ACTUAL ASPECTS OF ORGANIC AGRICULTURE DEVELOPMENT IN UKRAINE

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The monograph presents a conceptual analysis of the development of all sectors of organic production in Ukraine, the problems of sustainable increase in the efficiency of agrobiocenoses, the economic aspects of the formation of organic production according to European standards, and the analysis of opportunities for the agrarian sector. The approaches to the application of new methods and tools in organic production are described. The monograph is prezented for specialists, employments of the agrarian sector, scientists, professors, students and masters, all those who are interested in the specified range of questions that are being analyzed.

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INTRODUCTION

The development of the agricultural sector contributes to improving the material well-being of the population, enhancing the country's economic and food security, and increasing its export potential. The agricultural sector of production is one of the most risky in the economy, as it is strongly influenced by natural factors and biological drivers (Kobylynska, 2013).

At the present stage, in the agricultural production of Ukraine, there have been fundamental social and economic transformations leading to the introduction of new forms of farming on the basis of private ownership of land and property, and the market production relationship has been developed, based on commodity and money circulation in order to maximize profits. The consequences of such transformations, as well as the long-time extensive approach to land use have led to the unstable state of the industry, ecological imbalance in the natural environment and an increase in social tensions (Kaminskyi, 2015).

Modern observation of the land quality status indicates that the issue of ensuring sustainable soil fertility in Ukraine has not been given due regard. The land reform, initiated in 1991, has been implemented without taking into account the fact that agricultural land, as the main means of production, should be constantly monitored and protected. When eliminating the monopoly of state ownership of land that had existed before 1991, most agricultural land (28.1 million hectares of agricultural land) was transferred to private ownership, private agricultural organizations were spontaneously created, which led to a breach of the previously existing scientifically grounded system of sustainable land use. (Melnyk, Zhmurko, 2010)

Intensive economic activity and uncontrolled use of natural resources resulted in the increased destruction of soils with water and wind and in the weakening of certain components of the natural environment. The distribution of land shares has led to a violation of the agricultural land planning, in particular of crop rotation. (Melnyk, Zhmurko, 2010).

The land fertility is critically reduced because of the excessive and incorrect use of land. Progressing deterioration of soil quality, its reducing fertility creates a real threat of crisis for agricultural production, in particular for food production (Hensyruk, Furdychko, Bondar, 1995, Melnychuk, 2014).

The priorities of modern agrarian science are the search for ways to increase the efficiency of use and reproduction of natural resources, energy and resource saving, stability and ecological safety of agricultural landscapes, their adaptation to the natural self-regulation of biosphere (Ecological Problems of Agriculture, 2010).

The only way to prevent environmental threats to the biosphere is the environmentalization of agricultural production. This concept is understood as the complex of measures covering: rational use of natural resources at all stages of their processing; their reproduction and replacement with other types of raw materials; a dramatic reduction in waste and the content of useful substances in them; rational distribution of production facilities; development of ecological consciousness in all employees (Environmental Problems of Agriculture, 2010; Kobylynska, 2013; Stupen, Kazmir, 2014).

Consequently, there is a need for the development of alternative production systems (Sharapatka, 2010; Chaika, 2013). The practical implementation of the general concept of sustainable development is the transition to organic production, which allows meeting the challenges of society, without compromising the health and existence of future generations (Chornous, Hura, 2014).

Relevant promising strategies of organic agricultural enterprises development are shaped slowly to a certain extent due to imperfect infrastructure of organic agri- food market, which is the basis of effective operation of all components of the organic sector. The innovative component of agrarian products, which is formed in compliance with the requirements and, consequently, with the certification under organic standards, provides significantly higher profits with minor expenses for the development of organic production (Leheza, 2014; Connolly, Liamand McDonnell, James. 2008).

From the standpoint of agroecology, the attributes of organic production have been defined sufficiently, namely: initial paradigm, key concept, reference model, technology, compliance with the biodiversity conservation program, rules, standards and process of certification (Bellon, Lamine, Olivier, Abreu, Santiagode. 2009). At the same time, the availability of attributes, as well as the actual institutional and economic conditions, determines certain parameters of organic production development in a particular country, which ultimately affects global processes (Davis, Muller, Olesen. 2012).

To develop the most effective and rational methods of agroecosystem restoration, the study of their natural evolution processes is of great importance (Uzbek, 2009; Volokh, 1996; Zabaluiev et al., 2002; Kobets et al., 2013). This calls for the development of methods that enable timely detection of degradation, the establishment of long-term trends and natural ecosystems' buffer capacity in terms of negative factors. In addition, this allows establishing the positive development of agricultural land, the area of their development ("Biological...", 2010), and creating a forecast regarding the rates of restoring environmental capacity of agroecosystems (Sumarokov, 2009).

The development of organic production does not depend solely on state support, in certain institutional environment there are particular optimal conditions for the balanced development of the "agrobusiness-community-nature" relationship. It is possible to minimize conflicts within the "agrobusiness-community-nature" network provided that the production development mechanisms are selected in compliance with the positive trend of transformation of the environment and are in line with the organic standards.

The purpose of this research is to develop and substantiate theoretical and methodological, scientific and applied bases for the formation of organisational, economic and agro-ecological principles of organic production development.

The fundamental basis of the entire system of human and nature economic relations is the natural capital concept. Natural capital is an aggregate of bodies and features of natural or anthropogenic systems that can create new values (added value, natural resource rents), or modify available resources by providing them with additional consumer value (Bahrov, 2010; Chervaniov, Bokov, 2001). Natural capital is included in the national wealth of the country along with the produced, human and social capital (Chervanev, 2013). It is considered to be one of the drivers of country's economic growth and the well-being of its population and is used by the World Bank and other influential international foundations to identify the sustainable development indices (TEEB, 2009; TEEB. 2010; TEEB, 2010).

Awareness of the threats of resource scarcity and reducing possibility of natural self-regeneration of ecosystems forces society to review the basic principles of its interaction with nature and to constantly search for new ways of development. Strategic ecological and economic guidelines for the environmental management require the inclusion of natural capital in the mechanisms of economic functioning, as well as the development and implementation of economic mechanisms for the management of ecosystem services (Mishenin, Dehtiar, 2015).

According to the definition of the International Federation of Organic Agriculture Movements (IFOAM): "Organic Agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" [Official website of the International Federation of Organic Agriculture Movements [Electronic resource].

According to the Concept of Biodiversity Conservation, developed in accordance with Article 16 of the Constitution of Ukraine, the Convention on Biological Diversity, the Pan-European Biological and Landscape Diversity Strategy, the Program of the Prospective Development of the Protected Areas in Ukraine and the Cabinet of Ministers of Ukraine Activity Program (Resolution of the Verkhovna Rada of Ukraine dated October 15, 1996 No. 412 (412/96-BP), the biodiversity is the national wealth of Ukraine, which ensures ecosystem and biosphere functions of living organisms and their groups, and forms the environment of human vital activity. The purpose of this concept is the promotion of the transition to a balanced use of natural resources; raising the awareness of the population on biodiversity issues, as well as increasing the participation of citizens in its conservation activities; increasing responsibility for preserving the biodiversity of enterprises, organisations and institutions, whose activities relate to the use of natural resources or have an effect on the state of environment. (Resolution of May 12, 1997 No. 439 On the Concept of Conservation of Biodiversity of Ukraine).

In the United States of America, the ecosystem service of pest control by natural insect populations (Carabidae, spiders, etc.) is worth 13.6 billion per year (Losey, Vaughan, 2006). In spite of the fundamental importance of soil in agriculture, economic assessments of negative impacts on soils are mainly limited to erosion and pollution, while the value of biological diversity of soil biome has been very poorly investigated (Nuti et al., 2011). The value of soil biome activity in the soil formation process is estimated at USD 5 billion per year in the USA and at USD 25 billion globally (Pimentel et al., 1997; Ecosystem services ..., 2015).

Biological diversity is the main parameter of evolutionary process, being at the same time its outcome and the factor, operating under a feedback principle. The diversity is the basis for the mechanisms of sustainability of life on all its levels - from organism and cellular to ecosystem level. Substances can circulate only at a sufficient biological diversity (Chernov, 2008).

Formation of the animal species diversity under the influence of various environmental factors is of great theoretical and practical importance. It is also very important to identify the value of the factors promoting the conservation of ecological diversity and determining the complex biogeocenotical relationships, accounting for high biological productivity in ecosystems (Pahomov 2003), and therefore in agroecosystems.

Reduction in the diversity of the pedofauna results in the decrease of the level of zootic processes and degradation of soil mantle. Therefore, in modern conditions, the issue of the protection of soil fauna is pressing (Sokolova, 2011).

Fauna is an important component of soil groups, which determines the trend of the soil-forming process and the level of soil fertility (Giliarov 1987, 1965; Perel, 1979). Soil invertebrates play an important role in the decay of plant remains, transformation of organic material, formation of the humus horizon, formation of the soil structure, circulation of biogenic elements and maintenance of the homeostasis of the soil biome as a whole (Giliarov, Kryvolutskyi, 1985; Kryvolutskyi, 1984).

Biodiversity and soil fertility are the basis for the sustainable functioning of organic agriculture. During the formation of organic agroecosystems, it is necessary to create an agro-landscape and to implement agricultural measures that contribute to the conservation and increase of biodiversity of various living organisms and organic matter of soils (Nikolaieva, Grygorian, Sungatullina, 2011).

Implementation of the State Strategy for Regional Development for the period up to 2020, which states that Dnipropetrovsk region is one of the most economically developed regions of Ukraine. However, the current structure of the region's economy does not provide a guarantee of accelerated development of the region for the next period and a guarantee of a sustainable improvement of the quality of region residents' life in the mid-term perspective.

According to the data provided in the Strategy, agricultural production accounts for more than 80% of the region area (6.0% of Ukraine's agricultural land). It is also noted that extensive agriculture, using monocultures and applying no principles of crop rotation to maintain soil fertility, has a significant effect on the state of land resources. One of the main environmental problems of the Dnipropetrovsk region in the context of the strategic goal 3 "Ecological Safety" is the ecologically unsustainable agricultural development of the land, high level of territories ploughing. The assessment of the state of land resources by calculating the coefficient of land use environmental stability shows that the situation in the industry in Dnipropetrovsk region is referred to environmentally unsustainable, due to the presence of a high degree of human-induced impact on land resources.

The problem of unsatisfactory ecological situation in the region requires an urgent solution, the first step of which shall be the creation of appropriate conditions for carrying out activities for the improvement of the environment status, the list of which should include the development of the general consciousness of the population regarding the preservation and care of the environment, especially in urban and industrial zones. Particular emphasis shall be placed on shaping the ecological culture of children and young people.

Consequently, further successful implementation of the regional development strategy for Dnipropetrovsk region is impossible without taking into account the principles of sustainable development and without the use of "environmentally friendly technologies", especially in agriculture (Bezus, Amelina).

In a context of significant intensification of agricultural production, it is the organic farming that ensures not only the achievement of food security, but also the successful resolution of environmental issues (Bezus, Amelina). Organic agriculture is essentially a multifunctional agroecological model of production with defined goals, principles and methods, based on careful management (planning and controlling) of agroecosystems (Sirenko, Chaika, 2011).

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CHAPTER 1. CONCEPTS OF THE ORGANIC PRODUCTION DEVELOPMENT INVESTIGATION

The past century was characterized by the desire of mankind for the growth of technical and economic potential, which was expressed in the increase of the gross domestic product within the country. Scientific and technological progress, high dynamics of population growth and increase of life expectancy have raised the issue of guaranteeing food security to a new level. This was the root cause for finding operational decisions to increase the efficiency of farming, among which the widespread use of artificially synthesized fertilizers and animal and plant protection products, selective experiments that gave impetus to the development of genetic engineering, reserved a leading position. As a result, mankind found itself on the brink of ecological catastrophe.

The agrarian sector of the economy of Ukraine, the basic component of which is agriculture, forms food and, within existing borders, the economic, ecological and energy security, ensures the development of technologically related branches of national economy and creates social and economic environment for rural development. The agroindustrial sector accounts for up to 13% of the country's gross added value, and is one of the key budget-generating sectors of the national economy, the share of which in the consolidated budget of Ukraine in the recent years has constituted, on an average, 20%, and in the commodity structure of exports - more than a quarter, ensuring the leading position in the world market of sunflower oil, and the second position - in the export of cereals. The sector employs 23% of employable population and uses more than one fifth of the national economy's fixed assets. However, almost half of the gross agricultural output is produced today in households. Much of these products is manufactured in natural ways, which creates a base for the development of organic agricultural production (Munasinghe, M., Cruz, W.,1995).

In modern agriculture, there are such types of production, which are subsequently combined with each other as conventional (traditional) production; production using genetically modified products; alternative eco-friendly technologies. The predominating system of agrarian production, sometimes referred to as "conventional production", "modern production" or "industrial production", receives significant benefits in terms of productivity and efficiency. Over the past 50 years, food production has grown worldwide. According to the World Bank estimates, from 70% to 90% of growth of such products production is the result of conventional agricultural production, rather than the extension of cultivated area (“World Development Report 2008”, 2007).

The conventional system of management varies by its differences in each economy, in each country. However, there is a combination of numerous characteristics: rapid technological innovations, major capital investments for the application of technologies of production and management, large-sized enterprises, single-crop farming, uniform high-yielding hybrids of cereals, the widespread use of pesticides, fertilizers and external energy consumption, high efficiency of labor and dependence on agrobusiness. In the case animal breeding, the majority of production depends on constraints, a concentrated production system.

The trends of agricultural methods enhancement, the implementation of which ensures the positive dynamics in the environment remediation, are the introduction of alternative systems of agricultural management, which primarily include Conservation Agriculture; Biointensive Mini-Farming; Biodynamic Agriculture; technologies of using effective microorganisms or Effective Microorganism

Technologies; LISA – Low Input Sustainable Agriculture; Organic Agriculture or Organic Farming; Precision Farming or Precision Agriculture (table 1.1).

Table 1.1

Characteristics of the main soil cultivation systems

System of cultivation	Main trends	Effect on soil	Landfarming	Advantages
Conventional	Prevention of germination of weed seeds and fallen fruit, destruction of capillaries and cutting of weeds before plowing; preparation of the seed bed of uniform depth and aggregated structure of the soil seed layer; wrapping of seeds at a given depth provided that the seed is sown in a high-quality prepared soil	Soil loosening with full rotation of a seam to the depth of 20-32 cm	Complete remains burying at plowing to the depth of 8-12 cm	The availability of soil cultivation machinery and experience of its use
Conservation	Soil mulching; complete cutting of weeds; wrapping of seeds at a given depth	Basic subsurface tillage at a depth of 25-40 cm	Up to 50% of vegetable residues are ground and mixed	Additional accumulation of productive moisture in a meter-deep layer of soil up to 30 mm
Mulching	Soil mulching; wrapping of seeds at a given depth	Soil top layer treatment at depths up to 10 cm	At least 30% of plant residues are ground and mixed	Preservation of productive moisture in a layer up to 15 mm
No-ill	Soil mulching; chemical weeding; wrapping of seeds at a given depth	The soil is not cultivated	Plant remains are not removed and are left on the surface of the field	Preservation of productive moisture in the root layer of soil up to 10 mm

Note, that the above mentioned alternative agricultural system, aimed at environmentalization of agricultural activities, are usually associated with the concept of "organic production" and a counterbalance to the popularization of intensive technologies and genetically modified organisms (GMOs). The "organic production" and "conventional production" (with GM plants) systems are based on various key principles: organic farming does not utilize synthetic chemical pesticides, herbicides and fertilizers.

In organic production, the production issues can not be solved using one-time methods. The persistence of solutions can only be ensured by a combined effect of different measures: the method of cultivation, the selection of crop rotations, landscape ecology, useful insects, pesticides not harmful to the environment, and forecasting systems (table 1.2) ("GMO in organic…").

Table 1.2

Comparative analysis of aspects of organic production and genetic engineering

Aspects	Organic production	Genetic Engineering
Principles and ethical position	The motto: "Whole is better than the sum of parts." It seeks economic, social and environmentally viable production. The dignity of the living things is valued highly.	The motto: "Whole is the sum of the parts." Seeks simple production with high yields. The impact on the plant/animal and the interaction within the ecosystem are generally ignored or unknown.
Farmer/knowledge	Significant know-how and the fundamental right to make decisions. Based on solid empirical knowledge and skills of farmers and modern research to provide new innovative technologies.	Most know-how apply to agro-industry.
Product aspects	Goal: a product with high (vital) properties.	Goal: a product with optimized content of specific components.
Production and economic aspects	System solution of problems. The management system has a positive effect on the land plots value. The added value is formed on account of the positive impact on the environment. Local production and consumption. The diversity of plant species and livestock is a public good with a great cultural value.	Continuous remediation of the effects of activity. The management system leads to the degradation of the soil. The added value is created on account of damage to the environment. Dependence on multinational companies. Capital-intensive development. Bread and cereals -are the objects of commercial use (patenting).
Social aspects	Widespread use of manual labor involves a large number of employees per unit area. The owner of the production resides in the community and has a permanent connection with it.	Minimization of manual labor and high levels of automation do not involve a large number of employees. The community and the owners of the production are not in contact.
Environmental aspects	The risks of the generation of persistent harmful organisms are minimal. Promotion of natural self-regulation ability, including health and endurance of soils, plants and animals.	The risks are known, resistance control protocols are distributed among farmers, but are not always used.

Organic farmers have decided not to use either genetically modified organisms or their derivatives. Organic farming, in spite of this, is not a closed agricultural system.

