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PRECISION TECHNOLOGIES IN SOFT FRUIT PRODUCTION

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Abstract

The industrialization and mechanization of the agriculture in the 20th century led to an increase in productivity and efficiency and development of large-scale farms. The environmental concerns and resource scarcity transform the models of agricultural production. The implementation of new technologies and digitalization led to evolution of precision farming. The aim of the study is to analyse the economic efficiency of precision technologies in soft fruit production and discuss the possibility of their implementation. The survey focuses on case studies analysis and presents the economic benefits of precision technologies. Opportunities for adoption of innovation in Bulgaria are also outlined. The methodological framework is based on the "Case study" approach. The survey shows positive economic effect of precision technologies on agriculture. On the other hand, the analysis indicated that there are significant differences in total costs and especially in the investment costs. This in many cases this is the main reason related to the limited implementation of innovations by farmers. The application of precision technologies is concentrated mainly in extensive production with larger holdings. It is necessary to encourage their application in high value-added sectors and benefit from the EU funds in the field of innovation.

Key words**:** *precision farming, innovations, sustainable development*

INTRODUCTION

The industrialization and mechanization of the agriculture in the 20th century led to an increase in productivity and efficiency and development of large-scale farms. On the other hand, farmers sacrificed the ability to manage efficiently the spatial and temporal heterogeneity of farm fields [8]. The environmental concerns and resource scarcity transform the models of agricultural production. There is a need for a resource efficient global food system that takes into consideration the aspect of sustainability [1]. The implementation of new technologies and digitalization led to evolution of precision farming. Precision agriculture addresses the challenge of adapting management to site, crop, and environmental traits [13, 17].

From economic point of view precision agriculture is associated with different benefits. According to the European Commission the benefits from precision farming are related to: crop yield improvements; optimization of inputs; and improvement of the management and quality of the work [6].

Although the scientific interest and the conducted studies in the past twenty years, precision technologies are not widely applied [3, 18, 19].

The precision technology implementation and adoption vary significantly both by type of technologies and by sectors.

The global change in dietary patterns and consumer's perceptions led to increase in soft fruit production. Different studies point out the benefits from consumption of soft fruits - a greater life span [2] and weight management [14], among others. [9] The importance of these fruits is increasing based on benefits for human health and their role as antioxidants.

Precision technologies in soft fruit sector transformed their production patterns and led to wide range of advantages. The aim of the study is to observe the economic efficiency of precision technologies in soft fruit production and to discuss the possibility of their implementation.

The survey focuses on case studies analysis and presents the economic benefits of precision technologies. Opportunities for adoption of innovation in Bulgaria are also highlighted.

MATERIALS AND METHODS

The paper is based on the results from own survey for the period 2016-2019. The study is part of PhD thesis and project related to the impact of precision technologies on soft fruit production. The analysis is based on survey of four farms in the UK and one farm in Bulgaria. These holdings grow the same variety of blackberries, which allows comparison of the results.

The methodological framework is based on the "Case study" approach. For many reasons, econometric methods are preferred in the agricultural economy, as they provide a wide range of information covering a large sample [4]. The purpose of such a choice is to draw some general conclusions. Case study analysis involves more in-depth research. The aim is to survey a small number of operating systems in different perspectives and angles.

Yin [20] considers that this method is necessary to understand complex social phenomena because case studies allow researchers to "focus on the 'case 'while maintaining a holistic and realistic perspective". In this regard, according to Schramm, the essence of the case is that "it tries to shed light on a decision or set of decisions: why they were taken, how they were implemented and with what result" [15].

The analysis is based on interviews with different farmers. The focus is on the effect of precision technologies and comparison between different production systems.

RESULTS AND DISCUSSIONS

The survey is based on the analysis of UK-based Company. It has five farms in different parts of the country. The study was conducted in four of them. The company is international and develops a farming business in the UK, Portugal, China and South Africa.

The owner of the company, as a student worked on a course project in which tried to analyse the efficiency of strawberries production. After a few years, he implemented one of his ideas, the cultivation of strawberries and raspberries under high polyethylene tunnels.

Based on years of experience the engineers and agronomist found that the technology of glasshouse production of soft fruits allows control of environmental impact, maximizes productivity and product quality, protects plants from extreme low or high temperatures, hail, heavy rains, snow, frosts and strong solar radiation, diseases and pests.

The survey is based on interviews with farmers and agronomist in four farms in the UK and one in Bulgaria. Farm A in the UK grows soft fruits in open fields. The technology in Farm B, also located in the UK, is related to the standard tunnels. The fruits are grown in coconut fibre raised beds. Farm C has advanced tunnels production system. In Farm D the technology is associated with glasshouses. In this UK-based holding the plants are also grown in coconut fibre.

