario government, federal government, a strong Canadian horticultural sector and many others.

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A new breed of company

Michael Pautler, Platform Genetics' head of genomics services

Platform Genetics Inc. is on a mission to make breeding more efficient.

The two-year-old venture is Vineland's first spin-off company to be born of its work in advancing Canada's horticulture industry. It's also one of the only companies in the world to provide access to the tools needed to improve everything from flavour to disease resistance in crops.

Deep Variant Scanning (DVS), a method for rapidly identifying rare and valuable genetic variants, helps Vineland scientists home in on genes responsible for a crop's most prized characteristics.

"Using a technology like DVS, we can look at a population, for example, of tomato plants and if we know the gene that creates a certain flavour compound causing consumers to dislike it, we can selectively omit that gene so we're getting rid of what consumers dislike and make it something they like," said Michael Pautler, Vineland's research scientist in applied genomics.

"It's access to genetic variation," said Pautler, who doubles as Platform Genetics' head of genomics services. "Genetic variation powers breeding programs and enables you to discover great traits that can benefit consumers and growers."

"...Genetic variation powers breeding programs and enables you to discover great traits that can benefit consumers."

The company can do it with any crop, too. Pautler and his team have worked on onions, corn, tulips, broccoli and celery, to name a few. It's been tapped by companies throughout North America, Europe and the Middle East to help improve food and flower crops.

Platform Genetics and the DVS technology is a non-GMO approach that is more widely accepted by consumers and avoids enormous costs that transgenic seed companies face bringing a product to market. That positions the company to grow as a business, ushering in new jobs for research scientists to do high-skilled work, Pautler noted.

Platform Genetics and its DVS technology are also poised to help the cannabis industry as it moves into the mainstream.

"Cannabis companies, much like the rest of the horticulture industry, have problems with disease and pests and there's a huge opportunity for trait development and plant breeding. Hypothetically, the emerging field of cannabis is the perfect application for our technology," Pautler explained.

Better still is how efficiently and cost effectively the work can be done. The entire process, from creating increased variation, analyzing DNA sequences and identifying seeds carrying a desired genetic variation, can happen in under four weeks. Pautler credits Platform Genetics' high-tech bioinformatics algorithms for speeding up a historically slow process.

Digital and genomics-based technologies for agriculture, commonly known as AgTech, will be essential for feeding an estimated nine billion people by 2050. The continued success of Platform Genetics ensures that Canada will remain at the forefront of this emerging field, bringing a new generation of tools to the world of agriculture.

Apple buds and taste buds

Rachael LeBlanc

Every one of the 22,000 apple trees growing at Vineland's research farm is competing for the same job — to be the next great fall fruit into which Canadians sink their teeth.

First, the apples growing on those trees have to get past the taste buds of Daryl Somers, Vineland's research director of applied genomics and his senior research technician, Rachael LeBlanc.

"What we're looking for is great taste and texture," Somers said, standing among rows and rows of apple trees at various stages of maturity. "It's got to have a marketable taste and texture."

That means it has to be juicy, crispy and definitely not mealy. It needs to channel the crowd-pleasing characteristics of popular varieties on the market.

The genomics research group has worked with Amy Bowen, Vineland's research director of consumer insights and her team to fine-tune their taste testing. They're also guided by a preference map that Bowen's researchers created after working with consumers to compare the flavour and texture of 70 apple varieties.

Resoundingly, consumers favour apples that are crisp, juicy and sweet with aroma traits of fresh red apples — information Somers has used over the years to help direct his apple breeding and selection criteria in the Vineland test orchard.

"Apples are a competitive market and consumers have many options, so it's important to understand the preference drivers to ensure that apples progressing through Vineland's breeding program have the characteristics consumers want," Bowen said. "Apples from our program need to have the right texture and flavour profile in addition to performing well in the orchard for the best chance to market."

Now, eight years after Vineland launched its apple breeding program as part of a nationwide consortium tying apple research in Summerland, BC and Kentville, NS, Vineland is closer to bringing the world the next household name in fruit.

Somers has tasted thousands of apples bred at Vineland and so far 39 varieties have moved on to the next stage of testing.

Somers and LeBlanc will continue using Vineland's sensory preference map to ensure each of these apples is worthy of staying in the running. But now they'll look more closely at traits including yield, disease resistance and even how the trees fare growing in more typical orchard conditions using commercial spacing and drip irrigation.

The research will take another six to seven years for completion and not every apple among these initial 39 will last. They'll be replaced by some of the 22,000 candidates coming up behind them. Of those, two to four winners will be selected to satisfy consumers' appetite for apples while lessening Canada's reliance on imports to do so. The new varieties could also make apple growing more profitable for farmers.

