Innovations in Tillage

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Abstract. Modern agriculture uses many new practices, methods and technologies to improve the quality, increase the production volume, and generate higher incomes. The implementation of innovations by the agricultural producers can cover the different production stages of cultivating crops or farming livestock. The goal of this paper is to outline the innovations applied in tillage. They are classified by type like: mechanical innovations, innovative fertilizers and preparations, innovative ways of irrigation, and, last but not least, innovations to minimize the adverse effects of the farm activity. Based on statistical data and data from a survey on the subject, conclusions are drawn about the attitudes of the farmers regarding the innovations used in tillage. The paper analyzes the most frequently applied innovative solutions, it specifies their type they and makes recommendations for their more effective use.

1 Introduction

The main goal of agriculture has always been to grow as many crops as possible in the shortest possible time and at the lowest cost. For this reason, modern technologies are used more and more and can optimize all the variables in the agriculture. The ability to better control all the variables that affect crops and their growth helps produce bigger output [1].

The application of innovations in agriculture covers all production stages in the cultivation of crops or farming livestock. Innovations can be mechanical, chemical (fertilizers and preparations), methods and processes that limit the adverse effects of the farm activity and support its development and the value of the produced products. The goal of this paper is to outline the innovations applied in tillage. Used are statistics and survey data on the topic, through which basic conclusions are drawn about the attitudes of the agricultural producers regarding the used innovations in tillage. The most applied innovations are analyzed, classified by their type, and recommendations are made for their more effective use.

The term innovation comes from the Latin “novation” or “Innovatio”, which means previously unknown scientific novelty, “towards the new change”. The term innovation itself first appears in scientific studies in the 19th century. The term gets a new life in the scientific and legal literature in the 1930s, as almost every expert studying innovation issues reveals it in different ways. Thus, attempts to define the innovation are made by J. Schumpeter, P. Drucker, V. Hippel, V. Kingston and other authors.

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According to Schumpeter, productions and industries should often revolutionize the scientific and technological process in order to achieve efficiency of the processes and the output. He describes the basic processes of innovative solutions as "creation of new combinations", which is the core of the innovation, as well as further changes in the technological process, aiming at developing the market and the production in general. The author understands the innovation concept as a change and improvement for the purpose of economic development, implementation and use of new types of technologies, consumer goods, as well as new means of production, improvement of the means of transport, creation of innovation-based new markets, and their respective organization forms in the business and the production. As a result of the innovation process, new technological processes and achievements are created, as well as new (software) programs, products and services, and the corresponding organization forms and technological processes [2].

Peter Drucker defines innovation as the specific function of the entrepreneurship, whether it is an existing business, a public service institution, or a new venture started by "a lone person in the family kitchen". Innovation is the means by which an entrepreneur creates new wealth-producing resources or provides enhanced wealth-creating potential to existing resources [3].

In the international practice, widely spread is the definition of "innovation" in the international standards "Oslo Guidelines for Collecting, Reporting and Using Data on Innovation" ("Oslo Manual"). According to these standards, "innovation" is the end result of an innovative activity embodied in the idea of a new or improved product introduced on the market, a new or improved technological process used in practical activities or a new approach to the social services [4], [5].

According to the Common Agricultural Policy, each member country defines by itself the concept of innovation, as well as the institutions or organizations that can judge whether something is innovative or not. In general, an innovation is considered a product, system or technology that leads to an economic, social or environmental gain. In short, it is an idea successfully applied in the practice. This makes the innovations always modern and useful [6].

Building innovation capacity in agriculture, involving all stakeholders at local and regional level, is a critical factor for promoting the distribution of the innovations, for maintaining and strengthening the competitiveness of the agricultural producers and, accordingly, the local economic development and growth [7].

The paper examines the impact of the economic and socio-economic factors on the adoption of new technologies in tillage, in order to increase the competitiveness and productivity of the agricultural producers in Bulgaria.

2 Results of the Study

The main goal of the agricultural producers is to produce the maximum amount of output and get the highest price for it. This is a catalyst for constant improvement of the technique, machines and equipment, processes, etc. The development of new and innovative solutions for agriculture helps the agricultural producers to realize their output in the best possible and qualitative way, limiting the risk of a number of undesirable circumstances.

Table 1 presents examples of innovations in tillage. Innovations can be improved forms of the traditional technologies or found new ways of using these developments so that they can be effectively applied in the Bulgarian agriculture.

