RATIONALIZING THE ROLE OF THE UNIVERSITY AS AN ACTOR OF THE AGRICULTURAL INNOVATION ECOSYSTEM

RAȚIONALIZAREA ROLULUI UNIVERSITĂȚII CA ACTOR AL ECOSISTEMULUI DE INOVAȚIE AGRICOLA

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The goals of the research were the following: elucidation of the concept of the innovation ecosystem and of the importance of the agricultural innovation ecosystem; highlighting the role of the universities as innovation ecosystems` actors; synthesis of the cutting-edge innovative approaches in the agricultural field and, on this basis, formulating recommendations for curriculum improvement. In order to achieve the mentioned goals, the following research methods were applied: synthesis of the conceptual approaches and of some practical studies related to the research object, opinion survey, inductive method, analysis, generalization, systematization, formulation of reasoning and recommendations. As a result of the research, the directions of intervention in the agricultural undergraduate degree programs were identified in order to facilitate the exercise by the professional educational service providers of the role of active and effective actors of the innovation ecosystem.

The research was carried out within the project "Predictive approaches to increasing the quality of skills in agricultural higher education based on the partnership with the business environment", No. 20.80009.0807.41, contracting authority - National Agency for Research and Development.

***Keywords**: agriculture, curriculum, education, innovation ecosystem, skills.*

INTRODUCTION

Ensuring the economic and social prosperity of each state represents a mission both important and difficult, by virtue of the numerous factors involved. However, in the current context in which economic activities are carried out, marked by globalization, internationalization and, in particular, by the rapid development of information technologies, innovative approaches to technological and managerial processes are imposed as an imperative of the time and an indispensable factor of the success. In these circum-

stances, the need to focus efforts on the creation and effective functioning of innovation ecosystems is becoming more and more common.

It is considered that the concept of innovation ecosystem was first addressed by Adner in his work "Match your innovation strategy to your innovation ecosystem" published in Harvard Business Review in 2006. According to the author`s opinion, innovation ecosystems represent collaborative arrangements through which the firms combine their individual offerings into a coherent, customer-oriented solution [1].

Due to the growing interest in the given subject, the innovation ecosystem has been approached in an impressive number of scientific publications. By synthesizing 303 papers, the authors Granstranda and Holgerssonb selected 120 most frequently cited papers. Definitions of the innovation ecosystem were identified in 22 of them. By excluding overlaps, 21 definitions were established, having 7 different themes of defining components: actors, artifact, collaboration/complements, competition/substitute, activities, institutions, co-evolution/co-specialization [2]. Among the definitions analyzed by the authors mentioned above, the one proposed by Walrave et al. can be highlighted as having optimal relevance, according to which the innovation ecosystem represents „a network of interdependent actors who combine specialized yet complementary resources and/or capabilities in seeking to (a) co-create and deliver an overarching value proposition to end users, and (b) appropriate the gains received in the process" [3].

As previously noted, the significance of creating an innovation ecosystem in any field of activity is undeniable. Implicitly, the necessity of the innovation ecosystem for agriculture is indisputable, in the context of the environmental problems, but also of concern for food safety, as its proven advantages are mentioned: productivity, profitability, sustainability [4].

It is predicted that by 2050, the world's population will reach 9.6 billion inhabitants, which will generate an increase in the demand for agricultural products by about 70%, while the area of available land will increase by only 5%. Under these conditions, the world community's concern for food security is natural and justified.

However, increasing the volume of agri-food products is often associated with adverse effects on the environment. Thus, according to some estimates, agricultural activities generate about 24% of greenhouse gas emissions and up to 60% of biodiversity losses [4].