The target date for the first release from Vineland's research farm to wide-scale commercial plantings is 2027.

"The selection process is very intense," Somers said. "I know that there are some really awesome apples in our pipeline. I am confident Canada's next apple is among these. It will be great to see that apple."

Vineland's research apple orchard

Seeking some hungry predators

The biocontrol team at Vineland is on a bit of a fishing expedition. In this case, though, the big catch they're pursuing is actually quite tiny. But what that catch lacks in size, the team hopes it will make up for with a voracious appetite, particularly for pests that can do serious damage to greenhouse flower, food and cannabis crops.

Research director Michael Brownbridge and his team Rose Buitenhuis, Nadine Gaskell, Zelda Pieterse, Taro Saito and Ashley Summerfield are on the hunt for at least two generalist predatory insects or mites that will devour just about any pest that crosses their paths. A five-year project, in collaboration with the Université du Québec à Montréal (UQAM) funded by Agriculture and Agri-Food Canada includes commercial partners who can make Vineland's top biocontrol candidates widely available to growers.

"There's no shortage of predatory species out there and no shortage of information in literature about new discoveries," Brownbridge said. "But the strength of this project is we have partners in the commercial world. That keeps the focus on getting tools out the door that can be used in a commercial setting."

The Vineland team is scouring community gardens and other chemical-free sites to find the new poster bug for greenhouse biocontrol programs. Abandoned orchards or other swaths left uncultivated are potential gold mines for candidates, too. Brownbridge and crew will also keep an eye on locations that use flowers to recruit beneficial insects. And they're putting out their own pest-covered plant material in strategic sites to lure new predatory and parasitic species, then test how effective these recruits perform in Vineland's greenhouse.

"You're basically baiting, just like fishing," Brownbridge explained. "Plants emit a natural distress signal and predators are attracted to it. They'll go out in search of that food source."

Using biocontrol agents in greenhouses isn't new. The problem is many of the beneficial insects and mites used to control pests in such environments are picky eaters. They'll gorge on one destructive critter while ignoring others, or they'll work well only in certain jurisdictions or crops.

Plants also have pressure from more than one pest and not every creepy crawler has a known biological solution. As a result, growers may rely on pesticides from time to time to keep problems in check. But those chemical interventions don't discriminate against insect or mite, good or bad.

Meanwhile, growing cannabis on a large commercial scale is uncharted territory, Brownbridge noted. The Canadian industry is "basically forcing a square peg in a round hole" by using biocontrol agents and tools available for flower and vegetable crops but not necessarily suited for cannabis.

The need for generalist predators to protect crops is even more pressing with the increased crop diversity in Canadian greenhouses, issues related to climate change and the industry's use of propagative materials sourced from all over the world which can bring new pest problems with them.

"Some of the new pests coming in, we don't have biocontrols against them so there's a continued need for innovation in biocontrol. Generalists can also provide a stronger foundation for many existing biocontrol programs developed for resident pests," Brownbridge explained.

New generalist predators won't put existing specialist species out of work, he noted. Instead, they'll work in tandem to tackle pests while further reducing the likelihood of growers turning to chemicals for help.

"Specialists will still do their job but generalists help everything," Brownbridge said. "Research studies have shown that including a generalist predator in a biocontrol program typically leads to enhanced overall efficacy. Plus, the generalist and the specialist rarely encounter each other in the real world and so they can both do their jobs in a very compatible manner, which is good news for growers and for the future of our greenhouse industry."

"...The need for a generalist predator is even more pressing with the increased crop diversity in Canadian greenhouses, issues related to climate change and the industry's reliance on imported seeds and grafting materials."

Vineland makes expertise available to industry

There was a time when Vineland researchers would field sporadic calls from horticultural industry groups, businesses and individual growers looking for custom research services.

Recognizing this as a market need and a business opportunity, Vineland is now proactively offering its expertise to work directly with commercial partners on innovative solutions advancing horticulture in Canada.

Vineland's value is a proven research capacity spanning more than a decade in biology, engineering and consumer sciences and, in particular, the niche expertise that comes from merging these disciplines. Its impact-focused operating model, with immediate results, also positions the research and innovation centre as the ideal partner for solving horticulture's most pressing challenges, including those in Canada's new cannabis industry.

Vineland's services include trait development and crop improvement; systems integration with automation and process optimization solutions; biocontrol and integrated pest management (IPM); consumer insights and nursery and landscape advisory services.

