Is it the same story? – Comparing the performance of precision and non-precision arable farms of the FADN system

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Introduction

As an important part of the digital revolution of agriculture, the role and status of precision agriculture (PA) is obviously a relevant topic to study. There is a wide range of PA technologies available for farmers, but uptake varies by the technology and region. There are several publications focusing on this topic, but adoption is still not followed by official statistical data collections. The longest historical time series of PA adoption data is the precision dealer survey of the CropLife magazine and the Departments of Agricultural Economics and Agronomy at Purdue University, which was done for the 18th time (Erickson et al., 2017). They found that GPS guidance with automatic control (autosteering) continues to have the highest farmer adoption (60%), but all PA practices show steady growth, except VRT pesticide applications. Based on a worldwide literature review Lowenberg-DeBoer (2018) found that GNSS guidance adoption rate some places has reached 70-80%, while the use of VRT for fertilizer and other inputs is growing slowly. Among the U.S. commercial crop producers, the adoption rates were found much higher (Thompson et al., 2018). A very high percentage of respondents reported using yield monitors (93%) and autosteer (91%), followed by variable rate fertilizer application (73%) and precision soil sampling (60%). A recent study of Barnes et al. (2019) have focused on uptake of machine guidance and variable rate nitrogen technologies within European farming systems. They reported that 44% of the 971 respondents were non-adopters, 33% adopted only machine guidance, while 23% of the respondents own or rent both machine guidance and variable rate nitrogen technology.

Complaints about the slow adoption are a regular part of almost every analysis of the potential for PA and that slow adoption is often linked to uncertainty about benefits and profitability (Lowenberg-DeBoer, 2018). However, due to the many complex factors, profitability cannot be demonstrated in all cases (Zarco-Tejada et al., 2014). According to Vogt (2017) the net impact and influence on profitability are highly variable, in Australia there are examples where PA has generated a substantial net benefit of up to $75/ha, while other examples have demonstrated a net loss of up to $90/ha. In addition, several researches have shown that precision farming can be used as a risk management tool and there are potential environmental benefits (Balafoutis et al., 2017; Griffin et al., 2018). The climatic and general environmental conditions and degree of their variability can also influence the benefit that can be realised from a technology. In a long-term experiment Yost et al. (2018) found that profit gains were not realized, but PA had lower temporal variability in profit than conventional growing. This may indicate better resiliency in PA under variable weather conditions.

The CropLife/Purdue survey shows that farmer income (65% agree) and the value perceived by the growers (34% agree that cost of PA services is greater than the benefits) continues to be a barrier for adoption. The high cost is a barrier also for European farmers, therefore subsidy and taxation were considered positive drivers of uptake within the community (Barnes et al., 2019). Around 50% of respondents ranked some form of training as a potential incentive factor.

A questionnaire survey among the Hungarian FADN farms was completed in 2016 (Kemény et al., 2017) to examine the diffusion and status of precision farming. To reveal whether there is any difference compared to that results, the survey was repeated in 2018 on almost identical sample. This allowed both to compare the results and to follow the development.

Materials and methods

A questionnaire survey among the farms of the Hungarian Farm Accountancy Data Network (FADN) was conducted in 2016 and repeated in 2018 with the aim to obtain detailed picture about the penetration of PA and soil conservation tillage in Hungary. In 2016 responses were received from 656 farms, while 604 responses were obtained in 2018. The questionnaire was composed of a combination of multiple-choice questions where respondents could select and/or rank among several predefined answers, and questions to be answered using a 1-5 Likert scale from ‘very low’ to ‘very high’. The questionnaires received, generated 425-557 (depending on the questions and year of the survey) evaluable responses regarding PA. For the first results, univariate methods were used to describe the sample and represent frequencies, and results of the two surveys were compared.

The respondents also provided information about the area cultivated under PA by crop type and about the technological elements applied. The number of the precision agriculture farms were 45 and 43, respectively. Their questionnaire answers were analysed together with their balance sheet and profit and loss statement data. The cost and income calculations were based on the national extended FADN database maintained by the Research Institute of Agricultural Economics. Since the aim of the study was to detect the benefits of site-specific arable crop production, hereafter our analysis was conducted at the sector (crops) level, thereby filtering the distorting effect of subsidies and land lease.

During our research, we used several different benchmarking methods to test the economic benefits of PA. Among the PA farms 22 were identified as data suppliers in both surveys, and whose economic data were available for three consecutive years, 2015-2017. This paper focuses on the comparison of these farms to the three-year national average.

