LES Journées HORTICOLES & GRANDES CULTURES

réseau agriconseils Montérégie

MRC Jardins-de-Napierville

CLD DES JARDINS-DE-NAPIERVILLE

Desjardins Entreprises

Québec

Precision Techniques for Plant Agriculture

Haggerty AgRobotics

Haggerty AgRobotics Company, Ltd.

Haggerty Creek Ltd: 2001

Grain Elevator and Agronomy Company

Precision Agriculture sales and Service (2004)

Raven, Trimble and others

Baresich Farms

Long term No Till cropping operation

Haggerty AgRobotics: 2021

Robotics and Automation for Field Crops

Haggerty AgRobotics Company, Ltd.

Agriculture is under pressure from multiple fronts

Changing consumer trends affect our production methods

Let's assume chemicals are up for debate

- Weed resistance
- Limited chemical options with higher value crops
- Consumers perception

Labour shortages will continue to expand

We at Haggerty AgRobotics Company want to help provide solutions to our customers

AgRobotics Innovations in Weed Management

Kristen Obeid, OMAFRA

Chuck Baresich, Jason Gharibo and Grant Elgie, Haggerty Creek AgRobotics Company

Scale of Field Robots

- Multi Line Field Automation Products Perspective
  - Large Scale
    - Raven OmniPower, OmniDrive
    - Large fields 80+ acres, 400 acres per day+
    - Heavy equipment / high power
  - Small Scale (50 acre field sizes) (10 acres per day approx.)
    - Dino (Orio), Nexus, Ted, RoamIO, FarmDroid
    - Can expand acreage by swarming
  - Micro Scale (10 acre plots, 2 acres per day approx.)
    - Oz, Drones (spraying/spreading)
    - Can expand acreage by swarming

Haggerty AgRobotics Company

- Field Robots - Automation Products used in 2022
  - Raven
    - OMNIDrive (Autonomous Kit for Tractor) (2nd year)
    - OMNIPower (Autonomous Power Platform)
  - Korechi
    - RoamIO HCT and HCW (Autonomous Tool Carrier) (2nd year)
  - Naio
    - Oz (Small scale Autonomous Tool Carrier)
    - Dino (Commercial Scale Autonomous Tool Carrier)
  - Nexus
    - GOAT (Commercial Scale Autonomous Weeder)
  - FarmDroid FD20
    - Autonomous Seeder / Weeding tool
  - Drones
    - Spraying and Spreading Functionality (2nd year)

AgRobotics Working Group

- In 2021 an **AgRobotics Working Group (WG)** was developed to conduct on-farm demonstrations, build networks and collaborations and brainstorm about available and future technologies.
- The WG includes representatives from OMAFRA, Haggerty Creek Ag Robotics, University of Guelph, McMaster University, University of Waterloo, Conestoga College, Cornell University, Ontario Fruit & Vegetable Growers Association (OF&VGA), Fresh Vegetable Growers of Ontario (FVGO), Holland Marsh Growers Association (HMGA), Ontario Processing Vegetable Growers (OPVG), Innovative Farmers Association of Ontario (IFAO), Nortera, Vineland Research and Innovation Center (VRIC), Canadian Agri-Food Autonomation and Innovation Network (CAAIN), Korechi Innovations (Oshawa, Ontario), Nexus Robotics (Montreal Quebec), FarmDroid (Denmark), Naio Technologies (France) and Raven Industries (Canada and U.S)
    - The Ad Hoc WG meets weekly to brainstorm ideas, review new technologies, apply for funding opportunities and develop priorities for Ontario Agriculture.

Achievements

- Successes in 2021 included six demonstrations, with three different robots in eight different crops: Brussels sprouts, cauliflower, peppers, onions, carrots, celery, strawberries and haskaps.
- 2022 projects included four different robots in various crops and locations performing various tasks: seeding, weeding, mowing, soil sampling and analysis.
- Funding leveraged to date is $1,033,000 supporting 7 projects.
- Ten projects proposed and under consideration for 2023-2028.
    - $4,993,750 funding requested
    - $1,275,000 funding confirmed Canadian Agri-Food Automation Intelligence Network and Grain Farmers of Ontario

