

Farmer's perception of the opportunities offered by drone technology in arable crop production

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ABSTRACT

The incredible scale of development in the world requires constant innovation of technologies used in agriculture. Precision agriculture is also one of the most defining trends in drone technology, representing a revolutionary innovation in arable crop production. Its continuous monitoring provides many opportunities to assess the specific culture, estimate yields, determine water shortages and nutrient deficiencies, and apply for other decision support. Frequent flights provide farmers with up-to-date information so they can respond to changes in status quickly and cost-effectively. The use of drones is also responsible for improving the competitiveness of agriculture. Drones and solutions based on them are spreading rapidly around the world. After reviewing the relevant international literature, publications and materials published by stakeholders involved in drone technology, we conducted a questionnaire survey among farmers in northern Hungary. Commitment and willingness to precision developments were discovered as how open they are to modern agriculture achievements, to what extent they are willing to sacrifice technology, especially spray drones, to what extent they keep in mind aspects related to the environmental load and with what willingness to invest. Overall, the perception of precision elements is positive, farmers 71% consider the use of drones in plant protection, for example, a accurate and helpful and useful idea, which reduces treading damage, chemical use and soil use.

1. Introduction

Due to global growth, agriculture and industry will face many challenges in the coming decades. This is due to the explosive population growth, climate change and growing demand for energy and resources. The incredible scale of development in the world requires constant innovation of technologies used in agriculture. Precision agriculture particularly drone technology is a revolutionary innovation for the arable crop production sectors. Drone technology also offers many applications in agriculture, for example, it can be used for area measurement, map-making and nutrient supply to assess the degree of drought or weeding, but also the state of the waters or the operation of irrigation systems can be checked using this technology. The continuous monitoring of the fields provides many opportunities to assess the specific culture, estimate the yield, determine the lack of water and nutrients, and apply for other

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decision support before the advent of drones, these tests could only be carried out very expensive and challenging, for example by plane, helicopter or crane (Kovács, 2021; Felföldi et. al., 2017).

Digitized elements will be important indicators of intelligent agriculture. According to research, more efficient and environmentally friendly farming is achieved using of precision technological elements (Takácsné, 2020). The development of infocommunication technology has also caused an upsurge in agriculture. In Hungary, Precision Technology appeared primarily in crop production at the beginning of the 2000s, but today precision technology is also present in livestock and horticultural farms. The spread of technology is influenced by many factors agro-ecological abilities, economic-social factors, information available and human factors (Kovács, 2018). Precision cultivation is still not significant in Hungary's arable area. Current trends show large scale growth, due to the appearance and development of drone technology. One of the most defining trends of today, drone technology, represents a revolutionary innovation for the arable crop production sectors. Drone technology offers many applications, mainly to carry out various studies and surveys that help farmers, but it is also suitable for direct interventions. They provide farmers with up-to-date information on flights, enabling them to react quickly and cost-effectively to changes in their condition.

2. Literature review

2.1. The appearance of drones

The drone can fly remotely or be programmed. They can to fly completely autonomously from takeoff to landing. The name also comes from the English term UAV, because these devices are called Unmanned Aerial Vehicle in English, which means "aircraft without a crew". An unmanned device that can perform remotely or programmed information, logistics or operational tasks (Csóré – Major, 2021; Puri et al., 2017; Merwe et al., 2020; López ez al., 2021). the definition of the drone is regulated by the European Union regulation 2019/945, as there were significant differences between the early-looking drones. Previously, all devices that were radio-controlled and airworthy were named drones. Based on the above regulation, only devices with GPS transceiver units can be called drones. The 19. appeared in the middle of the XIX century. Crewless aircraft have been used primarily for military purposes. Still drones are used in many areas of civil life beyond military application: research, nature conservation, disaster management, entertainment, film industry. The first open-source flight controller was published in 2003, contributing to its widespread use, but the acquisition and high price of sensors limited the range of users. With the appearance of smartphones, it was easier and cheaper to obtain and apply sensors. (Ahirwar et al. 2019; Patay – Montvajszki, 2016; Elliott, 2017; Teschner et. al. 2019; Hajdú, 2019; Popp et. al. 2018; Zhang et al., 2019). Subsequently, the first specific drone company, one of the most well-known DJI (Da-Jiang Innovations), was released in 2006. This was followed in 2010 by the parrot brand, whose drone was already controlled via Wi-Fi, thanks to smartphones. In 2013, amazon's new development, the amazon prime air Service, was released, when drones were tested during parcel deliveries, and in 2016 the first Test delivery was made (PC World, 2016). Development of the DJI Phantom 4 drone in 2016, which was capable of machine learning and vision, not just following the GPS sign. Today, the palette has widened with technology. Different aspects can group drones. Different types of drones can also be distinguished based on their essential characteristics, as they are made for different purposes. Such aspects may be, drive, number of propellers, wing type, type of control and size (Elliott, 2017; Hajdú, 2019).