The three years examined had different climatic characteristics. 2015 was declared the third hottest year on record since temperature started being monitored with serious drought in summer. In June and July the precipitation was only 42% and 61% of the usual amount, respectively, while in October there was 2.5 times much precipitation than usual. 2016

started with a warm winter, the February temperature was 5.1°C higher than the long-term average, and at the same time the precipitation was almost three times more. July was also very wet with almost double amount of precipitation than usual. In 2017 the yearly average temperature was almost the same as in 2016. The average precipitation coincided with the long-term average, but had a different distribution. Until August there was mainly dryer season, while in September and at the end of the year was more precipitation.
Regarding the temperature, spring and summer were very varied, both with some positive and negative records (OMSZ, 2019).

Results

Adoption of precision agriculture technologies

The ratio of the PA farms was almost the same in the two surveys, around 7%. In the recent survey 3 of the respondents indicated the abandonment of PA, first of all due to lack of adequate workers and technical problems. At the same time, 26 respondents (4.3%) planned to introduce PA.
To reveal the main barriers and drivers of PA adoption, respondents had to rank factors that were taken into consideration. Results below are based on the first ranking factors. In both surveys the excess investment cost proved to be the main barrier to widespread adoption of PA (Figure 1a). In 2016 it was indicated by 52.2% of the respondents, while it had a slightly less importance in 2018 (41.6%). The proportion of the respondents indicating the lack of appropriate financing as the main barrier was also decreasing (11.9% and 8.6%). Many respondents indicated that the technology cannot work effectively for their farm size, and this showed an increasing tendency (15% and 24.7%, respectively). The lack of appropriate knowledge got also an increasing importance (from 5.2% to 13%).
Among the respondents, 28.2% indicated in 2016 that higher profitability would be their main motivation for adopting PA. This factor not only kept its first position but has become more important according to the 33% of the respondents. The importance of the more detailed information (15.8% and 19.3%) and to be a measure in a RDP (13.2% and 19.7%, respectively) has also increased, while the role of an income replacement allowance has decreased from 21.7% to 8.3% (Figure 1b).