Trait development and crop improvement

Vineland's business offshoot, Platform Genetics uses its patented Deep Variant Scanning to provide a variety of genomics services, including genetic mapping and marker development, genome sequencing and marker-assisted selection to improve any crop (full story on page 4).

Systems integration — automation and process optimization solutions

Vineland consults with companies to assess existing technology, provide recommendations to improve workflow and offer customized robotics and automation solutions to increase productivity and maximize profit.

The centre can also connect growers with a wealth of Canadian manufacturers able to build technology required to optimize operations in automated sorting, grading, packaging and palletizing; greenhouse process automation; produce processing solutions; labour tracking and performance management systems; lean process optimization and waste reduction.

"You can't necessarily do a Google search and find a ready-made solution in a catalogue," said Tania Humphrey, Vineland's VP, research and development. "This is custom work and part of it is introducing people and finding suppliers who can help address the issue."

Biocontrol and IPM

Scientists at Vineland are experts in entomology, biocontrol and taking a systems approach to IPM. They also have established vendor-neutral connections in the biocontrol industry, enabling them to objectively help growers develop strategies to deal with pests and disease in flower, food and cannabis crops.

In addition, product developers can call on Vineland to do independent third-party evaluations of innovations and provide recommendations for improvements.

Consumer insights

Vineland's consumer insights team helps companies understand consumer needs and preferences for edible and non-edible horticultural products. The centre boasts a trained sensory panel to evaluate product aroma, taste, texture and visual differences. It also hosts consumer research panels to understand what drives consumer preference, market segmentation and consumer behaviour. The panels' findings guide product and brand development and commercialization, helping companies best position new fruits, vegetables, flowers and cannabis in the marketplace.

> ***"...Providing these services creates a more customer-focused mindset and a timely, disciplined approach to Vineland's research."***

Nursery and landscape advisory services

Vineland's nursery and tree production specialists provide customized specifications for preparing sites, soil remediation and tree species recommendations. Vineland scientists also offer personalized soil sample collection and processing and analysis of organic matter, pH, texture and electrical conductivity and will help clients interpret the results and make recommendations based on site conditions and client requirements.

Providing these services creates a more customer-focused mindset and a timely, disciplined approach to Vineland's research, Humphrey noted.

"These types of projects have specific requirements and tight deadlines," she said. "Adopting a more business mindset helps us in more intangible ways. In every area of our research we have to understand the customer's needs and deliver on what we promise."

Aurora Borealis rose

Carving a path to commercialization

There's no shortage of cutting edge research happening at Vineland to advance horticulture in Canada and around the world.

But it takes more than modern science focused on developing products and solutions to set up the industry for sustainable success.

Bringing to market Vineland's findings, including disease-resistant landscape roses, sweet potatoes suited to Canadian growing seasons and flavourful greenhouse tomatoes, are just as critical as the research that goes into creating them. It's essential to forge commercial partnerships to keep Vineland's work relevant to industry and consumers alike, explained Amanda Moen, Vineland's business development advisor.

In 2017, Vineland's 49th Parallel Collection of cold hardy roses was launched with its first release, Canadian Shield®. The red bloom, bred for low maintenance and resistance to black spot disease, kicked off the series of five curated roses to be released in partnership with the Canadian Nursery Landscape Association.

Canadian Shield was followed by Chinook Sunrise,™ a bicolour rose introduced in 2019. Meanwhile, bright pink Aurora Borealis™ waits in the wings for a 2021 release at garden centres throughout Canada.

Vineland has licensed 17 Canadian nurseries to propagate and sell the roses wholesale or retail, making the flowers Vineland's most successful commercialized product to date.

Now sights are set on markets elsewhere to sustain the success of Vineland's National Hardy Rose Program, Moen said. The science that made them disease resistant will be the roses' gateway.

"It's vitally important to get into other markets — to take this collection not just across Canada but to wider markets as well, such as the U.S. and Europe," Moen said. "Our vision is to keep the collection small so people can find what they want aesthetically and know they're buying the same quality, the same cold hardiness and the same disease resistance."

"...Bringing to market Vineland's findings... are just as critical as the research that goes into creating them."

Radiance sweet potato

Vineland's greenhouse tomatoes-on-the-vine

Vineland's Radiance sweet potato, though only in its first year of commercialization, is poised to change the way Canadians consume this vegetable. Radiance was selected for a shorter growing season meaning less risks for growers and less of a reliance on imported sweet potatoes.

While Radiance checks all the flavour, texture and colour boxes with consumers, getting it to market remains one of Vineland's biggest challenges as it requires establishing a supply of sweet potato slips to Canadian growers.

"Trying to build a new industry that doesn't exist in Canada is risky and challenging," Moen said. "From a grower perspective, there's a bigger demand than we can meet with our current slip production."

