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Precision agriculture in Hungary: assessment of perceptions and accounting records of FADN arable farms

Technological progress can provide several solutions to the most significant challenges faced by agriculture. Precision agriculture (PA) technologies have been recognised as one of the rare win-win solutions for environmental and socio-economic goals. Although they have been available for decades, their diffusion progresses at a slow rate. Therefore, in recent years, precision farming has been receiving more attention from agricultural economists. Perceptions of Hungarian FADN arable farms about precision farming were collected through a survey in order to compare with cost-benefit analyses. The survey not only revealed the details of the application of different technologies but also their impacts perceived compared to a baseline situation. For the main crops, the results confirmed that precision farming leads to increasing yields and has profitability benefits compared to conventional farming. According to the respondents, the high investment cost is the main barrier to diffusion, while subsidies and more appropriate information could foster it. Therefore, a specific subsidy package implemented both in the 'greening' component and in the Rural Development Programme of the European Union's Common Agricultural Policy would be a stimulating factor for the wider spread of PA.

Keywords: site-specific farming, technology diffusion, cost-benefit analysis, FADN data, survey
JEL classifications: O33, Q11, Q16

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Introduction

Any technology – such as precision farming – that is in line with the concept of sustainable intensification can contribute to achieving a sustainable food system. However, these possibilities can only be achieved if the associated benefits can be properly measured and at the same time farmers perceptions and behaviour are better understood.

Modern precision agriculture (PA) started after 2000, when GPS signals were made available to the public. In the last ten years, PA has moved from state-of-the-art science to standard practice and already 70-80 per cent of new farm equipment sold contains some form of PA component (CEMA, 2014). Precision farming can be considered as an agricultural innovation. It has been shown that young, well-capitalised farmers with large land areas and higher levels of education tend to be more willing to apply new technologies. PA technologies require significant investment of both capital and time, but provide both productivity and profitability benefits. The data generated by these technologies have been one of the reasons that farmers adopt PA (Griffin *et al.*, 2017). Conversely, among the main barriers are the high investment cost, cost of specific precision services, lack of IT knowledge, insufficient communication and co-operation between actors and, very importantly, a gap in knowledge transfer between science and practical applications. (Fountas *et al.*, 2005; DEFRA, 2013; Antolini *et al.*, 2015; EIP-AGRI, 2015).

Currently, the biggest share of PA use takes place in the USA. The results of the most recent farm-level study in the USA show that the proportion of non-adopters has significantly declined, especially over the last six years, to 33 per cent by 2016 (Griffin *et al.,* 2017). It is important to note that in this case high labour costs encourage the spread of technology. Furthermore, significant state subsidy also promotes its broader application (Technavio, 2015). Even so, USDA's Agricultural Resource Management Survey (Schimmelpfennig, 2016) shows that adoption rates vary significantly across different types of PA technology and uptake also depends on the crop. For example, maize and soybeans have higher shares of cropped area (above 30 per cent) using yield mapping than other crops, guidance was used by 45-50 per cent of all crops, while the adoption of variable-rate technology (VRT) in maize, soybeans and rice were all above 20 per cent.

In Australia, 20 per cent of maize producers used precision cultivation in 2012 (OECD, 2016), but this proportion is much higher among farmers with large land areas. Llewellyn and Ouzman (2014) reported that 77 per cent of farmers growing more than 500 hectares of grain use automatic steering and 33 per cent carry out yield mapping. Thirty-five per cent of farmers have variable-rate fertiliser capability, but only 15 per cent of them use VRT.

PA has been making its way into farms across Europe, but the uptake is still very slow, and there is great variation among European Union (EU) Member States. According to a survey completed in 2012 (DEFRA, 2013), in England only

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22 per cent of farmers used GPS-based vehicle navigation, 20 per cent used soil mapping, 16 per cent used variable-rate application and 11 per cent used yield mapping. In Germany, 10-30 per cent of farmers have adopted at least one element of PA (OECD, 2016; Paustian and Theuvsen, 2017). According to recent data of EurActiv (2016), 150 000 hectares in France are managed using precision agriculture, and half of the farms have a tractor equipped with a monitor.

