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IMPACT OF INNOVATIONS ON TECHNICAL EFFICIENCY OF SOFT FRUITS PRODUCTION

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Abstract

This research is focusing on the efficient use of different technological innovations in greenhouse production of soft fruits in the United Kingdom. Variety of sensors measuring the temperature of water and air, controllers of microclimate, irrigation and fertigation technologies etc. is described and analyzed. Results show that innovations could improve the efficiency of water and nutrients use, contribute to higher yields and lower negative impact on the environment, influence positively on the humane health.

Keywords: innovations, technologies, productivity, technical efficiency.

INTRODUCTION

The agricultural sector faces many challenges, including increasing population and consumption, shortages of resources, climate change, etc. It is necessary to implement new technologies to increase the productivity and efficiency of agricultural production and reduce negative effects on the environment. Innovative technologies are at the heart of sustainable development of agriculture and other sectors of the economy.

The objective of the study is to present the latest technologies for soft fruits growing and to analyze their potential for increasing productive efficiency. Environmental benefits are also assessed.

MATERIALS AND METHODS

This article summarizes some of the theoretical concepts about innovations and the methodological approaches for research and analyzing technical efficiency of production systems.

The study focuses on technologies used in soft fruits (raspberries, blackberries, strawberries and blueberries) growing farms. To simplify the analysis, only blackberry growing systems are studied. Variation of technical efficiency for the other crops is expected to be similar.

Three farms from the UK are an object of the analyses. The first case study analyses a farm system where blackberries are grown outdoors in the soil in raised beds. The second case study describes a farm with standard polyethylene tunnels, where plants are grown in pots with coir, and in the third case study the tunnels are technologically advanced and plants are grown in pots with coir too.

Information is gathered by the authors, conducting interviews and filling up questionnaires. The period, covered by the analyses is 2015-2018.

Yields during the years vary within a small range, which allowed averaging the results from the whole period of observation.

Comparative, historical and monographic methods of analysis are applied in the study.

The survey does not claim to be detailed and exhaustive but could be a starting point for conclusions and a prerequisite for further research and measurements.

RESULTS AND DISCUSSION

In the broadest sense of the term, innovation is understood as a human-proposed, targeted change relating to products (putting new or significantly improved products into production and placing them on the market), production methods (processes), the organisation of work and production (new organisational solutions of structural importance), and management methods used for the first time at least, as a minimum, by the firm in question.

Thus, according to some definitions, the main characteristics of innovations are change and considerable novelty. The thesis, therefore, discusses innovations as activities tied to improvement of the production process or the products and services and the economic potential of enterprises.

While innovations based on experience gained in practical activities prevailed in the past, today's innovations are mostly obtained through the application of findings in science and technology.

The founder of the economic theory of innovations, Austrian economist J. A. Schumpeter, understands innovations as:

• The introduction of a new good (unknown to the consumer) or a new quality of a good;

• The introduction of a new method of production, i.e. a method which has not been applied in the given sector to date but is not necessarily based on a new scientific discovery;

• The opening of a new market, i.e. one which has not yet been occupied by-products from the given sector and country, regardless of whether that market already exists.

• The conquest of a new source of supply of primary inputs (raw materials and intermediate inputs), again notwithstanding whether they already exist or must be newly created.

• The carrying out of a new organisation of industry, such as the creation or destruction of a market monopoly (Schumpeter, 1912).

"Innovation is the specific tool of entrepreneurs, how they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practised.." – Peter Drucker (1985).

"Innovation is understood as comprising the renewal and enlargement of a range of products and services and their associated markets; the establishment of new methods of design, production, supply and distribution; the introduction of changes in management, work organisation, and working conditions and skills of the workforce." – European Commission (1995).

