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## **Automation of Agricultural Machines: The Farmers' Perspective**

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**ABSTRACT** As world population increases every year, so does the demand for quality and affordable food. Mobile agricultural machines like tractors, planters, combines, and sprayers have played a major role in ensuring that there is adequate food for this growing population. As a result, these machines have undergone several modifications to increase their productivity and safety. Today's farmers make use of current technology to perform various farm operations. Some of these technologies include GPS, autosteer, and variable rate technology. Efforts are still being made to further improve the efficiency and operability of agricultural machines. Agricultural machine manufacturers and researchers are currently working toward full automation, meaning that these machines would neither have an operator in their cabin nor would they require human involvement to navigate and control their operations. But, is this what farmers desire? Is the farming community willing to fully embrace a driverless tractor, or do farmers prefer to remain in the operator's seat? The goals of this study were to gain an understanding of farmers' satisfaction regarding the various modifications that were made on previous/current agricultural machines and to determine the prevailing perception of farmers towards full automation of agricultural machines. To achieve these objectives, a survey was developed and distributed to farmers and university agriculture students in Alberta, Manitoba, and Saskatchewan. Findings from the study provided valuable information that will foster decision making during future modification of agricultural machines. Likewise, it will help manufacturers design machines that will focus on the needs of the farming community.

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**Keywords:** Agricultural machines, farming, automation, machine design, autonomous sprayer.

**INTRODUCTION** According to FAO (2009), it is estimated that global food production would need to increase by 70% to be able to feed the projected world population in 2050. Countries like Canada, a major global exporter of food, will need to increase their production. The effect is that Canadian farmers would either acquire more farmland or produce more crops from the same farmland (i.e., crop intensification). Considering the decline in the number of farmers, increased cost of farm inputs, and urbanization of rural areas, the latter seems to be the feasible direction.

Researchers (Blackmore et al. 1995; Doss, 2006; Redhead et al. 2015) believe that to achieve crop intensification would require the use of advanced precision agriculture (PA) technology. Such advancements in the past led to the introduction of GPS, automatic steering (autosteer) systems, variable rate application, remote sensing, and data management systems. The associated results were enhanced efficiencies of farm machines as well as minimal drudgery and harm to the operators (Goering and Hansen, 2004). On the contrary, the adoption of some of these technologies had been slow. For example, only 20.1% of farmers in Canada used Automated steering (Auto-Steer) in 2015 (Statistics Canada 2017). One would have expected a higher percentage of Canadian farmers adopting this technology considering its numerous benefits? Steele (2017) identified five factors that generally hinder the adoption of PA in western Canada: 1) price; 2) Internet speed and/or cellular coverage; 3) Lack of knowledgeable people; 4) Continuously evolving technology; and 5) Older farm equipment. Mbosso et al. (2015) also noted that the adoption of any technology depends on farmers' perceptions of the benefits that would arise from its usage. Hence, as researchers and agricultural machine manufacturers are currently working towards full automation of agricultural machines, it is important to investigate the perception of farmers towards this innovation. Is the farming community willing to fully embrace a driverless tractor, or do farmers still prefer to remain in the operator's seat? Gathering information on the farmer's perspective will assist manufacturers of autonomous systems to design machines that are easily adopted by the farming community.

Therefore, the goals of this study were i) to gain an understanding of farmers' satisfaction with regards to the various modifications that have been made on previous and current agricultural machines and; ii) to determine the prevailing perception of farmers in relation to full automation of agricultural machines. Due to the unique characteristics of each farm machine, we decided to focus on the agricultural sprayer given the prominent role that it plays in crop production, However, the knowledge gained may be transferable to other types of field machines.

**MATERIALS AND METHODS** To achieve these objectives, a survey was developed and distributed to the farming community to gather their opinions. The target groups were farmers and agriculture students attending universities within three Canadian provinces (Alberta, Manitoba, and Saskatchewan). The survey comprised of three sections. The first section gathered demographic information of respondents (i.e., name, age, gender, location, etc.), the second section focused on farmer's satisfaction regarding the various technological modifications that had been made on agricultural sprayers over the years, and the last section focused on the perception of farmers in relation to autonomous sprayers.

Respondents were given the option of either completing the survey online through the survey link (Survey Monkey) or filled and returned a hardcopy of the survey. Prior to the study, ethics approval was obtained from the research ethics board of the University of Manitoba. Overall, four universities and nine distinct producer groups were contacted to assist with the distribution of the survey.