Precision farms emerged in Hungary in the last 15 years, but for many people it is still an unknown concept. According to Tóth (2015), only half of the crop producers have heard about it, but this percentage depends on the farm size. Adopters of precision farming are primarily younger than 40 years old, have higher education and cultivate more than 300 hectares of land, which is consistent with international experiences (Lencsés *et al.*, 2014). In 2015, 44 per cent of farmers used GPS, and among farmers under the age of 40 years this share reached 48 per cent (Pólya and Varanka, 2015). Site-specific soil sampling, the use of guidance systems and, increasingly, automatic steering can be considered to be standard management practices. More than half of the precision farmers use guidance systems, and around 30 per cent of them use autopilot, followed by machine control, VRT seeding and fertiliser applications (25 per cent). The applications of sensors for pest control, drones and precision irrigation are still at the inception phase: the rate of their application is only around 5 per cent (Kemény *et al.*, 2017).

It is widely accepted that the economic potential or profitability of PA depends on the farm size, heterogeneity of agricultural land cultivated by the farm, the applied technology mix (both PA and non-PA), the cultivated crops, and the experiences and ICT skills of the farmers. Castle *et al.* (2017) demonstrated using regression analysis that the profitability of PA technology adoption increases with the years after adopting the technology.

In order to lower the additional investment costs of PA, technologies are usually introduced sequentially. However, this approach to adoption may seem inefficient and time-consuming compared to adoption of complete, possibly complementary technologies (Schimmelpfennig and Ebel, 2016). Zarco-Tejada *et al.* (2014) estimated the economic benefits of guiding systems for a 500-hectare farm in the UK to be at least EUR 2.2 per ha. A more complex system would lead to additional returns of EUR 18-45 per ha for winter wheat production. In Germany, economic benefits due to savings of inputs were assessed at EUR 27 per ha for winter wheat. According to Schrijver (2016), the potential savings for EU farmers are EUR 260 per ha compared to a gross margin of EUR 400-700 per ha, which could be realistically achievable by 2050.

Although profitability is critical to the adoption decision by farmers, several studies only estimate changes in input use and yield, and the reported data are sometimes rather variable. For example, automatic machine guidance is expected to result in a 10-25 per cent decrease in fuel consumption, weed detection can reduce the herbicide use by 6-81 per cent, and precision irrigation typically enables 25 per cent water savings. For site-specific nitrogen management, the input use saving ranges from 6 to 46 per cent, and the yield increase from 1 to 10 per cent. Beyond the economic benefits, lower environmental impact (reduction of residual nitrogen in soils by 30 to 50 per cent) is also mentioned (Jacobsen *et al.*, 2011; Zarco-Tejada *et al.*, 2014, Schrijver, 2016; Balafoutis *et al.*, 2017).

Based on these insights, the aim of the study was to demonstrate statistically the economic benefits of PA for arable farming in Hungary. At the same time, farmers' perception related to different aspects of PA was assessed. The paper investigates the following hypotheses: H1: The most important hindering factor for the penetration of precision farming in Hungary among arable farms is the high investment costs; H2: The introduction of precision fertilisation and pest management applications would cause a decrease in the input use; H3: Precision farming in case of the main arable crops (winter wheat, maize, oilseed rape, sunflower) increases yield, with cost and profitability benefits compared to current conventional agronomy practices.

Methodology

Farmers' perceptions and the main barriers are usually evaluated based on questionnaires. A questionnaire survey among the approximately 1,000 arable crop farms of the Hungarian Farm Accountancy Data Network (FADN) was conducted in 2016 with the aim to obtain detailed picture about the penetration of PA and soil conservation tillage in Hungary. Responses were received from 656 farms, i.e. approximately 70 per cent of the sample farms, so the sampling can be considered as representative. During the survey, we investigated how different information sources are used by farmers to gain knowledge about PA and soil conservation management; farmers' opinions on the barriers (H1) and stimuli to the diffusion of these technologies; their judgement on the contribution of PA to environmental/economic/social sustainability; and their experiences (if any) after the adoption of these technologies. The questionnaire was composed of a combination of (a) multiple-choice questions where respondents could select and/or rank among several predefined answers, and (b) questions to be answered using a 1-5 Likert scale from 'very low' to 'very high'. The 656 questionnaires received yielded 425-460 (depending on the questions) evaluable responses regarding PA. Although some researchers have used Poisson regression (e.g. Castle *et al.*, 2016) or binary logistic regression (e.g. Paustian and Theuvsen, 2017) to determine the factors influencing adoption, we did not gather data on factors such as age, education level, computer literacy and number of employees. Firstly, univariate methods were used to describe the sample and represent frequencies. Quantitative scores assigned by farmers were used to generate the average numeric assessment of indicators.

