The present and future of the precision agriculture

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***Abstract*— The article would like to introduce the main steps of agricultural changes, followed by the appearance and main analysis of precision production. One of the possible answers to the emerging problems of pollution and efficiency is the use of precision agriculture. The one of the greatest challenges of the agricultural sector is to feed significantly more people on more or less the same size of agricultural land. The size of the utilized agricultural cannot be expanded significantly. The other pillar of the production growth is the higher yields. It can be reached in various ways starting from optimal fertilizer use, more fertile seeds to irrigation. Precision agriculture use most of these opportunities. PA can contribute to food security and safety, it supports sustainable farming (EP, 2016). The high initial costs, PA technologies are closely related to the farm size, which is an important factor of the adoption.**

Keywords—precision agriculture, modern technologies, benefits of precision farming

I. INTRODUCTION

Since the agricultural revolution, production has been able to meet the needs of a significantly larger population. On the one hand, the changes that have taken place are the proliferation of crops that have higher yields than conventional cereals (wheat, rye). On the other hand, widespread use of crop rotation took place. Thirdly, the animal husbandry sector has been transformed. Fourthly, technological tools improved a lot. These changes date back to the 18th century. Since the Industrial Revolution (since 1760, several stages have taken place), it has become easier to achieve higher production yields, which have led to both structural changes in production and social changes. However, there are many concerns about the industrial agricultural production. It caused an enormous burden on the environment, used chemicals harmlessly, which was not controlled. There have been several solutions to the damage that has arisen. One is biodynamic agriculture, renewed by Rudolf Steiner, and integrated production. (Kaposi, 1996; Buday-Sántha, 2002; Gyarmati, 2019)

After the proliferation of IT tools, satellites, it was obvious that these technological innovations were also applied in agriculture. Precision agriculture is, in fact, the birth of this.

According to the definiton of the European Parliament „Precision Agriculture (PA) is a farming management concept based upon observing, measuring and responding to inter and intra-field variability in crops, or to aspects of animal rearing." (Zarco-Tejada – Hubbard – Loudjani, 2014, pp.9.)

The major benefit of this activity is the increasing yields, therefore increasing production and profitability. We can find other opportunities, such as better working conditions, increased animal welfare and better results in the environment protection as there is less contamination. When using PA, sensors combine processes and farming practices such as soil cultivation, sowing, fertilizing, harvesting or even animal husbandry. The advantage of PA is its positioning. These benefits are most pronounced in large cultivated areas, especially in grain harvesting. PA results in higher yields. Guided Traffic Management (CTF) and self-driving systems are the two main pillars of the technology. Variable Dose Application (VRA) methods provide the most optimal results.

In the case of fruits and vegetables and vineyards, high yields of high value products are already contributing to better quality and higher profits. It also helps in optimal irrigation, water saving, and the well-being of the animals. It is used to monitor the behavior, welfare and productivity of animals, as well as their physical environment. (Zarco-Tejada – Hubbard – Loudjani, 2014)

Precision agriculture would be a way to measure the environmental footprint of farming, which can help farmers to comply with good farming standards, improve farmers' role as providers of public goods, and support specific efforts. (Kritikos, 2017)
In agriculture, we are witnessing changes for which precision production can be one of the answers. Firstly, generation transition: today's European agricultural society is characterized by old farming society. As the generations change, that is, young people take over the relay bot, new solutions will come to the fore. Secondly, rapid growth in the technology sector: where a relatively high level of technical application is present, the achievements of technology also appear. And it created a technical gap between old technologies and new ones. Thirdly, ethical farming practices: ethical and moral issues are increasingly in the forefront of consumer demand, and they are increasingly looking for products that are reliable, fair in production, and commercial. Fourthly, farms are finding their niche: more and more farmers are choosing to

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specialize for higher sales and profitability. Many of them have decided to review the entire farming process and provide organic produce, and there are farmers who find much more specific areas for their operations. If they do not find such a general specialty, they will reduce competition and thus increase the price of their produce. they produce. GMO-free, specialty crops and special breeds of animal husbandry are used to increase profit margins in the less competitive sphere. Fifthly, growing demand for food: growing population demands more, therefore higher output is needed. PA can help to increase yields and output. Sixthly, rapidly changing economies and trade areas: we are witnessing many changes that have upset the traditions. Brexit, protective tariffs, epidemics. Seventhly, odd changes in meat consumption: more and more people are turning to vegetarian and vegan lifestyle. Only 6% of the US population claims to be non-meat consumers, with a surprisingly high growth of over 600% in the last few years. In the Far East, by contrast, meat consumption is growing significantly, as China and India rely heavily on meat to feed their vast populations. This has changed the dynamics of meat production and farmers are finding that meat is being exported to places other than historically. With such a sudden increase in people consuming plants, crop growers have to keep up with the growing demand in the United Kingdom, the EU and the United States. Eighthly, animal welfare and livestock conditions: in some countries there are notorious farmers, but it is important for consumers to respect animal welfare conditions. This requires an increasingly sophisticated control system. Ninthly, looking after the environment: the environmental issues caused by farming today are mostly solved with precision farming techniques. By focusing on reducing environmental damage and improving farm performance, technology can help deliver a cleaner farm landscape. Farming can reduce its carbon footprint and regulations are tightened to make farmers accountable for any negative impact they have on the environment. And finally, increased profitability for precision farmers. Most farmers that use precision farming practices see an increase in their overall profit margins. As the precision farming community grows and technology becomes more accessible and easier to use, this profitability is likely to grow. (Farm management, 2020) This is summarized on Figure I. below.