## **RESULTS AND DISCUSSION**

***Respondents' Demographics*** One hundred and forty-one responses (116 online and 25 paper base) were collected throughout the duration of the survey (Nov. 2016 – Jan. 2017), however, only 61 responses were used during the analysis. The other responses were excluded either due to

incomplete entries or lack of experience of the respondent in relation to sprayers and its operations. Of the 61 eligible responses, 3% were female while 97% were male. Manitoba had the highest number of respondents (71%) followed by Saskatchewan (26%) and Alberta (3%). Overall, 61% of respondents resided in various rural communities across the three provinces (Fig. 1).

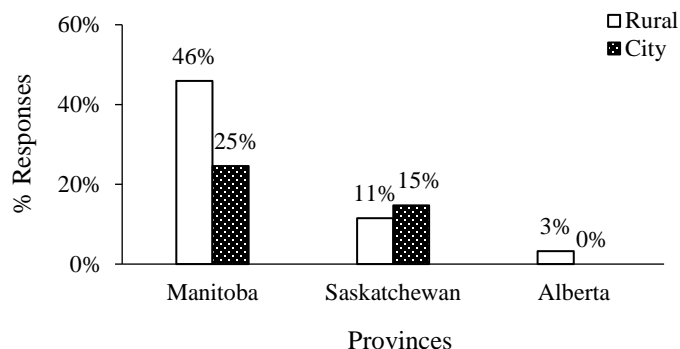


Figure 1. Location of survey respondents based on rural vs city.

The ages and years of experience of respondents are shown in Fig. 2. The survey had most of the respondents within the age categories of 15-25 years and 41-65 years, respectively (Fig. 2a). 54% had 1-5 years' experience in spraying while the remaining respondents (46%) had more than 5 years of experience (Fig. 2b).

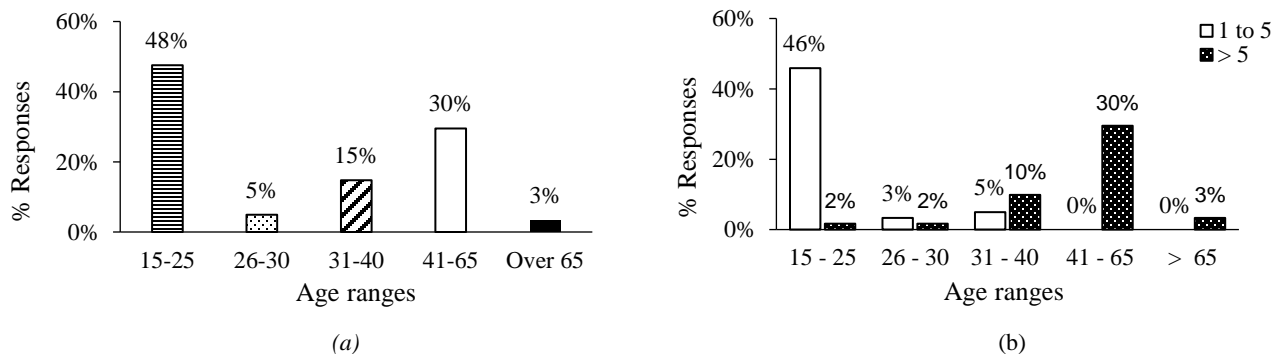


Figure 2. Ages of respondents highlighting a) age group, and b) years of experience in sprayers.

Most of the least experienced respondents were younger than the more experienced ones, indicating that experience increases as the age of respondent increases. However, regardless of their years of experience, most respondents (72%) were farm owner (Fig. 3). Only a few respondents were custom applicators (10%). The “other” category (18%) were hired farm workers.

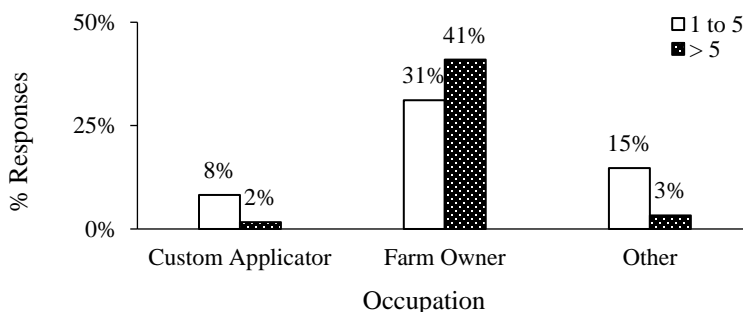


Figure 3. Comparing the vocation of survey respondents base with their years of experience in spraying (“Other” include farm workers, hire hands, or agricultural educator).

