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PROSPECTS ON BIO-ECONOMY DEVELOPMENT: BIOTECHNOLOGY IN AGRICULTURE AND ENVIRONMENTAL SAFETY ON THE BASIS OF NBIC-TECHNOLOGIES

Abstract
The article reviews modern trends in bio-economy development on the basis of biotechnologies application in environmental safety and agriculture including the genetically modified and other agricultural crops. The article demonstrates that in the implementation of converging NBIC-technologies in agricultural-industrial system is achieved a synergy effect for the development of the bio-economy in the World and Ukraine in following directions: industrial biotechnology (food biotechnology; biotechnology of sea products; biotechnology to increase oil recovery); environmental biotechnology (cleaning soil from pollution; environmentally friendly biocides to protect materials from bio-damage and oxidation; waste water treatment from toxic metals and radio-nuclides; air cleaning, including also cleaning of enterprises' vent emissions from volatile organic components, etc.); biotechnology in power engineering (modular biotechnological equipment, including bio-reactors and bio-diesel).

Key words
bio-economy, biotechnologies, NBIC-technologies, agriculture, environmental safety.

Introduction

Production of primary bio-products today and in future would be connected with human natural life support systems efficiency improvement at the expense of a number of things including also biotechnology implementation. In future, biotechnologies would play exceptionally important role in agriculture and environmental safety because our planet population is expected to considerably grow and correspondingly, the demand for bio-products would also grow. As to OECD data, the Earth population as of today is 7 billion people; by 2030 it would reach 8.3 billion and by 2050 it would grow up to 9 – 10 billion.

Growth of agricultural products production rate at the expense of plough land area increase has very strict limitations. According to Food and Agricultural Organization (FAO) review, to satisfy the needs of the developing countries in food it would be necessary to develop more than 120 million hectares of land during the next 30 years, which is 12.5% of plough land increase, and which would be very dangerous as regards the planet environmental impact increase [1; 2].

The more efficient problem solving would require implementation of innovative biotechnologies based of nano-, bio-, info- and cogno- (NBIC)-technologies, which would empower people in the 21st century to satisfy the needs of the growing planet population in food, in drinking water, and in other natural resources on the basis of increasing efficiency of bio- and hydro-resources as well as on the basis of the planet atmosphere potential increase [3, p.258]. Many well-known scientists dealt with the mentioned problem and with other issues regarding convergence of knowledge, technologies and society - M. Roco, W. Bainbridge, B. Tonn, G. Whitesides [4; 5]; the issues of using nanotechnologies for bio-economy - L. Foster [6]; development and future prospects for NBIC-civilization – A. Kazantsev, V. Kiselev, D. Rubwalter, O. Rudenskiy [7], including also Ukrainian scientists: M. Kyzym, I. Matyushenko, I. Buntov, O. Khanova, Yu. Moiseienko, V. Khaustova, et al. [8 – 14].

At the same time, implementation of biotechnologies on the basis of NBIC-technologies in developed countries' economies requires review of the technologies to be utilized for bio-economy build-up in the World and Ukraine. The aim of the article is to study design and production trends in biotechnology implementation in agriculture and environmental safety on the basis of NBIC-technologies.

Materials and methods
Content analysis has been used as the main method of research, which allowed making a meaningful analysis of classic papers and researches of modern economists-practitioners devoted to the peculiarities of the modern prospects of bio-economy in the World and Ukraine with using of NBIC-technologies. General scientific methods make up a methodological foundation of the research. They include: description, comparison, statistics review, system analysis and others, which help characterize this phenomenon development in a more comprehensive way. We also apply the methods of dialectic cognition, structural analysis and logic principles that provide for making authentic conclusions as regards the investigated topic. Official statistical data of the state institutions and international organizations, publications of reference character, analytical monographs, annual statistical bulletins, and Ukrainian National Academy of Science reports serve as an information grounds for our research.