Table 1. Examples of innovations in tillage

Improved forms of traditional technologies	**Innovations in irrigation**	**Precision farming**	**Technical innovations**
Appropriate rotation of crops and treatments	Unconventional water sources	Management of the nutrition value of the rangelands	Mechanical weeding through "machine vision"
Strip-till or so-called row tillage	Soil moisture monitoring	Online platform for irrigated vegetables	i-Plough
Selection of crops that grow well without large investments	Options for storage of irrigation water	Thermal tillage	Autonomous tractors
Practicing conservation tillage	Optimized water distribution systems	Agricultural spreading drone	Electric weeding

The use of non-conventional sources of irrigation is a good solution to the problem ofwith the lack of enough irrigation water. Practice shows that seawater and industrially polluted water, which, through purification and filtration, becomes suitable for irrigation, can be used. The use of optimized distribution systems such as drip irrigation and micro-raining, as well as the opportunities for storage of irrigation water (mulching coatings, water-retaining gels, etc.), are a good strategy for obtaining the required amount of water for the crops grown on the agricultural holdings.

The monitoring of the soil moisture is usually done by ground sensors, which include various devices for data collection, cables, connectors, etc. A disadvantage of the method is the significant increase in the value of high-resolution maps determining the soil moisture. A better alternative is a wireless smart sensor network with active radio frequency identification, which reduces the power consumption of the network communications and tags points and geographic location data, thus reducing also the costs.

The maintenance and improvement of the soil structure implies the implementation of improved instruments for mechanical treatment of both the surface and the lower layers of the soil. Similar effects can be achieved through a number of ameliorative measures such as draining the waterlogged areas, liming/plastering to improve simultaneously the soil structure and the access of the nutrients. For areas with severe drought, super moisture-absorbent gels can be used, which allow the soil moisture (and many physico-chemical properties) to be maintained in an optimal condition in the zone of the plant root.

With the increase of the agriculture intensity, the need for detailed characterization of the agricultural areas appears, aiming at differentiated application of fertilizers and preparations, the so-called "precision agriculture". It requires the availability of adequate technology for collecting objective input information, computerized systems for processing large data sets, as well as ability to make and implement decisions in real or near-real time. This includes accumulating information from satellite images, drones and ground-based sensor systems and using it in making decisions on the farm management.

Another example of precision agriculture is the agricultural spraying drone, which sprays different types of pesticides, herbicides and fertilizers from the air and at a safe distance from the crops. It is equipped with an intelligent spraying system, working in different climatic conditions, which regulates the amount of the used substance. It achieves efficiency and minimizes the risk of crop damage during the process.

The technical innovations are most eagerly accepted by the farmers. A possible reason is that their effect is visible immediately after their use. Examples of technical innovations are:

- Combined plow – a device for crushing the plowed soil, combined with a plow. The machine has also innovative technology for pre-sowing soil preparation. It serves for the pre-sowing preparation of the areas intended for sowing, combining a plow for plowing the soil and a clod breaker, which optimally breaks up the plowed soil with minimal dusting, while at the same time compacting it. It has high efficiency in all weather conditions.
- i-Plow – facilitates and improves the quality of work in the grain farms. The software records the information about the plowing done and can show on the display records of all tilled acres. In this way, the settings of the plow can be further tuned to ensure a more efficient operation. The system supports quality plowing, especially when working in plots with irregular shapes, by optimizing the movement of the tractor at the beginning and the end of the furrows. The settings of the new mounted reversible plows can also be set in the software according to the condition and the moisture of the soil. The settings of each plow can be saved automatically and transferred with the stored data when the tractor used for aggregation is changed. The plows have an automatic system for protection and lifting of the plow bodies when hitting a stone, a possibility of mechanical and hydraulic adjustment of the wheels to control the working depth, and an electronic sensor regulating the angle of the plow.
- Autonomous tractors – work independently, without human intervention, can be controlled remotely via phone. This is possible by means of two modules that are attached to either end of the tractor and contain 12 cameras and a graphics processor. The farmer can not only control the machine via the phone, but also watch live video while the tractor works the field.
- Precise use of herbicides – the sprayers identify the weeds and spray them with herbicides without harming the crops. The process of “weeding” is carried out both efficiently and according to the desired speed.
- Units that identify weeds and mechanically eliminate them weed up to 20 rows at a speed of about 3 km per hour.
- Electric weeding – a copper bar with a spreading boom that is charged with high voltage from a large generator. When the electricity reaches the weed, the current is strong enough to destroy it.