About 170 million hectares, constituting 10% of the world's plowland, are used to grow GMO plants, although unofficial statistics provides considerably higher figures. The leaders in the cultivation of GM plants are the USA, Argentina, Brazil, India, Canada and China. However, there are the countries that have completely or partially refused from the cultivation of GM plants. Among them there are France,Switzerland, Austria; at least 35 countries have created GMO-free zones (Timochko, Gulenko, 2007)**.**

The central authorities of executive power of Ukraine keep the State registers of GMOs and GMO-based products, post information about them on their official websites and publish it regularly in mass media. Moreover, depending on the objects of registration, there are four relevant public registers in Ukraine, in particular, the State Register of GMO varieties of plants and breeds of animals based on GMOs, which is kept by the Ministry of Agrarian Policy and Food of Ukraine; the State Register of GMO means of crop protection, obtained through the use of GMOs, kept by the Ministry of Ecology and Natural Resources of Ukraine; the State Register of GMO food sources, as well as food products, cosmetics, medicines, which contain GMOs or are GMO-based, kept by the Ministry of Health; the State Register of GMO feed sources, as well as feed additives and veterinary drugs that contain GMOs or are GMO- based, which is maintained by the State Veterinary and Phytosanitary Service of Ukraine.

From the date when the law "On the State System of Biosafety when Creating, Testing, Transporting and Using Genetically Modified Organisms" became effective, no GMO have been registered in Ukraine (“State regulation of GMO…”). The uncertainty of the GMOs' impact of and the difficulty of implementing the GMOs transfer permanent monitoring systems make the operation of farms, certified according to organic standards, even more complicated, because at the exchange of seeding machines or harvester threshers with inorganic producers, the probability of

GMO contamination becomes too high.

Unlike modern industrial methods of farming, organic and, in particular, biodynamic technologies are based on the use of internal resources of the economy. Consequently, organic farmers improve land and build a model of independence of food production from expensive external materials. This practice leads to greater economic independence of agrarian production and the possibility of lowering prices for food products, to improving its quality and to building a trust-based relationship between the producer and the consumer. It is obvious that the most important role in this concept is played by the branch of organic production itself. After all, according to the official point of view of theInternational Federation of Organic Agricultural Movement (IFOAM) ("IFOAM Basic Standards…", 2002), the production and processing of organic products is based on numerous principles, which cannot be prioritized, because they are all equally valuable. It should be emphasized that these principles are interrelated with the mentioned principles of transition to sustainable development (table 1.3).

Actually, the industry of organic production the most successfully solves the problem of the sustainable development strategy, offers food, which not only support activities, but also improve the health of the people; provides economic benefits for the manufacturer and the consumer; uses fairly simple, consistent and available methods and tools for farming; maintains the biological balance in nature.

In the long run, organic production is able to align and harmonize the economic, environmental and social goals of the agricultural sector.

The key motivating factor in the consumption of organic agricultural products is the person's care about its own health, the health of its family and relatives. It can be argued that such a motivation will continue to dominate. This idea is supported by a famous statement by Arthur Schopenhauer: "Health so far outweighs all external goods that a healthy beggars is truly more fortunate than a king in poor health" (Schopenhauer). Therefore, the maintenance of health is the most valuable thing not only for a particular person, but also for society as a whole.

Table 1.3.

Compliance of the organic production principles with the principles of sustainable development

The sustainable development principle	The organic production principle
The priority of humanistic spiritual values, as opposed to the model of consumption, characterized by the wasteful use of natural goods and resources	Production of high-quality food, raw materials and other products in sufficient quantity
Adaptation of public life support systems and territorial management to existing natural structures (landscape systems, catchment basins, etc.)	Harmonization of work in the system of production with natural cycles and living systems of soils, flora and fauna
Social partnership and involvement of citizens in the process of making environmentally significant and other decisions to strengthen the role of social structures of a decentralized information society	Recognition of wider social and environmental impacts outside/within the organic production and processing system
Encouraging the spreading of best practices and the introduction of advanced technologies	Conservation and improvement of soil fertility and biological activity of soils by means of local cultural, biological and mechanical methods instead of using external factors (resources) of production
Equal and fair access to natural resources, financial capital markets, modern technologies and knowledge	Use of renewable resources in production and processing systems whenever possible, the prevention of losses and pollution of such resources
Inter-industry cooperation in society, causing a synergistic effect of multiple collaborating efforts due to the improvement of the interaction between economic, social and environmental spheres, coordination of plans and programs of different levels	Ensuring each worker employed in organic agriculture and its products processing a quality of living that satisfies the requirements of a healthy and safe environment

Below, the origins of the development of alternative methods of management and organic production as one of the most widespread technologies are studied. One of the founders of the ideology of search and introduction of new forms of farming was the Japanese philosopher Mokichi Okada, who believed that agriculture should fulfill the following tasks: to offer food products that not only support livelihoods, but also improve the health of people; be economically profitable for the manufacturer and the consumer; to produce products in sufficient quantities to meet the needs of a growing population; not to violate the biological balance in nature, to be environmentally safe;

to use fairly simple, reliable and available methods and means of farming (Kobets, 2004).

The British agronomist Sir Albert Howard used the principles of organic production since 1900. In the early 1920s, a group of British practicing farmers, in order to address the problem of soil degradation and the general deterioration of crop and livestock production and, as a result, of future agriculture, consulted Dr. Rudolf Steiner (the founder of anthroposophy), who in June 1924 set up the fundamental principles of biodynamic agriculture and gardening (Minenko, 2011).

For many decades, organic farming has remained an unpopular trend in the overall global agricultural production process. A small number of farmers began in the 1930s to practice organic farming on their pilot lands, producing natural products for a limited range of consumers (Petrina, 2010, p. 207; ("Biodynamic Farming…"). Proponents of the farmers' movement determined the destructive characteristics of American agriculture, the essence of which was the interest exclusively in short-term profit (Guthman, 1998, p. 138). J. Rodale, a producer and a publisher, popularized the American organic movement even more in the 1940s by supporting the safety and nutritional value of organic products. Organic agriculture eventually turned into a complex of alternative methods of production (Artish, 2012, p. 19).

Development and popularization of the organic movement led the so-called "green revolution", the goal of which was to introduce complex changes in agriculture of developing countries in order to enhance the efficiency of agricultural activity. The main trends in improving the farming efficiency were high-yielding plant lines breeding, expansion of irrigation, the popularization of the use of chemical plant protection products and fertilizers, as well as of modern technologies. In fact, it became a "chemical revolution", which resulted in a rapid increase in the number of consumers who refused from the products obtained using pesticides and fertilizers ("Agribusiness: problems…", 2011, p. 143).

The modern organic farmer movement emerged in the 1960s as a reaction to the "green revolutions" of the 1950s and 1960s. It was ready to meet growing food needs of the population, whose number was constantly increasing. In her book on organic farming, J. Gutman identified five components that influenced the development of organic farmer movement. The first ones were the movement for clean food and the adoption of the US Food Security Act in 1906, introducing food regulation and standards. The second component was a healthy food movement, which focused on natural foods. One of the main arguments declared by this movement was that the food industry impairs the nutritional value of products. The counterculture movement of the 1960s also influenced the organic movement of agriculture. These campaigns persuaded to become engaged in organic production or join food cooperatives where participants were engaged in organic farming. Participants in these movements in general shared the fundamental philosophy and values based on the integrity and health of the body, earth and spirit (Guthman, 2004, p. 312).

When equating and consider the establishment of organic agricultural production in France as one of the countries which is one of the ten largest countries in terms of acreage of agricultural land used for the organic agro-production (Willer , Lernoud, 2013), then company leaders caring about the quality of food raw materials, were the pioneers of organic agriculture. The development of organic farming in this country can be divided into three stages.

Summarising the above and based on the study and systematization of approaches to evolutionary change in the theory of organic production development, on the basis of structural and functional approaches to the analysis of retrospective nature of the organic method, we can state permanent qualitative changes in the economy and society and distinguish the four stages of its formation: I - the formation of a theoretical and applied basis of ecological awareness (3d century BC – 1950); II -the emergence of groups of pioneers-practitioners within the organic movement and the "green revolution" in individual countries (1950-1980); III - the separation of organic products market segment and the emergence of specialization of producing farmers (1980-1990); IV – the formation of the institutional environment, infrastructure development, growth of the market of organic agricultural food products, enhancing the industry specialization (1990 - to present).

Therefore, the agricultural production is the main consumer of natural resources and at the same time the source of environmental pollution. At the production of agricultural products, different types of resources are used, which can be divided into non-renewable and renewable. Agriculture, like any other industry or activity, should strive to operate in accordance with the concept of sustainable development. The essence of such an approach is that development should be carried out in such a way as to fully meet the needs of modern society without threatening to limit the ability of future generations to use natural resources. That is, the production activity should be based on minimization of use of non-renewable natural resources and on a thrifty attitude towards the environment. Thus, organic production, while ensuring the coordination of the economic, environmental and social goals, produces a synergistic effect in the form of new competitive advantages on the market and is able to increase the level of economic security both in a separate field, and in the country in the whole. For the purpose of consumer's comprehensive informing, "organic", "ecological"and "biological" marking, as well as their reductions to "eco-" and "bio-" can be applied only on the products in which the minimum content of the weighted components, produced on environmental farms that are certified according to organic standards, is at least 95%.

The use of terms that confirms the use of organic technologies in the production of products is defined by historical, cultural and mental prerequisites. Thus, in Austria, Germany, Switzerland, Italy, and France, the most commonly used term is "biological", in Switzerland, Norway, Denmark, Spain – "ecological", in Australia, England, the United States, Canada and Georgia – "organic." In addition to the terms "biological", "environmental", "organic", the term "biodynamic" agriculture is used. Biodynamic agriculture is aimed not at the production of crop products directly, but, primarily, at the creation of environmentally sustainable agro-landscapes through the system improving soil structure and enhancing their natural fertility. The foundation of biodynamic farming is a complete refusal from chemical plant protection products, because the crop protection chemicals cause damage to soil inhabitants, i.e. the basis of biodynamic farming (Bezus, Buhalo, 2012, p. 28).

The imperfect system of consumer rights protection and the growing popularity of organic products in Ukraine contributed to the emergence of examples of unfair competition among agricultural producers. Thus, in Ukraine, there are several types of products that do not meet the standards, but have been positioned as "environmentally friendly products", "grown in an ecologically balanced environment", "green". The use of these estimates and deceiving of Ukrainian consumers is now possible due to the lack of a regulatory framework. Ukrainian legislation operates with the concepts of "environmentally safe", "ecologically balanced", and "organic". The first two terms focus on environmental safety, which are similar, but not equivalent to the concept of product quality. According to Art. 29 of the Law of Ukraine "On the production andcirculation of organic agricultural products and raw materials", organic products imported from other countries of origin, which is confirmed by the relevant standards, marked with the text "organic", "biodynamic", "biological", "ecological", or words with the "bio-" prefix, etc., must be translated into the Ukrainian language and labeled as "organic product". When marking the imported organic products, its marking is carried out and the "organic product" state logo is used (“ On the production…”, 2013). Pioneers in agriculture, whose ideology follows the principles of sustainable development system and holistic system of organic agriculture, industrial organic producers are currently unable to agree on a single concept of "organic agricultural production". Industrial organic farmers with large volumes of production of organic products and with the use of technologies that minimize the role of humans in the process of farming, obtain a lower cost, and due to the scale effect they reach the best financial results of management. They are more competitive and actually do not provide any prospects for the formation of a market for agricultural producers, who practice a holistic approach to the production of organic products (Fig. 1.1).

Organic agriculture is a prerequisite for the conservation of numerous wild animals and birds, whose life cycle is connected with the use of agricultural land. Due to the rapid reduction in numbers of species and amount of fauna representatives, many of them are included in the Red List. Usually, all company activities should proceed to organic production. In the case of fragmentation of the production process, the company units must be clearly distinguished between each other. The period of the enterprise transition to organic production is two years.

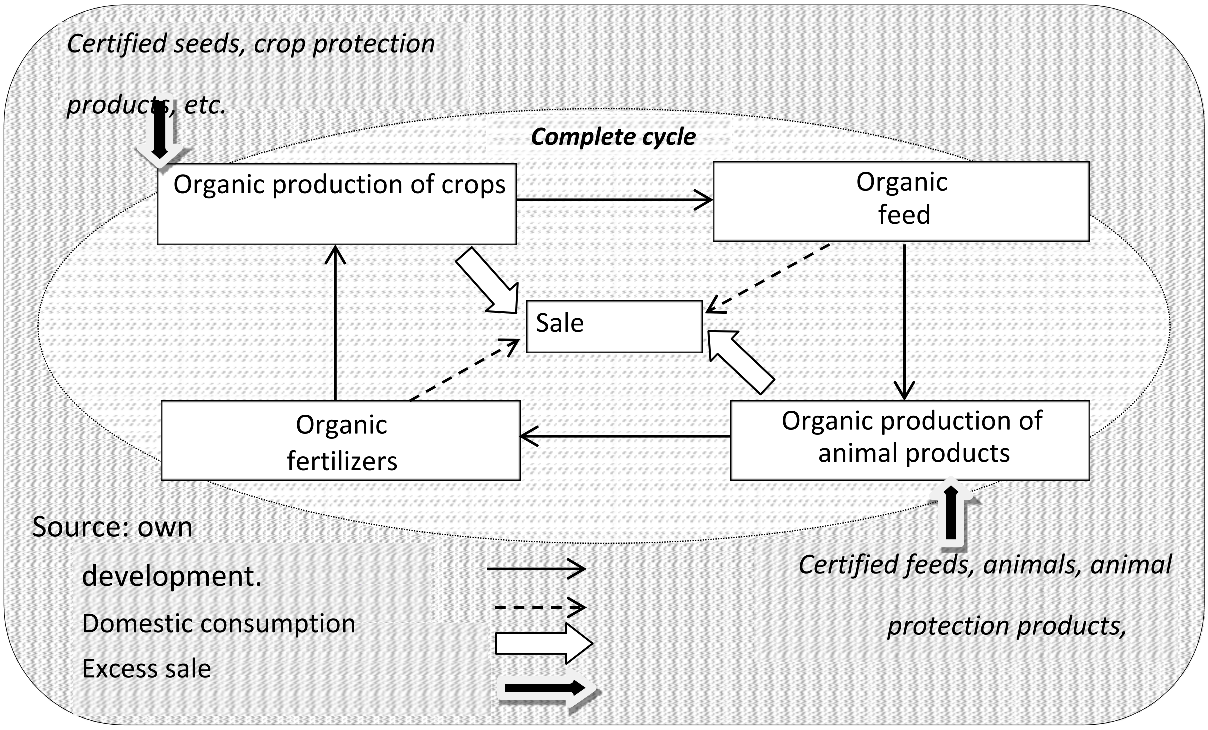

Fig. 1.1.

The maximum allowed amount of organic fertilizers per 1 hectare, related to the active substance, 170 kg of nitrogen, which is equal to keeping two cows per hectare of the area. As of early 2015, in Ukraine, as a whole a relatively low efficiency of plow lands management was registered, and from year to year the number of eroded areas increases, the development of erosion processes extends to the territory of 80-90 thousand ha, that is 5 times more than the area of a country like Liechtenstein. Another negative phenomenon is the deficit of main fertilizer elements in soil, which amounts to 110 kg/ha, and losses of humus by soils, according to various estimates, constitute from 0.5 to 0.9 t/ha annually (Bezus, 2012; “State Land Cadastre…”, 2009; “Evil gene”, 2011). In modern economic management conditions, soil quality improvement is achieved by the various agrotechnological methods, including intensive technologies of crop production. However, improving the quality of the soil with the use of intensive technologies means high rates of application of artificially synthesized chemical fertilizers and herbicides, which damages the microorganisms that create natural fertilizers in soil. Moreover, the effects of artificially synthesized plant protection products on the environment are often unpredictable.

Awareness of the fact that mankind creates artificially synthesized substitute fertilizers and pest control products that have an unpredictable effect, including the negative impact on soil, a long period of decay of individual components, and ability to accumulate not only in plants but also in the human body, encouraged the progressive part of mankind to change environmental approaches, to the technologies used for the farming and for the production of agricultural and food products. Stabilization of the situation, restoration of species and amount of animals and birds in the areas, where products are produced, certified according to organic standards, are the consequences of the following (Elkabidze, 2004, p. 172).

– use of organic fertilizer only, which helps to increase the amount of organic matter in soil and supply opportunities for soil fauna and the species that feed on soil invertebrates;

– high diversity of cultural and agrarian species on organic fields, loose and layered structure of the grass that creates normal conditions for reproduction, hatching and care of the offsprings;

– structuring of lands (according to production standards, the thickets of bushes and forest bands are created) and reduction in their size. The investigated organic farms fields are smaller than normal (10-30 hectare on organic farms, 70-100 ha on traditional farms), which expands the "boundaries of the fields" that are important habitats of many species; extensive grazing of domestic animals (1.0-1.5

animals/ha), forming meadows rich in herbs;

– less production operations on organic farms than on conventional ones: plowing, pest control, use of mineral fertilizers, etc. That is, the life cycle of animals is much less affected; less disturbed due to farming;

– periodic allocation of land for fallowing.

According to production standards, organic farms allocate at least 10% of the land for fallowing yearly, on some farms the number amounts to 30%. It is these lands that create favourable conditions for the existence of many species of animals and birds (Elkabidze, 2004, p. 172). Farmers engaged in the production of organic products are forced to use genetically traditional varieties and species of plants, since they are most adapted to cultivation without introducing artificially synthesized crop protection products and fertilizers.

Organic farming is an agricultural system that promotes the preservation of environment, socially and economically supports the production of healthy food, fiber, etc. It avoids the use of chemically synthesized fertilizers, pesticides, veterinary drugs, while actively using natural drugs to increase the natural fertility of soils, the resistance of plants and animals to diseases (Milovanov, 2009, p. 258).

