Adoption barriers for precision agriculture technologies in Canadian crop production

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Abstract: Although precision agriculture is touted to enhance both farm returns and environmental quality, its perceived uptake is not as widespread as would be expected. The objective of this paper was to update and compare the adoption rates for precision agriculture technologies in Ontario. Geographic service technologies were the most adopted technology and showed an increase in adoption between 2017 and 2019. The survey was extended to include crop input suppliers across the country. Increasing adoption rates for precision agriculture technologies requires overcoming barriers, specifically reducing the cost and providing demonstrated value.

Key words: precision agriculture, crop production, adoption, digital revolution.

Introduction

Precision agriculture has the potential to bring about significant benefits to the agri-food industry while at the same time reducing its environmental footprint. However, there are concerns that their adoption is not as rapid as would be expected if its use is indeed a win–win scenario as suggested by proponents, and an understanding of the barriers to adoption is necessary to spur the desired use. Suggested barriers include an inability to interpret data to develop useful decision support tools and the need to train farmers in the use of those tools (Weersink et al. 2018).

Lowenberg-DeBoer and Erickson (2019) recently reviewed studies on adoption rates of precision agriculture globally and found the perceptions are different from reality—the uptake varies with the type of precision agriculture technology and across countries. In terms of types of technology, Kolady et al. (2020), Michels et al. 2020, and Miller et al. (2019) note the higher adoption for embodied-knowledge forms, such as auto-steer, versus information-intensive forms, such as variable rate application methods. In a review of studies examining the factors affecting adoption, all of which were conducted in the US and EU, Pathak et al. (2019) found farm size and farmer education were the common determinants regardless of the type of precision agriculture considered. Recent Canadian studies include Mitchell et al. (2018) and Steele (2018), while Turland and Slade (2020) examined the willingness of farmers to participate in Big Data platforms but not the adoption of the associated technologies. To assess adoption barriers, it is important to understand farmers’ perceptions of the benefits, which can be multi-faceted and differ along the adoption process (Thompson et al. 2019; Weersink and Fulton 2020).

The purpose of this short communication is to update and compare the adoption rates for precision agriculture technologies in Ontario agriculture found by
Mitchell et al. (2018). The survey was extended to include crop input suppliers across the country through the support of the Canadian Association of Agri Retailers (CAAR) and determine the barriers to adoption in both regions. Both the OABA and CAAR surveys are available with this article as Supplementary Material.

**Surveys**

A survey of Ontario agriculture service providers was initially undertaken in 2017 to assess the adoption of precision agriculture. It was repeated in June 2019 with an electronic version sent to the emails of 144 registered members of the Ontario Agri Business Association (OABA) that were identified within the organization’s trade directory as potential users of precision agriculture technologies. Forty responses were returned with usable data, yielding a response rate of 27%.

From the Ontario survey, a modified questionnaire was developed and distributed in partnership with CAAR. The survey was posted on the CAAR website, where the association internally directed its members to respond. Additionally, over 1200 members of CAAR were initially sent the survey electronically on 2 Aug. 2019. 122 completed surveys were received, resulting in a response rate of 10%. Over 84% of the CAAR respondents are in the Prairie provinces.

**Results**

**Overall adoption by Ontario agri-retailers**

The rate of adoption for most precision agriculture technologies has increased among agronomic service providers in Ontario between the 2017 and 2019 survey iterations (Table 1). All four geographic technologies saw increases in levels of adoption among respondents between the 2017 and 2019 surveys. Despite the increase in adoption rates, their assessment of the profitability for these mapping tools fell, particularly for profit/cost mapping. The result suggests that the use of these technologies may be a means to increase crop input sales rather than being independent profit generating investments.

The use of observational technology to enhance crop monitoring has become increasingly important as farm sizes increase and the sophistication of farm management continues to increase. The majority of respondents reported using some sort of observational technology, with 80% utilizing satellite/aerial imaging and 63% using uncrewed aerial vehicles to capture imagery from low altitudes. As with geographic technologies, the perceived profitability of observational technologies fell compared with two years earlier. The majority of respondents felt the three imaging methods either lost money or were unsure about their profitability.