Results and discussion
"Green Revolution" of 1960–1980 launched active utilization of chemical fertilizers to increase crop yield as well as utilization of pesticides to protect plantations from pests, but still by this time it has failed to solve food shortage problem. Moreover, intensive chemicalization of biosphere and human organisms caused serious side effects: burst of the population allergic incidence rate especially in developed countries; pollution of hydrosphere and lithosphere with chemicals, which are subsystems of human life support [1; 2]. Some modern biotechnologies, which also include genetic modifications, DNA sequencing (i.e., one of the mostly used methods to determine DNA molecules' nucleotides sequence), bioinformatics and metabolic engineering (technologies to change metabolism in a body), have already found their commercial use in specific agricultural sectors. For example, the mentioned technologies are mainly used in agricultural grain sector in the spheres of breeding and diagnostics, in animal farming and partially in veterinary medicine. Biotechnologies are widely used to generate new types of agricultural plants, food, fodder, fibre crops, domestic animals and poultry with improved genetic qualities. Table 1 presents examples of using biotechnologies in agriculture **[15, p.255].**

Table 1. Advantages and risks of using biotechnologies in agriculture

Technologies	**Advantages**	**Risks**
Transgenes (in general)	Opportunity to improve all forms of agriculture	Biodiversity decrease with the threat of new pathogens stronger impact; genetically modified products entry into human food intake without consumer's notification; technology may not work in new conditions
Resistance to herbicides	Agricultural productivity increase; decrease of herbicides use that are not bio-degradable	Outcrossing that entails emergence of super-weeds resistant to herbicides
Resistance to pests	Agricultural productivity increase, decrease of pesticides use that are not bio-degradable	Outcrossing that entails emergence of biotechnologically resistant pests; farmers that deal with organic husbandry would not be able to use bio-technologies; unfavourable impact on moths population
Feed value increase	Positive impact on food products nutritive value in the developing countries population intake	Could have inconsiderable effect, but at the same time could serve as only a promo method to throw dust into the eyes for commercial organizations
General resistance	Provide for agriculture development in the regions with unfavourable conditions	Development of super-resistant plants that could cause annoyance, e.g., grass that actively vegetate
Resistance to frost	Agricultural productivity increase	Could cause climate change

Technologies	Advantages	Risks
New food sources (lauric acid from genetically modified rape)	Cost decrease to produce some plantation products	Could cause losses and downfall in economy, that depends on traditional production methods
Biologically engineered agricultural animals	Increase of food production having animal origin	In case a trans-gene fish from the farm appears in wild nature it may force out the natural population

As of today, genetic and reproductive biotechnologies have a break-through impact on agriculture (especially in animal farming) in the developed world countries. For example, molecular genetics achievements have provided for an opportunity to build-up gene selection enginery mainly to combat animal diseases and alleviate gene defects. Innovative biotechnologies including also the technologies of cloning, transgenesis and somatic (body) material transfer would have an immense impact on animal and poultry farming in the 21st century.

One of the innovative methods is implementing genetic modification technologies with the help of transferring genetic material from one organism to another, which could not be done with the help of crossing. The other method is to use genetic material, which has natural crossing capacity, with other organisms with the help of genes “mixing”.

Moreover, reproductive biotechnologies also include artificial insemination (AI) and embryo transfer (ET) technologies [7, p.22]. As of today, animal farming in the developed countries actively uses artificial insemination biotechnologies. Technologies of embryo transfer and molecular-genetic technologies mainly include such innovative biotechnologies as, for example, molecular DNA-markers, that serve as tooling for genetic improvement of agricultural animals.

Biotechnologies, like, for example, biologic or chemical markers, are used to identify genetically modified plants’ characteristics, to shorten the time period of new types' generation, to improve their resistance and the ability to withstand the action of herbicides and pesticides. For example, in the USA till 2010 75% of 85 types of genetically modified plants (GM-plants) were recognized as herbicides-resistant and pesticides-resistant **[16, p.55].**

Preserving genetic diversity of agricultural crops is the most important goal for the modern biotechnologies development. Genetic resources of agricultural plants is the biologic foundation for human life support and global food safety including also pharmaceutics development, production of food and feed grains as well as biomass for animal farming, development of bioenergy, etc. As of today nearly 150 types of plants are under cultivation, of which 12 types yield 75% of world food.

Table 2 presents forecast for global use of plough land for genetically modified and other agricultural crops till 2015 [17].