The most commonly used substantive typology of innovations is the one of Oslo Manual, prepared by experts in the field of measurement and evaluation of innovation activities from OECD member states. (Fig. 1):

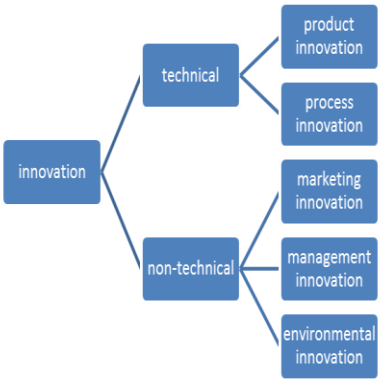


Fig. 1. *Types of innovations*

Source: OECD, 2005

According to the more recent, broader approach of the Oslo Manual, four main types of innovations are recognized

• product innovations,
• process innovations,
• marketing innovations,
• organisational innovations (OECD, 2005).

The innovative practices and technologies may very well prove to be more than just the future of farming and agriculture — they may be the very keys to the survival of the human race (Andy Heikkila, 2018).

In the past 50 years, the topic related to innovations and innovative technologies is highly relevant. The implementation and management of innovation processes in agriculture are quite complicated. Therefore, the previous surveys on the innovation processes in the sector are highly fragmented. Besides, several peculiarities in agriculture affect the development of the innovation process. Consequently, in agriculture, it is difficult to summarize the diffusion and development of innovations (Crossan and Apaydin, 2010). Most of the research so far has been focused on large farms (Christensen et al., 1996; Huiban and Bouhsina, 1998), while studies on small farms are much less developed (Avermaete et al., 2004).

On the other hand, innovation technologies are very important for the sector. Innovation could help for improving productivity, competitiveness and is playing a major role in creating employment, generating income, poverty reduction and social exclusion (Beluhova-Uzunova et al., 2018).

The innovative technologies in soft fruit growing make and control microclimate, which is optimal for the production system. This precision is achieved with the use of smart sensors for reading and controlling humidity, temperature, precision irrigation, pest and disease control, etc.

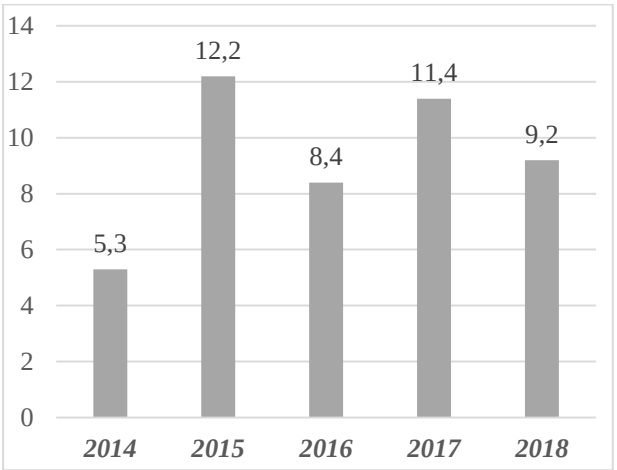
Farm-I: There are 68 hectares of agricultural land. All crops are grown in soil. The main crops are raspberries, strawberries, blackberries, cherries and blueberries. 58% of the area is covered by tunnels; the other 42% are outdoors. Production structure is: 37% raspberries, 32% blackberries, 16% strawberries, 11% cherries and 4% blueberries. Production is realized in the local market – 65% as fresh fruit and 35% for processing (juices and jams). The farm has 80 permanent employees and 270 seasonal workers.

Farm-II: There are 80 hectares of agricultural land. All crops are grown in pots with the substrate – coir, covered with polyethylene tunnels – standard constructions. Production structure is: 33% blackberries, 25% strawberries, 19% cherries, 16% raspberries and 7% blueberries.

Production is realized on the local market – 90% as fresh fruit for supermarkets and 10% goes for juices and jams. There are 95 permanent employees and 350 seasonal workers on the farm. Seasonal workers are recruited during the harvesting period April – October.