Figure I. TOP 10 THINGS WE ARE NOTICING ABOUT PRECISION AGRICULTURE

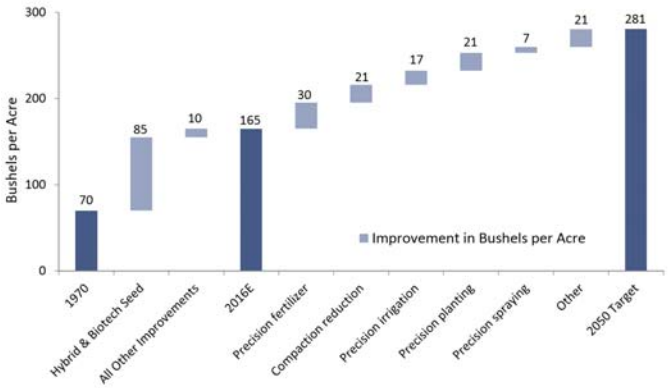
Source: Farm management, 2020

The major aim of this study is to give an overview of the present and possible future directions of the precision farming in a global content. As the humanity needs solutions to deal with hunger and malnutrition. Does PA able to solve these problems or do we need to seek for other solutions?

II. DISCUSSION

According to the Food and Agriculture Organization of the United Nations (FAO), the global population is expected to grow to 10 billion by 2050 (FAO, 2017). One of the greatest challenges of the agricultural sector is to feed more people on more or less the same size of agricultural land. The size of the utilized agricultural cannot be expanded significantly. The other pillar of the production growth is the higher yields. It can be reached in various ways starting from optimal fertilizer use, more fertile seeds to irrigation. Precision agriculture use most of these opportunities. Figure II. gives a detailed overview of the evolution of the US corn yields from 1970 to the 2050 target.

FIGURE II. EVOLUTION OF US CORN YIELDS



SOURCE: GOLDMAN SACHS, 2016

As seen on the figure above, corn yields are more than doubled from 1970 to 2016, mostly because of the use of hybrid and genetically modified seeds. All other improvements are slightly contributed to this achievement.

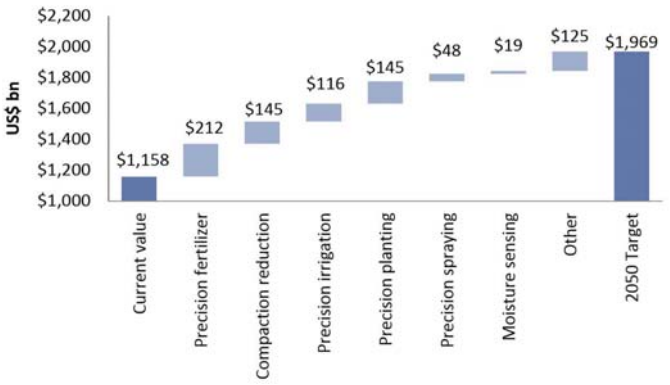
Since 2016, precision farming tools have been taken place. This contains different elements, such as precision fertilizer, irrigation, planting and spraying. These elements cannot be implemented without the use of precision technologies, such as the global positioning system (GPS), equipment guidance and automatic steering, computer-controlled planter or fertilizer spreader. The use of these equipment and tools have twofold advantages. For example, fertilizing according the soil need can not only increase the yields, but also results in lower fertilizer costs. The major advantage of the PA that these elements can be introduced separately, however, a complex system provides more and higher benefits.

What can we expect from this technology? According to Goldman Sachs study, it may result in an additional 70% increase in US corn yields. However, it should be noted that the growth in the first part of the analyzed period (1970-2016) was much higher (136%) than in the second one. This has another, very important implication. US corn yields are the highest globally, therefore the spread of precision technologies is expected to contribute to the global production much more than this 70%, particularly in the developing countries. This is a more likely option, because most of the developing countries, as well as some developed countries, refuse the adoption of any biotech industrial developments, most notably GMO technologies.

On the order of the contribution to the yield growth, precision fertilizer, compaction reduction and precision planting have the most significant effect, 30, 21 and 21 more bushel per acre, respectively.

According to the higher yields, the global production is also expected to grow. Figure III. shows a 70% growth by 2050. Precision fertilizer itself may increase the global production by 212 billion USD.