As Berezhnaia Y.S. notes, in a broad context, organic agriculture is a practical implementation of a general concept of "sustainable (ecologically and socially balanced) development" in the field of agrarian production, that meets the needs of the present, without threatening future generations' ability to meet their needs. (Berezhnaya 2010, p. 39-40). According to Kosianchuk N.I., Tiutiun A.I. and Yanenko U.M., organic farming inherently is a multifunctional agro-ecological production model, based on thorough management (planning and control) of ecosystems. It provides a possibility to balance and harmonize economic, environmental and social goals in the field of agriculture in the long run (Kosyanchuk, 2014, p. 77).

United States Department of Agriculture (USDA) in 1980 used the following definition: "Organic farming is a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests." (“Report and Recommendations…”, 1980).

Subsequently, the USDA National Organic Standards Board changed the definition of organic farming. Since 1995, according to the National Organic Program standards, it has been established that "organic farming is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony." (“National Organic…”).

According to the definition of the International Federation of Organic Agriculture Movements (IFOAM): "Organic Agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved." (“Agriculture of Ukraine…”, 2013).

Dudar T.O. characterizes "organic farming" as a complex ecologically balanced system of organic agricultural production, the key tasks of which are efficient production of natural products, which has biologically valuable qualities and healing properties to ensure a healthy diet of people and eliminates any risks to health, promotes the preservation of the environment the natural environment (Dudar, 2013, 193). In our studies, we equal the terms "organic production" and "organic farming". We believe that the use of the term "organic production" is appropriate in the case of products certified in accordance with organic standards, among which there are agricultural products, that is, the products of agricultural production.

In our opinion, the term "organic farming" means the system of soil cultivation, which is a component of organic crop production and involves the use of technology, aimed at soil quality enhancement, improving its fertility and prohibits the use of artificially synthesized crop protection products and mineral fertilizers. Unlike organic crop production, organic farming does not require the obligatory tracking of operations and drugs used in technological operations. Records keeping and the availability of accounting information at crop production makes provides for a certification for the conformity of crop production with organic standards.

Organic crop production is a prerequisite for the existence of organic animal breeding, since organic animal breeding should use organic feeds. Organic animal breeding is a system of production of livestock products that requires keeping records of the economic entity's activity, using organic feed during the process of animals fattening, a special treatment, prohibits the use of artificially synthesized animal protection and growth-promoting agents, and is certified by the national or international standards.

The result of the analysis of the organizational component of the economic entities in the investigated sphere was the reasoning of the practicability of interpreting the concept of "organic agricultural production industry" as an aggregate of allied enterprises (farms) of agricultural products production and processing, operating according to the regulations and principles of organic farming and selling the agricultural products in compliance with the national or international standards. The activity of these enterprises is accounted for by the respective controlling authorities and is aimed at the development of rural areas and the preservation of the environment. In accordance with the Law of Ukraine "On the Production and Circulation of Organic Agricultural Products and Raw Materials" of 03.09.2013 №425-VII, the production of organic products (raw materials) is the production activity of natural persons or legal entities (including cultivation and processing), where such manufacture excludes the use of chemical fertilizers, pesticides, genetically modified organisms (GMOs), preservation agents, etc., and at all stages of production (cultivation, processing) the methods, principles and rules defined by this Law are applied for the production of natural (green) products, as well as for the preservation and restoration of natural resources.

In accordance with the same Law, organic products are the products obtained as a result of a certified production in accordance with the requirements of this Law ("On the production…", 2013). Like conventional (traditional) agriculture, organic agriculture performs two functions:

1. Provision of people with the food products, taking into account the its growth rates. The life style is changing − less people in developed economy countries grow food on their own; the diet structure is changing (a proportion of meat is ramping up), the introduction of alternative energy technologies (often requiring the use of agricultural products as a source of energy).

2. Provision of industry raw materials. First of all, it is the lack of a sufficient amount of raw materials in light and food industries that leads to their rapid evolution, which is unlikely in modern technological environment, otherwise they will be destroyed (Penova, 2010; "Economics of Agriculture…", 2007; Zinchuk, 2013).

Unlike conventional agriculture, from our point of view, organic production additionally performs three functions, namely:

1. Environmental protection. Principles of organic agricultural production provide abstemious usage of resources and make it impossible to use artificially synthesized plant and animal protection products and fertilizers, which indeed produces a positive effect on the environment. In addition, organic farming ensures conservation of natural diversity.

2. Preservation of health. Unlike conventional products, growing and consuming organic products is safer, since their production process is certified and meets the criteria for food safety. It is well known that the production of organic products mitigates the negative impact on the environment, which in the future will have a positive effect on human health. That means, he products grown in compliance

with the organic standards, do not harm the health and fully correspond to the concept of food security.

Social function. The application of organic technologies requires more jobs as compared with conventional ones, and therefore contributes to the preservation of rural infrastructure. Finally, organic agricultural production involves preservation of traditions of production technology using local natural components (Bezus, 2014).

The result of organic production is organic products. According to international standards, organic products are the products, in the process of production of which:

– it is not allowed to use pesticides against weeds, pests and plant diseases, as well as synthetic mineral fertilizers in crop production, while the crops are protected using mainly the agents of natural origin, and the soil and plants are nurtured with organic fertilizers;

– use of genetically modified organisms is strictly forbidden;

– growth promoting agents, hormones and antibiotics are not allowed in animal breeding, and the animal are treated with preventive and homeopathic remedies.

The process of production, processing and marketing of organic products must be certified according to organic standards. The certification of activities itself at all stages allows the provision of consumers with the products that can be identified as organic. In the developed economy countries, the organic sector is a highly industrial sector, but it does not distinguish it from the other sectors (traditional and GM sectors are not less, but even more intense), but this sector is distinguished for the fact that with all the high intensity it uses fundamentally different methods of production. The difference consists not only in the absence of harmful substances in products, but also in the ideological component, which combines ecological, recreational, landscape, cultural, traditional and, as a result, a productive function. Thus, the formation of an organic production system remains a topical issue (Table1.4).

Table 1.4

Types of organic products and their characteristics

Type of organic products	Description	Marking of products	Adaptation of categories to agricultural production
100% organic	Must have 100% certified ingredients	100% organic product	Produced with the application of 100% organic resources, no chemical ingredients used during storage
Organic	Must have more than 95% organic ingredients. There are certain limitations of production methods used, allowing at most 5% of inorganic substances	Organic	Produced using resources containing over 95% of organic ingredients; no chemical ingredients used during storage
Made from organic ingredients	Must have over 70% of certified ingredients. Restrictions in production stipulate 30% of inorganic substances	Made from organic ingredients	Produced using the resources containing over 70% organic ingredients; no chemical ingredients applied during storage
Less than 70% organic	There can be only a certain percentage of organic matter in the product	A list of organic substances is provided	Use of production technologies applying some of the resources containing organic ingredients. It is allowed to use chemical elements during storage, provided that they are indicated on the product

Consequently, organic products are the result of organic agricultural production, the production, storage, transportation, processing and marketing of which is regulated by approved standards, stipulating the use of a certain list of fertilizers, plant and animal protection products, synthetic food additives, and its production contributes to the preservation of the environment and social infrastructure of rural areas. However, on the world market, depending on the percentage of components certified according to organic standards in the products, the certified organic products are divided into four categories.

Therefore, generalization of scientific approaches in terms of interpretation of the "organic production" concept revealed its essence and showed that the specified activity, in addition to economic, performs a number of additional functions, namely: environmental protection (saving resources and ensuring the preservation of natural diversity), medical and biological (preservation of health) and social (contributes to the preservation of rural infrastructure and keeps the traditions of production technology using local natural components).

It has been found out that the components of organic agriculture include: organic farming; organic crop production; organic animal breeding. The result of this activity is organic products.

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CHAPTER 2. INSTITUTIONAL BASES OF DEVELOPMENT OF ORGANIC PRODUCTION

Environmental aspects of organic production can in many cases contradict its social and economic components. At the same time, the modern economic science of social formations increasingly refers to non-traditional methodological approaches of scientific research. One of these paradigmatic aspects of generating a study of economic processes is institutionalism as a multi-purpose methodology of interdisciplinary nature.

A well-known Ukrainian scientist and economist characterizes the institute as a social phenomenon, the core of which are legal norms that provide clarity and predictability, structuring, and certainty of everyday life (Kasper, 1999; Ostrom, 1990; Chukhno, 2010). In Ukrainian economics, the institutions are a broad concept, including available economic organizations and establishments (government, parliament, central bank, ministries, services) and existing rules, according to which business entities interact. Available institutions limit and define the behavior of business entities in the business sector (Simonova, 2018, p. 59).

In fact, it can be concluded that in certain situations institutes are more important than administrative actions, especially in the context of developing a sustainable economic model, where social and environmental components are included in the basis of development. As a result of the theoretical study, it has been established that institutes create a field of research of problematics at all levels, while defining the choice of approaches to the posteriori estimate of game rules in the economy and society in a certain system of organization, traditions, norms and rules (Bezus, 2014).

It is advisable to distinguish between the so-called genetic institutes, that is, those including religion, mentality, attitude to labor, power, management system. Meanwhile, all the institutions are divided into economic, political, social, legal, and cultural and moral (Shpylulyak, 2010; Hamilton, 1932). It is the aggregate of mentioned formal and informal institutions that forms the institutional environment under the influence of demographic, social, economic, political and geographical factors.

It should be noted that the problem of environmental safety of agrarian production requires attention from the state and a certain legal regulation. The Law of Ukraine "On the Main Principles (Strategy) of State Environmental Policy of Ukraine for the Period up to 2020" (“About the main…”, 2010) emphasizes the need to create a biosafety system in Ukraine, the main objective of which is to ensure safety of genetic engineering activities and the use of genetically modified organisms, as well as to prevent their unauthorized and uncontrolled distribution. At the same time, the achievement of this goal is provided through the prevention of environmental, economic, social and other risks associated with the use of genetically modified organisms and the implementation of genetic engineering activities, as well as processes threatening national interests.

The ecologization of agriculture involves combining and co-operation in the sectors of the complex of innovative technologies aimed at the economic growth of the industry, protection of the environment as interdependent and complementary elements of the strategic development of agro-industrial complex, which guarantees high quality of food to the population, creation of added value to the producer of the products, and retained natural resources and population employment to the state.

In relation to organic agricultural production, considering the specific features of agriculture, all the institutions that influence the development of organic production can be grouped as follows: research, production, management, financial and credit, licensing and certifying, personnel support, service, information and communication.

The mission of institutions in the production of organic products is to ensure the establishment and operation of the necessary institutional environment with a view to build effective social and economic relations as incentives for the development of production and consumption of organic products. The main function performed by the institutions in society consists in reducing uncertainty by establishing a stable structure of interaction between people. Formation of the institutional component of the production of organic products is carried out under the influence of regulatory framework (Bezus, 2013).

According to the requirements of international standards, all types and varieties of plants grown in organic systems must be adapted to the natural and climatic conditions, soil surface, and also be resistant to disease and pests. Crop rotations in organic farming should include up to 20% of plants that accumulate nutrients and restore soil. It is recommended to use plants for green fertilizers, legumes and their mixtures.

In order to ensure the effective operation of organic production, the state may use incentives and coercive tools that promotes transition of agrarian producers to organic production standards. To this end, an effective agrarian policy must be created.

At the same time, it is still important to define the "agrarian policy" concept, since the understanding of its essence determines the correctness of the way of reflecting the activities of its entities. Historically, agrarian policy has evolved to address agrarian and food issues (“The providing of sustainable…”, 2015). Thus, O.V. Chayanov considered agrarian policy as a matter of land and land procedures, that is, the solution of the problem of possession, disposal and use of land for those peasants, who want to work on it and dispose of the results of their work (Chayanov, 1989).

From modern scholars' point of view, there is a great number of interpretations of the essence of agrarian policy. According to P.T. Sabluk, in general, the agrarian policy of the state represents its development by government agencies and the practical implementation of a large set of legal, organizational, economic, scientific, social, personnel and other measures in order to ensure the development of the agrarian sector of economy that fully meets the country's food needs ("Modern Agrarian Policy…", 1996).

This is not only about food interests, but also about meeting other needs, namely: elimination of food dependence, use of reserves of export potential of the agricultural sector of the country, creation of the sufficient amount of food stocks, guaranteeing of food security of the state, bringing the agrarian sector to the world level and diversification of sales markets.

Khorunzhy M.Y. treats agrarian policy as a set of scientifically justified ideas and concepts regarding the development of agriculture and related industries at a certain historical stage of the country's life. This includes the availability of certain economic structures that can ensure the implementation of these ideas, as well as the functioning of the appropriate economic mechanism that would financially encourage enterprises, organizations, management structures and workers to implement them (Khorunzhy, 1998). However, such an interpretation does not take into account the need for the development of rural areas.

In its essence, politics in the broad sense is a means of regulating the entire diversity of relations between people. It is the political sphere that generates the main impulses of the management of a social organism, which guide the efforts of many to meet current and future challenges.

Politics includes such elements as: economy, law, culture, ideology, religion, morals, social sphere. In fact, these components make it possible to focus the society potential to achieve the goal. The development and implementation of regional strategies should take into account the state agricultural policy. Virtually, each regional development strategy should take into account the principles of sustainable development, the possibility of using "environmentally friendly technologies", especially in agriculture (Bezus, 2013).

The purpose of agrarian policy, that is the combination of the above elements, is to ensure food security as a priority, and then the enhancement of the rural population welfare should be considered, as well as the promotion of the social sphere development, financial support of agricultural producers, and optimization agraricultural production.

Agrarian policy aimed at creating the food security of the state, contributes to a large extent to the implementation of the two most important needs groups - physiological and security needs (Zhogoleva, 1999).

The substantiation of practicability of creating a specific state policy in the agrarian sector based on financial support for the producer of agricultural products and focused on three main functions of agriculture, particularly:

1. Economic function consists in the economic activity in the agrarian sector and industries using agricultural raw materials for the production of goods and services.

2. Social function includes food security, the viability of rural areas and culture, cultural values, customs, and traditions.

3. Ecological function embodies agricultural landscapes and preservation of biodiversity.

The first two functions provide employment for the population.

Using the state social mechanism of economic development provides for the education of more than one generation of environmentally conscious consumers. For the manufacturer, the sentiments and beliefs that prevail in society are of great importance. It has been proved that the higher the awareness and concern of consumers with environmental problems, the higher their interest in the purchase of green products in order to facilitate these problems solution.

The mechanism of state support for producers of organic products is created by such tools as budget financing of agrarian sector programs and projects; price support of manufacturers; preferential lending and risk insurance; introduction of leasing procedures and preferential taxation of farms and processing enterprises

(Fig. 2.1).

It should be noted that in the aggregate of these instruments, budgetary funding is given an integrating role not only in the development of the main branches of agriculture, but also in the provision of financial services to producers of organic products. The effectiveness of the use of incentives is high and applied by leading countries in the production and consumption of organic products. Thus, in Germany and France, the subsidies allocated to support organic agriculture during the transitional (conversion) period are up to 950 euros/hectare.

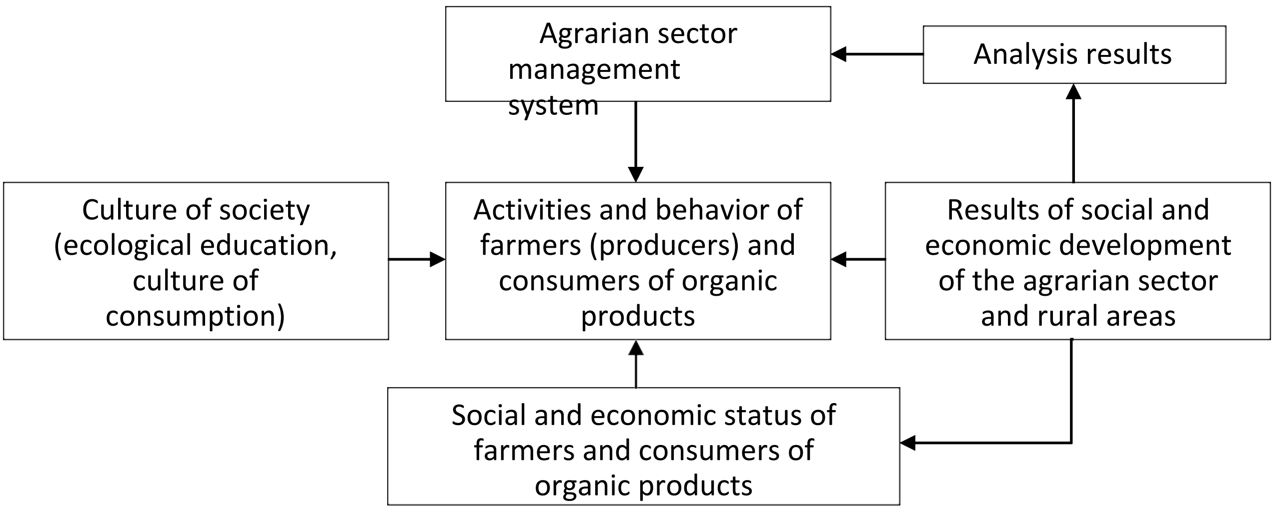

Fig. 2.1 Elements of the social mechanism for the development of organic production

In Poland, which is not the leader in organic products consumption, but the production volumes of which are rapidly increasing, the state partially reimburses the cost of certification of farms applying organic standards, and the amount of subsidies per hectare of arable land in 2012 has risen to 202 EUR/ha, of meadows and pastures to 67 EUR/ha, of perennial plantings - to 394 EUR/ha (“Possibilities of state…”, 2013).