Farm-III: There are 76 hectares of agricultural land. All crops are grown in pots with substrate – coir, covered with polyethylene tunnels. 40% of the tunnels are standard construction and 60% are technologically advanced (new generation). Production structure is: 26% raspberry, 24% blackberries, 8% strawberries and 4% blueberries. Production is realized on the local market – 95% as fresh fruit for the supermarkets and 5% of the fruits that don't meet the quality requirements are processed and used for compost. There are 90 permanent employees and 330 seasonal workers on the farm.

The average yields in Farm-I, where blackberries are grown on open fields are about 10 tons per hectare. Variation is observed between the production years, due to climatic conditions. Because the weather isn't always suitable for the crops, grown outdoors the yields are not predictable, which makes the business highly risky and revenues not guaranteed. Graph. 1 shows the yields of blackberries per hectare on farm-I, during the period 2014–2018. There are not many farms of this type in the UK any more. The strategy of the farm under investigation is for the next three years to invest in tunnels and convert to covered growing systems.



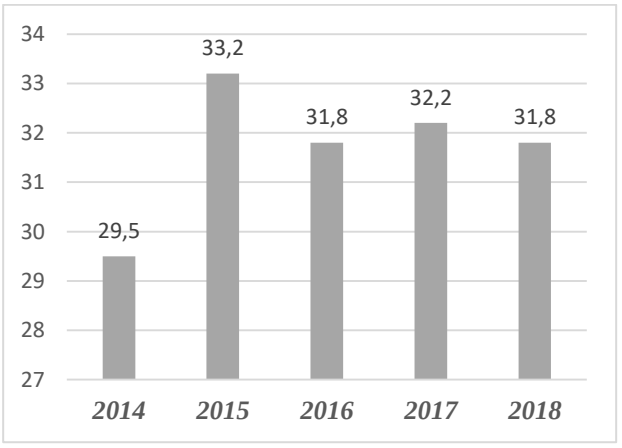
***Graph. 1**. Average yields of blackberries, Farm-I (ton per hectare)*

Source: Own study 2014–2018

This system is considered as an outdated and ineffective one. The high risk of crop damages and the poor production quality makes farmers look for different innovative fruit growing systems. Another important condition, which led to the reducing of outdoor production systems, is the requirement of supermarkets in the last years, fruits to be grown in tunnels or glass greenhouses, which guarantee a higher quality of production.

In the standard tunnels, blackberries are planted in pots with coir, not directly in the soil. There is an irrigation system, which is automated and controlled by a worker using computer software. There are sensors installed in the tunnels, which monitor temperature, humidity, wind strength and direction, etc. If necessary, ventilation windows are opened and closed manually. The aim is to ensure optimal conditions for the plants.

The average yields in Farm-II, where blackberries are grown in standard polyethylene tunnels is about 32 tons per hectare. This is more than 200% higher than the yields in open field systems. Graph. 2 illustrates the average yields per hectare of blackberries, grown in standard tunnels, during the period 2014–2018.



***Graph. 2.** Average yields of blackberries, Farm-II (ton per hectare)*

Source: Own study 2014–2018

In Farm-II, during the last five years, yields variation is very small, allowing predictability of expected results. This is extremely important to farmers when they are planning their inputs, outputs and money flows.

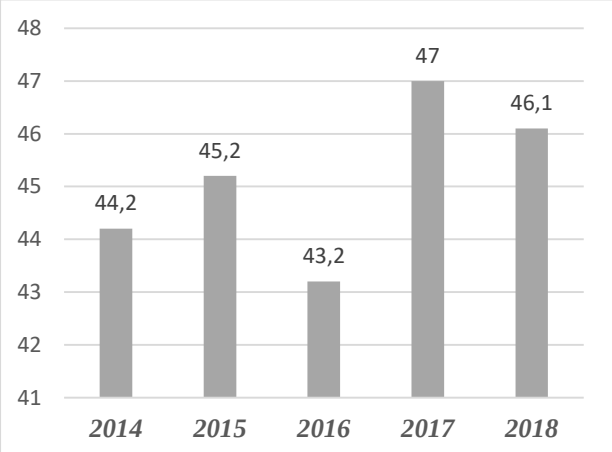
In Farm-III, blackberries are grown in advanced tunnel construction. A precise irrigation system is used, which is automatically switched on and off if it is necessary. When the optimum moisture is achieved, the sensors pass the information and the system stops, this leads to a major elimination of the human factor. The role of

workers is to monitor the indicators of the microclimate. Control is carried out with measurements of humidity in pots at specific time intervals.