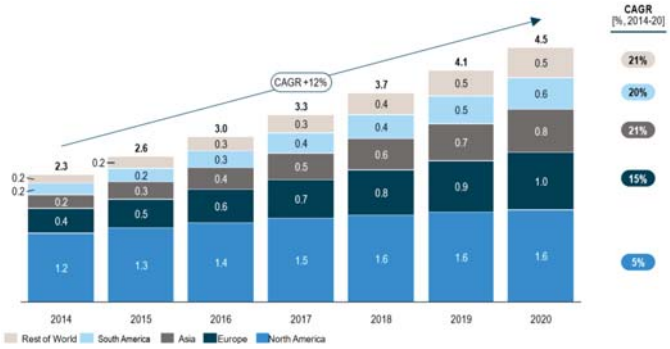
FIGURE III. ELEMENTS OF THE GLOBAL PRODUCTION GROWTH



SOURCE: GOLDMAN SACHS, 2016

Precision farming is a fast-growing industry. According to a study of the Roland Berger Strategy Consultants GmbH, its compound annual growth rate (CAGR) is about 12%. (Figure IV.) This differs widely among the continents. As the PA technology is widespread on the North American continent, this growth rate is the lowest (5%). This is followed by Europe, where this value is 15%. The rest of continents cab be characterized by at least 20% CARG. However, even the 5% value can be considered high, as the CARD of the global agricultural equipment market is expected to be around 4% in 2020 (Dressler et al., 2015).

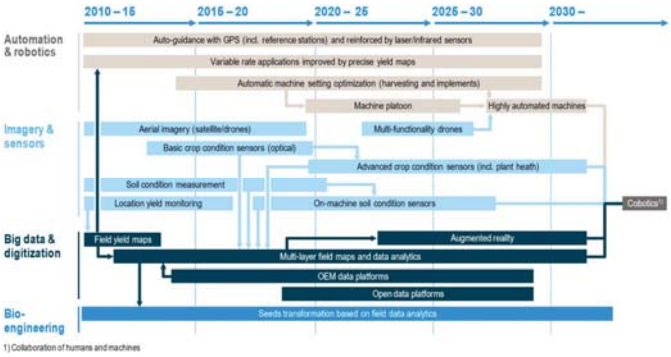
FIGURE IV. ESTIMATED MARKET OF PRECISION FARMING, 2014-2020, BILLION EUR



SOURCE: DRESSLER ET AL., 2015

The PA technology is based on data. The amount of these data is expected to enormous within a couple of years. The technology should reflect to this big data system. The key in this development process is connectivity. The greater challenge of the PA is how to handle, store and process the data, as well as how to connect the different devices to each other. Figure V. gives an overview of this technology roadmap.

FIGURE V. EXPECTED TECHNOLOGY DEVELOPMENTS



SOURCE: DRESSLER ET AL., 2015

As seen on the figure above, the technology will move towards even more automated data collection and processing, leaving mostly the strategic decisions at the hand of the farmers. The spread of the technology, naturally, will differ from country to country.

What are the major benefits and limitations of the PA? According to a recent systematic study, the major benefits are the improved farming efficiency and mitigating environmental impact (Koutsos – Menexes, 2019). As it was analyzed above, it can contribute to higher yields, therefore higher global production. According to an EP study, PA can contribute to food security and safety, it supports sustainable farming (EP, 2016). In the adoption process, financial and non-financial incentives, as well as technical support or training to the farmers play an important role (Barnes et al., 2018). The latter has outmost importance, as the introduction of PA requires new skills (EP, 2016).

The major limitation of the technology is the relatively huge initial investment. Various types of precision farming

machinery are more expensive than non-precision ones. Detailed cost-benefit analysis should be carried out on case by case basis, as farming opportunities differ from farm by farm. Because of the high initial costs, PA technologies are closely related to the farm size, which is an important factor of the adoption. Therefore, countries with larger farms, such as the US, Australia, Canada, Brasil, and Argentina are more likely to adopt these technologies (Say – Keskin – Sehri – Sekerli, 2018). The same results were found for German crop farmers, PA adoption rate was proportional to the size of arable land (Paustian – Theuvsen, 2017). However, adoption has also been increased if the farmer had more than 16 years or less than 5 years' experience in crop farming. Therefore, that study identified two different sub-groups: well-educated, experienced farmers and young experts in information and communications technologies. Besides the farm size and the related experience, non-adopters generally believe more in their knowledge and they are older than adopters (Barnes et al., 2019).

III. Conclusions

Precise production requires a great deal of experience and proficiency to perform successfully. Because of the high investment needed to get started and the risk of a successful start-up, mature, broad-based agricultural skills are essential. However, if applied professionally and with due care, it is definitely characterized by higher yield, profitability, accelerated return time and more sustainable production. On the basis of international data, we see that larger, more capital-intensive companies are able and willing to employ them. At the moment its growth is gaining momentum, but its proportions are approx. Represents 4% of total production. The big question is how much it will be able to achieve higher rates and how it can become part of everyday production.

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