There are many examples of innovations in tillage, but in the practice in Bulgaria the innovations are not widely used in the farms. Figure 1 shows the number of farms that have introduced innovations, clasified by the farm specialization. The data are from the last national census of the farms in 2020. The results show that the largest number of agricultural holdings have used innovations for management of crop production (129) and for management of livestock farming (123). There are at least 27 agricultural holdings with implemented innovations in the processing of agricultural products. There are 86 agricultural holdings that have used other innovative technologies applied in agriculture.

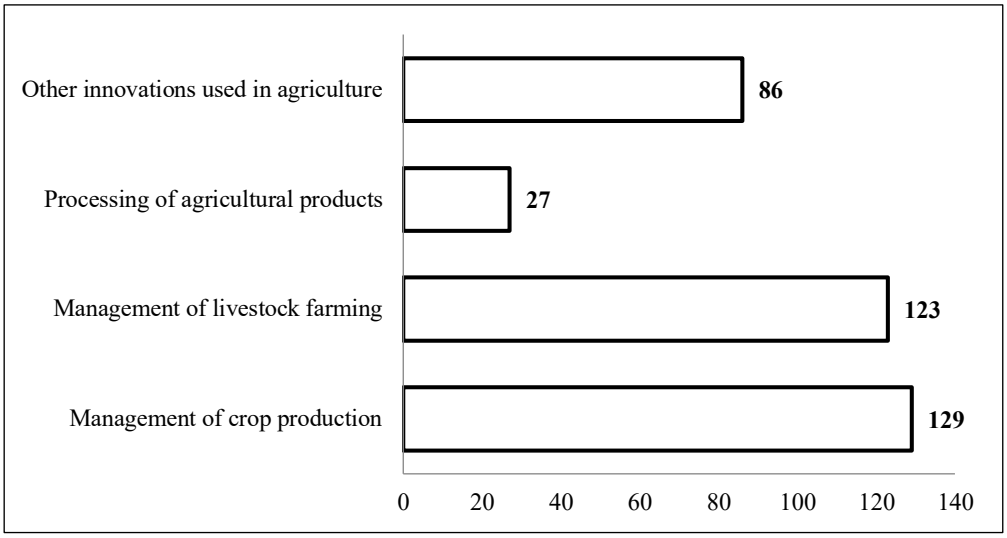

Fig. 1. Number of agricultural holdings using innovations in the production process.

The results of own survey conducted in August – November 2021 on the farmers' attitudes to use innovations on the agricultural holdings show that farmers identify themselves as innovators and users of innovations, but official census data indicates that very few of them apply in practice innovations in their farms. The structured interviews are conducted with an online questionnaire. The goal is to identify specific cases of adoption of innovative technologies by the agricultural producers in Bulgaria and to provide insight based on the experience, the views and the opinions regarding the effectiveness and the impact of the identified cases, as well as the local conditions, incentives and barriers to the adoption of specific technological innovations. The questionnaires are filled out online personally by the farmers or in a phone conversation with them.

Figure 2 presents the expectations of the agricultural producers from the use of innovations in tillage on the agricultural holding, as well as their actual results. There is a match between expectations and results.

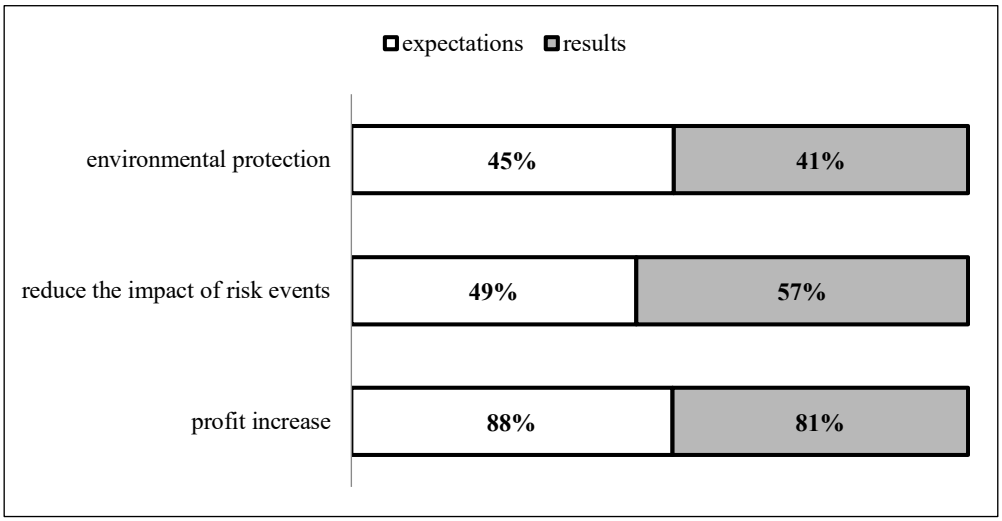

Fig. 2. Expectations and results of the use of innovations in the agricultural holding.