Table 2. Forecast for global use of plough land for genetically modified and other agricultural crops till 2015

Years	GM soya beens		GM corn		GM cotton		GM rape	
	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%	Plough land, million ha	Share in the general plough land area for this crop,%
1996	0,5	0,8	0,3	0,2	0,8	2,3	0,1	0,5
2000	25,8	34,7	10,3	7,5	5,3	16,9	2,8	10,9
2001	33,3	43,4	9,8	7,1	6,8	20,1	2,7	12,0
2002	36,5	46,2	12,4	9,0	6,8	22,7	3,0	13,1
2003	41,4	49,5	15,5	10,7	7,2	23,2	3,6	15,4
2004	48,4	52,9	19,3	13,1	9,9	28,9	4,3	17,1

Years	GM soya beens		GM corn		GM cotton		GM rape	
	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%	Plough land, mln.ha	Share in the general plough land area for this crop,%
2005	54,4	58,9	21,2	14,4	9,8	29,7	4,6	16,7
2006	58,6	61,7	25,2	17,0	13,4	40,6	4,8	17,1
2007	58,6	65,0	35,2	22,3	15,0	45,5	5,5	17,9
2008	65,8	70,4	37,3	23,3	15,5	47,1	5,9	18,5
2009	73,7	76,0	35,5	21,9	16,3	49,5	6,2	18,9
2010	79,1	78,7	38,2	23,4	17,6	53,4	6,6	19,4
2011	84,6	81,1	41,0	24,8	18,8	57,2	7,0	19,9
2012	90,0	83,3	43,8	26,2	20,1	61,0	7,4	20,3
2013	95,4	85,6	46,5	27,5	21,3	65,0	7,8	20,7
2014	100,8	86,8	49,3	28,8	22,6	68,8	8,2	21,0
2015	106,3	88,2	52,1	30,1	23,8	72,7	8,7	21,3

GM-plants development is rather a costly matter; therefore, the leading world developers – biotechnological and chemical corporations – focused their efforts exactly on those crops the production output of which is rather big: soya, corn, cotton, rape and also canola. According to Table 2, in 2015 the world general plough land distribution for different GM-plants would be as follows: 88% - for GM soya; 30% - for GM corn; 72.7% - for GM cotton; 21% - for GM rape. According to FAO today we have nearly 50% of GM-soya and 20% of GM-cotton. In the USA practically all the soya (90%), corn (75%) and half of cotton are genetically modified [18, p.46]. Among other GM-plants we have potatoes, pumpkin, papaya and canola. GM-tomatoes, GM-coffee, GM-sunflower are in the course of development. Moreover, a number of food products are under development to have enhanced food value.

As of today, GM-crops available on the market have [3, p.275]**:**

- Increased protection level on the basis of created GM-resistance to plants' diseases caused by insects or viruses;
- Increased GM-resistance to herbicides.

In general, primary agricultural farms demonstrate GM-crops increased output, while enhanced plants' resistance to herbicides achieved due to bio technologies, entails decreased herbicides use, which generally goes in line with strengthening environmental systems sustainability. At the same time usage of GM-plants and GM-organisms could have negative impact on human health and on society in general, causing the need to set up corresponding research institutes to evaluate the mentioned risks and general safety of using GM-crops and GM-organisms. In relation with this, many world leading countries, which are developing genetically modified plants and organisms, create corresponding research institutes to assess biotechnological risks and bio-safety connected with GM-foodstuff to perform research by the following directions [19, p.1]:

- Direct impact on human health (toxicity);
- Possibility of allergic reactions manifestation (allergic impact of food products);
- Identifying components that may have both nutrition and toxic properties;
- Determining resistance capacity of the embedded gene;
- Impact on the nutritive process which relates to the genetically modified product, etc.

Implementation of nano-technologies and nano-materials in agricultural-industrial system is a vivid example of converging NBIC-technologies application to achieve a synergy effect in biotechnologies development. It includes [20, p.351–357]:

- Biotechnology (it pertains first of all to genetic engineering);
- Agro-industrial output production and reprocessing;
- Water treatment;
- Solving the problem of agricultural products quality assurance;
- Environmental protection (including also agricultural lands).

Solving the problem of providing sufficient volume of drinking water for the humankind would become one of the most important tasks for the next decades. With regard to the current water consumption volume, population growth and industrial development, two-third of the Earth population would experience lack of usable fresh water by 2050. Nano-technologies implementation to clean and disinfect water would help solve the indicated problem at the expense of using cheap decentralized water treatment and desalination systems, as well as systems to separate pollutants on the molecular level and cutting-edge filtration systems. For example, IBM company signed agreement with Saudi Arabia government to open a laboratory «Green nanotech», the most important task of which would be designing a water treatment system using nano-membrane materials for reverse osmosis and sea water desalination [21, p.49].