The transitional period in organic farming, which is from 2 to 4 years, is characterised by the reduction of volumes of the harvested crop, and the additional cost is not paid for products certified in accordance with organic standards, and this takes place in highly competitive agrarian environment, which cannot operate efficiently at high income without proper economic conditions established in the state. In fact, the level of economic concern is low. The reasons for this conclusion are as follows: low demand, lack of a mechanism for providing producers with income at the declared or fixed asked price level through a system of state organizational and legal measures. At the same time, taking advantage of the weaknesses in price mechanism in agriculture, the monopolist enterprises in industrial and processing branches continue to implement the policy of increasing their own profits through the redistribution of value.

Therefore, in order to provide a favorable starting conditions for economic activity, it is expedient to move from a generalized indicator of profitability to the formation of the profitability of agrarian production on the basis of the methodology of the production price and the return rate on advanced capital in order to obtain equal income for all sectors of the economy

The institute of management of agrarian sphere is responsible for the establishment of clear-cut and easy-to-understand "rules of the game". This institute operates through state authorities, which must take care of national interests and interests of ensuring national security. Unfortunately, however, its work will be ineffective until the public administration is guided by the principle of top-down decision-making, as has been the case so far. Under such a scheme, decisions made are often irrelevant and pursue the interests of an immediate circle of individuals, while producing no nationwide effect. The development of efficient, regulated production of organic products, which would fulfill its functions, is characterized by incompleteness, consisting in the absence of a favorable economic mechanism of management, and on the part of the state - in the absence of effective regulatory institutions.

One of the most important problems in the development of organic production is the unsettled issue of acquisition of land ownership, which under the conditions of transition to organic technology is unacceptable. The solution of this problem lies in the plane of non-market institutional relations between landowners and tenant entrepreneurs. Existing institutions induce tenants to be irresponsible, and the peasants form a persistent stereotype of indifferent attitude towards their own property as a source of income. But in the case of the organic products cultivation, the situation becomes more difficult, because the time for certification and the loss of profit during the transition period make a manufacturer of organic products a hostage of circumstance, because if the lease agreement is terminated on the initiative of the share holder, the producer will not be able to grow products certified according to organic standards. In its turn, the shareholder receives a land plot ready for organic production, potentially in a better condition than before the lease.

In Ukraine, the organic producers and certifying companies were the driving force behind the institutional changes that influenced the development of organic production. So, even before the adoption of the Law of Ukraine "On the Production and Circulation of Organic Agricultural Products and Raw Materials", the conferences were arranged for the producers of organic products, and in 2007, the first certifying company appeared, which conducted the first certification inspection the same year, the public associations were founded to deal with the problems of implementation and spreading of organic technology, a network of information centres at agricultural universities was established, and a distribution network was created.

According to Dudar T.G. and Dudar O.T., in spite of the Law of Ukraine "On the Production and Circulation of Organic Agricultural Products and Raw Materials", the particular promising strategies for the development of organic agricultural enterprises are developed slowly due to the imperfect infrastructure of the organic agricultural food market, which is the basis for ensuring effective operation of all components of the organic sector (Dudar, 2014, p. 13).

The components of justification of the expediency of agricultural organic production, labeling, logistics and promotion of organic products are shown in Fig. 2.4. The above mentioned advantages of production of organic products, including preservation of the environment, production of healthy and nutritious products not contaminated with chemical components. In our opinion, the economic, environmental and social priorities are indisputable. Undoubtedly, a careful attitude towards environment contributes not only to improving the health of the population, but also to the growth of the economic component, because the implementation of organic agriculture provides the country's place in the world trend of sustainable development. However, as it has been noted above, at this stage of the country's economic development under the conditions of wide production of conventional products there is an urgent issue concerning the marking of organic products. The marking gives the opportunity to guide a consumer to purchase organic products among a wide range of other goods.

At establishing the consumer choice, the motivation of which is both health and care about environment, with the general awareness about organic brands available, the consumer will focus on familiar marks. Informational support of organic farming development is one of the effective tools for increasing interest in its implementation.

Despite the fact that traditional production is powerful in Ukraine, the majority of the population are well aware of the harm caused to human health by high-content chemical food and genetically modified products. That is why parents choose high- quality and organic products for children, which subsequently becomes a mainstream for the whole family.

In search of quality organic products families carry out extensive marketing research, engaging relatives and acquaintances. Substantial assistance is provided by online resources in the form of social networking, blogs for women, women's clubs on the Internet, where members actively share their experience on the organic products stores websites, giving a detailed description of their quality. That is, in fact, the information support for the promotion of organic products on the Ukrainian market is ensured by the last niche market, which an ordinary resident of the country may discover either accidentally or on the advice of friends or acquaintances.

In our view, the active use of the information space is necessary for all institutions involved in the production and promotion of organic products, and, in particular, for state authorities in order to preserve and improve the health of the nation.

As scientists, particularly, Prutska O.O. and Bieliaeva N.V., point out, the development of organic farming and the formation of organic products market is extremely slow (Prutskaya, Belyaev, 2012). The reason for such a state is a set of factors, including the imperfection of the regulatory framework (more precisely, the unwillingness of market participants to adhere to it for a number of reasons); the absence of a single effective national certification system, control of production by the so-called "organic farms"; the lack of stable and proven technology of livestock and farming; lack of environmental technology due to shortage of operating assets from agricultural commodity producers; insufficient development of the internal infrastructure, namely: unions, associations, information and consulting centers, etc.; low growth rates of welfare of the population, due to which there is no increase in demand for high-quality products yet; insufficient level of environmental education of the population and low level of healthy food culture.

Modern organic production institutions are limited in attracting consumers, as the economic situation in the country does not facilitate the transition from the consumption of traditional food products to organic and the use of related products such as hygiene products, clothing and accessories. It should also be taken into account that the volumes of sales of organic food depend mostly on the population solvency. And the cost of organic products in stores, supermarkets, and in the online stores is 2-6 times higher than of traditional ones. Therefore, organic products currently are preferred by limited categories of consumers. Undoubtedly, under such circumstances, the state has a greater power of economic impact on the economic situation than other institutions.

Within the competence of other institutions there exists the production of organic products according to standards, a wide PR-campaign for the promotion of organic products on the market, formation of the people mindset focused on the preservation of the environment and consumption organic products. It should also be noted that for most agricultural enterprises, the production of organic products is not the main activity. This is due to its high cost and the inability of most of the population to buy it in specialized stores or in supermarkets. Low purchasing power of the population does not contribute to the expansion of production volumes for all types of organic products, because the demand for it is limited.

Thus, the powerful institutions have been established, bringing together organic producers, research institutes and educational establishments, interested in the development of organic production and its market. In our opinion, the interaction of such institutions can have a qualitative effect on the legislative and executive branches of state authorities in order to implement their declared decisions regarding a balanced economic development and improvement of health and welfare of the society.

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CHAPTER 3. BASIC ORGANISATIONAL AND ECONOMIC PROBLEMS OF DEVELOPMENT OF ORGANIC PRODUCTION IN UKRAINE

Despite the fact that organic production in Ukraine has been developing since 1990s, the state recognised it as such only in 2013, with the adoption of the law of Ukraine On the Production and Circulation of Organic Agricultural Products and Raw Materials. It is the slow reaction of the legislative branch in recognition of the organic production as such, as well as the absence of appropriate by-laws have created prerequisites for "non-existence" of organic production for the country. And even after the adoption of the Law, there is still no official statistical information about the production of organic products in Ukraine (“State Statistics…”), and all data on it is accumulated at private certification companies and international organisations.

In addition to the Strategic orientation of the Ukrainian agriculture development included the increase in the share of organic certified farmlands, up to 5%, as it was expected in 2015, up to 7% - in 2020, among them - 3 and 5% of the arable land by years respectively, and the growth of the share of organic products up to 7 and 10% of the gross product, against 5% in the 2010 (Lupenko, 2012). Such plans were justified by the fact that, despite the lack of a legislative act, regulating the process of cultivation, storage, processing and sale of organic products, Ukraine was among the five world leaders by the share of agricultural land area, on which organic wheat was cultivated, as early as 2009.

There is another explanation why domestic producers are among the leaders in terms of the share of agricultural land, where organic wheat is cultivated. The reason is less demanding certification procedure, with the possibility of exporting organic grains abroad. The total area of certified agricultural land in Ukraine, where organic products are grown, increases year by year.

As of 2016, it amounted to 421.2 thousand hectares, which is by 156.2% more than in 2002. This rapid growth of cultivated areas can be explained by the specifics of the economic development of Ukraine. In the difficult period of transition to market relations, some fields here have not been processed for several years. With the availability of the history of fields and permissible chemical soil indicators, the process of certification of production according to organic standards took up to two years.

A positive trend also persists in terms of changing the number of enterprises engaged in the production of organic products. In 2016, their number increased to 390, which is 12.6 times more than that of 2002. An important point when evaluating the domestic agricultural production is that its development is carried out without any financial support from the state (Boyko, 2011). And for producers, the current legislation provides for neither financial assistance, nor compensation for the introduction of organic technologies or the receipt of certificates. Though, according to international experience, it is the financial support of the state that stimulates an increase in the number of organic producers, the development of the organic agricultural market and its structure.

Ukrainian producers of organic products are mostly large enterprises, but the average area of agricultural land cultivated by them is decreasing every year. For example, in 2016 this indicator was 1080,0 hectares, that is only 20.4% in comparison with 2002.

In general, the dynamics of the average area of agricultural land of Ukrainian enterprises producing organic products is characterised by a straight-line equation and is as follows:

$$y = -196.6x + 4165.$$

The regression coefficient in the above equation indicates that the average annual decrease of the average agricultural land of Ukrainian organic producers amounts to 198.6 hectares.

The determination coefficient of this equation is 0.744, which indicates a high degree of confidence in the forecasting, compiled using a linear trend.

Based on the results of the analytical expression of the middle area of farmland of Ukrainian enterprises producing organic products, and the equation (3.2), it is conceivable that the average area of agricultural lands of the Ukrainian enterprises, producing organic products, in the year 2015 will be approximately 500 hectares. Nowadays, 63 domestic producers of organic products, accounting for almost 40% of their total number, cultivate from 2.5 to 25 ha (Chudovskaya, 2014, p. 484).

The infrastructure support for the production of organic products has its regional peculiarities, which depend on the type of certified activity of the business entity and their concentration (Table 3.1).

Logically, a significant number of entities that produce organic products will contribute to the formation of an appropriate infrastructure, able to ensure repeatability of the organic production process. The infrastructure support of the sector or industry has to include an information item to ensure a process of self-regulation and external and internal communication. The information element has become an obstacle to a rapid spread and the mass appearance of pseudo organic products in Ukraine in 2010 - 2016, the fight against which consisted in the formation of the information space, providing the possibilities of identification of genuine products certified according to organic standards, as well as the places of its purchase. The outcome of this challenge to the institutions, caring about the originality of organic products and of its consumers, was a number of existing projects and the Internet environment.

Thus, of the 15 companies that provide certification according to the organic standards in Ukraine, only one represents Ukraine, 13 are from the EU countries and one is from Turkey. The availability of most of the certification companies, which are registered outside Ukraine, indicates that they are interested in the development of the production of organic products, as it creates clients for them, and also they transfer domestic products on the markets of the countries of their registration.

Table 3.1

Distribution of certified activity of organic farming entities in Ukraine, 2016

	Number of farms	Activities						
		Production	Processing	Trading	Export/Import	Transportation	Storage	Other
Ukraine	390	277	113	120	114	7	16	52
Autonomous Republic of Crimea	32	25	11	9	7	0	0	0
Regions								
Vynnytsia	29	25	5	7	9	3	3	5
Volyn	14	9	7	4	0	0	0	0
Dnipropetrovsk	5	0	0	3	4	0	0	2
Donetsk	9	9	4	5	1	0	0	0
Zhytomyr	18	18	2	4	5	0	0	0
Zakarpattia	16	11	2	0	0	0	0	3
Zaporizhzhia	14	9	6	5	4	2	2	2
Ivano-Frankivsk	3	0	3	3	2	0	0	0
Kyiv	58	42	18	20	8	0	12	0
Kirovohrad	9	9	0	0	0	0	0	0
Luhansk	0	0	0	0	0	0	0	0
Lviv	25	25	11	6	3	0	0	0
Mykolaiv	9	6	0	4	5	0	0	0
Odesa	27	11	11	14	9	2	5	7
Poltava	11	9	5	7	4	0	0	2
Rivne	14	9	7	4	4	0	0	0
Sumy	2	2	2	0	2	0	2	0
Ternopil	7	7	0	0	3	0	0	0
Kharkiv	20	15	4	5	3	0	0	0
Kherson	27	9	3	11	22	0	0	16
Khmelnytsk	4	4	2	0	0	0	0	0
Cherkasy	4	2	2	2	3	0	0	3
Chernivtsi	4	5	3	2	3	0	0	0
Chernihiv	18	14	5	2	5	0	2	2
Cities								
Kyiv	11	2	0	3	9	0	0	6
Sevastopol	0	0	0	0	0	0	0	0

That is, the German certification companies not only provide services to national organic producers, while actively developing the market, they also ensure the supply of Ukrainian raw materials to the German market, since the companies processing the organic raw materials gave more confidence in the national certifying authority that operates outside the country. The country of origin of the certifying company determines the prospects of export of its customer's products. Although the national Organic Standart certifying body issued certificates for most of organic market participants, including manufacturers, according to the Ministry of Agrarian Policy and Food of Ukraine, most products produced in Ukraine were exported.

As of the early 2015, according to FiBL, 74.6% of organic agricultural land were ploughed, most of which was used for growing cereals of all the businesses that represent the organic agriculture sector, most are the limited liability companies (54.9%), besides, 12.1% are farms, 11.0% are private enterprises and 9.8% are individual entrepreneurs. The number of private farms is only 4%, that is, 7 units. The organisational and legal form of the enterprise indicates potential possibilities of the entity in terms of activity organisation, search and attraction of financial resources, volume of production and the public image. This is confirmed by our research among the representatives of the organic market, namely: − among all 95 limited liability companies, 57 (60%) are engaged in more than one activity, and 39 of them are not the producers of certified organic products, plant protection products, and fertilisers. As a rule, these are the business entities involved in the storage and processing of organic products, provide advisory services; - 86% of farms are engaged in one type of activity, 72% of farms are engaged exclusively in the production of crops, and 19% - in the production of both crop and livestock products;

- all private farms are engaged in one type of activity, which is directly related to the production of organic products, mainly plant growing.

As of 2016, the supply chain organic products is made up of 277 producers, 16 storage companies, 113 recyclers, 114 exporters/importers of organic products, as well as 120 entities involved in the sale of organic products, 2 trading networks, which position themselves as the ones selling solely organic products, as well as 110 online stores. At the same time there is a substantial problem in controlling the activities of Internet stores that sell organic products. First, these are the conditions for the storage of organic products, as well as the issues of legal regulation of their producers' activities and responsibilities to the buyer and the state. In addition, online stores, as of today, are not involved in the development of the organic market through the public relations system. As a rule, their connection with society is limited to contextual advertising.

The largest producers of organic products in Ukraine are Argoekologia Enterprise in Shyshatskyi district, Poltava region and Galeks-Agro Enterprise in Novohrad- Volynskyi district of Zhytomyr region. Argoekologia Enterprise cultivates 8,516 hectares of agricultural land. In 2011, the enterprise's activity was certified for organic production of agricultural products (buckwheat, sunflower, rye, barley, winter wheat, oats, alfalfa, esparcet) and its processing (wheat farina, buckwheat groats, wheat groats, barley groats and others). Certificate No. 11-0033-03 states that the enterprise's products meet the requirements set out in the Council Regulation (EU) No.834/2007 and No. 889/2008 and are organic products. The activity of the company is certified by Organic Standard, the Ukrainian certification body.

Agroekologia Enterprise specialises in the cultivation of wheat, rye, barley, buckwheat, sugar beet, and has a large number of dairy cows. The agricultural enterprise year after year achieves good results of effective dairy cattle breeding and production of beef. Thus, for 2014-2016, the average annual productivity of the dairy cattle was 5,370 kg of milk at a profitability of about 51%. As to the production of beef by the enterprise the figures are as follows: daily average increase in young cattle body weight at fattening is 935 g. Profitability of beef production was 48.3% by 2016, and the profitability of the livestock production industry in general amounted to 52%.

Galeks-Agro Enterprise grows products certified in accordance with organic standards, on an area of 5,480 hectares. All products of the company are certified by the Institute of Environmental Marketing (IMO, Switzerland), and approved as organic and meets the requirements of the Bio Suisse standard. The activity of the enterprise is controlled by Organic Standard and certified in accordance with the requirements set out in the Council Regulations (EU) No.834/2007 and No. 889/2008.

The main activity of the enterprise is the production of organic certified crop and livestock products. The main cultivated crops are wheat, spelt wheat (farro), rye, barley, oats, Australian winter pea, beans, vetch, buckwheat, millet, soy beans, corn. As for livestock, the enterprise is engaged in breeding of meat and dairy Simmental breed.

Unlike Agroekologia Enterprise, Galeks-Agro Enterprise exports grown products. Export-oriented organic farming is a common trend. According to the Ministry of Agrarian Policy of Ukraine, about 70% of Ukrainian producers supply organic products abroad. The products grown in Ukraine are mainly exported to the EU (Italy, Germany, the Netherlands, Switzerland, France), North America (USA and Canada), Russia, Israel and Japan. About 80-90% of all organic products produced in Ukraine, mainly cereals, legumes and oil crops, are exported. The rest of the products grown by organic standards is sold on the domestic market, but the lack of proper processing and market infrastructure allows only partially sale of organic products as such, while the remaining stock is sold as high-quality standard (conventional) products. However, in general, the trend in the domestic market of organic products is positive for producers, the volume of organic market is continuously increasing (Fig. 3.8). The availability of organic products in supermarkets is promoted by the target audience, namely: the people with medium and above medium income, who appreciate high quality, natural and fresh food, and who are eager to try new products.