Based on the above, it is obvious that the priorities of the innovation ecosystem in agriculture consist in developing effective resources management tools in compliance with the principles of sustainable development. Operating with these priorities is up to each actor of the innovation ecosystem. An innovation ecosystem, in its turn, includes universities, government, corporations, startup accelerators, venture capitalists, private investors, foundations, entrepreneurs, mentors and media [5]. Therefore, the extent to which the innovation ecosystem will contribute to the economic and social prosperity of the state and the protection of the environmental resources will depend on the quality of the involvement of each participant of the system, as well as on the synergy of

their efforts. Universities, as institutions that provide qualified workforce, represent an extremely important element of the innovation ecosystem, due to the following roles exercised in this regard:

• provide the necessary skills for effective resources` management in the existing context and taking into account the future trends in the development of the technologies;

• create a specific way of thinking, oriented towards flexibility, permanent search for solutions, continuous adaptation to the turbulent exogenous environment, intransigence in achieving objectives, etc.;

• promote the latest achievements in production and management technologies among producers, through activities related to lifelong learning;

• establish and maintain effective relations of cooperation with the business environment in order to exchange information and innovative products, but also to carry out, through joint efforts, some training, research and innovation activities.

Based on the above, we conclude on the significance of the continuous connection of the objectives and mission of each higher education institution to the requirements that come from the real sector and which, in turn, require the permanent updating of the study programs offered by the institutions in terms of quality and the transformation of each institution into an active and effective actor of the innovation ecosystem.

MATERIAL AND METHOD

The methodological support of the research consisted of:

a) the synthesis of conceptual approaches and some practical studies related to the conceptualization of the innovation ecosystem, the role of the agricultural innovation ecosystem, the most publicized innovations at the current stage with reference to the rationalization of technological processes and digitization in agriculture;

b) the opinion survey carried out between May and August 2021 on a sample of 108 students from 5 agricultural undergraduate degree programs within the State Agrarian University of Moldova;

c) the opinion survey of the representatives of the business environment carried out in the periods May-August 2021 and March 2022 on a sample of 55 people using the structured thematic interview method;

d) analysis, induction, generalization, systematization, formulation of reasoning and recommendations regarding the necessary interventions in undergraduate degree programs aimed at improving the quality of the educational offer of the institutions as active and effective actors of the innovation ecosystem.

A series of scientific and analytical publications related to the researched subject, as well as the results of the opinion surveys, served as research material.

The limitations of the research refer to the low representativeness of the samples included in the opinion surveys.

RESULTS AND DISCUSSIONS

The need to develop innovative skills related to professional tasks is confirmed by both students and employers. In order to assess student satisfaction with the quality of the educational offer, in 2021 an opinion survey was conducted on a sample of 108 students from 5 agricultural undergraduate degree programs within the State Agrarian University of Moldova. The description of the student opinion survey sample is presented in table 1.

Table 1

The description of the student opinion survey sample

The agricultural undergraduate degree programs	The number of students involved in the survey, pers.	The share of involved students in the survey by undergraduate degree programs,%
Agronomy	52	48,1
Plant protection	8	7,4
Selection and genetics of the agricultural crops	6	5,6
Animal husbandry	13	12
Food safety	29	26,9
Total	108	100

Source: developed by the author

As a result of the evaluation of the students' opinions regarding the quality of the knowledge offered by the institution, it was found that, even if the majority of the respondents advocated the qualifications "excellent" or "good", 8.4% of the students evaluated them with the qualifications "satisfactory" or "poor ". With reference to practical skills, 9.3% of respondents selected the qualifier "satisfactory" or "poor".

Implicitly we can mention that approx. 13% of the students involved in the opinion survey evaluated the research and innovation activity carried out by them with the qualifications "satisfactory" or "poor". In this context, we can also specify the fact that 3.8% of the respondents are of the opinion that the skills offered by the educational institution do not correspond to the requirements of the labor market.

Interviewing the representatives of the business environment more actively involved in educational activities within examined programs made it possible to ascertain a higher appreciation given by them to the quality of the targeted programs compared to that offered by the students. However, if theoretical knowledge is valued more highly by them, about 18% of respondents evaluated the practical skills with the qualification "satisfactory". Regarding the extent to which the skills offered correspond to the demands of the labor market, 39% of the respondents are considering that they correspond only partially.