The two most numerous brands of sprayers among respondents were Case and John Deere (Fig. 4). Unfortunately, we did not ask respondents to indicate why they preferred their chosen brand. However, from discussion with other farm owners and custom applicators, some of the reasons given were: ease of operation, operating cost per acre, depreciation/resale value, efficiency, accessibility of dealers for parts, technological features, tank size, durability, boom width, reliable service dealers, and price.

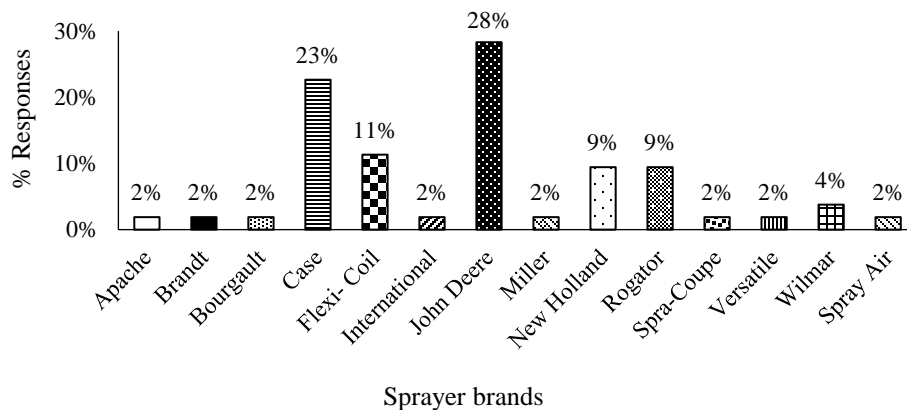


Figure 4. Brands of agricultural sprayer used among respondents (multiple responses were allowed).

Regarding the types of sprayer used, 69% of respondents had self-propelled sprayers while 20% had pull-type sprayers. The remaining 11% respondents had both self-propelled and pull-type sprayers. The result indicated that farmers and custom applicator had preference for self-propelled sprayers. Manufacturers of autonomous agricultural machines may consider designing autonomous sprayers to be self-propelled rather than pull-type.

**Satisfaction of respondents to technological advancement of agricultural sprayer**

Respondents were asked to indicate how satisfied they were with their current sprayer(s). 80% of respondents indicated that they were either “very satisfied” or “somewhat satisfied” while 8% indicated that they were “somewhat dissatisfied” with their current sprayer (Fig. 5). Interestingly, no respondents indicated that he or she was “very dissatisfied” with their current sprayer.

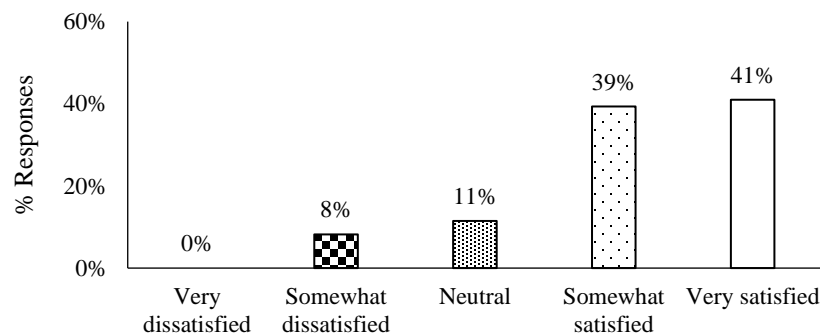


Figure 5. Respondents’ level of satisfaction with their current sprayers.

Similarly, 82% of respondents indicated that they preferred their current sprayers over their previous sprayers while the remaining 18% felt otherwise. The most common reasons they gave for this preference were technological features of the sprayers such as: autosteer, individual nozzle/section/rate control, and better boom height control. Other reasons were: longer boom, larger tank, more power, etc. (Fig. 6).