The main organic products grown in Ukraine and exported abroad are grains, legumes, oil, gourds, berries, vegetables, herbs, fruits, meat, mushrooms, nuts, and honey. The exported products are used as raw materials and are partially returned to Ukraine in the form of finished products. In this case, consumers pay a share of added value to the country that has completed the processing of this product.

In addition to individual producers and processors of organic products, there are also cooperatives in Ukraine. Some of them have been established with the support of international charity organisations, such as the ICF Community Wellbeing. Agricultural Service Cooperative (ASC) is the basis for mobilisation of rural communities to address common economic and social problems. On the ASC basis the function of economic self-organisation and association of rural families is implemented, and the mechanisms of protecting the interests of the cooperative and the village community are created. The most successful of these are as follows: Nadiya ASC Kulykivka district of Chernihiv region and Chysta Flora ASC of Kolomyia district of Ivano-Frankivsk region. Currently, the projects are being implemented to create co-operatives for the production of organic products, in particular, on "Improving the welfare of the owners of Chervoniy Lyman Private Farm through the development of organic vegetable growing and introduction of ecological methods of agriculture" in Pokrovske district of Dnipropetrovsk region, as well as the "Development of strawberry cooperatives" of Kremenets district of Ternopil region.

Since 2003, the Community Wellbeing charitable fund in Ukraine has been providing a substantial support for 69 agricultural service cooperatives, of which 43 are still functioning. As of June 1, 2016, the list of existing projects of the charitable foundation included three projects, which envisaged the production of organic products (Bezus, 2013; Bezus, 2014).

Private investors would take no chances of investing heavily in the development of agribusiness, while the international charity organisations are ready to take the risk. Their finances are an alternative source of funding the investment security of agricultural and rural areas development both at regional and at macro-levels. However, one of the conditions prevailing today is the participation of the community in agricultural and rural development projects. Experience indicates that in Ukrainian regions with mature and initiative communities, a form of cooperation between the owners of resources and their recipients, which is new for Ukraine, is developing, and the projects supported by charitable organisations became operative, which certainly has an effect on the sustainable development of rural areas and agriculture of the country in general (Bezus, 2014, p. 216).

The activities of domestic organic cooperatives are related to the production of vegetables and fruits, which may be referred to the specificity of their functioning. The group of fermented milk products, vegetables and fruits cultivated according to organic standards is of greatest demand in the market of food products.

According to the Institute of Agrarian Economics National Scientific Center, the potential volume of the domestic market of organic products by main types of products is EUR 3.7 billion, or UAH 39 billion, and the structure of the potential market is shown in Fig. 3.9 (Lupenko, 2013, p. 6).

However, given the fact that the total expenditure of households on food in 2016 accounted for 56% at a limit indicator of 60%, the consumers' switch to the consumption of organic products is a quite difficult process, since it will lead to additional costs, as the price for organic products is higher than for the conventional ones. However, it should be noted that in comparison with the developing countries, and in terms of grain production per capita (over 1 ton as compared with the global indicator of 450 kg) Ukraine has sufficient potential in providing the required level of food security.

The process of transition to organic agriculture is accompanied by certain costs, risks and problems (“ Modern problems…”, 2010). An indispensable element of the organic production process is the inspection and certification procedure. The process of obtaining a certificate of compliance of organic products involves the costs associated with its issuing. Moreover, the fee for a certificate confirming that the process is organic, in Europe is between 250 and 750 euros for the farms with an average agricultural land area of 30-50 hectares. In Ukraine, the cost of certification depends on the scale of production, the type of product, the stages of the certification process and is established individually for each customer. Thus, in Ukraine, the cost of certification services provided by the Living Planet certifying body (official representative of the 495 International Institute of Organic Certification and Ethics (ICEA, Italy), ranges from 3 to 8 thousand euros (“All-Ukrainian NGO…”). As for other foreign companies, the cost of certification corresponds to the prices of the countries, according to the standards of which the certification is performed. And the cost varies between 250-750 Euro per year (“Organic agriculture…”, 2011). The price of organic food is much higher than that for the conventional products and depends on the place of production (Table 3.2) (Slavkova, 2014, p. 414).

Table 3.2

The ratio of the price of organic products to that of the conventional products in Ukraine (as of September 01, 2017)

Products	Units	Price per unit, UAH		The ratio of the price of organic products to that of conventional products, times
		conventional products	organic products	
Wheat flour	1 kg	8.47	84.59	9.89
Sugar	1 kg	17.13	192.18	11.22
Milk	1 l	17.05	38.00	2.23
Eggs	10 pcs.	21.40	34.50	1.61
Chocolate (Milk Seed & Bean)	100 g	22.14	77.11	3.48
Organic beef	1 kg	74.32	442.00	5.95
Potatoes	1 kg	6.47	13.00	2.01
Beer	0.5 l	13.98	74.18	5.31
Apple juice	1 l	26.50	51.00	1.92
Ground coffee (Arabica)	250 g	84.27	226.65	2.69

Organic products in Ukraine are sold both through conventional and online stores, in particular, in common trade networks (Silpo, Metro, Megamarket, Billa, Velyka Kyshenia, Furshet, Fozzy, and Ecomarket) and in specialised ones (Eco-Chic and Nature Boutique). In Ukraine, there are about 150 stores selling organic products. Basically, the market for such products is concentrated in large cities - Kyiv, Dnipropetrovsk, Donetsk, Odesa, Lviv, and Kharkiv (“Federation of Organic…”).

As for the Internet shops, as of 2017 there are 110 operating Internet stores in Ukraine, engaged in the sale of organic or equivalent products. It should be noted that not every region has a registered online store selling organic products. Most of them offer the delivery of both imported and domestic organic products to the regions within one day. The range of goods from 26 countries importing organic products is represented in Ukrainian Internet-stores.

It is worth noting that no Internet store has organic products by all importers. The leader in the Ukrainian market is, of course, a national commodity producer. 56 Internet shops (80%) offer their customers the Ukrainian products, 29 - German products, 19 - Russian, 15 - USA, 11 - Italian products.

Almost all Internet stores sell branded goods. Thus, 16 online stores (22%) offer organic products by Ukrainian brands only, 6 (8%) – only the products by foreign trademarks, and the range of most stores (46, or 66%) includes both Ukrainian and foreign trademarks.

Two online stores have not specified the trademark of the products sold. In the Figure 3.11 the structure of the organic product trademarks offered in Ukrainian Internet-shops is shown. The producers of organic products offer Ukrainian consumers the following commodity groups through the represented trademarks, in addition to food: household chemicals; cosmetic products; goods for children; pharmacy series.

On average, one online store sells 3 groups of goods. At the same time, the online stores demonstrate a direct relationship between the number of represented countries producing the products and the range of products offered. As the number of manufacturers grows, its range increases (Bezus, Ulyanchenko, 2012 a, p. 130).

A high level of application of modern communication technologies is beneficial for all participants in market relations. Therefore, from year to year a range of goods in the Internet-shops expands. Earlier these stores were mainly a place of purchase of household appliances, and nowadays, thanks to modern logistics system allowing the fastest delivery of both conventional and organic food, they have become a place of purchase of such a specific product as organic food. This was, of course, promoted by an increase in the population's demand for organic products and the will to buy a really fresh product, preferably directly from the producer.

As the experience of the countries, where the organic market has been formed and actively develops, indicates, the structure of the distribution channels is individual and different in each country. Interestingly, over 12% of all potential buyers of organic products are willing to buy it and have it home-delivered, a priori, in online stores (Bezus, Ulyanchenko, 2012a).

To get the online stores' services, a buyer does not have to necessarily reside in the same region with the manufacturer, and the manufacturers are not required to focus solely on their proximity to the region with a higher level of competitiveness. The analysis of correlation between the index of competitiveness of the Ukrainian regions and the number of online stores selling organic products in the regions shows the dependency on the development level of only 59.7% of variation of online stores number, which is reflected in the index of competitiveness. The rest of variations in the amount of stores are due to other factors.

At the same time the availability of a local manufacturer of organic products is an extremely desirable phenomenon, because it allows a positive synergistic effect of organic production, which, in addition to obtainment of organic food, includes the preservation and improvement of environmental status, providing jobs for the residents of rural areas and ruralization. Another positive effect of this trend is the fact that 80% of Internet-shops offer Ukrainian organic products, although they do sell the products imported from 26 countries at the same time. Of the 70 surveyed online stores, which position themselves as the shops selling organic products, only 41 offer organic food. Undoubtedly, the functioning of Internet stores, as one of the channels for the implementation of organic products, will have a positive effect on the development of the market. And further expansion of communication services will enable Internet- shops to offer consumers fresh, high-quality organic products from the producer at a price lower than in conventional stores.

The increasing use of the open social networks by domestic representatives of the organic agricultural production market is minimal. Thus, in the most popular social network, Facebook, as of 2017, 42 participants of the organic agricultural market are registered. Organic UA is the most active user of social networks, since the information on their page is generally updated on a daily basis, and this means that 3449 social networking participants constantly receive updated information (Table 3.3).

Such a low-degree presence of organic producers in social networks has a negative effect, first of all, on the producers themselves, as they ignore the location of their clients (Bezus, Ulyanchenko, 2012 b; Bezus, 2013).

Table 3.3

Amount and activity of individual representatives of the organic agricultural market in Ukraine in open social networks, 2017

Company name	Location	Number of group members (or number of subscribers to the resource)	Number of likes	Activity (once a week, 15 days, 1 month, 2 months, 1 year)
Facebook				
Organic Farming Club All-Ukrainian Non-Governmental Organisation	Kyiv	5,292	5,029	once a week
Living Planet All-Ukrainian Non-Governmental Organisation	Kyiv	388	377	every two months
MAMA-86 All-Ukrainian Non-Governmental Organisation	Kyiv	333	333	every two months
Organic UA	Kyiv	3,449	3,544	daily
Organic Ukraine (Organic Products Manufacturers Association)	Kyiv	2,249	2,245	daily

Prior to the adoption of the Law of Ukraine On the Production and Circulation of Organic Agricultural Products and Raw Materials, the formation and development of the infrastructure of organic agricultural production in Ukraine were the key tasks of the most well-known Ukrainian organisations such as the Association of Bioproduction Participants BIOLan Ukraine, the Organic Standard Certification Body, the Federation of Organic Movement of Ukraine, the Organic Ukraine Certified Organic Products Manufacturers Association, the Chysta Flora Organic Producers

Association, Illinetsky Agrarian State College, Green Dossier Information Centre, Association of Organic Farming and Horticulture, Lviv City Public Organization Ecoterra, Retail Academy, NSC Institute of Agrarian Economics of NAAS, Natural Agriculture Centre of the Dnipropetrovsk State Agrarian University, Organic Farming Centre Poltava-Organic, Polissia Centre for Organic Production Polissia Organic, Tavria Organic Natural Farming Centre, Pivden Organic Ecological Farming Centre. Joint actions of the above-mentioned organizations, as well as of the Ministry of Agrarian Policy and Food of Ukraine, FiBL, USAID, SECO, GIZ, SCO, CIDA, the Embassy of the Netherlands and the French Embassy undoubtedly contributed to the development of the organic production infrastructure, as evidenced by the dynamics of the volume of organic products market and number of business entities that have certified their business in accordance with organic farming standards. Thus, it is possible to distinguish three stages that have already occurred or take place at the moment, and, considering the experience of leading countries in the production and consumption of organic products, to predict the fourth stage (Table 3.4).

Ukraine has fairly good preconditions for the organic production, namely: the availability of large areas of fertile soils; relatively low level of use of chemical plants protection products and mineral fertilizers; a potentially large domestic market for the consumption of organic agricultural products; development of organic movement in Ukraine.

Ukraine has fairly good preconditions for the organic production, namely: the availability of large areas of fertile soils; relatively low level of use of chemical plants protection products and mineral fertilizers; a potentially large domestic market for the consumption of organic agricultural products; development of organic movement in Ukraine.

Among the main causes of low efficiency of organic production in Ukraine, the following can be listed: poor institutional support and the lack of financial support by the government; innovative passivity of most producers and management structures; weak awareness of producers regarding the organic production specifics and of the population regarding the benefits of organic products; the predominance of export of organic raw materials; processing, manufacturing, wholesale and retail trade of organic consumer products are still undeveloped; the shortage of grain and other agricultural products of organic origin; insufficient number of cattle as the main producer of organic fertilizers; high cost of loan funds (farm loans interest rates of about 25-29%); great man-caused impact on the land of Central and Eastern Ukraine.

Table 3.4

Stages of organic farming development in Ukraine

Stage	Period	Name	Characteristics
I	1990s	The origin of organic farming in Ukraine	Export of raw materials.
II	2000s	Growth in demand for organic products	- rapid growth of organic producers and areas cultivated by them; - the beginning of the formation of the organic products internal market.
III	2010- till now	"Legalisation" of organic products	- creation of the first domestic brands and networks for the sale of organic products, Internet-shops; - the appearance of domestic livestock products certified according to organic standards; - adoption of the Law On the Production and Circulation of Organic Agricultural Products and Raw Materials.
IV	Forecast	Financial support for the production of organic products	- a spike-like increase in the number of producers and consumers of organic products; - an increase in the share of organic products by reducing the share of conventional products.

Therefore, despite the lack of a single state source of statistical data on the production of organic products in Ukraine, it can be argued that the organic production has developed despite of the state support, rather than due to it. The producers of organic products had to solve the problems of shortage of funds during the transition period and to rely only on deferred profits from exports of the products they grew. Despite everything, in 2009, Ukraine became one of the top five countries with the largest area allocated for cultivating wheat. The proposed assessment of the technical efficiency of production of organic products shows that Ukraine has a significant amount of unused reserves for the development of organic production.

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CHAPTER 4. RISKS AND PERSPECTIVES OF ORGANIC AGRIBUSINESS IN UKRAINE

Over the past decade the global organic movement, previously known only to a small circle of enthusiasts for half a century, scored a powerful momentum and has already become a vital philosophy for many people. The range of organic food, cosmetics, hygiene products, textiles, clothing and other goods is constantly expanding. Ukraine has successfully joined this trend, as the country has all the prerequisites for the efficient functioning of organic production enterprises. The development of organic production is a very topical issue, since the demand for safe and high-quality products is constantly increasing. For Ukrainian farmers, the production of organic products and raw materials for it is a useful experience, an opportunity to expand product markets and to integrate more closely into the world economic space (Antonets, Pisarenko, 2011, p. 5).

The function of organic agriculture both in production, processing, distribution and in consumption, consists in supporting and improving the health of ecosystems and organisms, from the soil single-celled microorganisms to human. In particular, organic farming involves the production of nutritious, high-quality food products that contribute to the prevention of diseases. According to the requirements of this type of agribusiness, the use of fertilizers, pesticides, veterinary drugs for animals and food additives that can adversely affect the health of consumers is prohibited ("Principles of organic…", p. 1).

The production of organic agricultural products is a special organizational and technological method of production, the use of which provides the following pending effects:

- obtainment of products of improved quality, more useful than traditional products;

- the use of special production technology that differs from the conventional approach, rejection of the use of mineral fertilizers, chemical protection, growth regulators, antibiotics, etc., using the special cultivation of soils (minimizing, nonmoldboard cultivation) and animal management according to their natural needs;

- organisation of rational land use at enterprises (Kovaleva, 2008, c. 6).

Successful development of organic agriculture depends on the supply of labour force, transport routes for transportation of products, guaranteed sales markets nearby. These conditions explain the concentration and specialization of production in suburban areas of large cities and in raw material processing industry areas. In the farms, which are nearest to the cities, the profitability of vegetables is higher than in remote ones. Suburban households in significant quantities sell products through direct communications, and have specialized production. For example, the production of organic fruit and vegetables in raw material areas is arranged taking into account the requirements of the processing industry, in particular, enterprises concentrate their crops near vegetable canning plants (Samoylyk, 2016, p. 23).

The market for growing and processing organic products in Ukraine is divided into the following components:

- the market for individual consumers, who buy products for their own gratification;

- the market for producers, who buy products for further processing and use in the catering industry;

- the market of resellers, who buy and resell products for the purpose of profit only;

- the market of state institutions purchasing products for specialised organisations – hospitals, orphanages, military units, etc.;

- external market.

The special effects of organic production of agricultural products, which positively differentiates it from traditional intensive production, there are ecological, economic and social effects of this type of activity. The essence of these effects is as follows:

ecological – leads to improvement of the quality of land resources through observance of natural crop rotation; application of organic fertilizers and methods of biological control of pests; soil cultivation technologies aimed at minimal interference with the ecosystem; reduction of pollution level of reservoirs and atmospheric air as a result of restrictions on the use of synthetic plant protection products;

- economic – is created by the willingness of consumers to pay a higher price for organic production and the decrease in the cost of material resources (chemicals, fuel and lubricants in the amount of 30 to 97%). However, significant economic effect is achieved after a period of conversion, as first organic production requires considerable investments, the cost of production increases due to declining yields in the period of conversion and in the case of low fertility of soil, and natural productivity of plants and animals;
- social – caused by a considerable scope of manual labour in organic production, which makes it affordable for small agricultural producers or family farms that do not hire additional employees (Kovaleva, "Regarding the directions…"). As an example, the statistics of the organic farming in France can be cited. In this country, 4.5% of the farms and 3.6% of the agricultural land are certified as organic, and the organic farms employ 2.4 of middle-aged employees, while the traditional farms employ only – only 1.5 (Moreau, 2013).

Exports of organic products remains the most attractive sales channel for large enterprises, because the export prices are higher than the retail prices of the same products on the domestic market, there is an opportunity to reach a high level of production profitability. Due to the release on the external market, the agricultural producers receive additional income, calculated as the difference between the international price and the internal price less costs for the shipment of products for export. To date, it can be noted that the main foreign markets for the export of vegetables, fruits and berries are Germany, the Netherlands, Latvia, and Poland. Along with these, the markets of Western Europe are still a promising trend, because at present Ukraine has become one of the seven largest suppliers of agricultural production, ahead of such countries as Spain, Egypt, Belgium, France and Germany ("Swiss-Ukrainian project…", p. 20).