Vineland is seeking partners with greenhouses or heated hoop houses to help grow Radiance's market share by producing slips that meet growers' cost and quality expectations, she added.

"That's the ongoing challenge with producing sweet potato slips in Canada. How can we get production and labour costs low enough to be competitive with the U.S.?" Moen said.

Vineland's new variety of greenhouse-grown tomato, set for commercial release in 2021, faces similar challenges.

The path to market will need to be developed quickly once the winning tomato-on-the-vine with enhanced flavour and production characteristics is chosen, Moen said.

"We're learning a lot about the greenhouse vegetable seed market, which is different than anything we've done in the past."

Working with the Ontario Greenhouse Vegetable Growers, Vineland is securing a relationship with a company to produce high-quality seeds and market them to growers.

"We're at the point now where we have someone we'd like to work with," Moen said. "Within the calendar year, we're looking to have that completely nailed down."

"There might be challenges building our commercialization plan and taking the science to growers," she said. "But there is a huge demand and once we work through the challenges, I'm optimistic there's going to be a good uptake by growers and we'll see significant market share in Canada. If we see lots of producers growing our roses, sweet potatoes and tomatoes in Canada that will be our success story."

Reporting for duty: Vineland adds VP, research and development role

There's a new job title in Vineland's organizational chart.

Tania Humphrey, Vineland's new VP, research and development

It's vice-president (VP), research and development and the role has been filled by Tania Humphrey, previously Vineland's director of strategic planning and research management.

In this role, Humphrey is the head of Vineland's entire research division, providing a greater oversight of the work carried out by the centre's 50 scientific and engineering staff.

But one of her first tasks is refreshing the centre's innovation strategy to guide research at Vineland in the years ahead.

Ultimately, Humphrey will use the strategy to determine which projects are pushed forward and ensure Vineland's scientists continue to work in a coordinated fashion to meet the objectives.

"It's really about getting a stronger sense of where we're headed as an organization. If we want to deliver, we really have to focus," Humphrey said. "When Vineland started, there were only a handful of people here and the strategy was about building and growing. Looking back, that was broad and ambitious. More than a decade later, we have established our teams and have a better sense of what works and what doesn't. We're taking a much more practical approach to refine some of those goals."

Having a VP, research and development was part of Vineland's long-term plan to establish itself as a North American leader in horticultural research. In addition, Vineland is creating a VP, business and client development position to focus on the business side of Vineland's scientific work, Humphrey explained.

"Between the two of us, we'll work together to facilitate Vineland's innovation programs," she said. "The strategic oversight piece will rest with us."

Vineland's Automation Cluster seeds a homegrown industry

The global market for Canadian agricultural production is growing and this is good news.

It also poses a significant challenge. Canadian agricultural producers must now navigate a future in which a strong production outlook and a growing need for labour coincide with a shrinking domestic labour pool and rising costs.

The labour challenge is sizeable. According to a 2014 Conference Board of Canada report, despite employing 2.3 million Canadians, Canada's agriculture and agri-food sector was unable to fill 26,400 jobs, costing the industry $1.5 billion. By 2025, the sector's labour gap is expected to double, putting nearly 114,000 jobs at risk of going unfilled. This is equivalent to one in four jobs.

The labour challenge is compounded by rising labour costs. The rising minimum wage has narrowed profit margins, threatening to stifle the industry's future growth. In some sectors, labour is the single highest component of production costs.

To meet the labour challenge, Vineland has launched a $5 million Canadian Agricultural Automation Cluster with support from Agriculture and Agri-Food Canada, through the *Canadian Agricultural Partnership*. The Cluster aims to improve labour productivity using automation, artificial intelligence and precision agriculture technologies. Additional benefits include savings in energy and water usage, input costs and increases in crop yield and value.

The Cluster's initial focus is on automation in horticultural applications to build collaboration with expansion planned into other agricultural sectors. Three projects led by Vineland researchers are currently underway:

- Develop and test robotic harvesters for greenhouse cucumbers and use big data for crop management and decision-making
- Develop smart, wireless irrigation technologies for potted flowers and vegetables
- Develop a full robotic solution for automated mushroom harvesting

Research activities will harness big data and artificial intelligence and make informed production decisions to develop platform technologies and critical components such as vision systems, end effectors, autonomous platforms and robotic systems. The impact will be a set of three automated technologies to improve labour productivity in cucumber, greenhouse floriculture and mushroom production. These technologies will be designed, developed, tested and demonstrated on-farm, resulting in validated prototypes that can be transferred to partners and licensees for commercialization.