A greater percentage of agri-retailers in Ontario have variable rate technology available to custom apply inputs than in 2017. Prescriptions for tailoring input rate spatially are steadily becoming more widespread. Concurrently, the use of variable rate technologies for input applications also increased. In contrast to the other two forms of precision agriculture technologies, the majority of respondents felt that variable rate technologies at least break even and fewer were unsure about its profitability.

Sales and analytical services related to precision agriculture technologies were relatively stable compared with other previously discussed categories. While guidance equipment sales were reported by 21% of respondents, yield monitor sales and related data analysis were reported to be offered by a smaller percentage of respondents than in 2017, while telematic equipment sales and precision planted equipment sales were stagnant, with only 3% of respondents offering these services.

**Barriers to farmer adoption as perceived by agri-retailers**

Although an agri-retailer may not use precision agriculture technologies to apply inputs purchased by their customers, the agri-retailer is likely to be aware of the use of precision agriculture by farmers and the barriers to its adoption. The percentage of respondents from the Prairies and Ontario that agree or strongly agree with seven potential barriers preventing producers in their area from further adopting precision agriculture technologies is listed in Table 2.

The ranking and percentage of respondents who agreed or strongly agreed that each factor was a barrier in producer adoption of precision agriculture technologies was similar across regions. The three most agreed upon barriers for further adoption were identical for the Prairies and Ontario and were also the three most important factors as ranked by agri-retailers in the Midwest (Erikson 2020). The most important barriers to adoption across all regions were

1. pressure on farm incomes preventing precision agriculture use;
2. cost of precision agriculture technologies and services is greater than the benefit received; and
3. producers lacking confidence in the agronomic recommendations made based on the data generated by site-specific data.

The first barrier to adoption is not necessarily specific to precision agriculture but reflects the financial pressures faced by most crop farmers. The decline in crop commodity prices since the peak period between 2007 and 2014 has reduced the ability to finance capital-intensive investments, including some forms of

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1Supplementary data are available with the article at https://doi.org/10.1139/cjps-2020-0234.
Table 1. Adoption and profitability assessment of precision agriculture technologies by type by Ontario Agri-retailers for 2017 and 2019.

| Type of technology               | Adoption rate 2017 | Adoption rate 2019 | Profitable 2017 | Profitable 2019 | Break-even 2017 | Break-even 2019 | Loss 2017 | Loss 2019 | Unsure 2017 | Unsure 2019 | Responses N² |
|---------------------------------|--------------------|--------------------|-----------------|-----------------|-----------------|-----------------|-----------|-----------|-------------|-------------|--------------|
| **Geographic**                  |                    |                    |                 |                 |                 |                 |           |           |             |             |              |
| Field mapping (with GIS)        | 79%                | 86%                | 35%             | 31%             | 33%             | 38%             | 18%       | 15%       | 15%         | 15%         | 40           |
| Profit/cost mapping             | 41%                | 57%                | 35%             | 5%              | 18%             | 30%             | 18%       | 35%       | 29%         | 30%         | 17           |
| Soil EC mapping                 | 23%                | 30%                | 25%             | 17%             | 42%             | 39%             | 8%        | 17%       | 25%         | 28%         | 12           |
| Grid or zone soil mapping       | 81%                | 87%                | 53%             | 43%             | 34%             | 35%             | 3%        | 14%       | 9%          | 7%          | 32           |
| **Observational**               |                    |                    |                 |                 |                 |                 |           |           |             |             |              |
| Chlorophyll sensors             | 39%                | 37%                | 8%              | 0%              | 54%             | 50%             | 15%       | 36%       | 23%         | 17%         | 13           |
| UAV or drone imagery            | 39%                | 63%                | 11%             | 10%             | 26%             | 25%             | 42%       | 35%       | 21%         | 30%         | 19           |
| Satellite/aerial imagery        | 66%                | 80%                | 32%             | 12%             | 32%             | 36%             | 28%       | 36%       | 8%          | 16%         | 25           |
| **Variable rate (VRT)**         |                    |                    |                 |                 |                 |                 |           |           |             |             |              |
| Seed prescriptions              | 58%                | 67%                | 29%             | 26%             | 48%             | 32%             | 10%       | 21%       | 14%         | 21%         | 21           |
| Fertilizer/lime prescriptions   | 74%                | 87%                | 45%             | 46%             | 26%             | 31%             | 16%       | 12%       | 13%         | 8%          | 31           |
| Pesticide application           | 32%                | 33%                | 29%             | 36%             | 21%             | 29%             | 21%       | 21%       | 29%         | 14%         | 14           |
| Lime application                | 66%                | 73%                | 59%             | 48%             | 22%             | 33%             | 7%        | 10%       | 11%         | 10%         | 27           |
| Fertilizer application          | 88%                | 83%                | 50%             | 48%             | 19%             | 32%             | 17%       | 12%       | 14%         | 8%          | 36           |
| **Sales and analytical services** |                 |                    |                 |                 |                 |                 |           |           |             |             |              |
| Telematic equipment sales       | 3%                 | 3%                 | 0%              | 0%              | 50%             | 33%             | 0%        | 67%       | 50%         | 0%          | 4            |
| Precision planter equipment sales | 3%              | 3%                 | 0%              | 0%              | 20%             | 33%             | 20%       | 67%       | 60%         | 0%          | 5            |
| Guidance equipment sales        | 8%                 | 21%                | 20%             | 33%             | 50%             | 14%             | 0%        | 33%       | 30%         | 0%          | 12           |
| Yield monitor sales             | 17%                | 3%                 | 22%             | 14%             | 22%             | 29%             | 11%       | 43%       | 44%         | 29%         | 9            |
| Yield monitor/data analysis     | 51%                | 50%                | 25%             | 0%              | 35%             | 33%             | 20%       | 50%       | 20%         | 21%         | 20           |