The respondents also provided information about the area cultivated under PA by crop type and about the technological elements applied during the 2014/2015 crop season. Among the respondents, 45 farms (6.9 per cent) were precision producers in the examined season. Of these, 17 had information available for a longer period, at least three years prior to the introduction of precision farming technology, and three years afterwards (the year of adoption also included). Their questionnaire answers were analysed together with the 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 (AKI) in Budapest. 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.

Economic assessment of PA is usually based on pairwise or ANOVA comparison of mean values of input cost, production cost, gross production value or net profit for adopters and non-adopters. Schimmelpfennig (2016) used a robust empirical treatment-effects model to test the impacts of farm size, labour, machinery and field operation variables on both the identified rates of PA adoption and different measures of profit. During our research, we used several different benchmarking methods to test the hypotheses of decreasing input use (H2) and economic benefits (H3), as follows:

- Comparison of the 45 PA farms to control groups of 'conventional' FADN farms, based on the results of the 2014/2015 crop year. Control groups farms were selected by crop type, and their similar legal status (corporate or private farms) was considered.
- PA farms having at least three years of data were compared to control groups. Crop area and production cost (as a proxy for the intensity of production) were also considered in the selection of the control groups, and a maximum of 20 per cent difference was allowed compared to the PA farms. The number of farms involved varied depending according to crop type, and three-year data were used as a repetition to minimise any bias caused by weather effects. One-way ANOVA was applied to check the treatment effects (precision cf. conventional farming) on the yield, production value, production cost, unit cost and income for the main cultivated crops. Assumptions of normal distribution and homogeneity of the variances were checked using the Shapiro-Wilk and Levene's tests respectively.
- In the following assessment, three-year results of the before and after adoption of PA were compared for the 17 farms, but no statistical analysis was done due to the small sample size. In this case, the effect of price level change had to be considered. The input costs were deflated based on the price indices determined by the Hungarian Central Statistical Office.

MySQL and PostgreSQL were used for database management, while statistical analyses were carried out using the SPSS software package (IBM Corporation, Armonk, NY, United States).

Results

Adoption of precision agriculture technologies

Although 95.5 per cent of respondents had heard about PA, only 6.9 per cent of the respondents (i.e. 45 farms) claimed to be involved in PA to some extent. The first farm (among the respondents) adopted PA technology in 2004. The uptake of the technology was initially characterised by slow growth until 2012 (Figure 1). Subsequently, a more dynamic increase can be observed, particularly in 2014 and 2015. The respondents have collectively cultivated 13 crop types, among which the prevalence of PA use was the highest for winter wheat, both in terms of the total area and the number of farms (Table 1).

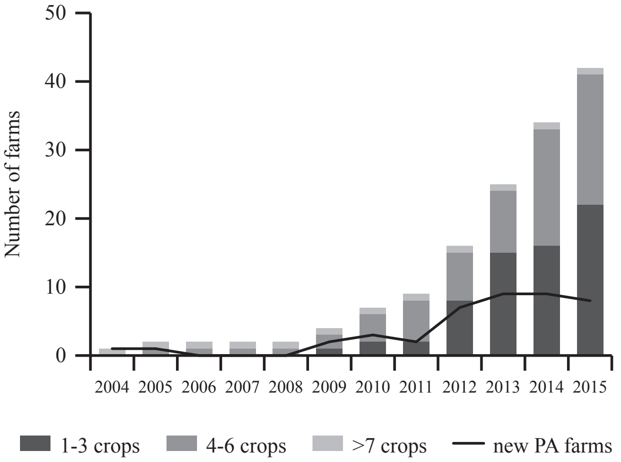

Figure 1: Adoption of precision agriculture among the questionnaire respondents since 2004 (n=656).