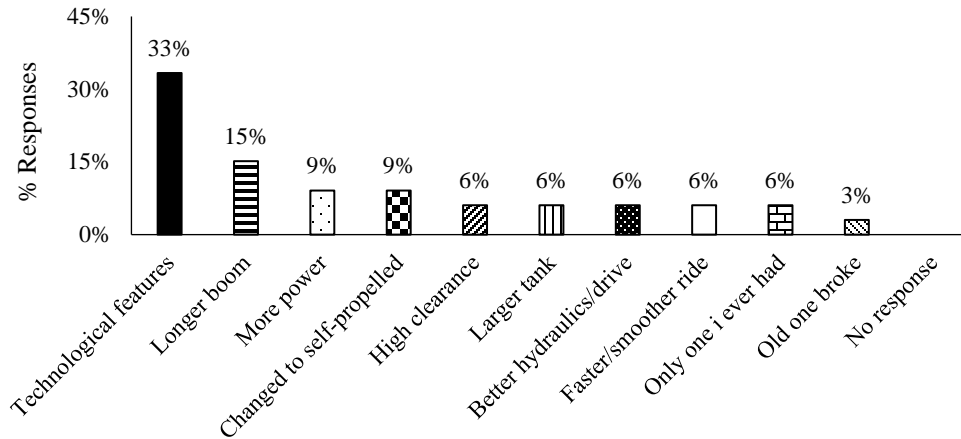


Figure 6. Respondents reasons for preferring current over previously used sprayer.

On the other hand, respondents who disliked their current sprayer compared to their previous sprayers were either those who either had no previous sprayer to make comparison to or respondents that bought similar types of sprayers. Only one respondent indicated that he disliked the current sprayer since it could not maintain uniform spray pressure when turning at headlands.

The rationale behind the question was that if farmers do not prefer technological advancement, they would prefer their old, less technologically-advanced sprayer. However, these results suggested that respondents were comfortable having all these technological features introduced to the sprayer. The inference is also supported by the results in Figure 7 which indicated that respondents are at least somewhat comfortable with the increased complexity of sprayers.

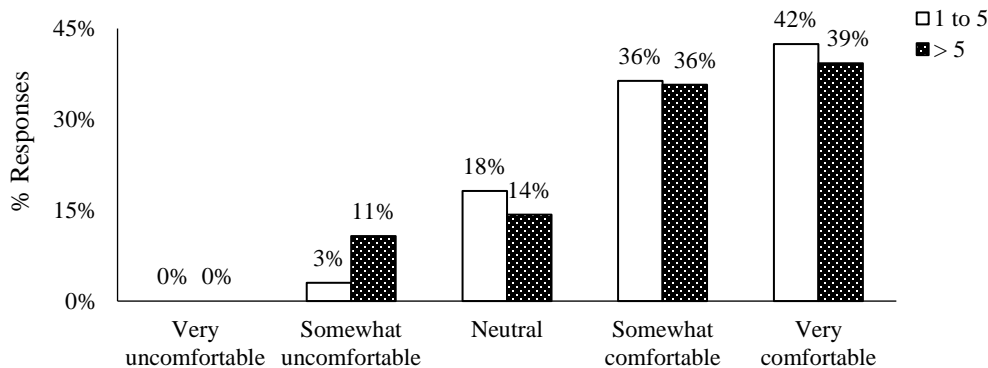


Figure 7. Comfort level of respondents regarding the increased complexity of sprayers.

Further analysis also revealed that less experienced sprayer owners/operators (1 - 5 years) were more comfortable than more experienced ones (> 5 years). As determined earlier, less experienced respondents are of younger ages (Fig. 2). Hence, they are likely to be more comfortable using technological features than the older respondents.

Figure 8 presents the results of some conditions that influenced decision-making when buying or renting a sprayer. Many respondents (61%) preferred buying what they had in mind, meaning that farmers have an expectation of how their sprayer should function and it is hard to convince them otherwise if what is presented to them is different from their expectation. Therefore, autonomous machine designers should take into consideration the expectations of the farmers.