The needs and the membership of the working group is expanding

HAGGERTY AGROBOTICS

Ontario

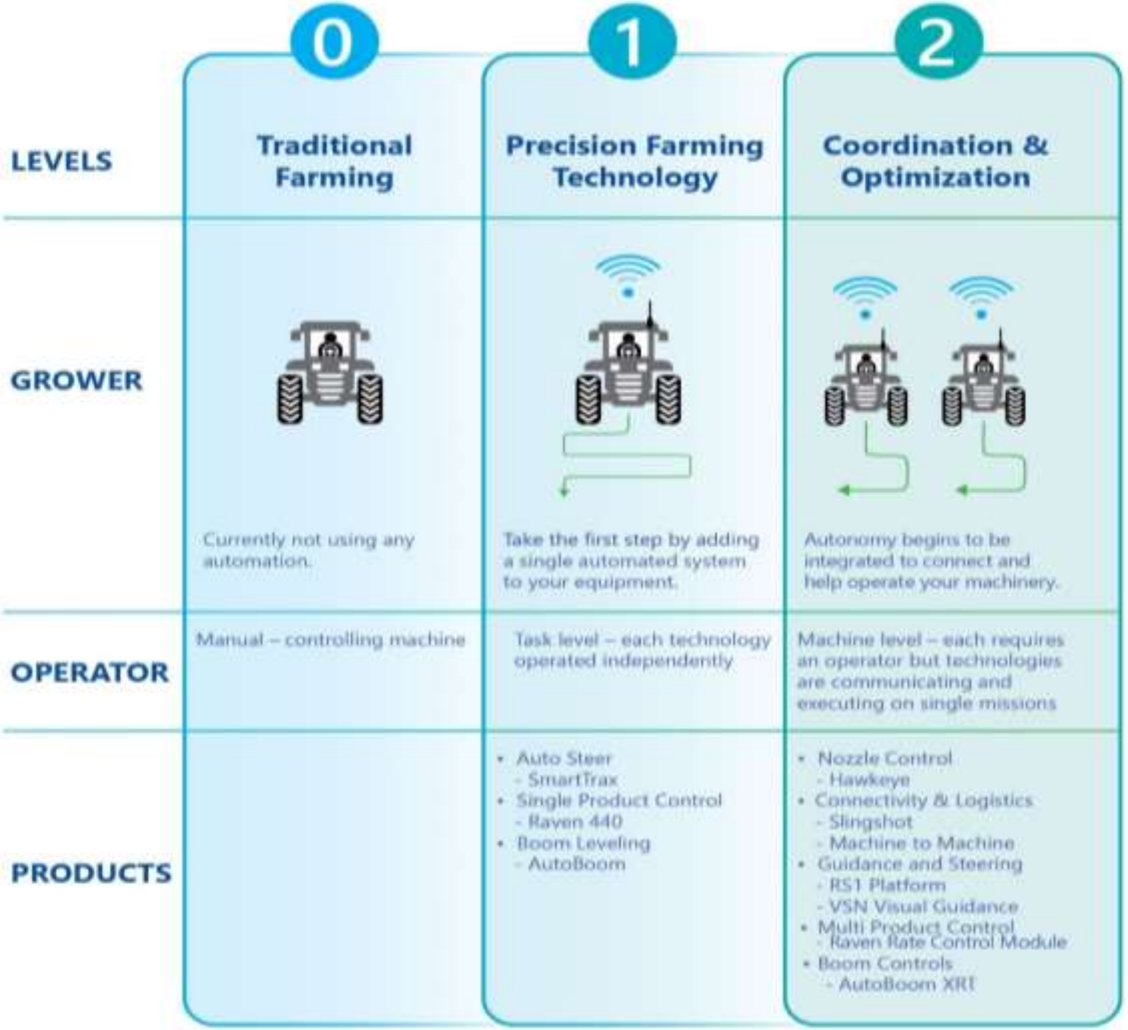
PATH TO AUTONOMY

	0
LEVELS	**Traditional Farming**
GROWER	 Currently not using any automation.
OPERATOR	Manual – controlling machine
PRODUCTS	