2.2. Use of drones in agriculture

The use of drones plays a significant role in agriculture. One of the perspective areas of the use of drones is agriculture. Precision crop production requires frequent, quick and accurate information about crop production. Drones can likely that drones be an essential tool of the operational GIS system even soon (Teschner et. al. 2019). Drone technology will play a vital role in the coming decades, according to various scenarios, it will take over the role of ground machines in a few years. Anyone who is engaged in agriculture anywhere in the world today will have to integrate drone technology into their economy sooner or later. The question here is to what extent you can incorporate the technology, it is worth

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looking for - to train further train the worker from the farm who is best suited for the task, who is able to handle technology, to manage integrated tools. From the easiest way to handle drones to the most sophisticated precision tools you can find in agriculture, whether monitoring area -test drones, or spraying drones. A series of related services and training services await farmers. Appia Drons is the first company in Europe to produce its drones. These drones are capable of centimeter accuracy in the area survey. Agricultural lands for air mapping, air spraying and fertilization, multispectral vegetation analysis and air diagnosis of soils with a multispectral camera (Bálint, 2019; Appia Dron Tech, 2022; Teschner et. al., 2019; Milics et. al., 2015; Sulyok et. al., 2022; Bai et al., 2022). The advantages of using drones in agriculture:

- centimeter, sometimes with millimeters accuracy, can be measured with a crop area, detection, status survey or any intervention
- problems can be recognized at an early stage, e.g. Nutrient water shortage, weeds, plant health, stress, other,
- the entire area of the board can be kept under control
- with regular flights, up-to-date information about the area can be obtained, which makes it possible to intervene flexibly thanks to fast and accurate detection, which also increases efficiency and reduces costs
- Quality and quantitative parameters can be measured, pl.: vegetációs tömeg, növénymagasság (Bálint, 2019; Patay – Montvajszi, 2016).

3. Methodology

We have started research by studying the materials released by domestic and international literature, publications and developers in drone technology. Following the secondary research, the questionnaire was completed by farmers with a seat in Northern Hungary.

The first part of the questionnaire typically contained open-ended questions, the purpose of which was to reveal general information about the farmer's education, farming experience, the main activity of the farm, the size of the crop area and the size of the arable area. In the second part of the survey were statements about drone technology. In this section, we assessed the commitment and willingness to precision developments, focusing on the spraying drones used in crop protection, how well they are aware of the potential of technology and their willingness to implement the technology element immediately. Farmers assessed claims about the use of drones on a Likert scale of 1 to 5. In all cases the lowest value is 1 – a disagree, while the highest value IS 5 – a definitely yes agree with a report, so that respondents could express their opinion on drone technology opportunities. In the third part of the questionnaire, we assessed the need for drone spraying, and the last block of questions related to how much, by what percentage, you would be willing to pay more if you were to order drone spraying.

We received 82 fillings during the survey. IBM SPSS Statistics 24.0 Statistics Program performed data processing and statistical analysis. The first step was to clean data in the database, after which we continued to work with 74 (n=74) evaluable questionnaires. The following questions were formulated during the survey:

- How open are you to the achievements of modern agriculture?
- To what extent are they willing to sacrifice precision technologies, especially spray drones?
- How vritical are environmental load criteria?
- Would they be willing to make investments? With what willingness?