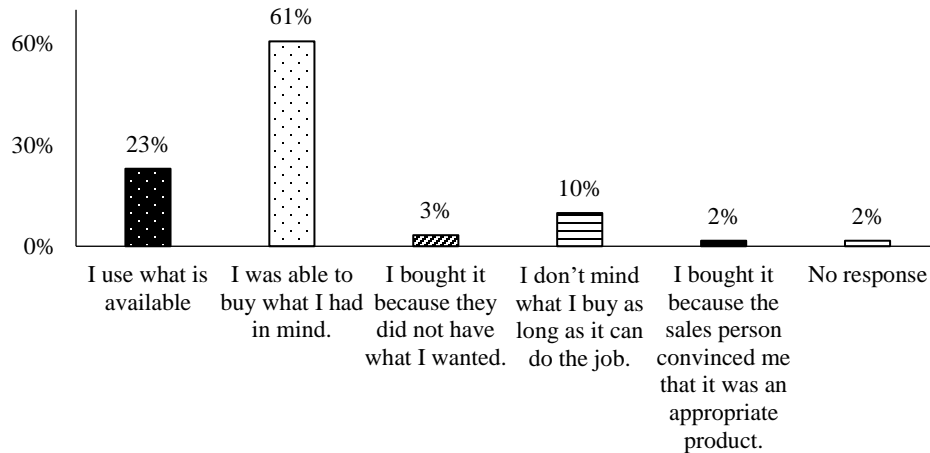


Figure 8. Decision statements regarding what type of sprayers respondents use.

Regarding the use of autosteer technology. 77% of respondents indicated that they had autosteer technology in the sprayer while 23% did not use this technology. Of the respondents that had autosteer, almost all respondents found the technology at least somewhat easy to adopt (Fig. 9). This result contradicts the 2017 report by Statistics Canada which stated that only 35.1% of Canadian farmers used autosteer technology. However, work done by Steele (2017) revealed that 79% of farmers in western Canada use auto-steer technology. Alberta, Manitoba, and Saskatchewan (our study focus) are in western Canada. Hence, the major population of farmers not using auto-steer were likely those provinces located outside of western Canada.

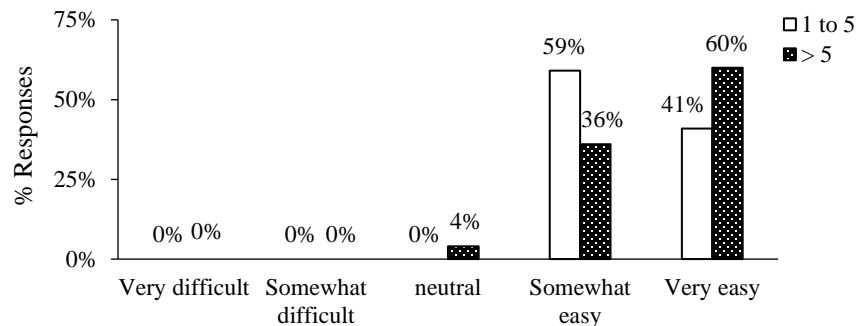


Figure 9. Responses on how easy it was adopting autosteer technology.

Comparing respondents' years of experience also revealed that 41% and 60% of respondents with 1- 5 years' experience, and greater than 5 years' experience, respectively, found it "very easy" adopting the technology. One would have expected that it would be easier for younger respondents (less experienced) to adopt the technology than older ones (more experienced) but this is not the case. There are other factors that affect the ease with which farmers adopt technology, and cost is a major one, and a challenge to younger farmers.

**Perceptions of respondents towards an autonomous sprayer** Regarding the introduction of autonomous machines in agriculture, respondents were asked if they would accept the autonomous sprayer. 31% of respondents said "No" while 69% said "Yes". Of the respondents that said "No", 42% of them still wanted to have full control of the sprayer's navigation (Fig. 10) while the remaining 58% had other concerns. These included: reacting to variability in field/soil conditions, monitoring spray pattern, managing drift and nozzle plugging, ability to view the crop while spraying, machine breakdown, complexity of setting up/controlling and repairing the sprayer, avoiding obstacles, return on investment, safety, and the actual cost of the autonomous sprayer.