PATH TO AUTONOMY

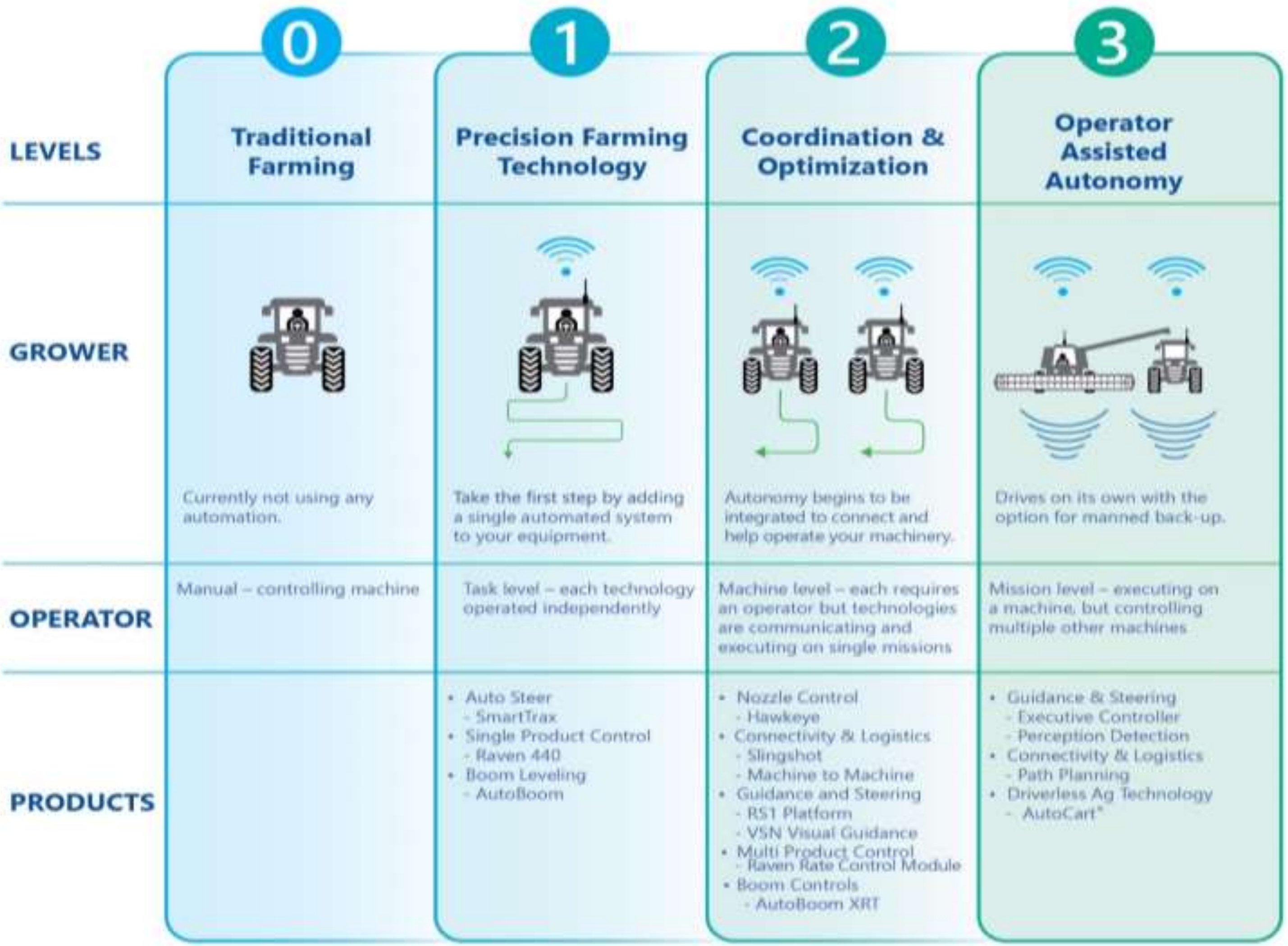
LEVELS	0 Traditional Farming	1 Precision Farming Technology
GROWER	Currently not using any automation.	Take the first step by adding a single automated system to your equipment.
OPERATOR	Manual – controlling machine	Task level – each technology operated independently
PRODUCTS		• Auto Steer - SmartTrax • Single Product Control - Raven 440 • Boom Leveling - AutoBoom

PATH TO AUTONOMY



LEVELS	0 Traditional Farming	1 Precision Farming Technology	2 Coordination & Optimization
GROWER	Currently not using any automation.	Take the first step by adding a single automated system to your equipment.	Autonomy begins to be integrated to connect and help operate your machinery.
OPERATOR	Manual – controlling machine	Task level – each technology operated independently	Machine level – each requires an operator but technologies are communicating and executing on single missions
PRODUCTS		• Auto Steer - SmartTrax • Single Product Control - Raven 440 • Boom Leveling - AutoBoom	• Nozzle Control - Hawkeye • Connectivity & Logistics - Slingshot - Machine to Machine • Guidance and Steering - RS1 Platform - VSN Visual Guidance • Multi Product Control - Raven Rate Control Module • Boom Controls - AutoBoom XRT