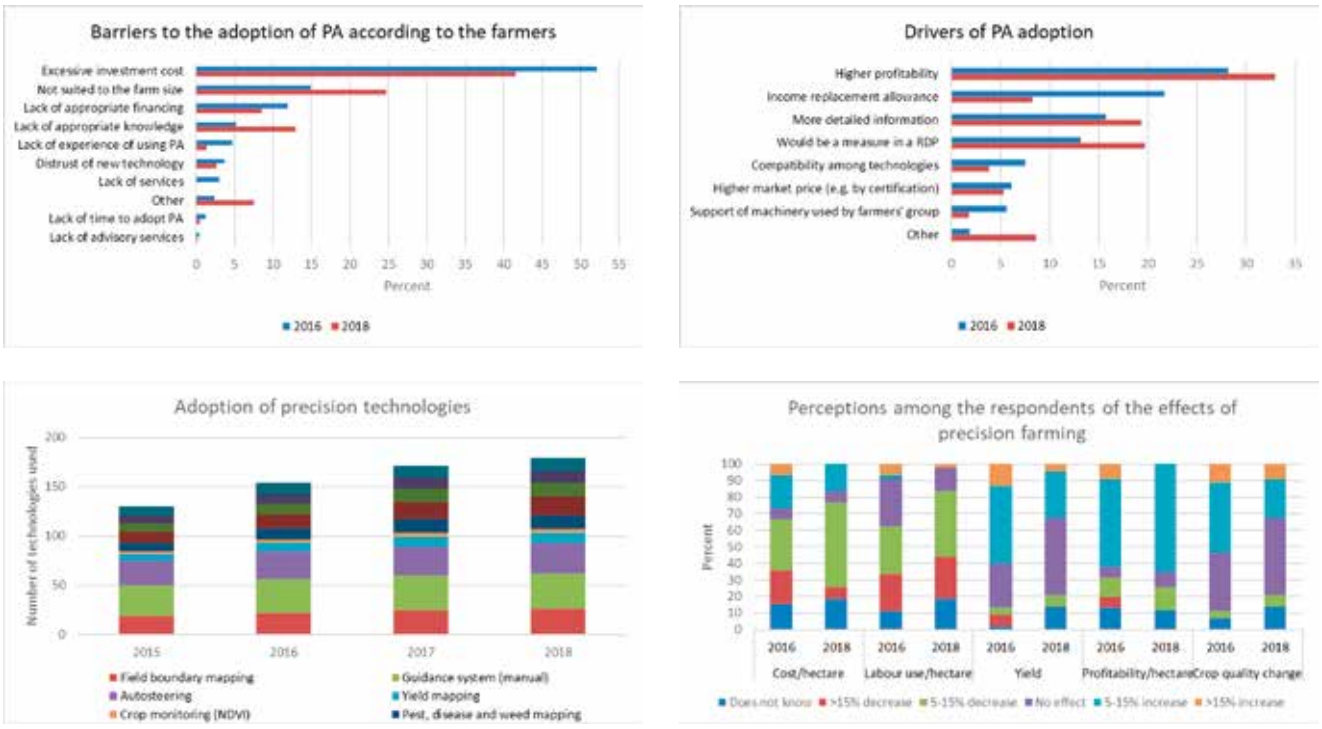

Figure 1. Main results and tendencies based on the surveys. Barriers (a) and drivers (b) of PA, adoption of technologies (c), and the effects perceived (d).

The adoption level could be characterised by the number of different technologies being adopted by the producers. The respondents of the survey indicated also the year of the introduction of each technology, from that – supposing that they kept using – the cumulative number of technologies used was calculated. A clear but slow increasing tendency can be seen both in the total number of technologies used and concerning each technology (Figure 1c.). GPS based guidance is commonly used among PA farmers, but the proportion of the manual (lightbar) system is still higher then one of the auto-steering. Field boundary mapping is on the third place (60%), followed by VR fertilization (44%). The adoption rate of the other technologies examined varies between 25% and 33%, except crop monitoring.
In terms of the differences perceived following the introduction of precision farming the recent survey shows mainly more favourable results than the former one (Figure 1d). The ratio of the farmers reporting a slight decrease in variable costs (mostly inputs) has increased from 31.1% to 51.2%, and no one indicated more than 15% increase in it. In 2016 opinions

were varied about the effect on labour use, in the recent survey there is a shift to the labour savings. Regarding the impact on yield there is an adverse situation. In the latest survey there were less farmers reporting yield increase (32.6% instead of the 60% in 2016), while more indicated no difference (46.5% in contrast to the 26.7%). In case of profitability the extreme categories (>15% increase / decrease) have disappeared by 2018, while the majority (65.1%) of the farmers has realised a slight increase. In 2016 crop quality improvement was reported by 53.3% of the farmers, which has fallen back to 32.6%, most of the farmers (60.5%) reported no effect or does not know.

Cost and profitability of winter wheat

For winter wheat production precision farms reached 8.2 % higher yield (6.1 t/ha) in 2015 than the three-year (2015-2017) national average (5.6 t/ha). The difference was even higher (16.0%) in 2016, while 18.0% in 2017. It can be considered that precision farms were able to increase their yield year by year, while the national average (based on FADN farms) was the highest in 2016. Considering input costs, the cost of seed was lower in each year for PA farms, but they spent more on fertilizer in these years. The cost of pesticide usage was not the same in the years: pesticide cost of precision farms was lower in 2015, while higher in 2016 and 2017 compared to the average. Crop income of precision farms was significantly higher in each year: it was almost three times higher (267%) in 2015, 154% in 2016 and more than double (232%) in 2017. The unit cost of winter wheat for precision farms was favourable, it was lower in each year than the three-year national average.

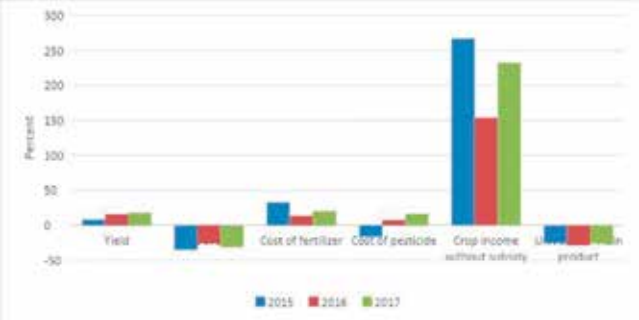

Figure 2. Main indicators of precision winter wheat producers compared to the national average (2015-2017)
Source: Based on FADN data calculation of Research Institute of Agricultural Economics

Conclusions

In both surveys, only around 7% of the respondents claimed to be involved in PA to any extent. This is a very low rate compared to the Western European countries, Australia, and especially to the USA. However, the number of technologies used has shown a slight increase, which might indicate the more intense involvement of the PA farms.

Guidance systems are well adopted, but in contrast to the international data the proportion of the auto-steering is still lower than one of the manual guidance systems. The adoption rates for information intensive technologies requiring additional data management ability – like yield mapping and crop monitoring – are low. This was observed also in the USA (Griffin et al., 2018).

PA farms have achieved better economic results than the national average based on annual comparisons, as well as compared to the three-year average. This indicate the advantages of PA under different weather conditions.

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