This cycle is repeated 24 hours per day. Advanced tunnels are higher than standard ones, which ensure better air circulation, resulting in increased yields. Good air exchange is of big importance for the quality of the products. The results are high-quality fruits, which retain longer their good appearance on supermarkets shelves.

The microclimate adjustment is ensured by an automatic system for opening and closing the tunnel-exchange vents (openings). This leads to elimination of the human factor in controlling the microclimate. The biggest problem with soft fruits is that they need to be held for a couple of days after harvesting and they have a very short shelf life. When applying precise control of humidity and temperature in advanced tunnel constructions, this problem is minimized.

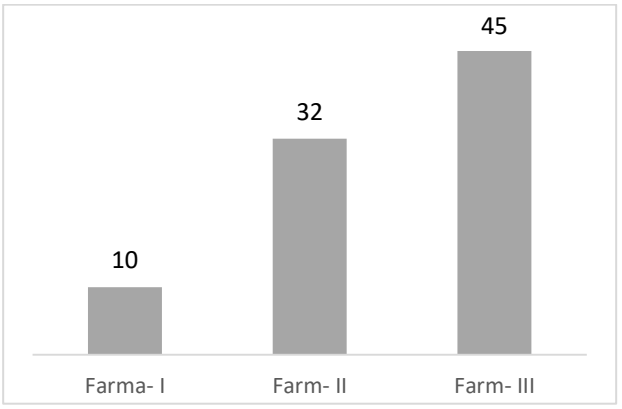
The average yield of blackberries, grown under this system is 45 tons/hectare (Graf. 3). This is more than 400% higher than open field systems.



Graph. 3. *Average yields of blackberries, Farm-III (ton per hectare)*

Source: Own study 2014–2018

The yields are high and the variations over the years are small, which guarantees predictability and better financial results. That is why many farmers in the UK started to replace their standard tunnels with advanced modifications that have emerged in the market, during recent years. Comparative analyses of the technical efficiency of soft fruit production, under the three different technologies, is shown on the Graph. 4.



Graph. 4. *Average yields of blackberries, grown in Farm-I, Farm-II and Farm-III (tons per hectare)*

Source: Own study 2014–2018

CONCLUSIONS

1. Innovative technologies in soft fruit growing are developing rapidly and enable farmers to improve their technical efficiency;

2. Growing of soft fruit outdoors in the UK has lost popularity in recent years. The reason is higher risk, low predictability and lower quality of the fruits;

3. Covering the fields with polyethylene tunnels or glass greenhouses is necessary for the effective use of precise irrigation technologies, climate control, pest and decease control, etc.

4. Despite the higher investment cost, innovation technologies can increase not only the quantity but also the quality of fruits and long-term profitability of the farms.

5. To achieve optimum results (yields), it is necessary to microclimate that guarantees appropriate temperature, humidity, carbon dioxide, illumination, pH, etc.

6. The use of coir for planting soft fruits has several advantages – precise control of irrigation and nutrition, no risk for planting in soils contaminated with heavy metals or other hazardous to human health pollutants, etc.

7. The use of coir and precision technologies allows constructing fields in some areas which are not suitable for carrying out traditional agricultural activities.

8. On the other hand, there are still many issues related to the adoption of new techniques. The need for skilled labour, investment costs, lack of support and consultancy services limit the process in Bulgaria at the moment. This is expected to be changed soon.

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