PATH TO AUTONOMY



PATH TO AUTONOMY

	0	1	2	3	4
LEVELS	**Traditional Farming**	**Precision Farming Technology**	**Coordination & Optimization**	**Operator Assisted Autonomy**	**Supervised Autonomy**
GROWER	Currently not using any automation.	Take the first step by adding a single automated system to your equipment.	Autonomy begins to be integrated to connect and help operate your machinery.	Drives on its own with the option for manned back-up.	That gives you freedom to get out of the tractor and back to your other priorities.
OPERATOR	Manual – controlling machine	Task level – each technology operated independently	Machine level – each requires an operator but technologies are communicating and executing on single missions	Mission level – executing on a machine, but controlling multiple other machines	Field level – executing outside of the machine, but still visible
PRODUCTS		• Auto Steer - SmartTrax • Single Product Control - Raven 440 • Boom Leveling - AutoBoom	• Nozzle Control - Hawkeye • Connectivity & Logistics - Slingshot - Machine to Machine • Guidance and Steering - RS1 Platform - VSN Visual Guidance • Multi Product Control - Raven Rate Control Module • Boom Controls - AutoBoom XRT	• Guidance & Steering - Executive Controller - Perception Detection • Connectivity & Logistics - Path Planning • Driverless Ag Technology - AutoCart*	• Connectivity and Logistics - Remote Command Center • Autonomous Power Unit - DOT Power Platform

CABLE-LOK
NL5000
NEW LEADER
TYLER

OMNI POWER - RAVEN AUTONOMOUS PLATFORM

THE OPEN U DESIGN

- Engine – Cummins QSB4.5 Tier 4 Final
  - 173 HP
  - 520 LB-FT Torque
  - 85 Gallon Fuel Capacity
  - Average fuel consumption 4.22 gal/hr
  - 10 Gallon DEF Capacity
  - Air intake grid heater

Hydrostatic System

2 – Eaton hydrostatic pumps to power the wheel motors

4 – Poclain wheel motors to drive the wheels

2 – Kawasaki load sensing axial piston pumps to power loading and unloading, as well as the steering system

2 – Stucchi couplers for connecting Dot Ready Implement

2- Directions of travel. Narrow mode & wide mode

2 – Speed shifting (1st gear 6 mph & 2nd gear 12 mph)

Electrical System

2 – Cummings 12-volt batteries

200-amp alternator

Safety status lights and audible alarm

ISOBUS for Dot Ready Implements

RAVEN

MANUAL CONTROLS

HRI REMOTE CONTROL


DOT
AUGER AG

PATH TO AUTONOMY

	0	1	2	3	4	5
LEVELS	**Traditional Farming**	**Precision Farming Technology**	**Coordination & Optimization**	**Operator Assisted Autonomy**	**Supervised Autonomy**	**Full Autonomy**
GROWER	Currently not using any automation.	Take the first step by adding a single automated system to your equipment.	Autonomy begins to be integrated to connect and help operate your machinery.	Drives on its own with the option for manned back-up.	That gives you freedom to get out of the tractor and back to your other priorities.	The fully autonomous farming future.
OPERATOR	Manual – controlling machine	Task level – each technology operated independently	Machine level – each requires an operator but technologies are communicating and executing on single missions	Mission level – executing on a machine, but controlling multiple other machines	Field level – executing outside of the machine, but still visible	Enterprise level – executing remotely
PRODUCTS		• Auto Steer - SmartTrax • Single Product Control - Raven 440 • Boom Leveling - AutoBoom	• Nozzle Control - Hawkeye • Connectivity & Logistics - Slingshot - Machine to Machine • Guidance and Steering - RS1 Platform - VSN Visual Guidance • Multi Product Control - Raven Rate Control Module • Boom Controls - AutoBoom XRT	• Guidance & Steering - Executive Controller - Perception Detection • Connectivity & Logistics - Path Planning • Driverless Ag Technology - AutoCart®	• Connectivity and Logistics - Remote Command Center • Autonomous Power Unit - DOT Power Platform	