Source: survey data (three farms did not provide the start date)

Table 1: Production area and number of farms involved by main crop among the questionnaire respondents (n=656).

Crop	PA area (ha)	Number of PA farms
Winter wheat	4,161	38
Maize	4,019	35
Sunflower	2,795	32
Oilseed rape	2,016	20
Winter barley	825	15

Source: survey data

Of the examined farmers, 31.1 per cent did not use GPS correction at all, so were not capable of ±2 cm cultivation (sowing, fertilisation etc.) accuracy. Annual Real-Time Kinematic (RTK) signal subscription was bought by 26.7 per cent of the respondents, while 13.3 per cent had their own RTK base station. In addition, 15.6 per cent used corrections other than RTK. The remaining farmers (8.9 per cent) used RTK services based on the amount of data used or had a temporary subscription only in work periods (2.2 per cent). In addition, one farm indicated that it had both a RTK subscription and a base station.

Of all tractors, 29.6 per cent were equipped with auto-steering and 45.6 per cent were suitable to use an on-board computer. While 5.7 per cent of the tillage machines could be linked to an on-board computer, only 2.1 per cent were suitable for variable-depth cultivation. Among the wide row spacing drills, 56.6 per cent could be connected to an on-board computer. One quarter of them were suitable for variable-rate sowing, while 27.6 per cent were suitable for non-overlapping cultivation. More than half of the fertiliser spreaders could be connected to a computer, 23.0 per cent of them could prevent overlaps, and 36.1 per cent were enabled for variable-rate application. Just over 26 per cent of the harvesters were capable for auto-steering and 15.1 per cent for yield mapping. The number of trailed sprayers was higher than the self-propelled sprayers, whereas the ratio was reversed as regards precision ability. Of the self-propelled sprayers, 84.2 per cent could be connected to an on-board computer, 57.9 per cent were suitable for overlap-free active ingredient spraying, and 47.4 per cent were variable dose rate sprayers.

Field boundary mapping was carried out 88.9 per cent of PA farms, 82.2 per cent of them carried out soil sampling and soil mapping, while 64.4 per cent made nutrient management plans. These technologies were primarily used as external services. Weed or pest monitoring by drones or field sampling was made by 42.2 per cent of the farms, but only one third of the respondents used yield mapping.

However, adoption rates depended greatly on PA technologies and crop type (Figure 2). Precision nutrient management was dominant in oilseed rape, winter barley and winter wheat, while precision sowing was typical for maize and sunflower. The adoption level could be characterised by the number of different technologies being adopted by the producer. In this respect, only half of the farmers can be considered to be advanced users, applying several technologies.

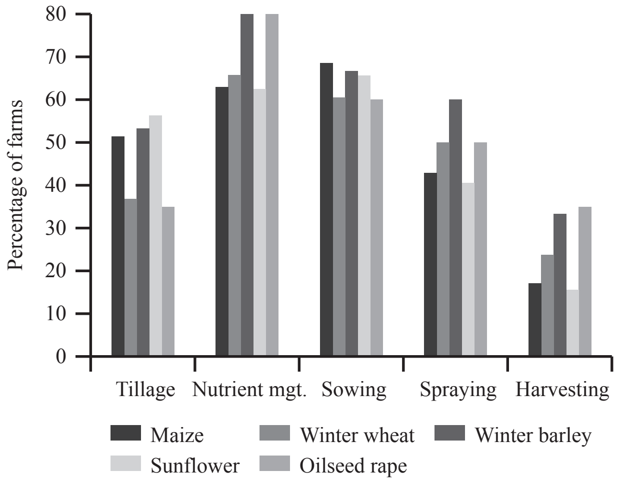

Figure 2: The share of precision technology components used in agro-technical factors in major crops (N=45).