The quality of organic products, like any agricultural products, is associated with a group of factors that contribute to the improvement of useful properties of the finished product. A negative factor in this case is an imperfect performance or a breach of cultivation technology. Product quality is deteriorating due to the lack of a proper post- harvest handling, sorting, prepacking and packaging, primitive equipment for storage in retail outlets. It is also necessary to highlight transport factors, namely, mechanical effects when transporting organic products: vibration and jogging; long time of transportation; unsatisfactory road conditions; poorly engineered transport containers, etc.

In addition to the impacts, there are also isolated groups of risks in the production of organic products, namely: climatic, financial and pricing, legal, risks of staff, institutional information, marketing and production risks (Colibaba, "Classification of agricultural…").

The cultivation of both protected and open ground in Ukraine is a risky business. And when cultivating organic fruit and vegetables on protected ground, in addition to the risks of traditional crop production the producer meets the risks inherent in organic technologies.

Risk is the potential loss of a part of assets, insufficient profit or non-receipt of profit as a result of the influence of adverse factors during the economic activity. On the basis of recent research, V.E. Krupin and Y.R. Zlydnyk presented a generalized risk classification by L.I. Donets, including their largest amount, divided by:

- the area of occurrence: external, internal;

- the scale of impact: national, regional, branch, individual economic entities;
- the degree of influence: at macro or microeconomic levels;
- the sources of origin: systemic or market, non-system;
- the nature of risk: economic, natural;
- the character of the object: activity, passive anticipation;
- the type of occurrence: rational, irrational, adventurous;

the duration of action: long-term, short-term, permanent;

- the level of probable losses: minimal, average, maximum, permissible, critical, catastrophic;
- the degree of legality: lawful, unlawful;
- the possibility of insurance: risks that can be insured, or risks that can not be insured;
- the objectivity of likelihood: objective, subjective, objective-subjective;
- the time of the occurrence: ahead, timely, overdue;
- the possible financial result: pure, speculative;
- based on taking into account the time factor: static, dynamic;
- the specifics of economic activity: operational, financial, investment, commercial, production, credit, innovation, currency;
- the sources of minimization of consequences: the risks, the consequences of which can be minimized or eliminated using own funds, the risks, the consequences of which can be minimized or eliminated using the funds raised;
- the methods of minimization or avoidance: limited, diversified, insured;
- the degree of impact at strategic planning of enterprise development: on the mission, on the goal, on the task (Krupin, Zlydnyk, 2011, p. 46-47).

Risk management should be carried out before the event takes place. Possible options for responding to risk events are as follows:

- risk avoidance: at unacceptable risk, it is necessary to take measures to eliminate its effect;

- risk transfer: some unacceptable risks can be transferred entirely or partially to third parties: partners, investors;
- risk mitigation: where it is impossible to avoid or prevent the risk, there is a possibility to reduce or diffuse its impact: for example, by engaging the partners to render assistance in management;
- risk acceptance: certain risks can be offset by business;
- ignoring: the manager is not prepared to manage the risk and refuses to interfere with the scenario (Resnichenko, 2010).

Risk management tools, at the existing level of risk, include: insurance, hedging, financial guarantees, orders, etc.

According to the findings of the survey of farmers, the risks of organic crops production were divided into three categories, depending on their similarity to the conventional risks of agriculture, namely:

- risks similar to those in general agriculture;
- risks that differ from conventional agriculture, but are temporary due to the recent rapid growth in the organic sector;
- risks that differ significantly from ordinary ones due to other types of production and other sales systems ("Risk and Risk Management…", p. 11).

In more detail, the first group includes the risk of yield loss due to unfavourable climatic conditions, the risk of losing access to production resources, subsidies, to better insurance policies. However, the opportunity to have higher prices for organic products and a diverse set of cultivated crops ensures effective management these risks. The second group is the risk of temporary decline in crop yields due to the transition to the use of biologically safe pests and organic fertilizers. During the period of entering new markets there is a problem of sales of products. Therefore, crop insurance can be particularly important for some entrepreneurs for the conversion period.

The third group of unique risks include those retaining for a long time and requiring new tools for their management. For example, the priority of organic production is a healthy agroecosystem. And, given this fact, special requirements for any usual process (construction, storage, and sale) should be put forward. Unfortunately, existing advisory bodies are not integrated into an effective system and can not effectively meet the need of farmers, who decide to switch to organic production. Moreover, the bulk of investments is directed to land resources. If they need to terminate their business activity, these investments cannot be repaid quickly and in full.

The main activities of risk management on organic farms are, virtually, as follows: naturally balanced cultivation of different types of early and late crops; the division of large farms into smaller units for easier management; modernization of greenhouse complexes, which increases their production efficiency and extends the production season; the production of their own organic seeds; associations and cooperatives; exchange of experiences (“Risk and Risk Management…”, p. 5-7).

Domestic organic production of vegetables and berries on protected ground is negatively affected by many risks. In order of increasing these are as follows: natural and climatic, financial and price, legal, personnel risks, institutional and information security, marketing and production risks (Amelina, 2014, p. 9; 13, p. 24).

As compared with conventional production, a group of industrial risks increases its influence when using organic technologies, because the smallest deviation from requirements will entail the loss of the status of organic products that will lead to a shortfall in the expected revenue. The negative impact of this group of risks on the quality of the products can be reduced using the methods of prevention, i.e. by means of a strict internal control of technological process and quality of the materials used.

The climatic risks include the negative impact of various natural phenomena, from rain to earthquake, on the volume and quality of agricultural products. This group of risks is typical for conventional agriculture. When applying organic technologies in the open ground, the indicated risks increase, as the resistance of plants to diseases and pests in unfavorable climatic conditions is low during the conversion period. In organic greenhouses, these risks are significantly reduced due to the plants protection by the greenhouse structure. A particularly important risk of the group under consideration in conventional crop production is considered to be the risk of decreasing soil fertility. In organic crop production, it is significantly reduced, since the use of organic fertilizers improves soil state. The use of protected ground mitigates the indicated the risk, as external influence on the soil is decreased, and the top layer of the damaged artificially prepared soil can be completely replaced (Amelina, 2014, p. 10).

Personnel risks are the likelihood of errors in processes controlled by personnel. The personnel participate in almost all processes in agriculture. And when introducing organic technologies, the impact of such risks increases until the new technology is mastered and the organic status of the finished product is confirmed. In greenhouses, the consequences of personnel risks can be minimized due to the fact that it is easier to control the state of the environment and plants on the protected ground, and damage can be timely eliminated. The risks of the group under analysis can also be managed using a method of preventing a risk event through additional educational activities for the staff, exchange of experience with Ukrainian and foreign specialists.

The market risks group includes marketing, financial and price, legal and institutional and information risks (Amelina, 2014, p.13).

The marketing risks include those related to the product, marketing, communication and competitive strategies of the enterprise. Such risks are characteristic of all manufacturing enterprises, including organic greenhouses. Due to the fact that organic products are still not common for the Ukrainian market, marketing risks are higher. In organic crop production, the share of marketing costs is higher than that of the products, produced using conventional technologies. When comparing the costs of organic crop production on the open and protected ground, it turned out that they are lower in the protected ground, but the marketing costs are approximately the same. In organic production, these risks are intensified, since the appearance of naturally grown products is slightly inferior to that of the usual products, and their shelf life decreases. Therefore, the enterprises growing organic products on protected soil also need to pay attention to quality control systems and logistics. The main disadvantages of the domestic infrastructure of organic crop production in this case are as follows: limited capacity for prepacking and packaging; lack of enterprise certification system and control of compliance with international quality standards and product safety standards; imperfect domestic legislation. At the same time, international consumers are very demanding in terms of availability of certification documents.

The main marketing and sale risks in the production of ordinary berries are those related to the storage and processing of products. Organic production of berries takes them over, they even increase at the products exporting. In this case the insurance method is the introduction of an organizational structure of quality management, in accordance with the functional purpose of each division of the enterprise. In addition, it is necessary to develop a clear scheme for the sale of the finished products in order to reduce the period of its sale and to provide consumers with fresh and quality vegetables and berries in a timely manner. The greater the concentration of certified organic productions of one profile and carefully designed supply chain, the greater the incentive to logistics and quality control at the conventional production enterprises of the same specialization. Ultimately, this situation can lead to a general increase in the quality of products throughout the industry.

The institutional and information risks are related to the legislation and changes in the state policy on agricultural production. As compared to "inorganic" businesses, the risks of organic crop production under analysis are more significant, because the basic law concerning organic production is imperfect and does not respond to the reality of the existing market for these products in Ukraine. It is possible to correct this situation through the participation of the association of producers of organic products in the legislative process.

Also, institutional and information risks are conditioned by the insufficiency or inaccuracy of information on production technology, market situation, etc. A separate kind of information risks are the risks related to the loss of own confidential commercial information. These risks are substantially intensified for the organic crop production, especially for protected ground, due to the lack of relevant official statistical data and limited private consulting services in this area for beginners and experienced farmers. To minimize the lack of information, direct contacts with leaders of the organic movement, including foreign ones, should be established. Protection of proprietary commercial information can be provided by private electronic data dissemination at the enterprise, particularly, with the use of corporate systems of data exchange, such as "Lotus" or "SAP" (Amelina, 2014, p. 14).

The legal risks in the organic production greenhouse enterprise are similar to the risks of conventional enterprises. Currently in Ukraine such risks can be managed by sharing their influence with other organic production enterprises. Through the association, small farms will attract increased attention of the state authorities and international relevant organizations to their problems. In 2012-2013, a number of state planning documents defined organic production as a promising area of activity in domestic agriculture, which enables organic enterprises to receive state support in the form of financial and credit support, thus reducing financial riskiness.

Financial and price risks in organic production on protected ground are reduced in comparison with conventional cultivation of the open ground and inorganic greenhouse production, as the technology of crop production on protected ground allows you to extend the production season. Diversification of production and innovative greenhouse systems help producers to introduce uninterrupted and profitable cultivation of vegetables and berries. Therefore, it is possible to minimize price risks by diversifying greenhouse production. Namely, when the light day becomes longer, it is possible to begin the preparation of seedlings for further transfer to the greenhouse. These may be now popular early varieties of lettuce, radishes, bunch onions and so on. Parsley and dill can also be sown. In the second decade of

April, the seeds can be planted in the greenhouse, which will later be grown in open ground. These are zucchini, pattypan squash, cabbage, cucumbers, beets, and the flower seeds. By the end of May – in early June the sprouts of the mentioned crops are transferred to the cultivation bed and instead of them early varieties of tomatoes, pepper and eggplant are planted in greenhouses, if it is permitted by the requirements of the certification authority. These crops can also neighbour on bunch onions (onion phytoncides can help protect plants from pests), cabbage lettuce, Chinese cabbage, and radish. By the end of July late varieties of radishes, salad, and onions are planted. By the end of August, tomatoes, peppers, eggplants are taken from the greenhouse. And radish and salad can be grown in the greenhouse up to the first cold days. By organizing crop rotation in a greenhouse this way, one can get local high-quality and useful products for almost all year round, while the open ground provides no possibility for that, where at the end of September the crop is taken, and fresh greens, radish, bunch onion are not subject to long-term storage (Ivanishin, Targon, Okolot, 2008, p. 46).

Consequently, the seasonality of the products allows greenhouse production to manage price risks and compete in the market by growing the most demanding products depending on the season. In other words, diversification of production is an effective means of control of both technological and price risks (Amelina, 2014, p. 15). An important risk management tool in organic production when choosing a specialisation is to take into account the environmental costs to support natural and resource potential of the areas involved in organic production.

These costs include: costs for the measures related to reducing emissions of pollutants into the atmosphere and wastewater, construction of wastewater treatment facilities, waste disposal, integrated use of raw materials, establishment of sanitary protection zones around enterprises, use of secondary resources, development and implementation of resource-saving technologies (Penova, 2010, p. 87-88).

From the economic point of view, these costs can be divided into:

preventive costs (preliminary costs);

economic loss;

expenses for remediation, neutralization and compensation of environmental disruptions (post-expenses).

Preliminary costs include activities aimed at:

ecological education, personnel training, advertising and publishing activities of ecological trend;

development of legal, regulatory, methodological materials and documents;

organization and improvement of the institutes of environmental activity management;

research and development works, including the design and implementation of environmental technologies;

environmental modernisation of technologies;

creation of objects of ecological infrastructure (systems of emissions treatment, wastes recycling, etc.);

development of ecological regulations: environmental expertise, monitoring systems, environmental impact assessment procedures, environmental standards. All articles of these costs are grouped by ecological orientation.

Post-expenses are the costs of reduction and compensation of economic loss.

They include the following measures:

medical and ecological insurance;

compensatory payments against environmental claims;

management of hygienic, medical, biological and ecological consequences of accidents;

reclamation and restoration of damaged natural habitats and objects.

In addition to the current cost of maintaining the qualitative characteristics of natural resources used in organic agricultural production, capital investments are also required for the protection of water resources and air basin, land, mineral resources and flora and fauna resources (Ivanishin, Targon, Okolot, 2008,, p. 46-47).

Like any other type of business, the cultivation of products on protected ground using organic technology requires attention and up-to-date approach to the use of innovative and resource-saving technologies. Then, with optimal observance of technological requirements and prevention of analyzed risks, Ukrainian producers will receive high-quality and competitive vegetable and berry products.

In the agrarian sector of the domestic economy, in recent years, the innovation strategy of long-term balanced development, which proclaims the need to achieve a balance between satisfying current needs and protecting the interests of future generations in terms of a safe and healthy environment, strengthens its position and spreads. It is the concept of a balanced development that led to the emergence of eco-innovations. These include the production of environmentally safe products, the use of natural, resource-saving technologies, the green office management concept, the eco- efficiency concept, the clean production model, international standards of eco-management and audit (ISO 14000, EMAS), methods of raising resource efficiency based on the MIPS concept, a new system ecological design and special labeling of products that provide a high level of environmental safety of production, products and services while strengthening the competitive positions of business (Andreeva, Kupinets, 2014, p. 52).

Today in Ukraine the production of organic products is becoming more and more popular, and this "green wave" has touched the domestic farmers, specializing in vegetable and fruit farming. However, as to the efficient production of ecological and organic products, there is a pending issue of choosing the type and grade of the product, cultivation and sale of which will bring the greatest benefit to the agricultural producers on their own land. Insufficient attention has been paid to the use of intensive technologies in the cultivation of environmentally safe products, depending on the country's region, types and varieties of fruit and vegetable products, the level of solvency of the population and other factors. Consequently, domestic producers of agrarian products need recommendations regarding the choice of the optimal type of activity and the most profitable sales channels.

Ukraine needs to create domestic demand for certified organic products, the key potential consumers of which are urban residents. Since in Ukraine the "clean" products are traditionally considered to be the products produced in rural areas in households (which account for about 50% of gross agricultural production), domestic consumers are often not willing to pay considerable amounts for organic products, except for baby foods.

The prospect of establishing organic production of agricultural products and food in Ukraine is conditioned by the strict regulation of the production process through the application of certain rules and standards, in particular regarding the proper animals management, the use of substances and processes of natural origin, providing in addition to economic effects an opportunity to achieve the objectives of preservation and restoration of natural resources, biodiversity, stepping up of backyarders activity (Amelina, 2012, p. 8-9).

Therefore, in order to substantiate the specialisation of the agrarian enterprise of organic and ecological production under current market conditions, it is necessary to analyze its resources availability and the components of the external environment of farming. The key resources that determine the industry's production include: the natural environment, in particular, the environmental position of agricultural land, fitting out, financial and labour resources, product sales channels.

At present, it is a challenging task to find absolutely "clean" territories within the state, since there are not only "local" sources of pollution, but also interstate and transcontinental transport of pollutants, which, besides the soil, also contaminate other natural components. Therefore, assessing the suitability of land for the production of environmentally safe products should be based on the principles of a systematic method of research and analysis.

The primary stage of implementation of a complex of works on determining the agricultural land capability for the cultivation of environmentally safe crops is the assessment of the environmental position of the territories. To this end, all available information is accumulated and analysed regarding the main types of lands, ground, agroclimatic conditions, ploughness, erosional features and fertility, the availability of industrial and other enterprises within the land plot, which are dangerous from an environmental perspective, the types and levels of pollution of atmospheric air, surface waters and soil (Grabak, Topiha, Davydenko, Shevel, 2008, p. 322).

In recent years the National Scientific Center "Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky" of the National Academy of Agrarian Sciences of Ukraine has paid their attention to the needs of the environmentally safe products market and started developing research and methodical grounds of biological farming in Ukraine, developing the methods for the identification and generation of a data bank of environmentally safe agricultural areas of Ukraine, as well as the methods of agrochemical certification of lands suitable for the production of quality products in conformance with the standards. The guidelines for the management of biological agriculture have already been developed, including regulations on the use of mineral fertilizers and by-products. In particular, the scientists have carried out the analysis of the ecological and toxicological state of Ukrainian lands and identified the areas where it is possible to practise ecological agriculture.

In addition to environmental factors, the economic factors also influence the favorable conduct of business in the field of organic production. Material and technical resources consist of a variety of tools, materials and supplies, ensuring the production process, technology compliance and the quality of the finished product. Due to the availability of material and technical resources, the regions of Ukraine are very much unlike. For example, the agrarian associations of Kyiv and Dnipropetrovsk regions are able to use licensed foreign technology and equipment, while private farms distant from the district centers, are deprived of such a possibility.