The projects form a critical foundational piece for Vineland to expand the partnerships seeded by the Cluster and accelerate technology development through the commercialization phase. Vineland also anticipates using the Cluster as a launching pad to reach beyond horticulture, expanding the Cluster into a cross-Canada network of expertise and leveraging support from other innovation and economic development programs.

Labour productivity gains aside, the Cluster will also drive growth and diversification in Canada's advanced manufacturing sector. The aim is to mobilize Canadian companies, academic expertise, technology developers and equipment manufacturers from along the agricultural value chain to create a collaborative ecosystem focused on this growth opportunity. Broad-based partnerships within agricultural and advanced manufacturing sectors have the potential to establish Canada as a global leader in agricultural automation.

The development of technology in Canada has key advantages. Canadian producers have unique needs including special climate/environmental factors, existing infrastructure and additional/other crop types. Technology discovered or adapted in Canada is most likely to fit the needs and priorities of Canadian producers and solve their most pressing challenges. With improved results and increased profits on the production side, benefits will ultimately be passed to consumers.

Smart, automated production systems have the potential to generate significant labour productivity gains by bringing comprehensive, adaptive and data-driven decision-making needed to minimize labour inputs — in terms of human and labour costs — maximize yield and improve quality. This will boost competitiveness and allow producers to meet the growing demand for top-quality products sold to Canadian consumers and worldwide.

Vineland is bringing smart mushroom harvesting within reach

Today, mushrooms destined for the fresh market are harvested solely by hand, making Canada's mushroom industry heavily dependent on human labour — a costly resource in short supply.

Vineland's robotics and automation team is hoping to change this. Thanks to new funding from Agriculture and Agri-Food Canada, the team is working to develop a fully automated mushroom harvesting system for medium-to-large commercial farms. The system will be the first of its kind and will put mushrooms among the early crops to be harvested autonomously, alongside crops like apples and sweet peppers.

The potential payoff for this new technology is huge. Once complete, the smart, automated harvesting solution is expected to add $7.6 million per year to Canada's mushroom industry.

Picture multiple robots navigating through multi-layer shelves on a mushroom farm, making decisions about which mushrooms to select, pick them, package them and convey these packages to a collection point. The goal is to save on human labour through the automation of the harvesting process, while improving yield and quality via intelligent, selective harvesting.

Designing a robotic system that can carry out all necessary tasks as well as, if not better than, humans is a considerable challenge. Mushrooms must be manipulated gently during harvesting since they bruise and damage easily. They also tend to grow in dense clusters of all shapes and sizes, making it difficult to pick individual mushrooms. To add to this challenge, commercial farms typically grow mushrooms on dense multi-layer metal shelves, so a robot developed for this purpose must be capable of very precise controlled movements.

Smart harvesting decisions can also dictate how a mushroom will fair in the marketplace. Harvesters must decide which mushrooms to pick based on their appearance and mushrooms must also be picked at different stages of maturity to meet market demands for different sizes. Yield is highly dependent on choosing the correct mushrooms to pick to "thin out a cluster" and free up space and resources for higher-yielding neighbours.

To overcome these challenges, Mohamed Kashkoush, the project's lead researcher, envisions a system incorporating three fundamental elements.

"A sensory component consisting mainly of a vision system will collect information about the location, health and physical attributes (e.g. size, shape, height, colour) of mushrooms and will move around on a mobile cart that runs on tracks between the mushrooms shelves," explained Kashkoush. "An artificial intelligence (AI) component will use information from the sensory system to decide which mushroom to harvest and when, to maximize quality and yield. The third component consisting of a robotic arm and gripper will be able to identify the best path to reach a mushroom selected by the AI component to pick without causing damage or bruising. This robotic component will also incorporate a conveyance system to deliver mushroom trays to a collection point."

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...The goal is to save on human labour through the automation of the harvesting process, while improving yield and quality via intelligent, selective harvesting."

Once the full system is ready, Vineland will license a Canadian manufacturer to produce the technology — a win-win for both agriculture and manufacturing in Canada.

In the meantime, the team at Vineland is moving forward in designing the individual pieces.

The primary focus in 2018 was on the vision system, which is now moving into a third phase of development. In the coming year, Vineland researchers will partner with the National Optics Institute (INO) in Quebec to further advance this prototype. There are also plans to refine the decision support system — key to the AI piece — that was developed through previous funding.

2020 will also see advances in the robotic component with decisions on which robotic arm design to pursue. "We will work closely with researchers at Carleton University to develop a sophisticated gripper system able to gently pick mushrooms in clusters. This will be accompanied by the design and development of a robotic conveyance system that maximizes access to the mushrooms growing on the multi-layer shelves," continued Kashkoush. Although the system is in its early days of development, some aspects will be tested at Vineland in 2019.