Path to Autonomy

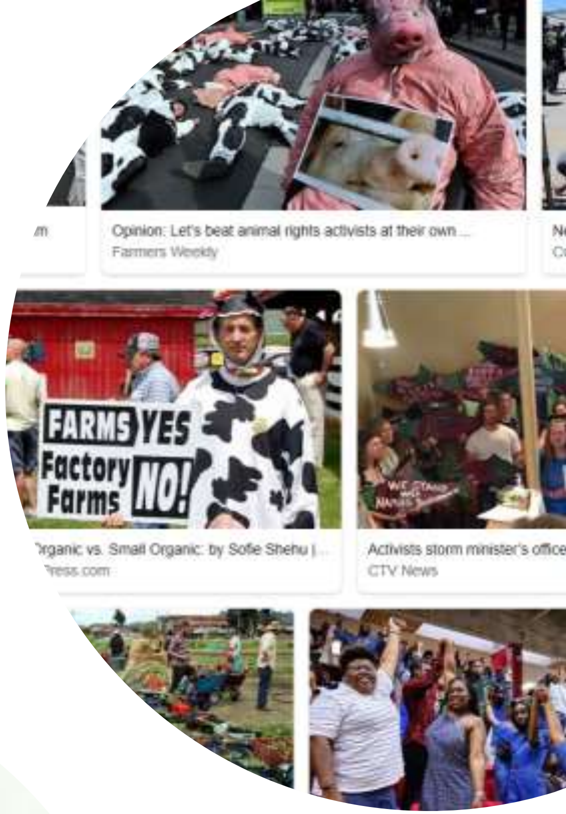
- Autonomy in Agriculture has progressed rapidly, in some areas
- Livestock Industry
  - Robotic Milkers
  - Automatic Feeders
  - Automated Ventilation and climate
  - Automated egg collection and sorting
  - Automatic animal weight and sorting
- Greenhouse
  - Spraying, planting, harvesting

Autonomous Farming

- Autonomous Agriculture is a mindset change
  - It is not just shiny equipment and robots
- First, What does a farmer actually do?
  - Does driving a tractor make you farmer?
  - (does actually milking the cow make you a farmer)
- It is not as simple as replacing current activities with robots
  - Or staff

Agriculture: Under Pressure

- Status Quo is being challenged
  - Labour
  - Productivity
  - Weather
  - Input Cost
  - Consumer Demands
  - Agronomic



Automation - Potential

- With current labour issues, we cannot reasonably assume that manual labour is available or affordable
- With higher value in crops, more care and precision is required
- Autonomous machines take the human emotion out of decision making
  - They do not get tired
  - They do not get bored
  - They do what they are told (sometimes that is not a good thing!)

Robotic Weeders

- Several weeding robots promise to provide reduced soil compaction, a lower carbon footprint, reduced inputs (seed, herbicide, etc.), less labour requirements, scalable mechanical weeding, and ease of use. However, questions about their practicality and return on investment remain.
- To test these claims, three autonomous weeding robots were trialed and compared to conventional vegetable growing practices in Ontario, Canada. The Naïo Dino, Nexus La Chèvre or the Goat and FarmDroid FD20 were operated with side-by-side control comparison trials to collect and analyze metrics important for practical farming considerations, such as:

  - Weed suppression (measured bi-weekly),
  - Crop health (assessed bi-weekly), and
  - Labour requirements (timesheets tracked weekly).



FarmDroid FD20 – https://farmdroid.dk Seeding and Weeding Sugar Beets

- Solar-charged batteries, CO_2 neutral
- 24-hours autonomous operation (sleep mode when batteries are low)
- Seeder, and inter- and intra-row mechanical weeder
- Passive weeder - cultivator

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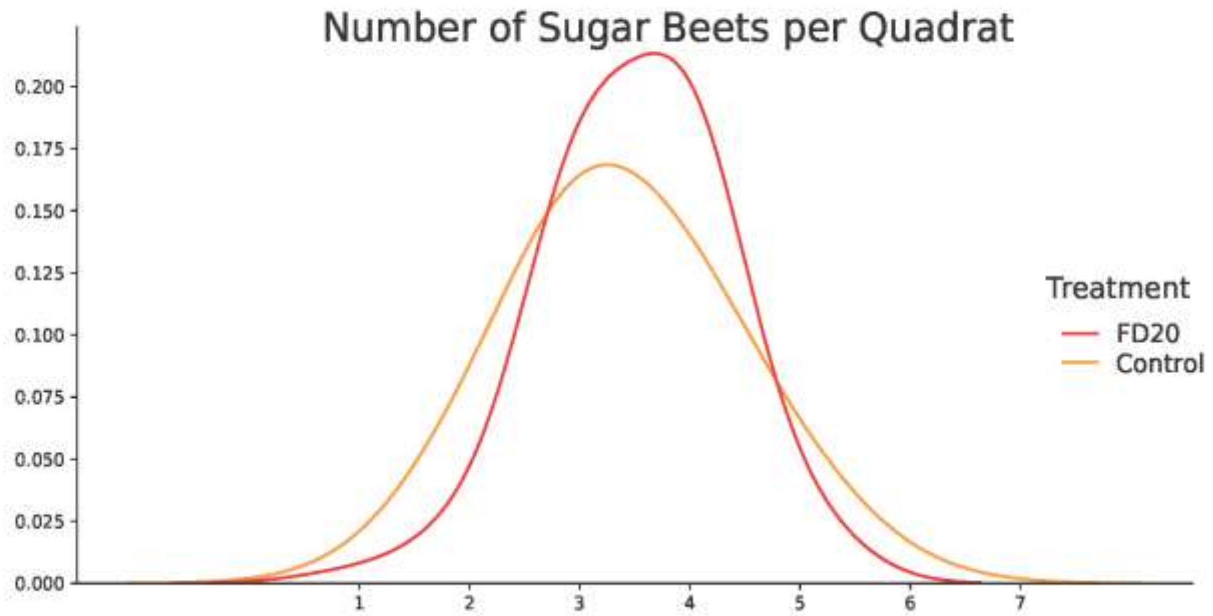
FarmDroid FD20 –
Seeding and Weeding Sugar Beets and Rutabagas