The need to increase the quality of study programs is also confirmed by the su-

ggestions offered by both groups of respondents on this subject. By systematizing them (table 2), we can deduce the following: the need to study innovations in related fields is recognized by the absolute majority of respondents, being mentioned by 92% of students and 95% of business representatives. An analogous situation can also be seen in the opinion of the respondents regarding the significance of studying ecological production technologies, which are supported by 87% of students and 91% of representatives of the business environment. Another important direction of program development mentioned by both groups of respondents is the development of the agricultural digitization skills. At the same time, only 25% of students and 57% of business representatives could highlight certain innovative approaches in the reference fields, most frequently referring to conservative agriculture, biological methods of plant protection, the use of drones in monitoring the technological processes. Based on the last statement, we deduce the superficial knowledge of the latest trends in the development of the sectors concerned.

Table 2

The opinions of students and representatives of the business environment regarding the directions for improving study programs

The directions for improving study programs proposed by the respondents	The share of students involved in the survey who advocated for the respective direction, %	The share of representatives of the business environment involved in the survey who advocated for the respective direction, %
Studying innovations in agriculture	92	95
Application of ecological production technologies	87	91
Acquiring agriculture digitization skills	75	78
Highlighting certain innovative approaches focused on process, product or management	25	57

Source: developed by the author

On the basis of what has been stated, we deduce that the permanent updating of the curriculum content in relation to the trends in the reference fields represents a requirement increasingly recognized by the target groups of the professional education. On the other hand, there is insufficient knowledge of the latest directions of innovative approach to the fields of reference. In this context, a synthesis of the most publicized innovations in agricultural production that are recommended to be addressed within the agricultural undergraduate degree programs is presented below, these being systematized into two basic categories:

• Innovations focused on technological production processes;
• Innovations aimed at the digitization of crop and animal production processes.

It is remarkable that the most of the innovations addressed by the specialists are also related to environmental protection concerns. Thus, in a publication of the CropLife International association [6], among the innovations aimed at saving the planet we distinguish some related to crop production technologies, namely:

a) use of bio pesticides - biological plant protection products obtained from natural substances. Being combined with conventional chemical products, bio pesticides contribute to increasing the yield, being reduced the damage caused to the environment. At the same time, they have the property of facilitating the development of many leaves and healthy roots in plants, thus contributing to the absorption of a larger volume of carbon from the air and its fixation in the soil.

b) formulation of plant protection products – establishing the combination of various compounds by adding, to the active ingredient, a plant protection product in order to increase their effectiveness and safety. The need for that approach arises from the emergence of the new invasive species as a result of climate change. Formulations help to reduce the toxicity and volatility of a plant protection product. In this sense, scientists use the biodegradable ingredients obtained from renewable sources. Among the latest achievements is "microencapsulation" - a type of formulation in which the action of an active ingredient can be triggered in a specific way: by temperature, exposure to the sun, etc.

c) application of inoculants on seeds (bacterization of seeds) - represents a natural method that contributes to increasing the productive potential of leguminous crops as a result of ensuring a nitrogen supplement. Specialists have identified a number of benefits of using inoculants, namely:

• reduction of production costs as a result of saving fertilizers;
• easier overcoming of the previous growth conditions by the culture;
• reduction of weeds;
• environment protection.

d) Seed treatment with plant protection products – is a measure applied before sowing. Its benefits include:

• protection from pests and diseases;
• earlier sowing of crops;
• increasing production yield;
• environment protection;
• reduction of production costs as a result of the reduction of the number of treatments with plant protection products from the vegetation, as well as the number of passes with the tractor.

Along with those mentioned above, we can also identify other innovative approaches to crop production processes that ensure economic and ecological efficiency at the same time. Among them, a special place belongs to conservative agriculture. The conservative farming system is one of the most publicized recently. According to the FAO definition, it

promotes minimal soil disturbance, maintaining a permanent soil cover and diversifying plant species [5]. Therefore, the respective system is based on three basic principles:

1. Minimal mechanical soil disturbance or its total absence through the application of No-tillage practices;

2. Permanent maintenance of the soil surface covered with mulch from plant residues and/or cover crops with an active root system;

3. Diversification of crop species [6].

Another important direction for improving agricultural production consists in the digitization of related processes. Digitization refers to the adoption of information communication technologies, including the Internet, mobile technologies and devices, and the analysis of data used to improve the generation, collection, exchange, aggregation, combination, analysis, access, search and presentation of digital content, including for the development of services and applications [7].