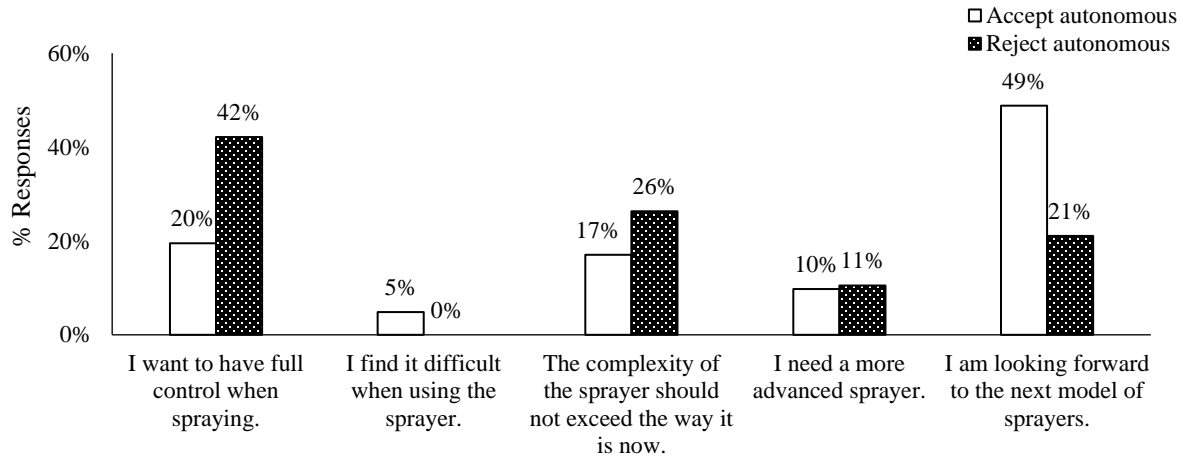


Figure 10. Respondents views towards navigating the sprayer.

Addressing all these concerns would further increase the percentage of farm owners and custom applicators within the three Canadian provinces (Alberta, Manitoba, and Saskatchewan) who will be willing to accept autonomous sprayer to 87% (i.e. from 69 to 87%).

Regarding how comfortable respondents would be having an autonomous sprayer in their field, 49% of respondents were at least “somewhat comfortable” (Fig. 11).

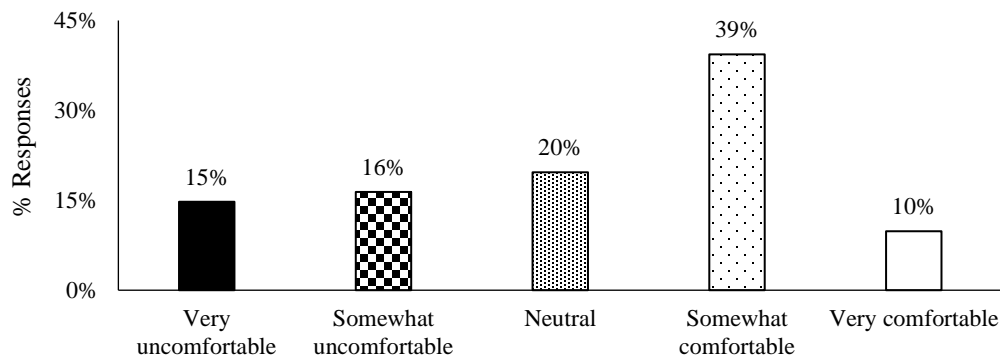


Figure 11. Comfort level of respondents regarding the use of an autonomous sprayer.

The result revealed that farmers are concerned about the reliability of an autonomous sprayer. They are aware of the liability issues that may arise if anything goes wrong and cannot be managed on time. Hence, they are “somewhat comfortable”. However, their comfort level in autonomous sprayers may increase as the level of trust in the sprayer increases. One way their trust level might increase is when some or all the concerns mentioned earlier on are addressed.

**CONCLUSION** Farmers in Canadian Prairies (Alberta, Manitoba, and Saskatchewan) are generally satisfied and comfortable with the current level of technological advancement of agricultural sprayers; since “they buy what they want” and what they want are mainly technological features. However, there are concerns about further increase in the complexity of the sprayer.

Generally, farmers are noted to easily adopt systems and technology that have visible or direct impact on farm input costs and crop productivity as well as in relieving the operator of various tasks associated with operating the machines. Agricultural machine designers should take these into

consideration and work closely with farmers so that future development of the agricultural sprayer can be easily accepted.

Canadian prairies' farmers are willing to accept autonomous sprayers provided they are reliable, efficient, easy to use, cost-effective, and safe. Also, designing the sprayer to be specialized (i.e. self-propelled as opposed to pull-type), having multiple access to diagnosis, compatibility with other brands of machines, accessible dealership and parts, and having a manual written for operators (and not engineers), may further increase its acceptability.

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