Results: Sugar beets

- Seeded at a lower seeding density with the FD20 than the conventional unit (45,000 versus 53,000 seeds/acre).
  - FD20 field had more sugar beets.
  - More consistent in size and shape
  - Higher sugar content
  - The producer commented that although the FD20 took longer to seed, it minimized seeding date risk, and precision seeding benefited the crop as it resulted in more consistent germination.



Challenges:

- Could not handle heavy trash
- Delayed seeding and weeding when soils were wet

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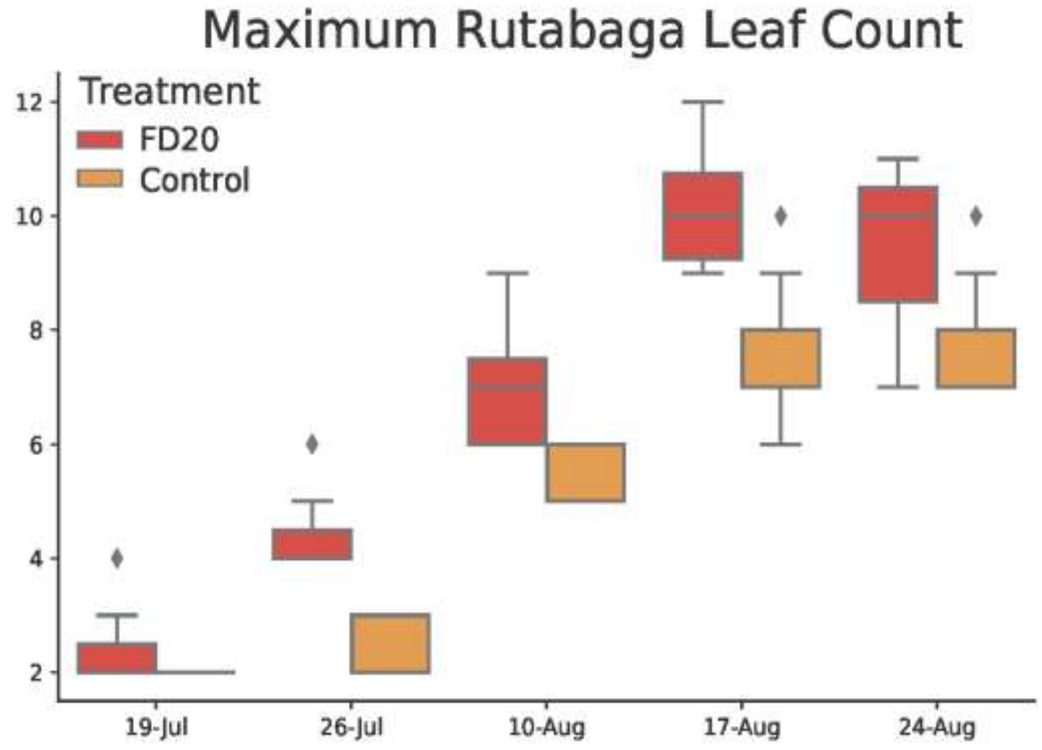
FarmDroid – Weeding Sugar Beets