Farm E is located in Bulgaria and has two different production technologies. In the first one the plants are grown in open field with soil raised beds. The other one is associated with standard tunnels technology similar to Farm C in the Great Britain.

The results of the economic efficiency in the four farms in the United Kingdom are illustrated on Figure 1. The results are averaged for the period 2016-2019.

Based on the indicator there are substantial differences in the farms in the UK.

The lowest efficiency is registered in farm A and the highest in farm D.

In Farm A the lowest total cost are observed. The main reason is associated with the implemented technology. In this holding there are not any tunnels or any precise control or precise management systems. The investments in farm A are related only to supporting plant construction and drip irrigation.

In the farms with standard and advanced tunnels (holdings B and C) the total costs include investments in technologies for microclimate control in the tunnels. There are also investment costs for irrigation system. On the other hand, in all farms in the Great Britain excluding farm A, the fruits are grown in pots with coconut fibre. Therefore substantial difference in investment cost is registered.

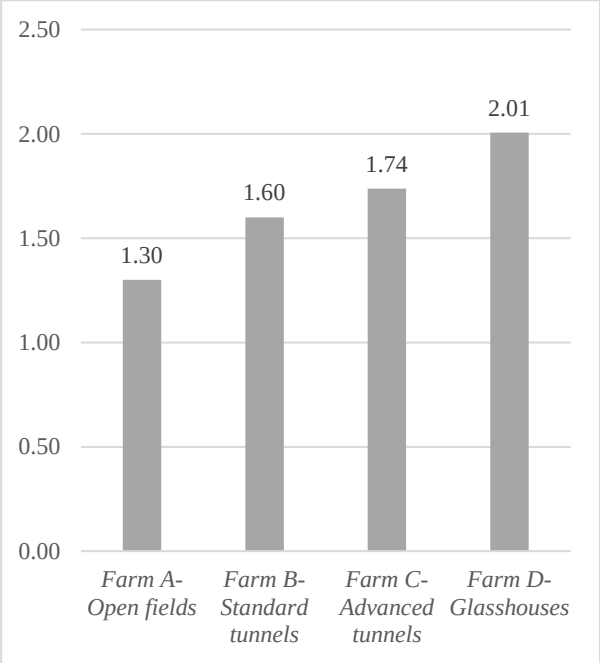

Fig. 1. Economic efficiency (coefficient) in the UK farms
Source: Own survey.

However, the highest levels of total costs are recorded in the holding D. The implemented technologies in this farm are related to the latest generation of precision systems that allow Climate management, Water management, Energy management and Data management. It also includes systems for pests and diseases control. The glasshouse construction is more expensive than the standard and advanced tunnels.

The revenue per hectare is the lowest in holding A. By contrast, the highest results of the indicator are registered in farm D. The observed tendencies are related both to the higher selling price and higher average yields in this holding.

The three holdings in the Great Britain, except farm D, have the same selling price of the production is 6.72 EUR /kg. They deliver their products to the market at the same time of year.

The selling price of holding D is 36% higher compared to the other three farms. The trend can be explained with the production technologies and implemented innovations.

The precision technologies provide the opportunity for extended harvest season. It could be lengthen from early spring and late autumn. The market prices of soft fruits are higher in this time of the year.

In open fields, the natural conditions have significant impact on soft fruits production. Although there are good drip irrigation and fertilization system in farm A, the natural factors can ruin the production quantity and quality. However, it should be noted that the optimal results of average yield are used for the analysis. The bad weather condition may lead to much lower average yields. In farm D is implemented of one of the most modern technologies of precision agriculture. These production systems ensure optimal conditions for plants [5].

Other important comparison is related to the standard tunnels (Farm B) and advanced tunnels (Farm C). The better growing conditions, which are one of the benefits of advanced tunnels, guarantee higher technical efficiency. Based on the production system of farm C, an increase of yield (13 t./ha) is registered.

Other important element of the comparison between the technologies is the production quality. The changes in consumer perceptions and demand transform production systems and remodel the quality standards in the farms. In order to compare the quality level in the different farms and systems the fruits are divided into two classes. Class 1 meets the quality standards and requirements of the supermarket, while Class 2 fruits are used for processing or thrown away. The production quality of the three farms in the UK is presented on Figure 2.

The data shows that in the production system of farm A (open field system) the lowest percentage of Class 1 fruits is observed.