**Note:** Green font indicates the value has increased in 2019 compared with 2017. Red font indicates the value has decreased in 2019 compared with 2017. Correlation between adoption rates and assessment of profitability = 0.71. The 2017 results are from Mitchell et al. (2018).

²Number of responses to the question on profitability assessment. Response rate was higher for adoption rate question.
precision agriculture. Debt-servicing capacity has been reduced and thus the ability to obtain credit for any purchase.

The second barrier reflects whether the value of the technology is sufficient to cover its cost, which includes not only purchase costs but also the costs of learning, implementing, and adapting the new technology to the current farming system. The differences in perceived value are reflected in differing adoption rates among alternative precision agriculture investments. GPS guidance systems are standard with new equipment given the positive net benefits in terms of reduced overlap, assurance of complete coverage, and lowering of operator fatigue. In contrast, the value of the additional information provided by variable rate technology may be relatively low due to the existence of a flat payoff function for many crop inputs (Pannell et al. 2019). Thus, the value of the precision from identifying and applying different rates across management zones in a field may not exceed its costs.

The third barrier accounts for the uncertainty in the net benefits from the technology. The uncertainty could involve the difficulty in its implementation. For example, variable rate technologies require vast amounts of data and the ability to interpret it so that management zones can be defined and the rates within those zones identified. Several agriculture service providers stated that both they and producers in their area lack confidence in the agronomic recommendations generated by this data. Others noted the lack of integration between equipment dealers, agronomists, and input suppliers that also lead to a lack of confidence in generating net benefits from particularly variable rate technologies. The uncertainty could also involve weather, as previous work by Rajsic and Weersink (2008) noted that there is greater value to knowing the growing conditions for the year ex-ante than the spatial variability in the field when determining the appropriate fertilizer rate to apply.

**Conclusions**

The 2019 edition of the Precision Agriculture Dealership Services Survey allows for an evaluation of the trends in precision agriculture technology adoption in Ontario between 2017 and 2019, and with the addition of CAAR retailers, offers a comparison between adoption rates in Ontario and the Prairies. While previous iterations of this research have alluded to precision technologies being adopted on a wide scale, this updated information affirms that not only are precision agriculture technologies being adopted, but the rate of adoption has generally increased.

Geographic technologies are the most commonly adopted of those surveyed and are now standard with any new equipment. Lowenberg-DeBoer and Erickson (2019) note that the adoption rate of these guidance systems is faster than for any other previous agricultural technology including GM seeds. The uptake for variable rate technologies, albeit lower than GPS, is similar to mechanized farm technology and conservation tillage and will likely continue to increase as improvements are made. In particular, the adoption rate will increase as the cost of the technology decreases, and the decisions generated provide consistent, demonstrated value. The uptake further relies on favourable farm income and coordination between equipment dealers, agronomists, input suppliers, and farmers. The coordination is easier in eastern Canada, where many of the inputs are custom-applied by the agri-retailer.
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