Although the domestic farms produce over 84% of the fruit and vegetable products, the supply of technical facilities to these farms is still insufficient and, in particular, they own: 172 thousand tractors, 21 thousand harvesters and 44 thousand mini-tractors and motoblocks. In its turn, the agricultural enterprises producing less than 16% of the fruit and vegetable products in the country, own 151,287 tractors, 72,366 machines for planting, 5,736 units of irrigation equipment, 32,750 harvesters and other specialised equipment (“Agriculture of Ukraine…”, 2016, pp. 202-204).

The equipment and material procurement of an individual enterprise and the region in general is of great importance in activating the organic production of vegetables, fruits and berries. In fact, when focusing on environmental principles, the volume of the product can be increased, in particular through the use of innovative technologies and technical facilities, reducing the cost of production on account of resource saving.

The financial support of the region also has a direct effect on the producer, since the volume of consumption of fruit and vegetable products increases with the growth of average income. So, in 2016, a person with an average income of 3,000 hryvnias a month consumed 85.2 kg of vegetables and 25.2 kg of fruit per year, and with the income of 4,500 hryvnias a month - 114 kg of vegetables and 42 kg of fruit per year (“Agriculture of Ukraine…”, 2016,, p. 160).

To start the production of organic products in Ukraine the best choice is to make an attempt to grow organic fruit and vegetable products, as when compared with other types of agricultural production, the initial cost of organisation of such production is the lowest.

The general reserve for increasing sales is to promote the consumption of fruits and vegetabes, since, according to the recommendation of the World Health Organization, a person aged from 18 to 64 should annualy consume about 157 kg of vegetables and 86 kg of fruit.

Human resources actively influence the production process from the two opposite sides: on the one hand, it is the producer's staffing support, on the other hand, it is the products consumers. The volume of consumption of vegetable, fruit and berry products is determined by a number of traditional macro and microeconomic factors: the level of family income, the number of family members, the number of children in the family, the place of residence. The regions with a high concentration of population are more attractive for the sale of products, since they have more powerful sales channels, and consumers have higher incomes, but the restraining factor is a tougher competition.

The sales market for organic and environmental crop products consists of internal and external parts. Choosing a market, an enterprise should reasonably determine the specialisation of production, focusing on the geographical location of production facilities and the technology of processing, storage and transportation of raw materials or finished products (Gavaza, 2014, c. 132 – 133).

The agricultural area mostly fit for growing of organic products in Ukraine includes Lviv, Kherson, Sumy, some part of Ternopil, Kharkiv, Zaporizhzhya, Mykolayiv and Volyn regions. The leader in the production of vegetables on an open ground according to the number of products sold in this agricultural area is Kherson region, Mykolaiv and Lviv region, however the most economically viable production of vegetables on the open ground is the production in Kharkiv region as contrasted with Kherson region. The largest amount of the vegetables grown in protected ground in this agricultural area is produced in Lviv region (4.5 thousand tons), and in Lviv region the production is most profitable (43.1%). A common trend for all areas of the zone is that the bulk of vegetables is produced in the citizens' households. Lviv region is the leader in the production of potatoes. Kherson region is the leader of the area in the production of fruits and berries, and Volyn region - in the profitability of their production (about 88%) (Amelina, 2014, p. 7; 19, p.44-48).

According to Organic Standard LLC, in early 2017 in this agricultural area actively worked 17 operators of organic vegetable and fruit production, particularly in Lviv region – 8 farms cultivating potatoes, maize, onions, cucumbers, tomatoes, peppers, strawberries, carrots, apples, cabbage, beets, potatoes, pumpkins, in Kherson region – 6 farms specializing in tomatoes, cucumbers, cabbage, carrots, peppers, water melons, in Kharkiv region - 3 farms producing artichokes, marrows, pattypan squashes, carrots, water melons, potatoes, different kinds of cabbage and beans, in Mykolaiv region – 2 private enterprises that cultivate strawberries, raspberries, currant and gooseberry (“Electronic database…”).

The most prospective consumer of the area is considered to be Kharkiv region due to lack of a sufficient number of certified producers of organic vegetables, fruits and berries on its own territory, the highest average salary and the smallest level of consumption of vegetables by the population (138.5 kg a year per 1 person) as opposed to Kherson region, where people consume 194.9 kg of vegetables and gourds per person annually (Amelina, 2014, p. 7-8).

As you know, the enterprises of Lviv and Volyn regions are the exporters of certified crops (particularly, vegetables, fruits and berries) to the nearest European Union countries, but the consumers of border areas have income below the average. Therefore, the producer can not count on the large volume and stable prices for the sale of fruit and vegetable products. Besides, the approximate costs for exports from these areas of 1 kg of vegetables of a "borsch set" will cost around 25-40 hryvnias (not including the cost of storage of products in refrigerators), while the prices for the same products in the EU are at least twice as much. In case of overcoming the restraining factors of customs and certification regulations, the exporter will have the products with a profitability level of 60% (Amelina, 2014, p. 7-8; Tomić, Dzhordjevich, 2012, p. 127).

The positive aspects for the production of organic vegetables and fruit in the above mentioned regions are as follows:

- excellent quality of surface water;
- small emissions into the air, except for the large cities areas (Kherson, Lviv);
- territorial proximity of Lviv, Ternopil and Volyn regions to the European Union states, which is a good precondition for the export of raw materials and products of vegetable and fruit farming industry;
- consumer demand for natural products.

These positive aspects provide the producers of organic and ecological products with the possibility to increase cultivation of fruits in the open ground, to focus on the production of regional types of fruit (apples and strawberries) and to actively export their products without any risk of production unprofitability.

The adversities of the ecological and organic products production in this area are as follows:

- almost no valuable soils;
- insufficient number of sunny days per year and increased humidity - poor conditions for growing of ground vegetables, but favourable for growing berries;
- shortage of natural irrigation water;
- low purchasing power of the locals;
- the concentration of agricultural production in small farms;
- low level of infrastructure development of the regions;
- close proximity to competing countries producing fruit and vegetable products (Poland, Turkey).

These negative factors of the area threaten to increase production and sale regional risks as a result of a dependance on the purchasing power of the population and failure to compete with the closest foreign manufacturers.

In view of this, we can conclude that the agricultural area under analysis is favourable for successful organic vegetable and fruit production. Organic production of fruit and vegetable products is most actively mastered by farms. Local businesses can develop in this kind of business as a result of favourable climatic conditions, convenient export-oriented distribution channels of production, availability of labour force, neighborhood with the regions with sufficient demand for the fruit and vegetable products and above-average purchasing power of the population. Negative regional risks are not significant.

The agricultural area, which is suitable for growing organic products to a limited extent, includes Chernivtsi region, parts of Kyiv, Ivano-Frankivsk, Zhytomyr, Khmelnytsky, Ternopil, Vinnytsia, Poltava, Chernihiv, Mykolayiv, and Kirovograd regions.

The largest producers of vegetables grown in the open ground in this area are farms of Cherkasy region. 84.3% of vegetables and 84.2% of fruits and berries are grown in gouseholds, and 15.7% and 15.6% of agricultural products respectively is produced by agricultural enterprises. The highest level of profitability of vegetable production was registered in the Chernihiv region. The largest amount of vegetables grown in protected ground has been produced by the farms of the Kyiv region, and the most profitable production of these has been registered in Cherkasy region (33.1%). Potato production has the highest profitability (77.6%) in the Kirovograd region, and the largest amount of potatoes is sold in Kyiv region. Vinnytsya region is in the lead in growing fruits and berries, and the greatest profitability index of fruit and berry products has been shown by the producers of Ternopil regiom (337.2%) (Amelina, 2014, pp. 8-9; "Agriculture of Ukraine…", 2016, pp. 44-48).

In this agricultural area, 14 operators produce organic fruit and vegetable products, 5 of which export their products. Particularly, according to the data by Organic Standard LLC, in early 2017 in Ternopil region 4 farms produced apples, carrots, onions and beets, in Kyiv region - 3 limited liability companies and 3 farms grew melons, watermelons, carrots, tomatoes, cucumbers, peppers, cabbage, marrows, potatoes, beet, radish, celery and strawberries, and the 3 enterprises exported their products. In Ivano-Frankivsk region, 1 entrepreneur sells fresh and frozen blueberries and blackberries, and exports them abroad, in Vinnytsia region 3 individual entrepreneurs, 1 farm and 2 limited liability companies grow chokeberries, apples, currant, pears, elderberries, strawberries, tomatoes, cucumbers, eggplant, peppers, marrows, potatoes, carrots, onions, cabbage, beets, and 1 entrepreneur exports its products. In Chernihiv region, one enterprise grows carrots, pumpkins, beans, cabbage, beets and potatoes ("Electronic database…").

The positive aspects for the production of organic vegetable and fruit production of the mentioned agricultural area are as follows:

- acceptable quality of surface water;
- availability of especially valuable soils in some areas;
- proximity to Lviv, Volyn and Kharkiv regions, where the main

production of organic products is concentrated, providing a possibility of not just cultivation of products, but also its major processing;

- popularity of organic products, a developed system of product sales (supermarkets);
- scientific research centers for organic production (Poltava).

These positive factors provide an opportunity for the development of one part of the agricultural area as a raw material base, and the other part - as the regular consumers due to a limited, but still existing fitness for the cultivation of organic agricultural products and the concentration of scientists exploring the process of introduction of organic, biodynamic and ecological technologies in the country (in the cities of Kyiv and Poltava).

The negative aspects of organic production of investigated agricultural area are as follows:

- less content of humus in soil compared to the agricultural area with suitable conditions;
- location far from the borders of the country, which complicates the export of products;
- the general orientation of regions to industrial production, which reduces agricultural land;
- a limited choice of crops due to climatic conditions.

These negative factors intensify the risks of reducing the agricultural land area allocated for organic vegetable and fruit growing due to the presence of dangerous objects and, and result in a lower quality as compared with that of competitors, located in a favourable agricultural area. Moreover, for the producers located in the agricultural area of a limited suitability in the central regions of the country, the conditions of export of fruit and vegetable products are considerably worse due to its short shelf-life in their natural state, high moisture content and deformation, even at low loads. "Solid" fruits and vegetables without special packaging are recommended to be transported at a distance not bigger than 750 km, and "soft" - 250 km. Accordingly, there is a need in quality product storage, for which it is advisable to rent or build specialised warehouses. However, entrepreneurs located in the agricultural area with a limited suitability, have more preconditions for the successful fulfillment to such recommendations due of the large concentration of industrial facilities (including the former ones), the availability of specialised research centers, as well as due to the fact that there are the largest vegetable fairs (Kyiv) and wholesale markets in regional centers, for example, the "Stolychny" market in the city of Kyiv.

Based on the analysis performed, it can be concluded that organic production in an agricultural area with a limited suitability requires additional substantiation of location and specialisation. In particular, in Vynnytsia region, in addition to the ordinary vegetables, organic berries and fruit trees are already successfully cultivated, and in Kyiv region a wide range of vegetables and gourds are grown. Ivano-Frankivsk region successfully exports raw products for processing (berries). In this agricultural area it is advisable to develop the conditions for the storage and processing of fruit and vegetable products. Active consumers of the agricultural area are the residents of Kyiv region due to higher density and purchasing power of the population, as well as more active pace of life in these areas. The least saturated segment of the agricultural area market is considered to be Ivano-Frankivsk region, since the average rate of consumption of vegetables per year is 117.5 kg, while the consumption of fruits and berries amounts to 38.3 kg, which is significantly lower compared to the recommended standards (157 kg and 86 kg respectively) (Amelina, 2014, p. 9; 21, p. 44-48).

The agricultural areas with unfavourable conditions for organic production include Zakarpattia, Dnipropetrovsk, Odesa regions, parts of Zhytomyr and Chernihiv regions. The largest number of vegetables grown in the open ground in this area was sold in the Odesa region. The largest seller of potatoes with the highest profitability index in this area is the Dnipropetrovsk region (44.6%).

Currently, 2 certified operators of organic fruit and vegetable production work in this agricultural area. Namely, in Odesa region 2 farms produce watermelons, melons, cucumbers, marrows, strawberries, Jerusalem artichoke, radish, carrots, onions, potatoes, cabbage, sweet peppers, eggplants, tomatoes, cherries, bird cherries, plums and apples ("Electronic database…").

The positive aspects of organic vegetable and fruit farming in this agricultural area are as follows:

- availability of valuable soils in some regions (according to National Scientific Center "Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky" of the National Academy of Agrarian Sciences of Ukraine), which allows growing products close to organic (using organic technologies, natural, etc.);
- possibility to use existing and new systems of energy saving and intensive production;
- proximity to the main transport centers of the country;
- high demand for organic products;
- developed system of sales of products (supermarkets, online stores, eco-restaurants);
- relatively high purchasing power of the locals.

The above positive factors increase market development due to the high demand and purchasing power of the population, and the variety of sales channels will only extend the area of marketing activities of producers.

The negative aspects of organic production in this agricultural area include:

- the availability of polluting emissions into the atmosphere, especially around large cities;
- orientation on growing the cereals;
- adverse climatic conditions.

The above mentioned negative factors intensify the risks of unprofitable organic production of vegetables, fruits and berries in unfavourable agricultural areas due to significantly lower quality of air and water, and sometimes soils are already exhausted by intensive agriculture. In case of their further irrational use it will be impossible to grow not only organic, but also any agricultural products at all. However, the high demand for organic products in these areas, the availability of extremely fertile soils (according to the National Geographic Atlas of 2017, the content of humus in the lands of Dnipropetrovsk region is 315 tons/ha, and in Lviv region - almost 4 times less – only 83.2 tons/ha), traditionally high yields of vegetables and the availability of innovative technologies for soil cultivation and products growing indicate the possibility of producing the quality close to organic (biologically safe, using organic technologies, ecological, natural, etc.).

Thus, the entrepreneurs of this agricultural area can specialise in the production of organic traditional vegetables, gourds and stone fruits, but in limited quantities due to the lack of certified areas. It is advisable to focus on the processing, storage and sale of finished products to end users, in particular in the form of eco-restaurants and family farms ("from the field to the table"). In the production one can specialise not only in organic, but also in natural and biological products, depending on the technology of production and existing natural conditions. The Dnipropetrovsk region is considered to be the most active consumer of fruit and vegetable products.

It may be beyond the power of households to overcome the risks identified in the first part of the study and implement the far-reaching plans, sometimes even the average agricultural enterprises are unable to pay the additional costs associated with the "organic" production. Therefore, the co-operation of the households is advisable in order to find financial resources for the improvement of the environment and participation in grant programs that can compensate for environmental costs partially or in full. Moreover, state is more focused on agricultural cooperatives, for example, in concessional lending, which can also help to cover environmental costs.

Co-operation of enterprises wishing to start producing or already producing organic products, provides an increase in the production efficiency of every participant.

Unfortunately at the moment the cooperatives are not yet a popular form of management in the organic agricultural sector of Ukraine.

To activate cooperation, at the state level it is necessary:

- to clearly define the role and place of cooperatives in the country's agriculture, which would be reflected in the national programs of social and economic development;
- to develop common approaches to the development and establishment of agricultural cooperatives;
- to provide training and retraining of personnel, including overseas training, training of employees of all levels and of peasants;
- to promote financial support of research in the field of cooperation;
- to involve cooperatives and their associations in implementing the state programs;
- to provide assistance in creating a material and technical facilities through the provision of start-up cooperatives with the start-up capital;
- to work on optimisation of activity at the level of the agricultural marketing cooperative.

Naturally, cooperation will not eliminate all the problems that agricultural enterprises and households are now facing, when they choose the path of organic production. However, such an association can help manage business more efficiently under current crisis conditions.

It was found that when moving to organic standards in organic crop production in the open soil: firstly, there are production risks arising for organic technologies - crop yields are reduced, and the least deviation from environmental requirements will lead to he loss of organic product status; and secondly, there are the risks of conventional production, in particular, financial and marketing, expressed in uneven income received by producers throughout the year; and thirdly, the climatic risks increase (due to the dependence of the production process on weather conditions that cannot be minimised by using inorganic means of plant protection), as well as the marketing risks (due to reduced period of the sale of fresh products). A way to mitigate or minimise the risks described above may be the transition to growing vegetables and berries in the protected ground.

During the transition to organic standards, the organic agricultural production in greenhouses is affected by strengthening institutional and informational, technical, technological and marketing risks. Institutional and informational risks are related to imperfections and insufficiency of legislation regarding the cultivation of organic agricultural products, changes in state policies on agricultural production, insufficient or inaccurate information on technology of production and organic products markets. As compared with the traditional production, the group of engineering and technological risks increases its influence in growing organic products.

For the development of agricultural production using organic technologies, it is necessary to determine the prospects of agricultural enterprises according to their distribution in agricultural areas with favourable, limited favourable and almost unfavourable conditions for organic agricultural business. Besides the ecological factor, the natural environment, fitting out, financial and labour resources, product sales channels will also influence the choice of specialisation of an agricultural enterprise. The results of the analysis of the production capacity and consumer opportunities show that natural and economic potential of agricultural enterprises of Ukraine allow them to be successfully engaged in various types of "green business": in particular, growing organic vegetables, fruits and berries in the open or protected ground, processing, storing, and profitable marketing of such products.

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CHAPTER 5. THE STATUS AND PROSPECTS OF ORGANIC ARABLE FARMING DEVELOPMENT IN POLISSIA OF UKRAINE

In today's conditions, the objective process is that of increasing the focus on the development of territories and regions as a territorial and specialised part of the country's economy, characterised by the unity and integrity of the reproduction process. This process is conditioned by the growing autonomy of the regions, the need to eliminate existing imbalances, taking into account the specifics of the domestic economy transformation processes. At the same time, in the context of the current globalisation challenges, namely fluctuations in the world market conditions, climate change, increase in biofuel production, commodity producers do not adhere to scientifically grounded standards of management, violate production technologies, adapting only to market conditions. These processes are especially relevant for the agrarian sector of the economy.