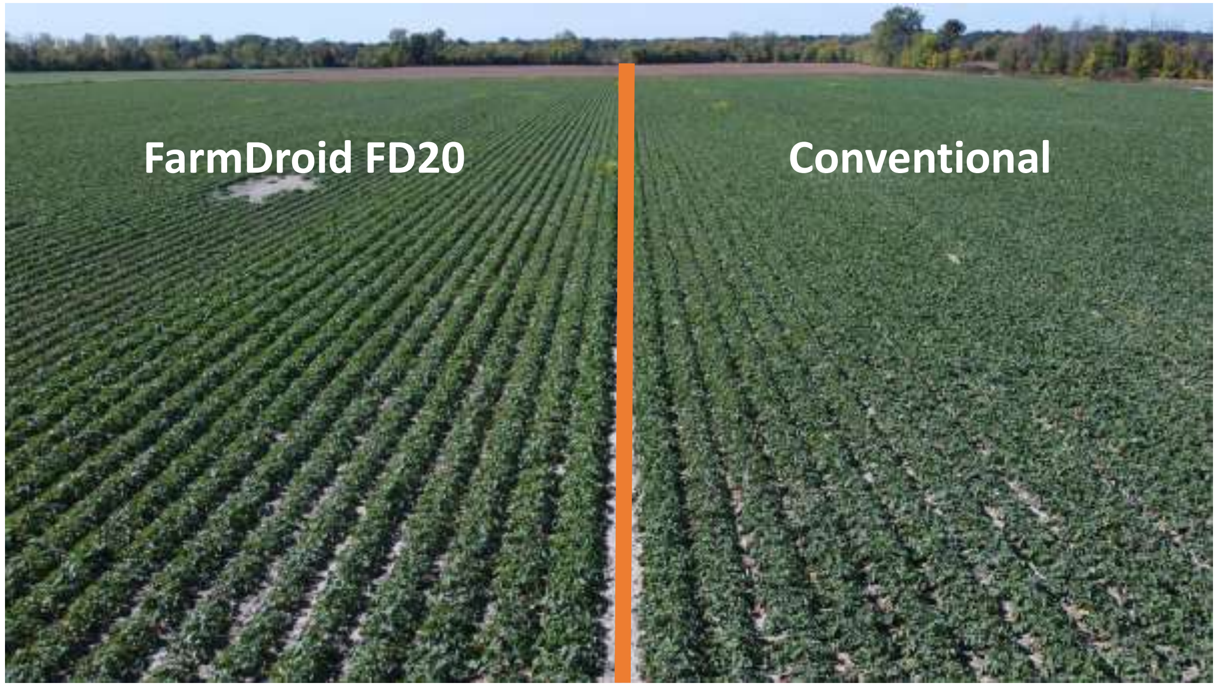
- Seeder, and inter- and intra-row mechanical weeder
- The intra-row weeding (weeding between the plants in the row) was important in breaking the soil crust. This action resulted in:
    - Larger sugar beets
    - More uniform sugar beets

FarmDroid FD20 – Seeding Rutabagas



Results

- Higher leaf count and better crop development in the FD20 treatment compared to the conventional treatment with the same seed and seeding date.
- Producer did not want to plant at a lower density, but now will use the FD20 to seed next year.



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Naïo Dino – Weeding Carrots

https://www.naio-technologies.com/

- Passive weeder - cultivator
- Rechargeable lithium batteries
- Up to 10 hours of autonomous operation
- Inter-row guidance and mechanical weeding
- Adjustable tool bar - detects crops rows and adjusts the tools to weed as close to the plants as possible

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Naïo Dino – Weeding Carrots

Results: Carrots

- This robot worked reliably at cultivating in between rows of a 25 acre carrot field.
- This plot was traditionally minimally cultivated and unfortunately due to the heavy cultivation of the Dino, the producer requested to remove the robot.

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Nexus Goat – Weeding Onions

https://nexusrobotics.ca

- Active weeder
- Electric hybrid motor
- 24-hour autonomous operation
- Machine vision inter- and intra-row mechanical weed removal

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Nexus Goat – Weeding Onions

Results: Onions

- Unforeseen challenges – just developing algorithms to identify the onion crop.
- The most advanced iteration was able to remove ~90% of weeds.
- After the weeds reached a certain height or diameter the Nexus was no longer able to remove them.
- Weed misclassification occurred ~1% of the time.
- Removed after 6 weeks of operation because the onions were too large for the robot to continue without damaging the crop.

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Robotic Weeders - Conclusions

A large part of this pilot study was spent learning how to operate these robots. The data is insightful for future studies and near-term operations, but more research is needed.

Conducting trials on commercial operations with high value crops was challenging.

- - Producer apprehension
- - Curve to adoption Producers need to see these technologies in their production systems.

Critical considerations for future work:

- Designated test plots

- Data adjustments based on weed pressure, field conditions, and resistant weeds.

