Dissemination of precision farming technologies in Austria in the context of energy savings potential

A survey on the mechanization of Austrian arable farms

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Abstract: The usage of precision farming technology can be a key factor in reducing greenhouse gas emissions in agricultural processes. In particular, automatic steering systems as well as automatic section control systems are two of the main contributors for the energy savings potential in agriculture. In order to estimate this potential for Austria, the degree of mechanization and the local agricultural structure have to be considered. An online survey was used to determine the extent of these factors, with more than 1000 arable farms participating in the two and a half months of the survey. Approximately one-third of those surveyed stated that a steering system is in use, while RTK systems are only used by just over a fifth of the farms. Further, while more than half of the farms already use section control in sowing and fertilization, only around 15 % of them use satellite-supported section control. These findings imply a considerable savings potential.

Keywords: energy savings potential, automatic steering, section control, survey

1 Introduction

In accordance with the sustainable development goals (SDGs) [UN15], Austria has committed itself to reducing its greenhouse gas emissions by 36 % by 2030 compared to 2005 [BK20]. In order to fulfill this global climate commitment, contributions from the agricultural sector are necessary, as it affects greenhouse gas emissions both directly and indirectly. The usage of precision farming technology, in particular automatic steering systems as well as automatic section control systems, can have a major influence on the reduction of greenhouse gas emissions by contributing to the energy savings potential in agricultural processes [As18,Ve13]. Both automatic steering systems and automatic section control systems achieve this by their ability to reduce agricultural inputs. Further,

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site-specific applications better target those inputs to the specific spatial and temporal needs of the fields, resulting in lower greenhouse gas emissions as well as in increased farm productivity and economics [Ba17]. Additionally, the automatic steering systems also directly influence the energy savings potential due to reduced fuel consumption. However, the actual potential for a reduction of greenhouse gas emissions is influenced by many factors including the degree of mechanization as well as the region-specific agricultural structure. The agricultural structure in Austria is – on a global perspective – distinctly different from other areas. Still, even sub-regions in Austria differ quite strongly in their agricultural structure, meaning in particular field shapes and total farm area [AM19]. Further, the actual dissemination and usage, i.e. the degree of mechanization, is affected by regional variations. Here, we present the results of a survey conducted online to determine the degree of mechanization of Austrian arable farms, which provides necessary information in order to estimate the energy savings potential of precision farming technology in Austria.

2 Material and methods

2.1 Data collection

Data on Austrian arable farms were collected using an online questionnaire with Lime Survey (version 3.21) [Li19]. In particular, key metrics on mechanization and agricultural structure were enquired. This included on the one hand various parameters on the farm as well as the farmer (e.g. farm location in Austria, farm size and its distribution according to use, crop cultivation, organic farming, age of the farmer) and on the other hand the use of machinery and precision farming technologies (e.g. machinery, automatic steering and usage of a correction signal via satellite, working width, section control). In January 2020, the survey link was distributed via the relevant agricultural media in Austria and the Chambers of Agriculture of the federal provinces. Further, the project partner Maschinenring included a solicitation for participation in the survey in its newsletter to its member farms in Lower Austria. This advertisement resulted in a response of 1229 questionnaires by March 2020 of which 732 were completed in full and 497 at least partially.

In order to correlate the obtained data to Austrian agricultural structures, data on farm sizes and number of farms per federal province were obtained from Statistics Austria as well as from the Green Report 2018 and 2019 [Bu19].

2.2 Data analysis

For data analysis, the Python programming language [VD09] was used. The dataset was filtered for input errors and outlier/non-plausible answers. Further, answers were only

included if arable land was stated. This resulted in 785 answers being included in the analysis.

3 Results

The quantity of survey completions indicates that almost 2 % of the Austrian arable farmers completed the survey. Further, an area share of more than 4 % of the total Austrian arable area is included. Consequently, the farm size in this analysis is above the Austrian average farm size.

3.1 Automatic steering

For automatic steering systems, the energy savings potential is primarily achieved by the reduction of overlap on consecutive tracks in cultivation and seeding, since 5 to 8 % of the technical working width remain unused in manual steering systems [La09, Re12, Fa18]. By using satellite navigation, this overlap can be reduced leading to a reduction in working time, fuel consumption as well as resources used. In order to achieve sufficient accuracies for agricultural processes, satellite navigation needs to be enhanced using correction signals. Using real time kinematic (RTK) systems, positions can be determined up to 2 cm leading to a substantial reduction of the overlapping area. In contrast, freely available correction signals of lesser quality only show a minor energy savings potential compared to manual steering systems.

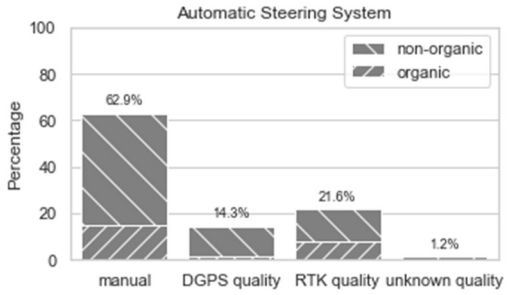

Fig. 1: Dissemination of automatic steering systems and the used correction signals (differential GPS, RTK, unknown) among the survey respondents. 37.1% of farms use automatic steering systems, with over half of them stating the integration of RTK correction signals. Hatches indicate the subdivision into organic and non-organic farming in each category

Fig. 1 shows that 37.1 % of those surveyed stated that they are already using an automatic steering system in contrast to manual steering. However, only half of them are using a fully automated steering system, i.e. a system that is fully integrated into the tractor (data not shown). Further, RTK systems are only used by 21.6 % of the farmers surveyed. This finding alone indicates a notable energy savings potential.