To evaluate the questionnaire, we have done one of the simplest bivariate methods, the cross-table analysis. One of the significant advantages of cross-table analysis is that it is used for frequency analysis of two non-metric variables and can be used on all kinds of scales, mostly applied on nominal and ordinal scales. Among the statistics related to cross-tab analysis, we examined Pearson's (Chi-square)

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significance, Cramer's, Goodman and Kruskal's tau and the uncertainty coefficient. Establishing the fact of significance, we also looked at the strength of the relationship. By using nominal scales, we tested for phi, contingency and Cramer's coefficients as symmetrical indicators. Related to this, chi-squared, Goodman and Kruskal's tau and uncertainty asymmetric indicators were used.

4. Results

Respondents have been farming for an average of 23 years, suggesting that experienced and highly experienced farmers completed the questionnaire. In addition, the average crop area is 81 ha, of which the farmers have an average of 60 hectares of arable land.

The first question is aimed at mapping the opportunities provided by the technology, whether farmers are aware of the benefits of using precision drones and if it is added to using it, even immediately the options offered by drone technology. We assumed that anyone familiar with the benefits of precision devices, in this case the benefits of drone use, would be willing to invest more in innovation. Based on the cross-table analysis, 38 farmers would not use drone technology, and 35 do not know what benefits. Of those aware of the opportunities would 65% adapt drones to cultivation technology. The Pearson chi-squared test is 13,886 at the bilateral significance level less than 5%. Accordingly, we assume that there is a significant correlation between knowledge of technology and willingness to use it. The significance of the Continuity Correction and the Likelihood Ratio is below 5% in addition, the significance of the Fisher test applied to small samples is also adequate, so the board is reliable, and none of the conditions has been violated (Table 1.).

Table 1. Chi-Square test 1.

Chi-square test					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	13,886a	1	0,000		
Continuity Correction ^b	12,129	1	0,000		
Likelihood Ratio	14,676	1	0,000		
Fisher's Exact Test				0,000	0,000
Linear-by-Linear Association	13,698	1	0,000		
N of Valid Cases	74				

I examined the relationship between two or two frequency variables. The item number of the sample in all three cases is unchanged at $n=74$. 71% of farmers believe using drones in plant protection is a real opportunity right idea and 58% of the farmers would use the services provided by the drones this year.

In all three cases, the uncertainty coefficients also support the dependence relationship, based on the approximate significance. Symmetrical indicators are all significant, based on values of a moderately strong relationship between variables.

Table 2. Chi-Square test 2.

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Chi-square test									
	1			2			3		
	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	0,007			0,024			0,024		
Continuity Correction	0,015			0,046			0,046		
Likelihood Ratio	0,006			0,022			0,022		
Fisher's Exact Test		0,01	0,007		0,033	0,022		0,033	0,022
Linear-by-Linear Association	0,008			0,025			0,025		

71% of farmers consider using drones in crop protection the correct and helpful idea. This ratio suggests that the farmer considers it essential that the use of drones helps to reduce

- called tread damage
- the use of chemicals
- the burden on soil use

what is good for humans, plants and animals. In one case, there was a significant relationship between the variables. 74% of the farmers consider the introduction of technology to be correct, and 98% of them attach essential to farmers to introduce technology into plant protection, because it reduces chemical use. There is a significant correlation between the use of chemicals and the assessment of usefulness, so those who consider the use of drones to be useful believe that it is worth it and can also reduce the use of chemicals. The results of the KHI square test show a clear relationship. PHI, Cramer's V and Contingence Cooperation also justifies significance and moderately strong relationship between variables.

Table 3. Chi-square test 3.

Chi-square test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10,915a	4	0,028
Likelihood Ratio	10,360	4	0,035
Linear-by-Linear Association	6,899	1	0,009
N	74		

Using logistic regression, we examined the influencing factors based on which we can classify the respondents into one of the two categories of whether or not they would use the technology. We examined the extent to which the questions marked as independent variables in the model play a role in whether farmers know the possibilities provided by precision technologies so that the influence of other variables is controlled. The model also informs on which category of variables, with what chance the change will occur, and to what extent the result increases the chance that the farmers are aware of the advantages of the technology and would apply it.