Source: survey data

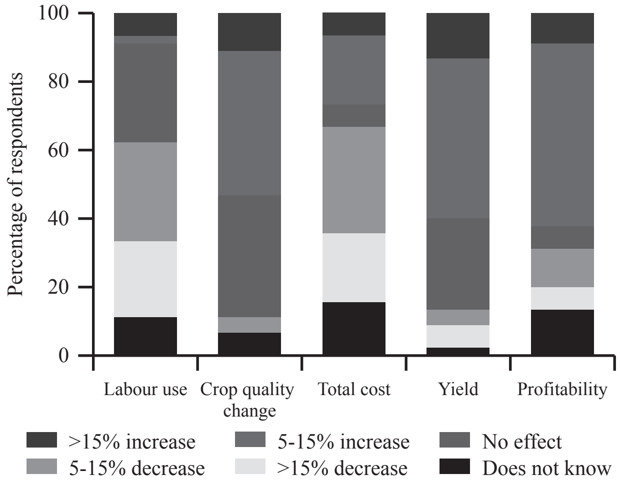

Figure 3: Perceptions among the respondents of the effects of precision farming (N=45).

Source: survey data

In terms of the differences perceived following the introduction of precision farming, 31.1 per cent of the farmers reported a slight decrease in variable costs (mostly inputs), 20.0 per cent noted a more significant decrease, while 20.0 per cent reported a slight increase (Figure 3). As to profitability, 53.3 per cent of the respondents gave an account of a slight increase, while 8.9 per cent reported that a greater increase occurred due to the technology. Regarding the impact on yield, 46.7 per cent of the farms reported a slight, 13.3 per cent a higher increase, whereas 26.7 per cent perceived no difference. Crop quality improvement was reported by 53.3 per cent of the farmers. Opinions varied about the effect on labour use: farms experienced almost equally a slight decrease or no effect, or a significant decrease.

Cost and profitability

Economic analyses were carried out using control farms as described above. The first comparison (Table 2) was calculated for the 45 PA farms compared to conventional farms. Based on the FADN balance sheet and profit and loss statement data analyses at crop level, it was found that the yields of PA adopters exceeded the control group's results for each crop examined. The average total income of precision farms, apart from winter wheat and oilseed rape, was higher – by 13 per cent for maize, 25 per cent for winter barley, and 50 per cent for sunflower – than for the control farms. Compared to similar but conventional farms, both the quantity and the cost of fertilisers were higher for precision farms, except for sunflower. This shows that the technology does not necessarily entail a reduction in production costs. The pesticide cost also exceeded, by between 8 and 56 per cent, the cost

Table 2: Impact of the application of precision agriculture on the most important financial figures based on the 45 farms, per cent (crop year 2014/2015).

Indicator	Winter wheat	Maize	Sun-flower	Oilseed rape	Winter barley
Yield	107	109	110	111	105
Production value	**113**	**116**	**111**	**124**	**113**
Total revenue	97	113	150	100	125
Cost of inputs					
of which:					
seed	*86*	*112*	*108*	*97*	*114*
fertiliser	*129*	*141*	*91*	*131*	*123*
pesticide	*110*	*156*	*125*	*137*	*108*
machinery	102	86	89	100	87
of which:					
tractors	*96*	*75*	*85*	*97*	*78*
Production cost	**109**	**123**	**103**	**119**	**109**
Gross margin	112	101	112	121	105
Crop income	**123**	**83**	**128**	**140**	**130**
Unit cost of main product	93	100	90	99	94
Return on costs	110	64	123	102	124

Source: own calculations

Table 3: Group results for precision agriculture (PA) and conventional (Conv.) farms.

	Winter wheat		Maize		Sunflower	
	PA (N=36)	Conv. (N=33)	PA (N=24)	Conv. (N=24)	PA (N=23)	Conv. (N=23)
Average yield (t/ha)	5.52*	5.05	7.56*	6.74	2.9***	2.54
Production value (thousand HUF/ha)	252.2	236.6	335.3***	286.5	292.3**	246.4
Production cost (thousand HUF/ha)	183.2	179.4	206.1	127.2	169.0	123.6
Crop income (thousand HUF/ha)	69.0	57.2	127.2***	80.5	123.6***	77.4
Unit cost (thousand HUF/ha)	33.6*	36.7	28.3**	33.3	58.6***	70.8

Source: own calculations (*P <0.05, **P <0.01 and ***P <0.001)