In order to investigate this further, the dissemination of automatic steering systems and the used correction signals (differential GPS, RTK, unknown) was analyzed with respect to different surveyed parameters. Whereas the age of the farmer had no significant influence on the usage of automatic steering systems, an influence of the farm size, i.e. the stated arable land, on the usage of automatic steering systems and the used correction signal could be observed with larger farm sizes being more likely to use automatic steering systems (see Tab. 1).

Arable land	manual	DGPS quality	RTK quality	Unknown quality
< 5 ha	17	0	1	0
5 – 10 ha	23	0	1	0
10 – 20 ha	67	4	1	0
20 – 30 ha	45	5	5	3
30 – 50 ha	104	15	21	1
50 – 100 ha	131	30	57	3
100 – 200 ha	31	34	42	1
> 200 ha	7	9	18	0

Tab. 1: Dissemination of automatic steering systems and the used correction signals (differential GPS, RTK, unknown) among the survey respondents with respect to the stated arable land

Further, the usage of automatic steering systems and the used correction signal showed also a significant correlation with the implementation of organic farming practices (see Fig. 1). Survey participants using an automatic steering system with RTK or unknown corrections signals reported being organic farmers in 35.67 % and 37.56 % of the cases, respectively. In contrast, survey respondents using manual steering or an automatic steering system with a differential GPS correction reported lower numbers, 23.80 % and 10.32 %, respectively.

3.2 Section control

Next to the usage of automatic steering systems, the use of section control systems, e.g. the deactivation of nozzle segments or the variation of spreading patterns, can also contribute to the energy savings potential in agricultural processes. This holds true in particular for precision farming applications with large working widths as are common in plant protection or fertilization. Using section control systems, areas smaller than one working width as well as non-rectangular and oblique-shaped fields can be cultivated with minimal overlap or underlap.

Asked for practices in sowing and fertilization, 55.5 % and 52.3 % of the survey respondents reported the usage of section control systems, respectively (see Fig. 2). However, only approximately 14.2 % and 15.8 % of those section control systems are used

automatically, i.e. supported by satellite navigation, respectively, in contrast to manual systems. This finding indicates that the implementation of automatic, satellite-supported section control systems offers a feasible energy savings potential.

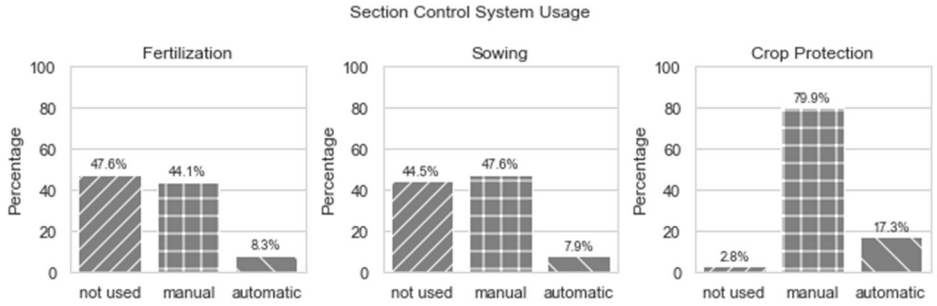

Fig. 2: The usage of section control systems for sowing, fertilization and crop protection among the participating farms

In contrast to sowing and fertilization, 97.2 % of survey respondents stated the usage of section control systems in crop protection (see Fig. 2). However, only 17.8 % of those operated in an automatic fashion. This percentage of satellite-supported systems used in crop protection is similar compared to its usage in sowing and fertilization processes.

4 Discussion and outlook

The presented results show that the dissemination of automatic steering systems and section control systems in Austrian arable farms has not reached its full capacity implicating that further distribution of these precision farming technology would lead to reduction of greenhouse gas emissions. However, the obtained average farm size of the survey is above the average Austrian farm size, which suggests that the degree of mechanization is most likely overestimated in our results. This would indicate an even higher energy savings potential.

Next to direct effects such as the reduction of fuel usage, also a considerable amount of energy used for fertilizer production can be saved. In order to determine more precise decision criteria, the greenhouse gas potential and further environmental effects such as eutrophication and acidification of the soil need to be taken into account in addition to the energy considerations. This information can be obtained by using the method of Life Cycle Assessment (LCA) on the collected data.

It is important to note that the probed measures and practices to reduce energy saving do not necessarily affect farm productivity and economics negatively as this would limit its implementation. This consideration, together with further influential parameters such as tracklength, turns or dead track, and the yet unknown contribution of indirect

environmental effects make estimating the exact amount of possible savings a challenging task, which is going to be the subject of subsequent research.

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