Increasing crops yield in agriculture is one more important task. Regardless of the world community protests, a number of world regions, where there is big rate of population growth and unfavorable conditions for agricultural work, would continue solving the food problem with the help of designing, creating and producing transgene high-productive plants with the help of bio- and nano-technologies, which would be resistant to virus infections.

It is stipulated that nano-technologies implementation would help change the technology of soil treatment at the expense of using nano-sensors, nano-pesticides and water treatment decentralized systems. Nano-technologies would provide for curing plants on the gene-level, would help create high-yielding breeds, which would be especially resistant to unfavorable environmental conditions.

In crop farming, usage of nano-powder, combined with anti-bacterial components, would ensure resistance increase to unfavorable weather conditions and would lead to two-fold increase of crop-yield of many food crops, as, for example, potatoes, grains, vegetables, and fruit & berry crops. Zeolite materials could successfully be used in the composition of fertilizers to ensure a more durable effect (prolongation effect), prevention of nutritious elements washing out after the application, or as pesticides carriers to optimize soil acidity as well as to prevent caking of mineral fertilizers in the process of their storage. New types of nano-bio-technological drugs could be generated to combat phytho-pathogenic bacteria on the basis of using new micro-organisms (predacious nano-bacteria) to serve as sort of "living antibiotics" for plants. Nano-technologies could also be successfully used for optical deciphering of protein-lipid-vitamin-chlorophyll system in plants as well as to decrease a harmful impact of motor transport on nature [14].

In animal farming bio-nano-technologies could be used to create bio-compatible materials, to restructure and build up tissues, create artificial tissues that are not rejected by organism, and create sensors (molecular-cell composition). Nano-admixtures are widely used in fodder production, where they provide for 1.5 – 3 times animal productivity increase as well as providing for the resistance to infectious diseases and stress. Nano-size of fodder admixtures helps not only considerably decrease their consumption but also ensure a more abundant and efficient digestibility by animals.

Research in the field of bio-nano-technologies is one more important direction of NBIC-technological work in agriculture. That research includes [14]:

- Directed protein synthesis to obtain peptides with desired immune-gene properties;
- Creating vector-systems to clone immune-meaningful proteins-causal agents of especially harmful animal diseases as well as cutting-edge vaccines, that have increased activeness and safety;
- Obtaining nano-particles of gene-engineering proteins; development of biotypes and test-systems for biologic screening, immunological monitoring and forecasting dangerous and economically meaningful infectious animal diseases;
- Implementing membrane systems as well as biocide surfacing material and materials on the basis of silver, which would provide for a simpler and improved keeping of agricultural animals and providing them with qualitative drinking water;
- Developing nano-bio-technological methods to identify markers, matched with economically valuable features and with virus, bacterial and parasite diseases in fish for their probable utilization in the practical fish-breeding;
- Developing nano-bio-technologies for functional food supplements and substances with using the methods of ultra- and nano-filtration, nano-encapsulation, disintegration as well as using directed ferment modification of nano-bio-structures (e.g., cheeses, yogurts, etc.) and so on.

Food companies use biologic nano-particles with the size of several hundred atoms in food products (edibles, beverages, chewing gum) in ever increasing scale. For example, nanometric layer of titan dioxide, which has been applied to Mars bar, increases its storage life several times. In reality we have a product, which is packed into a package (nano-foil) made of titan dioxide. With this, an organism can also digest the nano-metric titan dioxide. At the same time, similarly to nano-cosmetics, the level of safety of nano-technological admixtures wide use has not yet been clearly determined. For example, Dutch company "Friesland Foods" – one of the biggest cheese producers – has been developing technology of using nano-size sieves, which are more acceptable to ensure end product safety [22]. The aim of the work is to organize highly efficient milk separation into proteins, polysaccharides, and fatty acids. In near future nano-technological admixtures that are capable of changing food taste and dietary qualities would become mandatory components for many food products.

Conclusions

In conclusion, the results indicate that the most promising for the development of the bio-economy in the World and Ukraine are following directions: industrial biotechnology (food biotechnology; biotechnology of sea products; biotechnology to increase oil recovery); environmental biotechnology (cleaning soil from pollution; environmentally friendly biocides to protect materials from bio-damage and oxidation; waste water treatment from toxic metals and radio-nuclides; air cleaning, including also cleaning of enterprises' vent emissions from volatile organic components, etc.); biotechnology in power engineering (modular biotechnological equipment, including also bio-reactors and bio-diesel).

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