The long-term goal is to test the system on commercial farms. Vineland has already developed a strong partnership with Monaghan Mushrooms in Campbellville, ON and is actively working to recruit other mushroom growers to participate in prototype testing.

Apart from the automated harvesting system, Vineland researchers are also looking to solve another problem that plagues mushroom operations: the loss of mushrooms during packaging due to tray overfilling. Vineland's packaging tray weight optimization system will solve this issue by determining how much weight is put into each tray during packaging. Vineland expects to have a complete prototype of this system by the end of 2019.

Getting smart about greenhouse irrigation: using artificial intelligence to guide watering decisions in Canada's greenhouses

For Canada's greenhouse operators, crop irrigation and finding experienced growers to manage it, are among their greatest challenges.

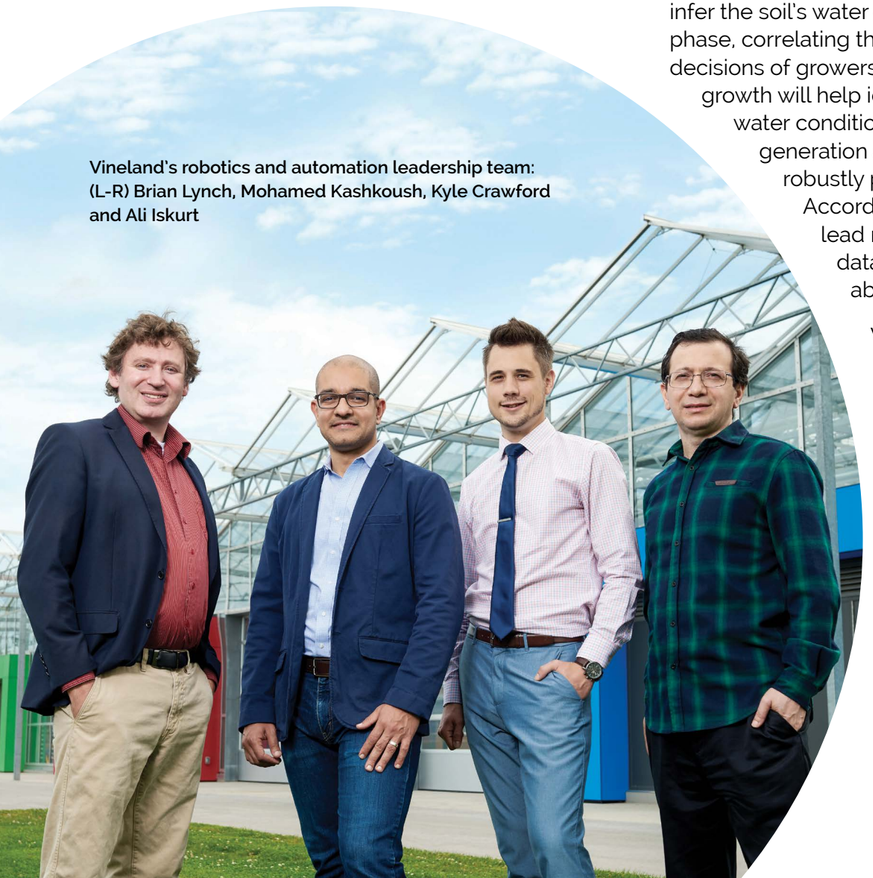
Historically, greenhouse growers have made decisions about where and when to irrigate, visually checking the water status of plants — often spending several hours and covering tens of kilometres each day. Watering is based more on intuition than measurement and growers tend to base their irrigation decisions on the driest pots. Inevitably, many plants receive more water than they need. Not only does excess watering waste a precious resource, it can also impact quality and yield and may put plants at risk of disease.

To overcome this hurdle, Vineland's robotics and automation team together with their European partner, LetsGrow, have been busy developing technologies to help greenhouse operators optimize how and when to water plants.

The first generation automated smart irrigation system is set for release fall 2019, thanks to three years of funding from the Federal Economic Development Agency for Southern Ontario (FedDev). The system uses soil and climate sensors to collect data on plant water status in real time. Advanced machine learning algorithms use this data to make decisions about where and when to irrigate, which are then conveyed to the grower. Basing decisions on hard data rather than perception help growers avoid unnecessary irrigation.

The results of pre-commercial testing have been promising. In one commercial greenhouse, the system reduced water usage by 15 per cent and saved roughly $2,800/acre per year on labour. Plant quality also improved. Across all floral greenhouses in Canada, the new technology is expected to generate $31 million per year in labour savings alone.