It is undeniable that digital technologies contribute to increasing the efficiency of the agricultural production. Thus, they help producers to use physical, natural and human capital more efficiently, as well as to reduce the costs related to the interaction with the supply, sales and financial markets, by reducing the time consumption and the cost of transmitting enormous volumes of information over large distances [8]. At the same time, through the comparative analysis of the agriculture digitization index in different countries, we find the existence of a substantial gap between the respective indicator in the Republic of Moldova and other countries of the European space (figure 1).

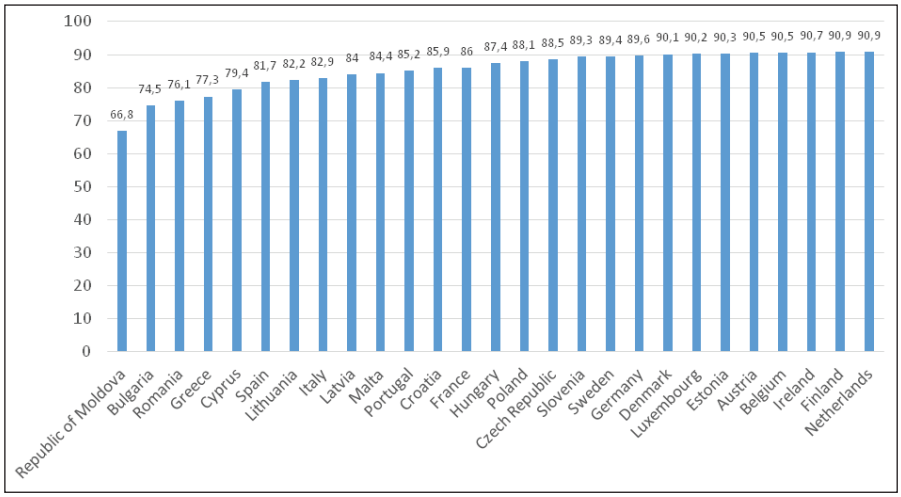


Fig. 1. The agriculture digitization index in Europe, 2021

Source: [4]

Referring to the publication of the CropLife International association, we identify, among the innovations stated as being meant to save the planet, the “Big Data” system, stating that it involves a large amount of information, which can be analyzed to reveal

trends and patterns. In this context, the authors specify that the agricultural data are generally represented from images of fields from satellites and drones, to data processed by sensors embedded on farm machinery. Another wide-ranging digital innovation mentioned in the publication is represented by mobile diagnostic applications that can be used on a smartphone or tablet and are intended to help produces to obtain and record various data from the field. In this context, it is stated that annual harvest losses caused by weeds can reach up to 40%. Unfavorable climate change facilitates the increase in the number of pests. At the same time, consumers are demanding a reduction in pesticides. Diagnostic applications enable the solution of the mentioned problems, helping producers to protect water, soil and biodiversity [9].

A recent publication by the Organization for Economic Co-operation and Development highlights 17 digital tools relevant to modern agriculture. The brief reflection of their content and systematization by areas of use is shown in table 3.

Table 3

Recommended digital tools for modern agriculture

Digital tools for general use	Digital tools for crop production	Digital tools for animal production
Controlled Traffic (Entry Precision Adjustment) - controlled traffic farming is a system that limits all car loads to the smallest possible area of permanent traffic lanes.	*Harvest sensors (data collection)* - help farmers improve the crop conditions by measuring the plant water potential, the yield, the stage of the development (maturity), the nutrient levels, the pest and disease infections, and the various morphological factors such as biomass, leaf area and plant and organ distribution.	*Accelerometers (data collection)* - are electromagnetic devices that measure the acceleration forces. In combination with digital systems, the accelerometers generate data that are processed by algorithms to interpret the animal movement that signals behavioral patterns. These animal behaviors include feeding, watering, walking, standing, sitting, and lying down.
Distributed accounting technologies (decision support tool) – are digital ledgers shared by several entities operating in a distributed network. In agriculture they can be used to certify the food exports, to track inputs and transparency of the food chains, to store and monitor the results.	*Variable rate technology (precision input adjustment)* – allows the materials (seeds, fertilizers, chemicals, irrigation water, etc.) to be dosed differently across a field without manually changing equipment rate settings or having to make multiple passes over a work area.	*Automatic heat detection (data collection)* - can be used to identify the pre-mating heats of cows to be artificially inseminated during the mating period and those that have aborted.

