Case Study: Field Crop Agricultural Robotics

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A case study prepared for Remote controlled: The impacts of disruptive technologies in the Ontario agriculture sector

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About the Project

This case study is part of the *Remote controlled: The impacts of disruptive technologies in the Ontario agriculture sector,* which includes 48 key informant interviews with 52 key informants including agricultural industry experts, agricultural-related technology companies, and agricultural business experts to understand AgTech adoption in Ontario. For more information, please visit our project website.

Field Crop Agriculture Robots

Farming and food production operations involve labour-intensive work characterized by repetitive, time-consuming, and difficult tasks.[i] Animal labour and farming machinery have historically helped farmers accomplish these tasks in field crop agriculture.[ii] Recent advances in robotic equipment with autonomous and self-reliant capabilities are beginning to transform the sector.[iii] Robots can sense, perceive, navigate, manipulate, communicate, and cooperate with other devices, as well as with agriculture workers.[iv] In field crop farming, the primary categories of robot applications include planting, weeding, mowing, harvesting, grafting, precise application of fertilizer, crop assessment and grading, and other farming tasks.[v]

Field crop agriculture poses unique challenges for robots, including navigation of slopes or steep terrain, fragmentation of fields or orchards, variations in soil stability and moisture, cover crops and layers of leaf and debris cover on fields, extreme environmental and weather conditions, and biodiversity.[vi] To address these requirements, field crop robots generally consist of several systems including a mobile base (or chassis) to transport the robot, a computer vision system to perceive the environment, a control system to manage the overall activity of the robot, and manipulators or actuators to accomplish specific tasks related to the field, plant, or crop.[vii]

A Focus on Ontario

The Government of Ontario's provincial agri-food strategy, *Grow Ontario* (2022), includes a focus on utilizing agri-food technology working groups to prioritize technology adoption in areas such as robotics, as well as enhancing academic and technical capabilities in agricultural robotics.[viii] Field crop robots are used in Ontario to perform tasks such as active and passive weeding, seeding, mowing, soil sampling, and analysis.[ix]

The provincial government and other stakeholders have been testing autonomous field robots originating from Canada and elsewhere through the AgRobotics Working Group. For example, in 2021, the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), Haggerty AgRobotics, and several grower associations conducted technology demonstration projects with selected field crop robots to determine their adaptability to Ontario production systems.[x] Participating robotics companies included Naio Technologies (France), Korechi Innovations (Canada), Nexus Robotics (Canada) and Raven Industries OmniPower (USA). In addition, a number of Canadian robotics companies with specialized agricultural applications (including prototypes) have emerged and are gaining traction among farmers in Ontario (for examples, see Table 1).

Table 1: Examples of Field Crop Agricultural Robotics Companies Headquartered in Canada

Company	Year Founded	Headquarter Location	Description
Barnstorm AgTech	2020	Senlac, SK	Barnstorm AgTech is a robotic swarm farming venture providing an open platform for precision and powered deployment of farm technology.
Clearpath Robotics	2009	Kitchener, ON	Clearpath Robotics (acquired by Rockwell Automation in 2023) produces a fleet of mobile robotic platforms used in outdoor applications including field crop farming, orchards, and vineyards.
CropAxis	2023	Whitby, ON	CropAxis offers robotics as a service to specialty crop producers, reducing per acre growing costs by aiding growers in mitigating economic and environmental impacts and enabling sustainable production and scalability for growers.
Haggerty AgRobotics	2020	Bothwell, ON	Haggerty AgRobotics assists in adaption and implementation of field crop robots to help solve challenges facing crop agriculture.
InDro Robotics	2014	Victoria, BC	InDro Robotics produces a range of robotics including ground-roving industrial robots for field crop agriculture for monitoring plant growth and health.
Korechi Innovations	2016	Oshawa, ON	Korechi Innovations makes robots to automate simple, repetitive, and often unsafe tasks so that farm workers can be redeployed into higher-value activities on the farm.
Nexus Robotics	2017	Brossard, Quebec	Nexus produces autonomous weeding robots that integrate a real-time computer vision module and artificial intelligence-driven algorithms.

Source: Created by authors based on company websites.

