Adoption of Precision Agriculture Technologies in Ontario Crop Production

<table>
<thead>
<tr>
<th>Journal:</th>
<th>Canadian Journal of Plant Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuscript ID</td>
<td>CJPS-2017-0342.R4</td>
</tr>
<tr>
<td>Manuscript Type:</td>
<td>Short Communication</td>
</tr>
<tr>
<td>Date Submitted by the Author:</td>
<td>17-May-2018</td>
</tr>
<tr>
<td>Complete List of Authors:</td>
<td>Mitchell, Sean; University of Guelph, Department of Food, Agricultural and Resource Economics Weersink, Alfons; University of Guelph, Department of Food, Agricultural and Resource Economics Erickson, Bruce; Purdue University, Department of Agronomy</td>
</tr>
<tr>
<td>Keywords:</td>
<td>precision agriculture, technology adoption, crop production, agriculture input supply retailers</td>
</tr>
<tr>
<td>Is the invited manuscript for consideration in a Special Issue?:</td>
<td>Not applicable (regular submission)</td>
</tr>
</tbody>
</table>

https://mc.manuscriptcentral.com/cjps-pubs
Adoption of Precision Agriculture Technologies in Ontario Crop Production

Sean Mitchell
(smitch17@uoguelph.ca)
Dept of Food, Agricultural and Resource Economics
University of Guelph
Guelph, Ontario, Canada N1G 2W1

Alfons Weersink (corresponding author)
(aweersin@uoguelph.ca)
Dept of Food, Agricultural and Resource Economics
University of Guelph
Guelph, Ontario, Canada N1G 2W1

Bruce Erickson
(berickson@purdue.edu)
Dept of Agronomy
Purdue University
West Lafayette, Indiana, USA 47907-2053

ABSTRACT

Ontario agricultural service providers were surveyed on their use of precision agricultural technologies. Global positioning systems are the most commonly adopted while adoption rates for variable rate systems are significantly less. Enhancing adoption requires turning the vast amount of data collected on crop production into valuable decisions for the farmer.

Key Words: precision agriculture, crop production, adoption, digital revolution

Introduction

The potential ability of precision agriculture to increase productivity and at the same time reduce the sector’s environmental impact has spurred significant investment into these technologies by multinational corporations typically involved in other areas of agricultural production (Lev-Ram, 2017). This investment into agricultural technologies has been largely due to optimistic prospects for precision agriculture, but this venture-capital has recently moved away from companies focused on data (Brown 2017). The shift in investment focus coincides with...
with a perception that the digital revolution has been slow to catch on at the farm level (Weersink et al. 2018). Evidence from several U.S studies, including Schimmelpfennig and Ebel (2016), Erickson et al. (2017), and Griffin et al. (2017), find that adoption rates are high for yield monitors but sluggish for other precision agriculture technologies such as variable rate application (VRT). This paper presents the current adoption level of precision agriculture technologies for crop production by agricultural service providers in Ontario.

**Survey**

A survey of agriculture service providers used previously by the Departments of Agricultural Economics and Agronomy at Purdue University with support from CropLife magazine was adapted for Ontario. The Ontario survey was sent out electronically initially on June 28th, 2017 to the emails of 182 Ontario Agri Business Association (OABA) registered members that were identified within the organization’s trade directory as potential users of precision agriculture technologies. Of the surveys sent out, 62 were returned with useable data, yielding a response rate of 34 percent. Although the number of responses is small, it represents a relatively high proportion of the population. In addition, the area on which the respondents custom apply fertilizers and herbicides represents a large amount of the corn and soybean acreage in Ontario, and thus also a significant amount of the potential crop production area on which precision agriculture could be employed.

**Results**
**Overall Adoption within Business Operations**

Over 96% of respondents reported using precision agricultural technologies in some form within their crop production business. These retailers also use precision technologies within their own business operations to manage vehicle logistics (25%), to exchange information among applicators or office locations (8%), or for billing, financial, or legal purposes (34%) with the aid of geographic information systems (GIS).

**Adoption of Geographic Services**

While geographic services encompass many precision technologies, this section focuses on mapping technologies and/or services, and guidance (second column of Table 1). Around 80% of respondents offer field mapping through GIS or soil sampling either through a grid or zone approach. Net return mapping is offered by 41% of the responding retailers while soil EC (electrical conductivity) mapping is offered by around one-quarter of respondents.

Automatic guidance systems (autosteer) are used by three-quarter of retailers while GPS guidance systems with manual control (light bar) guidance systems are used by 30%. Precision spraying technology is also commonly used among the respondents with two-thirds using automatic boom control, 40% using Y-drops and one-quarter using sprayer turn compensation. While 60% of agricultural retailers report to use automatic steering for over 75% of their custom application, almost all (>90%) report to using automatic steering for at least some of their custom application.