Bolstered by the success of the first generation system, Vineland is now moving into a second phase of development with funding from Agriculture and Agri-Food Canada.



Vineland's robotics and automation leadership team: (L-R) Brian Lynch, Mohamed Kashkoush, Kyle Crawford and Ali Iskurt

One drawback of the first prototype is its generous use of soil moisture sensors which can drive up the cost of implementation — up to 2,000 sensors may be needed to cover a medium-size greenhouse's entire growing area. The sensors can also get in the way.

This has prompted Vineland to take a different approach this time around. The goal is to develop a decision support tool that works with the hardware already in use in greenhouses. Instead of using sensors to tell the grower how much water is in the soil, the system will use variable measurements including humidity, moisture and temperature to infer the soil's water content. In the developmental phase, correlating these variables with the irrigation decisions of growers and observations of plant growth will help identify patterns in climate and water conditions. These will drive the next generation algorithm to accurately and robustly predict whether or not to irrigate. According to Brian Lynch, Vineland's lead researcher on the project, the data "will help us 'teach' the system about which decisions to make".

With data-driven decisions for crop irrigation and no requirement for new hardware, the return on investment for growers could be huge. A software-based solution also means the system can be maintained and updated relatively easily over time if needed.

Collecting data — lots of it — will be key. Vineland has been building relationships with greenhouses to support this effort. According to Lynch, "it is really important to do this work in a commercial greenhouse. [The data collection] is non-invasive and they see the potential value".

In 2020, Vineland will test the algorithm on both plant growth simulation models and on real plants grown in its greenhouses.

The technology solves another problem plaguing many commercial greenhouses in Canada — the dwindling supply of experienced growers. Vineland's new decision-making tool will enable a greenhouse to expand without worrying about the availability of additional growers or the quality of service delivered by each new grower hired. The smart irrigation system can also manage the greenhouse's historic and real-time data for further analysis and future reference, assisting greenhouses in maintaining their crop knowledge and operations — even after a grower moves on.

Irrigation in commercial greenhouses is a universal challenge. With Vineland's first generation smart solution for irrigation coming to market and a next generation technology in the works, greenhouse operators will be empowered with a data-driven decision-making tool that can guide them toward optimal irrigation of their crops.

"...The results of pre-commercial testing have been promising. In one commercial greenhouse, the system reduced water usage by 15 per cent and saved roughly $2,800/acre per year on labour."

An automated workforce to harvest Canada's greenhouse cucumbers

Canadian cucumbers are a hot commodity. Canada is the world's fourth largest cucumber exporter with a farmgate value of cucumber production at roughly $326 million in 2014.

Amidst this strong production outlook, human labour — both cost and availability — are holding the industry back. Human labour accounts for roughly 30 per cent of total costs in cucumber greenhouses and harvesting — the most labour intensive production task — accounts for roughly 20 per cent of all work required to produce the crop. This translates into approximately $27 million spent annually on cucumber harvesting alone.

This has Canada's cucumber greenhouse operators looking toward an automated workforce of robots to maintain or increase production even as labour pools shrink and labour costs grow.

With help from Agriculture and Agri-Food Canada funding, Vineland's robotics and automation team is working to develop an autonomous robot capable of harvesting cucumbers in a greenhouse environment. By creating efficiencies and reducing labour costs, automated cucumber harvesting is expected to save a 40-acre operation roughly $1 million annually.

The challenge is to develop a robot that can harvest cucumbers as well as, if not better than, humans.

"It is not just a matter of picking an individual cucumber — the robot has to do it quickly along a whole row," explained Brian Lynch, Vineland's lead researcher on the project. "The robot must reach through vines to grab the cucumber, detach it from the vine and pull it back out (and not anything else), which is challenging for a robot. It wouldn't take much to snag a vine and drag down an entire row." To match the speed of a human picker, the robot needs to harvest one cucumber per second — all without causing damage.

> ***"...the applications of the vision system are also not just limited to harvesting. The system can be used for crop monitoring."***

Greenhouse cucumbers in Canada are typically produced using the "high wire" method, in which cucumbers are grown in a vertical, hanging configuration. Vineland researchers have been busy since 2018 visiting local greenhouses, trying to understand the nuances and challenges of harvesting cucumbers grown in this environment. The team has also started to build computer models on how high wire cucumbers grow, incorporating information such as where cucumbers are most likely to be found, their spacing and their ripeness.