The model's fit is also indicated by the number showing the explanatory force nagelkerke r, showing how many percent of the explanatory variable k explain the evolution of the result variables. The other important indicator is contained in the classification table - result matrix, this is a so-called "accuracy" table, which shows in what percentage it can be said that the farmer is aware of the possibilities provided

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by the technology. In the first model, we examined the combined effect of three factors. And independent variables were the following (Table 4.):

1. Using drones in plant protection is considered a real opportunity, a correct idea.
2. If you could, you would immediately use the opportunities offered by drone technology.
3. Using drones in plant protection is an opportunity for the farmer to benefit.

Based on the Nagelkerke RA in the matrix, the model's explanatory power was 25%, and according to the matrix, in 70.3% the farmer is aware of the possibilities of technology. Table 4, examining the three independent variables together, shows a significant result in examining the willingness to use, which shows us that if you change the use of technology, that is, if possible, you would immediately use the options offered by drone technology then there is 8,242 times more chance of being aware of the benefits technology has to offer to the farmer.

Table 4. Independent variables

Variables						
	B	S.E.	Wald	df	Sig.	Exp(B)
Approving the idea	-0,160	0,630	0,065	1	0,799	0,852
Willingness to use	2,109	0,618	11,645	1	0,001	8,242
Useful to farmer	-0,113	0,640	0,031	1	0,860	0,893
Constant	-1,884	1,293	2,125	1	0,145	0,152

In the following case, the environmentally friendly role was examined as the independent variable. Based on the Nagelkerke R fit index, the model's explanatory power was 21.7%, and based on the hit matrix, there is a 73% chance that the farmer is aware of the possibilities offered by drone technology. And table 5. shows that if the farmer considers a form of farming to be more environmentally friendly by one unit, the chance that he is aware of the advantages of the technology increases 2.743 times.

Table 5. Variable 1. – More environmentally friendly farming

Variable						
	B	S.E.	Wald	df	Sig.	Exp(B)
The use of drones in plant protection is an option that can be used much more environmentally friendly	1,009	0,315	10,258	1	0,001	2,743
Constant	-3,440	1,281	7,212	1	0,007	0,032

5. Conclusion

The first question was to explore the possibilities offered by the technology; the correlation analysis resulted in that farmer who is aware of drone technology's potential to sacrifice more for development. After that, we examined the relationship between three factors, the willingness to use, the approval of the use in plant protection and the assessment of usefulness, whether they are statistically dependent relationships. The three factors examined depend on each other; the variables have a weak and moderately strong relationship. Farmers who approve of the use of technology have seen it as beneficial for their farms, benefiting from it and seeing it as a real opportunity. 71% farmers consider using drones in crop protection an accurate and helpful idea. This means that the farmer considers it essential that the use of drones helps reduce the so-called trampling damage, the use of chemicals, and the load due to soil use, which is good for people, plants and animals. In one case, there was a significant relationship between the variables. There is a significant correlation between the use of chemicals and the perception of usefulness, so whoever considers the use of drones useful, believes that it is worth it and believes that they can also reduce the use of chemicals. And finally, we examined whether they are willing to do:

pay more for the technology than it currently costs to reduce the use of chemicals, keeping in mind the willingness, usefulness, and environmental impact. In this case there was no significant relationship between the factors and the willingness to pay, i.e. there is no correlation between the perception of the technology and the willingness to pay.

The use of drones is also responsible for improving the competitiveness of agriculture, drones and solutions based on them are spreading rapidly around the world, more and more drone development and distributing companies are entering the market, and they are maintaining their products and even training drone pilots. Drones have been significantly reformed in the agricultural sector and will become major actors in agriculture in the coming years. Existing regulations on drone use need to be drafted or revised in each country. Drones can be helpful for farmers in many ways, but before investing in expensive equipment, it is crucial to understand their limits and functions.

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