The accuracy of these guidance technologies can vary widely, with some technologies being accurate to less than 1 m, and other being accurate to less than 2 cm. The Wide Area Augmentation System (WAAS), used to augment GPS accuracy was used for 57% of guidance applications, while 12% used some type of purchased satellite correction service, and 5%
purchased some real-time network (RTN) connection. RTK, the highest accuracy of the
guidance technologies mentioned, was used by 26% of respondents but none of those mounted
their own personal RTK base station.

**Adoption of Observational Services**

Observational services are associated with technologies that collect data from the field.
Approximately two-thirds of the respondents offer satellite and/or aerial imagery to gather
information on field or crop characteristics. Chlorophyll sensing is offered by 39% of
respondents, and a similar percentage of respondents offer UAV or drone imagery (Table 1).

Management zones and grid pattern soil sampling are two common formats for precision
prescriptions to be based upon. Survey recipients were asked what types of soil sampling they
offered. Traditional whole field soil sampling was the most common service available from the
agri-retailers (77%), while 64% and 53% of respondents offered management zones and grid
pattern sampling, respectively. While management zones and grid pattern sampling are not
mutually exclusive, the survey did not provide for the joint option.

Half of those using grid sampling said that they used a 2.50 acre grid, while 36% used
2.51 to 5 acre sized grids, and 14% used 1 to 2.49 acre sized grids. None used a grid sampling
area less than 1 acre. For those input service providers that offer management zones for soil
sampling, yield maps were used by 38% of respondents to determine the size and location of a
management zone. Satellite or aerial imagery was used by 29% to define management zones,
while 9% and 3% of respondents used soil mapping units and electrical conductivity,
respectively, as determining factors for zones. Topography, normalized difference vegetation
indexes (NDVIs), and customer knowledge were also used to identify management zones.
**Adoption of Variable Rate Services**

Over two-thirds of those surveyed provided some type of precision agronomic consulting service. Variable rate (VRT) seeding prescriptions are offered by 58% of respondents, while three-quarters offer VRT lime or fertilizer prescriptions (Table 1). Unmanned aerial vehicles (UAVs) were used to develop prescriptions for fungicides by 19%, for seeding by 13%, and for fertilizer by 21% of respondents. While chlorophyll/greenness sensors and soil electrical conductivity mapping are used by approximately 15% of respondents, the actual use of these tools for prescriptions is on less than 5% of custom applied acres.

The majority (88%) of respondents use variable rate technology to apply fertilizer and two-thirds offer VRT for lime application. The adoption of VRT rate for pesticide application at 32% is significantly less than for fertilizer application (Table 1). While a significant number of retailers have the VRT equipment, it is used to custom apply fertilizer on only 27% of their fields and pesticides are applied with VRT on less than 5% of application area.

**Adoption of Sales and Analytical Services**

Sales and support of precision agriculture equipment is limited among the survey respondents, as their businesses tend to focus on the sale and application of crop inputs. Telematic equipment sales and precision planter equipment sales are each offered by 3% of respondents while 8% of respondents offer guidance/autosteer sales and support. The sales and support of precision technology among the agri-retailers is primarily limited to yield monitors and over half of respondents offer analysis with the data collected by the farmers’ yield monitors.

**Perceived Profitability of Precision Agricultural Technology Service**

The perceived profitability of the precision agriculture technologies by category are listed in columns 4 through 7 in Table 1. The correlation coefficient between the adoption rate and the
percentage of respondents who feel the technology is profitable is 0.81. As expected, the adoption rate generally increases with perceived profitability of the technology.

**Client Data Management**

The retailers were asked whether their business had a customer data privacy statement and/or a data terms and conditions agreement with their farm clients. Fully 50% of respondents said that their company had a customer data privacy statement and/or a data terms and conditions agreement, while 39% said they did not and 11% were unsure if they had one.

Respondents were also asked how they assisted their clients in managing their farm-level data to assist in a farming business’ decision making. A majority said they printed maps (77%) or archived data for future use (52%), while 18% of respondents reported working with farmers by using data aggregated from other producers within their dealership and 5% reported using data aggregated from producers outside of their dealership. Some respondents said that their customers did not need help with their data (7%) and 34% said that they work only on an individual basis when aggregating data for a client.

**Future Adoption of Precision Agriculture Technologies**

The projected levels of adoption of precision agriculture technologies in 2020 are given in column 3 of Table 1. Field mapping with GIS will be offered by over 90% of the respondents by 2020. Other precision agriculture technologies that are currently widely used such as grid or zone soil sampling and VRT fertilizer application will continue to be adopted by more of the respondents but there is little scope for further increases. In contrast, more than half of the respondents will be using VRT for the application of pesticides by 2020 compared to the one-third that currently do so. Observational service technologies, such as electromagnetic mapping,
UAV or drone imagery, and chlorophyll/greenness sensors for N-management, are the ones with the greatest projected growth potential.

The major barriers to adoption relate to profitability and adjustment costs; the significance of the barriers is illustrated in descending order in Figure 1. Over 60% felt they could not charge fees high enough to generate sufficient returns and around half felt the costs of the technologies were too expensive resulting in 46% feeling it was difficult to demonstrate value of precision agriculture to farmers. Another set of barriers were associated with the technology itself; either it is changing so quickly to make it obsolete in a short period of time or compatibility issues with the equipment and/or data. Respondents indicated that technology complexity, competitor pricing, and lack of manufacturer support were not perceived as being major impediments to customers’ use of precision technologies either on their own, or through the dealership.