The natural conditions damaged the fruits which are cultivated outdoors. Only 65% of the produced blackberries are Class 1. It should be noted that the results are registered under favourable conditions. By contrast, the bad weather conditions could lead to much lower results. The poor quality of produced fruits could cause serious financial losses.

In the other three farms that implement innovation technologies, the production quality is higher. In Farm B, which has standard tunnels, 87% of the cultivated

blackberries are Class 1. The observed trends outline the advantages of the new technologies. They reduced the farmers` risk and lead to higher yield and quality.

On the other hand, in Farm C and D are registered the highest results. The advanced tunnels production system has 93% Class 1 fruits. An even higher result is recorded in glasshouses where 96% of the produced blackberries are Class 1.

The registered results in Farm C and D are evidence for the advantages of precision technologies implementation and adoption.

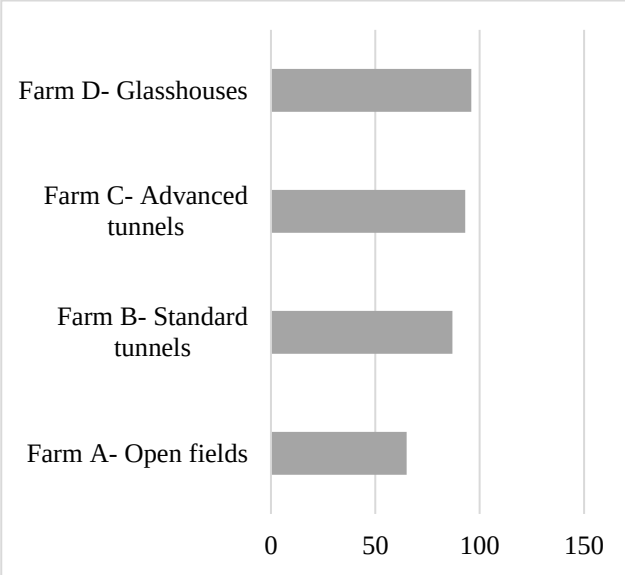

Fig. 2. Quality of the production, % Class 1 in the UK farms
Source: Own survey.

The technical and economic efficiency, as well as the production quality of the farms located in the UK highlight the positive economic impact of innovation and precision farming. On the other hand, the differences in the investment costs should be noted. The higher investments are one of the main reasons for the limited implementation of precision technologies.

The survey in Bulgaria is based on interviews with the owner and the agronomist of Farm E. The holding is located in Strelcha, South Central Region. It has 20 ha of utilized agricultural area. In 2013 the holding is established. The main purpose was to implement precision farming technologies and innovation in soft fruit sector.

Due the financial situation of the farmer, until 2016 the blackberries are cultivated in open field. During the period 2013-2016 the production system outdoors led to low yields and quality of the fruits. The blackberries could not be sold in the supermarket because the quality was poor and did not meet the requirements in the stores. Furthermore in unfavourable climatic conditions the required quantities could not be guaranteed.

In 2016 the farmer invested in standard tunnel structures similar to the technologies in Farm C in the Great Britain. The blackberries in open fields and standard tunnels are grown in raised beds [5].

The substrate of the raised beds is based on coconut fibres which are preferred by farmers due their qualities. On the other hand, drip irrigation systems provide precision growing condition for blackberries cultivation. The holding also has sensors that ensure accurate temperature and humidity in the tunnels. In Farm E a meteorological station is installed. The tunnels in the farm have shading nets. They are necessary for the production of soft fruits in Bulgaria. The reason is related to the strong solar radiation from mid-June to late August in the country [5].

Figure 3 presents the economic efficiency in the Bulgarian farm. It is calculated for the period 2016-2019.

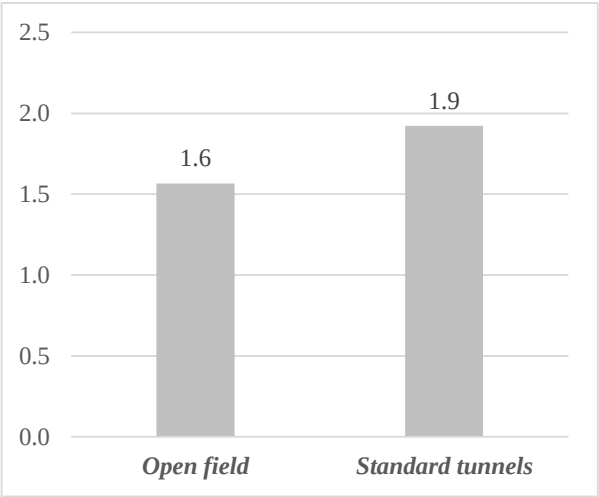

Fig.3. Economic efficiency (coefficient) in Farm E
Source: Own survey.