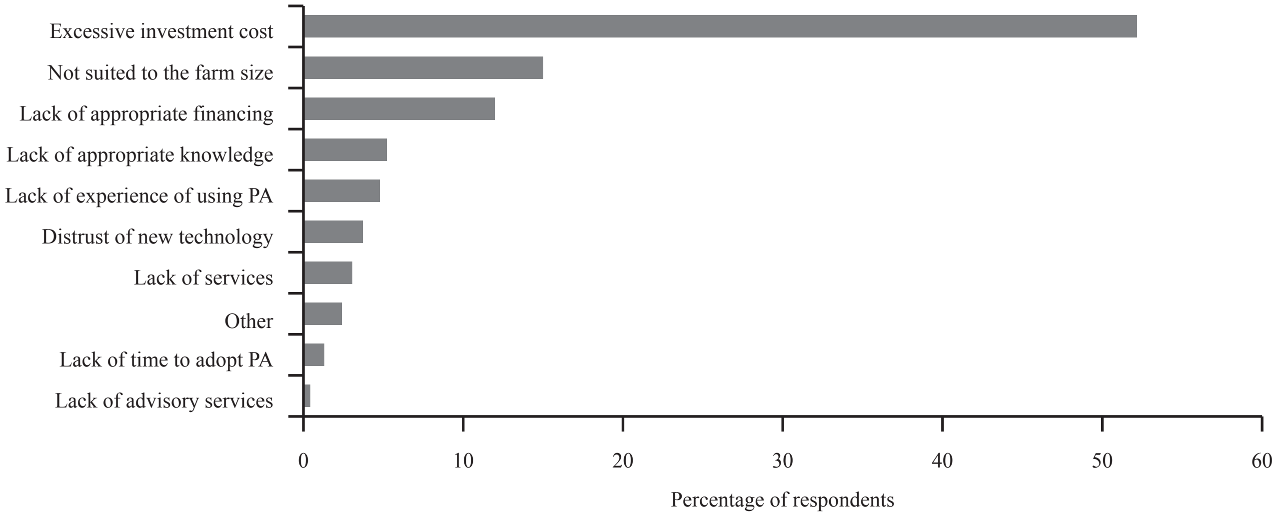

Figure 4: Barriers to the adoption of PA according to the farmers (N=460).

Source: survey data

incurred by conventional producers. Thus, our hypothesis H2 on decreasing input consumption could not be verified based on one-year data of the examined sample.

The total production cost exceeded the values of the control farms. In contrast, the gross margin rate surpassed the conventional farms for all included arable crops. The income results for crops, apart from maize, also showed positive differences. For winter wheat 23 per cent, for sunflower 28 per cent, and for barley 30 per cent surplus was achieved using PA technology, while the highest sectoral income excess was resulted for winter rape (40 per cent). However, PA sample farms achieved 17 per cent less income for maize.

During the research, we assumed that the introduction of precision farming would result in extra yield, cost savings and profitability advantage for arable crop producers (H3). This hypothesis cannot be assessed statistically based on a single year, therefore a smaller group having three years of data were selected both from the PA farms and the control group. We found that the use of precision technology had a clear benefit on the yield and unit costs for winter wheat, while the crop income did not increase significantly (Table 3). However, for sunflower and maize, the effects of PA were significant for all the economic indicators examined, except production cost. The latter is understandable, since production cost was considered in the selection of the control farms, in order to achieve the same production intensities.

As a final step, the effect of the transition to precision technology was assessed for the 17 farms having three years of before and after data. Owing to the small sample size, statistical analysis was not carried out in this case. However, we found that the new technology generally did not reduce the production costs, but resulted in yield increases. The yield increase was 17 per cent for winter wheat, 8 per cent for maize and 9 per cent for sunflower. Of the 35 crops grown by the examined farms, the crop income increased for 23 crops, but above 250 hectares the increase in crop income proved to be obvious. Overall, therefore, PA provides higher yield and higher production value, but the reduced input use (H3) and increased efficiency could not be verified. The effect of the PA on the crop income depends on the crop and the farm size.

Factors influencing the adoption of PA

Economic considerations appeared to be an important aspect in the decision to adopt, as can be documented by ranking factors that were taken into consideration. Fifty-two per cent of the respondents indicated the excess investment cost as the main barrier to widespread adoption of PA. Fifteen per cent of the respondents indicated that the technology cannot work effectively for their farm size, and according to 12 per cent of the respondents, there are no adequate financial possibilities for the additional expenditures (Figure 4).