Discussion
Agricultural service providers affiliated with the Ontario Agri Business Association (OABA) were surveyed on the extent to which their businesses use precision agricultural technologies for crop inputs purchased by farmers in Ontario. An indication of the widespread use of precision agriculture in some form for crop production is that 96% of respondents report using precision agriculture in some form within their business. The most popular use of the technology within the businesses and in their custom application services are GPS autosteer systems and precision spraying technology to minimize overlap and to ensure complete coverage. Almost all reported using automatic steering for at least some of their custom application and 60% indicated using automatic steering for over 75% of their custom application. In addition to guidance systems,
other geographic services widely used were the field mapping and soil sampling. Variable rate technologies are not adopted to the same extent as the geographic category of innovations but do hold promise.

The survey is for a single year and only provides a snapshot of current adoption. While the survey is expected to be repeated in the future so that trends in adoption can be observed, the first-time assessment does allow us to draw inferences about relative adoption rates over time and the subsequent implications. The difference in rates of adoption for GPS technologies, such as auto-steer systems that require no additional skills to capture value, versus variable rate application technologies, which require new skills plus a decision-making model, highlight the major factors influencing adoption—does the value added from precision agriculture technologies exceed the cost. Many pieces of information ranging from geo-physical to climatic to production to economic are necessary to generate a prescription for the variable application of inputs to reap the benefits. The difficulties of constructing, collecting, maintaining and sharing data limit the opportunity to derive effective decision rules with high information value to producers. Enhancing the adoption of non-GPS precision agriculture technologies will require turning the vast amount of new data collected on crop production into manageable and valuable decisions for farmers. There is a role for crop production researchers to assist in the development of the knowledge base and usefulness of the decision-making model underlying VRT.

ACKNOWLEDGEMENTS

Financial support was provided by Food from Thought, sponsored through the Canada First Research Excellence Fund, and by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). The comments and support from Nicole Rabe, Steve Redmond, and Ron Campbell are gratefully acknowledged.
REFERENCES

[Accessed 17 May. 2017].

Erickson, B., Lowenberg-DeBoer, J., and Bradford, J. 2017. 2017 Precision agriculture dealership survey. Departments of Agricultural Economics and Agronomy, Purdue University, December.
http://agribusiness.purdue.edu/precision-dealer-download


[Accessed 17 May. 2017].


Figure 1. Agri-Retailers’ Self-Identified Barriers to Further Adoption
Table 1. Adoption (Current and Future) and Profitability Assessment of Precision Agriculture Technologies by Type

<table>
<thead>
<tr>
<th>Type of Technology</th>
<th>Adoption Rate</th>
<th>% of Respondents</th>
<th>Responses (n)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Profitable</td>
<td>Break-Even</td>
</tr>
<tr>
<td><strong>Geographic</strong></td>
<td></td>
<td>2017</td>
<td>2020</td>
</tr>
<tr>
<td>Field mapping (with GIS)</td>
<td>79</td>
<td>91</td>
<td>35</td>
</tr>
<tr>
<td>Profit/cost mapping</td>
<td>41</td>
<td>67</td>
<td>35</td>
</tr>
<tr>
<td>Soil EC mapping</td>
<td>23</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>Grid or zone soil mapping</td>
<td>81</td>
<td>86</td>
<td>53</td>
</tr>
<tr>
<td>Guidance/auto-steer</td>
<td>92</td>
<td>98</td>
<td>53</td>
</tr>
<tr>
<td><strong>Observational</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorophyll sensors</td>
<td>39</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>UAV or drone imagery</td>
<td>39</td>
<td>73</td>
<td>11</td>
</tr>
<tr>
<td>Satellite/aerial imagery</td>
<td>66</td>
<td>81</td>
<td>32</td>
</tr>
<tr>
<td><strong>Variable Rate (VRT)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed prescriptions</td>
<td>58</td>
<td>69</td>
<td>29</td>
</tr>
<tr>
<td>Fertilizer/lime prescriptions</td>
<td>74</td>
<td>81</td>
<td>45</td>
</tr>
<tr>
<td>Pesticide application</td>
<td>32</td>
<td>53</td>
<td>29</td>
</tr>
<tr>
<td>Lime application</td>
<td>66</td>
<td>71</td>
<td>59</td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>88</td>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td><strong>Sales and Analytical Services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telematic equipment sales</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Precision planter equip sales</td>
<td>3</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Guidance equip sales</td>
<td>8</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Yield monitor sales</td>
<td>17</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>Yield monitor/data analysis</td>
<td>51</td>
<td>66</td>
<td>25</td>
</tr>
</tbody>
</table>

Correlation between adoption rates and assessment of profitability = 0.81

<sup>a</sup> Number of responses is to question on profitability assessment. Response rate was higher for adoption rate question.