Auto Guidance/GPS/ GNSS (Precision Equipment) – are relatively inexpensive navigational aids known as visual parallel tracking devices for manual steering used by operators to view their position relative to previous passes and to recognize the need to make heading adjustments if a measured geographic position deviates from the intended track.	*Satellite/drone images (data collection)* - involves the use of unmanned aerial vehicles (drones) that help farmers to monitor crops located on large areas.	*Digital pasture management tools (data collection, precision equipment)* – typically these include pressure sensors, plate meters and probes, the latter being commonly used to measure the temperature and other attributes of animal health. Satellite and drone imagery are also considered digital tools for rangeland management.
	Soil maps (decision support tool) – are a product of digital soil mapping (also known as predictive mapping) that aims to create the database and georeferenced soil maps at different scales.	*Milking robot (precision equipment)* – refers to automatic milking systems that involve the use of a camera with sensors that determine whether the cow needs to be milked based on the time of the previous milking and other information.
	Telemetry (precision equipment) – is an information system designed to provide data on irrigation parameters over the course of a year, taking into account various meteorological parameters.	*Precision scales (data collection)* – are automatic platform scales equipped with sensors. Recently such scales have been used for chickens and turkeys.
	Yield maps (decision support tool) - allow continuous visualization of the crops in the fields using the data from sensors and other tools associated with geospatial coordinates.	*Livestock tracking (decision support tool)* – involves the use of wireless connected technologies and other sensors (such as GNSS collar) for the geographic tracking of the grazing animals.
	Yield monitors (data collection) – with the help of sensors mounted on the harvesters, the amount of grain passing through the combine is measured in real time.	*Virtual fence (data collection)* – are digital fence systems that replace the traditional physical barrier with an acoustic stimulus.

Source: developed by the author based on [7]

Thus, based on the data in table 3, we find out that there is a varied range of digital tools, capable of contributing to increasing the economic and ecological efficiency of agricultural production due to their high precision, the contribution to increasing labor productivity, the ability to provide the necessary framework for sustainability of the resources and other benefits.

The rapid pace of technical-scientific progress comes with permanent updates and upgrades of applied production technologies as well as digital tools relevant to each sector. Vocational education institutions, as actors of the innovation ecosystem, have the mission to be aware of the latest innovations, to reflect them in the curricular content and to ensure the necessary skills to apply them in practical activity.

CONCLUSIONS

The creation and effective functioning of innovation ecosystems is an important factor of the development and prosperity of each state at the current stage. Implicitly, the need for the innovation ecosystem for agriculture is indisputable, in the context of environmental problems, but also of concern for food safety, as its proven advantages are mentioned: productivity, profitability, sustainability.

The priorities of the innovation ecosystem in agriculture consist in developing effective resources management tools in compliance with the principles of the sustainable development. Operating with these priorities is up to each actor of the innovation ecosystem, including universities. The latter are called to provide adequate skills to future managers and specialists by continuously connecting the content of the study programs to the requirements of the sectors.

By investigating the opinion of students and agricultural business environment representatives, we find out that, even if the need for innovative approaches in the reference fields is recognized, the latest trends are insufficiently known by both parties. Based on the synthesis of a series of publications on the topic of innovations in agriculture, the following subjects were identified recommended for inclusion in the agricultural undergraduate degree programs:

I. Innovative approaches to production technologies: the use of bio pesticides; the formulation of plant protection products; application of inoculants on seeds (bacterization of seeds); seed treatment with plant protection products; application of the conservative system of agriculture;

II. Digitization of crop and animal production processes, including:

a) Application of digital tools for general use: controlled traffic; distributed accounting technologies; automatic guidance/GPS/GNSS;

b) Application of digital tools in crop production: harvesting sensors; variable rate technologies; satellite/drone images; soil maps; telemetry; yield maps; yield monitors;

c) Application of digital tools in animal production: accelerometers; automatic heat detection; digital pasture management tools; milking robot; precision scales; livestock tracking; virtual fence.

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