Impacts for Work & Rural Development

Efficiency and cost reduction are major drivers for the adoption of robots in all types of agriculture.[xi] In field crop farming, the introduction of field robots can introduce shifts in labour demand. Field robots may also provide farmers with an opportunity to diversify their agricultural products by using robots for farming methods and/or growing specialty crops that would not have been economically practical due to labour costs.[xii] However, testing in Ontario has indicated that some robots have difficulty working effectively in certain soil types and with some cropping systems.[xiii] Nonetheless, a number of field crop robotics-related companies commented on the wide range of applications for which robots can be used, indicating their potential value across the farm. For example, Ag-Related Tech Company 2 explained how smaller robots can be used for "[…] *data gathering […], for yield estimation, disease, detection, and so on"* while larger field robots can do additional work like spreading cover crops and light tillage. They also discussed a robot designed especially for row crops "*where it moves in between rows of crops. So you don't have to use as much chemical fertilizer, chemical herbicides to combat weeds*.

Below we highlight a number of specific impacts related to employment and skills, health and safety, and the environment.

Shifts in Employment & Skills

As agriculture and food operations in Ontario and across Canada continue to face labour shortages, the use of field crop robots may enable farms to increase productivity and efficiency on farms. For example, adopting field robots can alter labour-intensive processes by eliminating the constraints of human strength and endurance, as well as the limits of daily working hours, which leads to cost efficiencies.[xiv] As one interviewee noted, *"[Ontario farmers] are taking a lot more interest in these little field robots that don't need an operator and go out and do stuff by themselves once they're programmed"* (Ag Industry Expert 12). While Ag Industry Expert 11 argued, "*[…] robots don't get sick. They show up on time, you know. That's a big piece of it*." A number of interviewees also noted how field crop robots could free up time for farm workers to attend to other important tasks:

> *I guess for the farmers specifically, they're gonna have a few options depending on how they want to run their operation. They can free up the labour from the tasks that the machines are gonna be working on or they could completely reallocate the person or just retraining to be able to service the machines or just being able to operate them… In addition to that, that's also gonna grow their technical expertise over time, right? Because that's gonna be ultimately required* (Ag-Related Tech Company 23).

Relatedly, concerning robots replacing labour, our interviewees noted that it is more likely to shift labour from lower skilled to higher skilled work. For example, field crop robots may contribute to demand for more high-skilled labour needed in robotic development, robotic

servicing and maintenance, robotic management, and data analytics as Ontario agriculture becomes increasingly digitalized.[xv]

Improving Health & Safety

Field crop robots may also improve the health and safety of farm workers by reducing strain related to repetitive manual tasks, exposure to agrochemicals, or accidents with large machinery.[xvi] Interviewees described the potential benefits to farm worker health:

> *Some of it could improve worker health and safety. So, you know, there are some robots […] being used in orchards, where it's a quote unquote dumb robot. It just follows the user. And so as the user walks down the orchard, this robot just follows along. And so instead of having to say pick an apple and then bend over and place it in a basket. And then drag the basket or cart forward or have a second person drive it. This basket would be on an automated cart that would follow the user […] So that makes it a little bit easier on their on their back and any kind of twisting motion or activity that the worker needs to subject themselves to and then when the basket is full. The robot runs back […] to the barn and someone unloads the basket, plops on an empty basket and the robot runs back out to where the last person left off and continues on and that saves effort in running back and forth* (Ag-Related Tech Company 13).

Similarly, Ag Business Expert 3 discussed how in a previous summer season they had robots in the field on one of those "100-degree days" and "*the next field over, they had […] four foreign workers […] And the poor guys were out in the field with like physical hoes, you know, weeding a field. And you can tell, hot day, they didn't want to be there.*"

Reducing Environmental Impacts

Field crop robots may also reduce the environmental impacts of cultivation, such as soil compaction, due to their lower weight compared traditional farming equipment.[xvii] Autonomous robots that perform tasks such as weeding and seeding can extend the benefits realized from the application of other agricultural technologies, such as precision agriculture, in rural communities. These benefits include boosting crop growth with less water, fertilizer, pesticides,[xviii] increasing productivity and profitability, and improving the livelihood of farming communities.[xix] Field crop robots powered by electric battery or solar power may also reduce farmers' use of fossil fuels. As one ag-related technology company noted:

> *In terms of emissions, there's a huge saving. So the cost of fuel as high as it is. Our robots typically only use one to $2 of electricity a day. The full charge. And that helps. That really helps because […] when farming pretty much everything is diesel right at low speed. Any internal combustion engine is very inefficient. […] They produce a lot of pollution, because they have to run much faster to generate a little more torque, but at low speed* (Ag-Related Tech Company 2).

Future Considerations

As a result of the COVID-19 pandemic, a number of interviewees, particularly ag-related technology companies, noted how they saw increased interest in adopting robots and autonomous technologies as a result of the pandemic. Likewise, a number of the ag industry experts discussed how there will be increased interest and adoption of robotics to meet labour needs and address food security.

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