The observed trends in Farm E are similar to the results in the UK-based holdings. The comparison of the investment cost show that

they are lower in open field system. The costs include investments in support structure and drip irrigation. In other production technology, significant elements of the investments are the costs for tunnel structures and microclimate monitoring.

The registered average yields in the Bulgarian farm indicate large differences. Standard tunnels are three times more productive. The main reasons are related to the growing conditions, combined with the risk reduction. Precise management of the irrigation and fertilization ensures higher yields and efficiency.

Figure 4 illustrates the quality of produced blackberries in standard tunnels and open field.

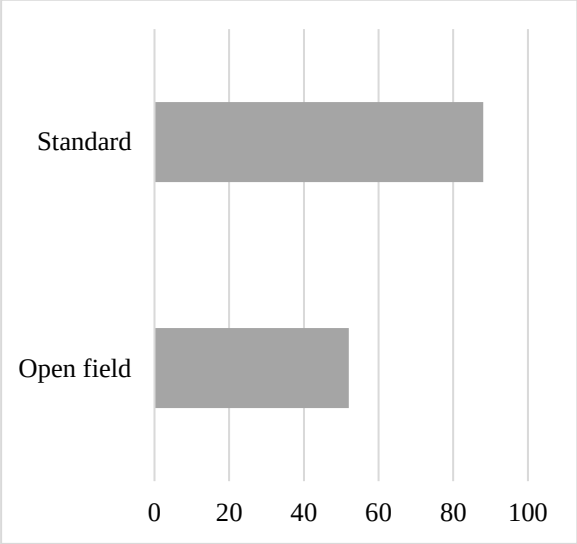

Fig. 4. Quality of the production, % Class 1 in Farm E
Source: Own survey.

In open field production system only 53% of the fruits are Class 1. The bad weather conditions in 2018 caused serious financial losses for the holding.

By contrast, the other technologies lead to better level of quality. The data shows that 88% of the cultivated blackberries are Class 1. Based on the results it can be concluded that the standard tunnels technology is more productive and effective.

The farmer intent to invest in advanced precision technologies and will not continue to cultivate blackberries in open field.

The higher investment costs are obstacle for adoption of innovation technologies in Bulgaria. However, the farmers should consider their implementation in order to compete on the EU market and ensure the required quality standards.

Although not object of the paper it should be noted that precision technologies led not only to higher economic efficiency, but also help in resolving challenges as food security and environmental issues [11].

The application, adoption and diffusion of the precision technologies in Bulgaria are associated with major issues. The low education level and qualification, combined with higher investment costs and lack of consulting services are one of the main obstacles for the process [10, 12, and 21].

The precision technologies in Bulgaria are applied mainly in larger structures and extensive producers. Therefore it is necessary to encourage their implementation and adoption in high value-added sectors.

The EU considers as one of its priorities the implementation of the precision agriculture systems. The LEADER approach is direct reflection of changes in Common Agricultural Policy [16] and also supports precision farming. Horizon Europe - the next research and innovation framework program also will encourage innovation and adoption of precision technologies [7].

In order to realize the opportunities of the EU funds post 2020, it is necessary to build institutional capacity for project implementation and stimulate the improvement of educational level and practical experience of the agricultural producers.

CONCLUSIONS

Based on the survey some conclusions can be drawn:

-Precision technologies in soft fruit production have developed rapidly over the last two decades in parallel with the transformation and digitalization in other agricultural sectors.

-The production of soft fruits outdoors is considered as inefficient in the UK and other Western European countries. In Bulgaria, this is the main system for growing soft fruits,

which is a prerequisite for low yields and poor fruit quality.

-Based on a comparison of the different soft fruit technologies in the UK, the highest yields are registered in glasshouses, followed by advanced tunnels, standard tunnels and open fields.

-After the adoption of standard tunnels in Bulgaria, a significant improvement in terms economic efficiency are achieved.

-The other advantage of precision technologies application is the greater quality, which allows sales of fresh blackberries in supermarkets.

-In Bulgaria, the benefits of precision technologies are widely discussed. However, there is no official information on their perception by farmers and their implementation and diffusion.

-The adoption of precision technologies in Bulgaria is concentrated mainly in large farms specialized in the production of cereals and oilseeds.

-In Bulgaria several large fruit and vegetable producers implement precision irrigation systems.

-On the other hand, small and very small farms do not adopt precision systems and their access to new technologies is limited.

-The new programming period 2021-2027 provides opportunities for financial support and Bulgaria should to improve coordination between ministries, agencies and other actors in the system in order to benefit from the EU funds.

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