We are working together with collaborators and innovative growers to de-risk these technologies enabling producers to utilize them with confidence in the future.

Future Work: Naïo Orio, FarmDroid and Picketa Systems Vegetable Project

https://www.naio-technologies.com

https://farmdroid.dk

www.picketa.com

U of G/OMAFRA Agri-Alliance Program

- Testing Orio's weeding ability and ROI in carrots and beets compared to grower standards.
- Testing FarmDroid's seeding and weeding ability and ROI in onions and beets compared to grower standards
- Real time leaf tissue testing using Picketa's light sensor. Will use one of the robots to collect the leaves. Compare to results from 2 labs.

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Future Work: Naïo Oz, Nexus Goat and Korechi RoamIO HCT Strawberry Project

- Naïo Oz, Nexus Goat and Korechi RoamIO HCT will be tested in strawberry fields next year:
  - Oz – cultivating and cutting stolons
  - Goat – picking weeds out of the planting whole
  - RoamIO HCT – mowing laneways and renovation

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Future Work

Naïo Ted

https://www.naio-technologies.com/

- For grapes and trellised fruit
- In Ontario early 2023
- Autonomous 100% electric vehicle – up to 10 hours
- 10 acres/day
- Inter- and intra-row weeder
- Hilling and De-hilling
- Vine hedger
- Yield estimation
- Photo and video from G. Farintosh

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What Else is the AgRobotics Working Group Investigating?

- **Apple AgRobotics Sub-Committee**
  - Interest in working with Advance Farm to bring and test their Apple Harvester in Ontario Production Systems https://advanced.farm/echnology/apple-harvester/

- **Drone Sub-Committee**
  - Working with PMRA to determine how to set up trials and what data to collect for Drone spraying

- **COP/ROI Sub-Committee**
  - Working with growers of commodities we conducted trials/demos on in 2022 to determine economics and ROI of technologies

- **Asparagus Harvesters** from Triton Innovations www.tritoninnovation.com and Muddy Machines www.muddymachines.com

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Ontario

Future Work

Apple AgRobotics Sub-committee

Members:

- Kristen Obeid, OMAFRA
- Chuck Baresich, Haggerty Creek
- Jason Gharibo, Haggerty Creek
- Grant Elgie, Haggerty Creek
- Erika DeBrouwer, OMAFRA
- Garson Law, CAAIN
- Andrew Taylor, Intelliculture
- David Tao, BH Frontier Solution
- Mahdi Fazaeli, U of Waterloo
- Mike Kauzlaric, Vineland Research and Innovation

- Erika DeBrouwer plans to make connections with various tech companies including: FFRobotics, Monash University, Ripe Robotics, Tevel, Advanced Farm, Munckhof, while at Interpoma and will address this in her District Meeting Updates taking place in late November and early December.
- WG will also reach out to Dr. Joe Davidson from Oregon State University who is working with a team on an apple picker and mechanized pruning. Joe is an Assistant Professor in the School of Mechanical, Industrial and Manufacturing Engineering.

Future Work

Apple AgRobotics Sub-committee

Advanced Farm Robotics
https://advanced.farm

- Took robotic strawberry harvester and made it vertical
- Focus is in California and Washington
- Only one apple picker in operation, currently in Washington
- Picks 1200 apples an hour

Future Work

Apple AgRobotics Sub-committee

UV-C Technology

- Germicidal (UV-C) light is effective against bacteria, algae, & some fungi
  - Medicine, aquaculture, & agriculture
  - Organic approved
  - No residue
- Excellent results in Cornell trials against fireblight
- potential for frequent use & robotic automation
- Obtaining specifications for building a unit in Ontario
- Could be used in any trellised orchard/vineyard system

Future Work

Apple AgRobotics Sub-committee

Autonomous Sprayers

- **AgXeed Agbot 2.055W3 and H.S.S. CF2000AB**
- **https://holsprayingsystems.com**
- Provide Agro www.provideag.ca has sold 3 of these units that will be operational spring 2023.
- Need a better understanding of the liability and limitations in Ontario.
- Could be used in any orchard/vineyard system

Check out more AgRobotics Innovation from the FIRA AgTech Show
https://youtu.be/StKLHD7LGT0

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We Greatly Appreciate The Support From:

- The AgRobotics Working Group
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- **Industry Collaborators:** RH Accelerator, The Western Fair Association, Vineland Research and Innovation Center, and sponsors at Tech Alliance, OMAFRA, and BioTalent Canada

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