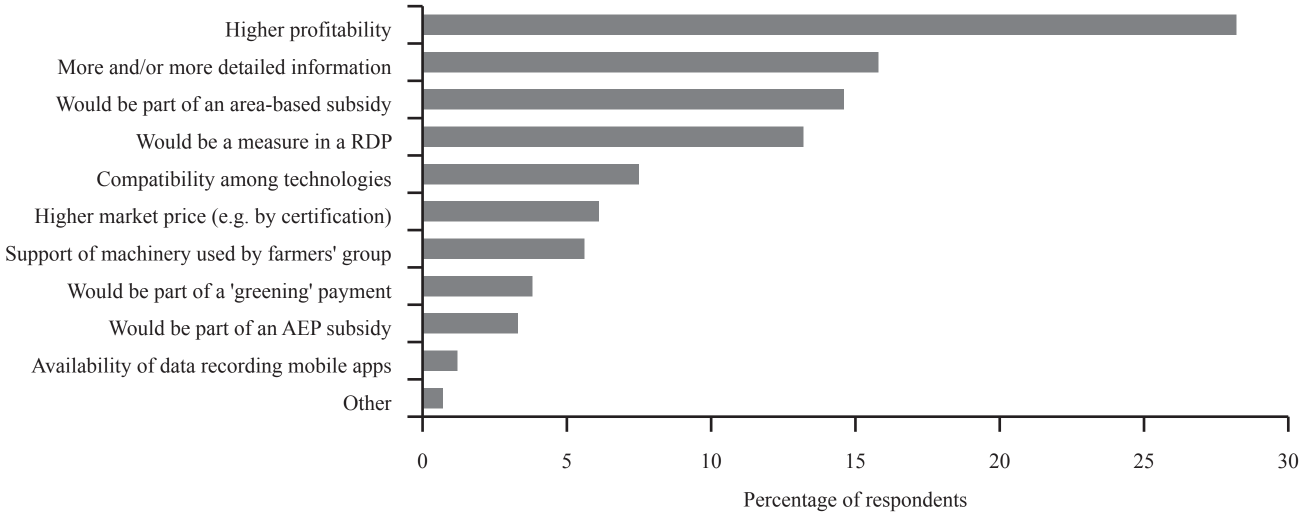

Figure 5: Drivers of PA adoption (N=425).

Source: survey data

Among those respondents which could not envisage the success of the introduction of precision technology for their farm size, 77.8 per cent cultivate fewer than 200 hectares of land. Just under 84 per cent of those emphasising the lack of financing opportunities are members of small family farms, private entrepreneurs or licensed traditional small-scale producers. Our hypothesis H1 was confirmed as in the producers' view the biggest barrier to the PA diffusion is the high access investment cost.

Among the respondents, 28.2 per cent indicated that higher profitability would be their main motivation for adopting PA. More detailed information was in second place on the list and, according to our survey, any benefit related to subsidy would also promote the use of PA (Figure 5).

Discussion

The aim of our survey was to examine the penetration and application levels of PA technologies in Hungary. The 425-460 evaluable responses (depending on the questions) can be considered satisfactory, compared to other survey samples, for example 227 respondents in Germany (Paustian and Theuvsen, 2016) or 228 returns of questionnaires in the Czech Republic (Kušová *et al*, 2017).

Almost all of our respondents had heard about precision agriculture, in contrast to the 50 per cent observed in an earlier survey (Tóth, 2015). However, only 6.9 per cent of them 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 (BIS Research, 2016; OECD, 2016).

Among our respondents, PA was most commonly used for winter wheat, followed by maize, sunflower, oilseed rape and winter barley. However, compared to the total harvested areas published by the Hungarian Central Statistical Office, the proportion of PA fields is more than double for oilseed rape than for the other crops.

According to CEMA (2014), 70-80 per cent of new farm equipment sold has some form of PA component inside. The survey shows that only 29.6 per cent of the tractors are equipped with auto-steering and 45.6 per cent are suitable to use on-board computer. It means that PA farmers do not have modern machines. Complete machinery change is not a realistic option but existing machinery can be updated with precision equipment.