Although the automated harvester is in its early stages of development, Lynch envisions a system that will deploy mobile robots mounted between rows of cucumbers in greenhouses. The robots would use a vision system and a series of complex algorithms to find and differentiate a ripe cucumber from surrounding leaves and vines, to reach out and grab it, harvest it, then place it into a collection bin.

Lynch's team has made the most progress on the computer vision system. "We are starting to investigate using different sensors to look at colour, infrared, 3D scanning and combining these to search for and locate a cucumber in an image, determine if it is ripe and calculate how far it is from the robot." This is the type of information the robot will need to do its job. "By 2020, we will see the vision system come together and we will have results indicating it is working." The ability of the system to detect cucumbers at certain thresholds and levels of accuracy will be key measures of success.

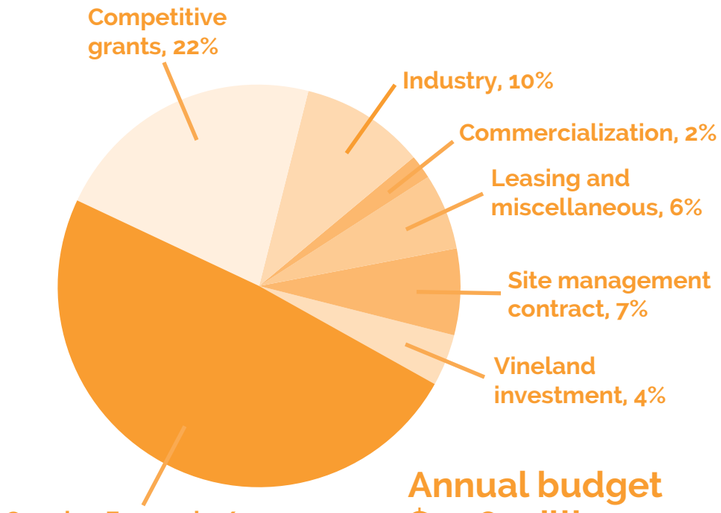
Apart from its integration into the automated cucumber harvester, Vineland intends to commercialize the vision system as a stand-alone device. "The solution we need to find cucumbers and characterize ripeness can easily be applied to any fruit or vegetable with enough water in it, such as tomatoes, apples or peppers," explained Lynch. In addition, "the applications of the vision system are also not just limited to harvesting. The system can be used for crop monitoring, for example."

The Quebec-based National Optics Institute (INO) is an important partner in Vineland's efforts to develop the vision system. Once Vineland completes the prototype, INO will take it and make it work as a more commercial-ready product.

The design of the robot will be improved by 2020. The plan is to explore different robotic arm designs, as well as gripping and cutting strategies, to see which designs work best in a vine environment. A prototype that can reach out and pick a cucumber will be ready by spring 2020.

Vineland at a glance

Revenue 2018-19



Annual budget $12.6 million

Partnerships

157 partners*

116 industry **20** academic
21 government

From

8 Canadian provinces (Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island and Québec)

14 countries (Australia, Belgium, Canada, France, Greece, Germany, Luxembourg, Netherlands, New Zealand, Spain, Switzerland, Taiwan, United Kingdom and United States)

*Covering *Canadian Agricultural Partnership* five-year funding cycle.

Research capacity and performance

15
research scientists

$235,218
research intensity
(research revenue generated per researcher)

$11,046
innovation strength
(royalties generated per researcher)

82%
grant application success rate

53
peer-reviewed publications of Vineland's research have been cited 536 times

Commercialization

11 Vineland developed technologies with patents issued/filed

22 plant varieties protected by PBR and/or U.S. plant patents

7 trademark applications filed

40 technologies commercialized

85 per cent of Vineland's protected IP is out-licensed and/or under further collaborative R&D with business partners

Job creation, education and training

85 full-time staff

48 highly qualified positions

3 PhD students graduated, 3 more underway

8 MSc students graduated, 5 more underway

5 co-op students hosted each year

Warren Jestin, PhD, Board Chair

Karen Belaire, Board Vice Chair

Vineland's Board of Directors (2019-20)

- Warren Jestin, PhD, Board Chair
- Karen Belaire, Board Vice-Chair
- Greg Devries
- Kristin Ego MacPhail
- Carolyn Hurst
- Fred Koornneef
- Shelley Martin
- Christy McMullen
- Ian Potter, PhD, CEO
- Ray Price
- Allan Visser

With a highly-skilled research team, oversight from an independent Board of Directors, engagement from an international Science Advisory Council and collaboration with 86 global partners including a Stakeholder Advisory Council, Vineland's goal is to enhance Canadian growers' commercial success through results-oriented innovation.

We are an independent, not-for-profit organization, funded in part by the *Canadian Agricultural Partnership*.

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