In terms of environmental protection, 45% of the interviewed farmers expect that the use of innovations in tillage would contribute to it. Results in environmental protection from the implementation of innovations are reported by 41% of the farm managers. The difference between expectations and results for this indicator is 4%, with expectations higher than results.

In terms of limiting the impact of risk events, 49% of the interviewed farmers expect that the use of innovations in tillage would contribute to this. Results in limiting the impact of risk events from the implementation of innovations are reported by 57% of the farm managers. The difference between expectations and results for this indicator is 8%, with results exceeding expectations.

In terms of profit increase, 88% of the interviewed farmers expect that the use of innovations in tillage would contribute to this. Results in increasing the profits from the implementation of innovations are reported by 81% of the farm managers. The difference between expectations and results for this indicator is 7%, with expectations higher than results.

Of the three studied indicators, the biggest impact of the use of innovations in tillage is reported in "limiting the impact of risk events". In "environment protection" and "profit increase", the results are closer to the expectations of the farmers. It can be concluded that the use of innovations in agricultural holdings has a favorable impact on the work process there.

3 Conclusion

The innovations in agriculture and the development of the rural areas take place in a given socio-economic context and are determined by the presence (or the lack) of favorable conditions, including domestic development, institutional and regulatory frameworks, knowledge and human skills, economic and financial conditions, a society that demands innovations and a welcoming regional and global environment [8]. Certain interactions and connections also drive the innovations. Innovation processes usually occur in response to various types of stimuli, like the market, the technological development, the society or the environment. They always require favorable conditions [9]. That is why it is important to provide a favorable environment for innovations, and government authorities (including the various sectors, ministries and institutions) should play a key role.

The challenges and priority areas for innovations suggest that the public policy should guide the direction of the demand process, which is essential for the innovations. The effective impact of innovation on economic development is closely linked to the legal, institutional and financial environment. They have an impact on all the economic agents that transform existing and newly created knowledge into advanced competitive products and services for the market [10]. Bulgarian legislation depends on European legislation and is influenced by legislative changes at EU level, so anticipating such changes is extremely important for the country [11]. There is a need for development of broader programs that focus on several areas such as: climate change, environmental issues and resource efficiency; cooperation on food chain innovations and territorial innovations [9]. These directions should be coordinated with other government actions that limit and/or stimulate the agricultural producers: subsidies, taxes and agro-environmental contracts [10].

By introducing innovations in tillage, farmers can directly acquire some benefits, such as saving materials and improving cost efficiency. There are also less obvious, indirect effects, such as reducing the burden on the environment and improving the food safety.

Possible impacts of the use of innovations in tillage, documented in the scientific literature, are:

- Decrease of the use of pesticides after the adoption of innovations in the farm could be 30 000 tons (pesticides) per year at EU level, while reducing the ecological footprint of agriculture;
- Crop insecurity can be reduced and farmers' income reliability can be increased by using the right combination of innovative elements in crop cultivation;
- Improved management of the use of fertilizers and other resources can increase the competitiveness of the farmers;
- The use of more compatible agricultural practices with the help of innovative technologies leads to better quality of crops and livestock products.

The reasons why the implementation of innovations in agriculture has not progressed as expected are:

- Limited availability of affordable automated identification systems and/or lack of good financial track record of many farmers;
- Limited high-speed access and affordable internet in the rural areas, hindering the efficient storage and analysis using more expensive satellite systems;
- Privacy concerns related to data captured on the farm;
- Lack of a consistent consulting service for the farmers on maintaining technology components, interpreting data captured by sensors, formulating and sending regular simple and relevant advice to the farmers and involving them as users in the technology development so that new technologies meet the needs of the farmers;
- Lack of clear data on the costs, benefits and returns of the innovative technologies and limited awareness of the economic and environmental benefits of these technologies;
- Problems that prevent the widespread use of the innovations in agriculture due to the different levels of knowledge and skills of the farmers.

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