Field boundary mapping is the most frequently used PA practice, followed by site-specific soil sampling and nutrient management. These findings are in line with international experiences. Somewhat surprisingly, only one-third of the respondents reported that they use yield mapping. This might indicate that yield level optimisation is not the main goal in general. In accordance with the findings of Schimmelpfennig (2016), adoption rates among our respondents vary significantly across PA technologies as well as across crops.

Our farmers' perceptions and the analysis of their accounting figures do not always match. Only 60 per cent of the farmers perceived an increase in yields. Based on the 'before and after' analysis, farmers could realise an average 16.5 per cent yield increase for 80 per cent of the crops. According to the FADN figures, the technology change resulted in a 7-17 per cent yield increase for winter wheat, 2-9 per cent for maize, and 6-10 per cent for sunflower. This is consistent with the international literature (Basso *et al.*, 2016; Balafoutis *et al.*, 2017).

Most scholars have approached the expected economic effect of PA from decreasing input costs (Tozer, 2009). In our survey, 51.1 per cent of the farmers reported a decrease in variable costs. In contrast to this and our expectations, we could not prove the H2 hypothesis statistically. The increase of input use can be explained by the low initial level of fertiliser use, quite common among arable farms in Hungary. However, the amount of fertiliser itself is not the issue that really matters. The real question is how the efficiency of use changes. Therefore, the yield level and associated nutrients need to be studied. The exact input application results in a more efficient nutrient utilisation and less negative environmental impact. And even if input use and production costs increase under PA, yields can grow enough to increase profit (Schimmelpfennig, 2016).

Owing to the many complex factors, profitability cannot be demonstrated in all cases (Zarco-Tejada *et al.,* 2014). Based on our calculations, 23-133 per cent additional income can be achieved for winter wheat and 28-52 per cent for sunflower, while income growth for maize is uncertain. A significant increase in profitability could be confirmed only in those farms that apply PA for at least three years. Accordingly, 62.2 per cent of the respondents reported some increase in profitability, while 17.8 per cent realised a fall in crop income. The fact that many farmers have not realised/perceived any direct increase in their profitability is a real barrier to the wider adoption of PA. That higher profitability would be the main driver for PA was reported by 28.2 per cent of the respondents. The sigmoid (S-shaped) curve can be representative of many different skills and certainly could describe PA technology. Castle *et al.* (2017) demonstrated that the impact of adoption is initially small but during this period knowledge and skills are gained and important data are collected. Then, once sufficient data and skills are present, the gains from adoption of PA technology could grow quickly to a point where the benefits are largely realised and further gains are limited. The parameters reported suggest that from 5 to 19 years after adoption of PA there is a significant improvement in the net farm income. Most the farmers surveyed are still in the learning phase of PA, having only a few years of experience. Therefore, this is a very important message, which has to be well communicated to the farmers, and advisors have a great role in doing so.

Most of the farmers that believe that PA does not fit to their farm size have fewer than 200 hectares of land, and 83.6 per cent of the respondents that emphasised the lack of financing opportunities are traditional small-scale producers. PA technologies can be applied successfully also in medium-sized or in small farms, partly based on own equipment and partly through common machinery usage (i.e. machinery rings), as well as of course by services.

More than half of the respondents indicated the high investment cost as the main barrier to adoption. A lack of appropriate financing was listed in third place among the barriers; at the same time the need for subsidies appears in third place among the drivers. Our view is that precision crop production can be one of the means of enhancing the green component, as an environmentally-friendly farming practice, drafted within the direct subsidy system of the EU's Common Agricultural Policy proposed for the 2020-2027 planning period. Within the range of Pillar II measures available within Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013, several of them are available to EU Member States to support PA development through their rural development programmes (RDPs, Zarco-Tejada *et al.*, 2014). Since PA benefits are rather specific to local conditions, it is for Member States to define the measures they want to be co-financed in their RDPs. With the aim to help decision makers in this respect, Kemény *et al.* (2017) demonstrated macroeconomic estimations.

Hungary was one of the first countries to establish a national Digital Agriculture Strategy, and as part of this it will be the task of AKI to monitor the development of ICT use among the country's farmers. The wealth of data that will become available from this work will allow the further adoption of precision agriculture in Hungary to be analysed in detail.

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