Excessive use of natural resources, overloading of the main life-supporting natural systems, depletion of fertility potential of agricultural lands and a decrease in their quality, disfigurement of natural landscapes and their inconsistent balance - all this has led to large- scale destructive processes in the environment that reach the level of threats to regional and national security of Ukraine. In modern conditions of economic activity, the competitiveness of domestic agricultural production in international markets is largely ensured by overloading and over-use of the main life-supporting resources: land, water and mineral resources. At the same time the issue of application of environmentally safe technologies of agricultural production and reducing the anthropogenic impact on the natural environment has not been tended with a particular care.

The problems of formation and functioning of regional ecologically safe technologies are discussed in the works by P.A. Boiko (Boyko, Kovalenko, 2003), V.I. Vovk (Vovk, 2004), B.V. Burkynskyi, T.P. Halushkin, V.Y. Reutov (Burkinsky, Galushkin, 2011), Y.Y. Kakutych, Y.V. Khlobystov, B.M. Danylyshyn (Zharova, Kakutich, Khlobistov, 2009), T.O. Zinchuk (Zinchuk, Dankevich, 2016), V.I. Kysil (Kisil, 2000) et al. Investigations of the environmental imperative of agricultural enterprises activity are associated with the names of leading scientists of agrarian economics, namely: S.P. Azizov, V.Y. Ambrosov, Dankevych (Dankevych, Dankevych, Chaikin, 2016), O.V. Khodakivska (Sabluk, Khodakivska, 2012), M.V. Zubets, T.V. Marenych, V.K. Zbarskyi and others. The issue of studying the influence of agricultural producers on the environment is considered in the scientific papers of: S.S. Antonets, V.M. Pysarenko, M.M. Opara (Antonets, Pisarenko, Opar, 2001), M.Y. Malik, V.Y. Mesel-Veseliak, V.K. Tereshchenko, M.A. Khvesyk, M.I. Kobets (Kobets, 2004), O.V. Kovaliov (Kovaleva, 2008) and others. In the papers of the above researchers, the concepts and basic approaches to the definition and classification of economic zones and depressive regions are considered, and the characteristic elements of environmentalization of land use are provided. At the same time, there are no methodical bases for the establishment of priority development territories and comprehensive analysis of performance indicators of economic entities' activity depending on the environmental and economic characteristics of certain regions. The issue of assessment of regional specialization in the context of use of alternative, environmentally safe technologies of agriculture requires further research.

Environmental and economic problems of land use are the most acute and threatening in terms of sustainable development, therefore the system of regional development management should incorporate environmental tasks, criteria-based evaluation of reproduction process should be improved taking into account the environmental requirements, the compensation for the use of green technologies should be envisaged.

While studying the ecologization of agricultural production as a key component of modern agriculture, P.T. Sabluk and O.V. Hodakivska note that intensive technologies of land use in crop production include the impact on natural resources, processing and changing their natural properties. Such changes are necessary for the cultivation of crops, but they are harmful to the environment (Sabluk, Khodakivska, 2012, p. 121-122). Therefore, the quality and safety of agricultural products are directly related to the region in which they are grown.

The regional organisation is a process of continuous improvement of zoned systems of farming, allocation of agricultural crops and industries, enhancement of technology and methods of growing crops and breeding productive livestock, complex mechanisation and automation of production processes. The differentiation of labour, which is reflected in the allocation of agricultural production and the economy specialisation in the production of certain types of products, is one of the important factors of highly efficient use of agrarian and resource potential, a steady increase in the production of agricultural products and livestock, increased accumulation, raising the living standards and welfare of the population. The regional factor has a significant impact on the development of agricultural production (Fig. 1). For example, the Wooden steppe is a zone of guaranteed agricultural production due to better weather and climatic conditions, natural soil fertility, and lower risks to economic activity. In this region, all shared lands are leased, and land reserves have been managed. The sustainable use of crop rotation with perennial legume grasses and annual bean-cereal mixes makes it possible to increase the soil fertility and create a reliable forage base for the development of the livestock sector. It is in the Wooden steppe area that the lion's share of animal breeding products' production is concentrated in the public sector of the economy. Such an integrated approach to the development of crop and animal breeding industries enables the development of the processing industry and infrastructure in the countryside, creates conditions for the production, processing and marketing of cultivated products.

During the last decades, there have been significant changes in the weather and climate conditions of agricultural production. Thus, the average annual air temperature in Ukraine increased by 3-5 0C, which led to a reduction of moisture content and caused an increase in dry days during plants vegetation period. This had a particular impact on the agrarian production in the area. In addition, the reduction of irrigation operations scope in certain regions of this zone calls into question the expediency of growing some crops. Even though the raw material market for such crops as grain maize, soybeans, rape, sunflower is not limited, the land area for these products in the Steppe is reduced. Such risky agrarian production provides no possibility to attract investment funds in full, to develop innovative projects, to develop social and cultural life in rural areas.

In contrast with the Steppe area, the change in weather and climatic conditions in Polissia contributed to the expansion of the list of cultivation of crops that had been uncharacteristic for it. The increase in the temperature regime and a relatively sufficient amount of moisture content shifted the "corn and soy belt" towards the Polissia region of our state. In recent years, these crops area has increased by 32%, replacing such crops as fibre flax, potatoes, winter rye and oats in the structure of sown areas. However, in the region there has been no primary processing of products established so far. Infrastructure and logistics systems are developing at a slow pace.

Taking into account the market environment, the natural and economic conditions of each zone, it is possible to determine the specialisation of its agrarian production in the long run. Thus, the farms in the Steppe area have the best conditions for developing focused specialisation of agricultural production in the cultivation of durum winter wheat, grain maize, sunflower seeds, milk, beef, pork, poultry meat, eggs, berries and grapes production. At the same time, it is important to establish the processing of products. Depending on the specific conditions, the integrated organizations in this zone may prefer the production of a particular type of agricultural products.

Product manufacturers of the Wooden steppe zone can develop focused specialisation in the production of grain of winter wheat, brewer's barley, sugar beet, potatoes, milk, beef and pork. In order to increase the efficiency of economic activity, the cooperation with processing enterprises must be established by concluding long-term contracts for the supply of raw materials.

The farms in the Polissia area should use their conditions and resources to increase the production of winter rye, potatoes, common flax, hop, barley, beef and pork. The conditions of the Carpathians area allow specialisation of farms in the production of beef and mutton, wool; in Zakarpattia – fruit and grapes; in Prykarpattia - winter wheat, grain, sugar beets, common flax, milk, beef and pork.

The zonal specialization of integrated formations prevails in the market conditions as a process of isolating certain natural and economic areas by the production of those types of products for which they have the best natural and economic conditions. Agrarian zones are shaped, first and foremost, under the influence of natural environment. The steppe zone occupies the largest area - 40% of the total area of the state. The Wooden steppe area is located in the central part of Ukraine and extends from the southwest to the northeast, from Prykarpattia to the border with the Russian Federation. Its area is 34% of the entire territory of Ukraine. The Polissia area is located in the north of Ukraine, within the southern part of the Polissia lowlands, and occupies 20% of the territory of the country. The Carpathian area of Ukraine includes the vast majority of the territory of three western regions: Lviv, Ivano- Frankivsk, Chernivtsi and the whole territory of Zakarpattia region. The total area of the zone is 6.7% of the territory of Ukraine.

It should be noted that just before the declaration of Ukraine's independence there were significant differences in the regional rates of development of agriculture and industry, due to different levels of intensification of production. The average annual rate of increase in the gross output of agricultural enterprises ranged from 2.6% (Vinnytsia, Dnipropetrovsk, Zhytomyr, Kirovohrad, Poltava, Sumy, Kharkiv, Khmelnytskyi, Chernihiv regions) to 6.9% (Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Rivne, Chernivtsi regions), where the rates of intensification of production were the highest.

During the period of 1991-2016, there was a significant relationship between the growth rates of agricultural production and structural changes in production. The relatively low rate of development was in the regions with the traditional structure of agriculture - grain-focused specialisation, with a low percentage of industrial crops and inadequate development of animal breeding (Sumy, Kirovohrad, Khmelnytskyi, Zhytomyr regions). The high rates of agricultural development in the regions combined with the stability of the demographic situation, and even the growth of the rural population was in evidence. In some regions, the rural population grew by 9% over the period indicated due to its natural increase. In a group of regions with a low rate of agricultural development, the population has decreased by 40%, which was caused, above all, by its migration to industrial centres and depopulation as a result of the rapid aging of the village dwellers. The same dependence was found in 2016.

The main task of the zonal organization of agrarian production is to develop for each zone and sub-zone a system of economic, technical, agronomic, zoo veterinarian, environment-forming, nature protection, complex land reclamation and other measures aimed at increasing productivity and economic efficiency of agrarian and resource and human potentials. In this context, it is important to work out the measures aimed at environmentalization of production, optimal allocation of agricultural crops, taking into account the conditions of each natural and economic area.

In view of the above, the selection of a region suitable for approbation of ecologically safe production technologies becomes urgent. While studying the development of organic farming in conditions of Ukrainian Polissia it is necessary to analyse the economic and ecological status of the region, which involves assessment of geographic location, natural and climatic features, state of the land resources and influence of these factors on the specificity of the producers' economic activity and the ability to change their specialisation towards environmentally sound production.

For the purposes of economic activity, Ukrainian Polissia has a favourable geographical position along the northern border of the state. The region relief and climate are suitable for farming. Polissia terrains, characterised by moderately warm, humid climate, expanding sandy plains, forests, swamps, wetlands, meadows, and lakes, are endemic to this region. Volynian upland with average altitudes of 220-250 m is located in the southwest of Polissia, within the Volyn and Rivne regions. The southern areas of Zhytomyr and Kyiv regions occupy the northern part of the Dnipro Uplands (average altitudes of 220-240 m). Partially south of the Kyiv, Chernihiv and Sumy regions are occupied by the Dnipro Lowland with prevailing heights of 100-150 m. Thus, mainly flat nature of the Polissia area creates favourable conditions for the development of the transport network, communications, construction, various branches of agriculture and industry.

One of the main features of the land resources of Polissia is the high level of bogginess and water-logging of the territory. The total area of marshes is 384 thousand hectares, that is 2.7% of the region area. Marshy and water-logged lands account for more than 20% of the total area, or 44% of the area of agricultural land. Land use problems in Polissia are largely related to land degradation, the dominant role being played by anthropogenic degradation - the process of reducing the quality and productivity of soils caused by changes in soil conditions due to economic or other human activities. Moreover, in the Polissia area, the main reason for degradation of soil qualitative characteristics is the intensive drainage reclamation ("Agro-ecological bases…", 2003, p. 24).

The structure of natural resources conditioned the peculiarities of the economic development of Polissia, creating favourable conditions mainly for the functioning of agriculture, other branches of the agro-industrial complex, processing, light industry, forestry, woodworking, construction industry, non-metallic machine-building and metalworking. Due to the lack or non-availability in most areas of the region of fuel and energy and ore resources, raw materials for the chemical industry, fuel and energy complex branch, the metallurgy, chemical industry and heavy engineering, which are areas of specialisation in the economy of Ukraine, had limited resource development possibilities in Polissia. At the same time, this region has a strong resource potential for the development of the agrarian sector of economy.

When studying the production of traditional agricultural products, it should be noted that there are almost no restrictions for the economic activity in this field in Polissia. The only exception is the radiation-polluted area. At the same time, while exploring the prospects for introducing organic farming, it is necessary to carry out a comprehensive assessment of the environment status of the region. After all, there is a restriction for organic farming, related to available resources and their pollution status in the conditions of economic activity.

According to the research by I. Syniakevych (Sinyakiewicz, 2004, p. 57-58), a comprehensive assessment of the environment status is carried out on the basis of analysis of three groups of indicators determining the ecological state of soils, water sources and atmospheric air. Since it is impossible to choose only one indicator determining the potential of organic farming in Polissia region, we consider it appropriate to conduct a comprehensive assessment of integral environmental influences in every region of Ukraine and on the basis of the obtained data to find out the possibility of introducing the organic farming.

The process of calculating the ranking score of the ecological status of the Ukrainian regions, assessed within this study, consists of three stages. At the first stage, the selection and calculation of standardised indicators of ecological status in Ukrainian regions is carried out. In particular, the data used is related to: the application of mineral and organic fertilizers for sowing of crops; the use of water; discharge of contaminated return water; the use of plant protection products; emission of harmful substances into the atmosphere from stationary and mobile sources of pollution; the formation of waste of I and III hazard category. The second stage is the calculation of the integral rating criterion for assessing the ecological status of the regions. The third stage involves determining the place of each of the regions of the country in the rating (Table. 5.1).

Table 5.1

Rating assessment of the ecological status of the regions of Ukraine

Regions of Ukraine	Standardised indices							Integral rating criterion for assessing the ecological status of the regions
	use of plant protection products	mineral fertilizer	organic fertilizers application	emission of harmful substances into the	generation of wastes of I-III hazard	discharge of contaminated return water	water intake from natural water	
Volyn	0.9	0.8	0.3	1.0	1.0	1.0	1.0	5.9
Zakarpattia	1.0	1.0	0.0	0.9	1.0	1.0	1.0	5.9
Chernivtsi	0.9	0.9	0.0	1.0	1.0	1.0	1.0	5.8
Iv.Frankivsk	0.9	0.9	0.1	0.8	1.0	1.0	0.9	5.7
Rivne	0.8	0.7	0.2	1.0	1.0	1.0	0.9	5.6
Zhytomyr	0.7	0.7	0.3	0.9	1.0	1.0	0.9	5.5
Lviv	0.8	0.7	0.1	0.8	1.0	0.9	0.9	5.3
Chernihiv	0.5	0.4	0.5	0.9	1.0	1.0	0.9	5.2
Ternopil	0.6	0.5	0.2	1.0	1.0	1.0	1.0	5.1
Cherkasy	0.3	0.2	0.7	0.9	1.0	1.0	0.9	5.0
Khmelnytskyi	0.4	0.3	0.3	0.9	1.0	1.0	0.9	4.9
Poltava	0.0	0.1	1.0	0.9	1.0	1.0	0.9	4.9
Mykolaiv	0.4	0.6	0.1	0.9	1.0	1.0	0.9	4.8
Sumy	0.3	0.4	0.4	0.9	0.8	1.0	0.9	4.7
Kherson	0.6	0.7	0.0	1.0	1.0	1.0	0.4	4.7
Kirovohrad	0.1	0.4	0.1	1.0	1.0	1.0	0.9	4.4
Luhansk	0.5	0.7	0.0	0.6	0.9	0.8	0.8	4.4
ARC	0.6	0.7	0.3	0.9	0.8	0.8	0.2	4.4
Kharkiv	0.1	0.3	0.3	0.8	1.0	1.0	0.8	4.4
Vynnytsia	0.1	0.0	0.4	0.9	1.0	1.0	0.9	4.3
Kyiv	0.4	0.4	0.7	0.7	1.0	0.8	0.2	4.2
Odesa	0.2	0.5	0.1	0.9	1.0	0.8	0.1	3.4
Zaporizhzhia	0.3	0.6	0.1	0.8	0.0	0.8	0.5	2.9
Dnipropetrovsk	0.1	0.4	0.2	0.3	0.9	0.1	0.2	2.2
Donetsk	0.5	0.6	0.3	0.0	0.4	0.0	0.0	1.8

In order to compare the indicators that have different dimensions and units, we suggest a procedure for comparing their values with reference indices for one of the regions of the country. Studies have shown that the ecological state of the Polissia region (Volyn, Zhytomyr and Rivne regions) makes it possible to identify it as one of the most promising for organic farming. The following point is confirmed by the following statement: according to indicators such as the amount of plant protection products, pollution of atmospheric air and water sources, the generation of hazardous waste, the Polissia is in one of the top positions among all Ukrainian regions. Although in the studied region there is a clear tendency to increase the volumes of mineral fertilizers applied for crops sowing, however, their level is significantly lower than the average level in Ukraine, which indicates a lower chemical load on soils compared to other regions of the country.

Polissia is one of four regions of Ukraine, where the soils have not been contaminated to dangerous point and where the cultivation of environmentally friendly products is possible in line with the world standards. Soil and agroclimatic conditions in the Polissia area are favourable for organic agricultural production. The above general description of the natural resources of Polissia of Ukraine proves that the natural resources available in the region, which are the basis for the development of organic agriculture, at creating the appropriate legislative and regulatory framework, are able to ensure further long-term social and economic development of Polissia.

Starting from the 70s and 80s of the last century, in the conditions of Polissia, as well as in Ukraine as a whole, industrial methods of agriculture were widely introduced, which ensured a significant increase in production volumes. However, such industrialization of the agrarian sector was accompanied by an increase in anthropogenic impact on the environment, exhaustion of natural resources, reduced fertility of soils, the loss of small rivers, pollution of the environment with toxic substances. Added to this were the problems associated with the Chornobyl tragedy, which affected the vast areas of the Polissia region.

Another thing characteristic of the agrarian sector of the studied region is that high- liquid and energy-intensive crops such as grain maize, rape, and sunflower have replaced winter crops, legumes, sugar beet, common flax, potatoes, vegetables and forage crops in the structure of crops. This way the scientifically grounded shift of crops in crop rotation is affected, which negatively affects the efficiency of farming, causes a decrease in soil fertility, deterioration of the phytosanitary condition of farm ecosystem. Not conjuncture but structural changes began to appear in the development of agriculture, caused by a number of miscalculations that have been made in the agricultural sector of the economy.

Over the past 25 years there has been a significant transformation of the cultivated areas structure due to the crop sowing reduction 4-5 times and an almost 3 times increase in the share of industrial crops sowing, without taking into account the zonal features (Table 5. 2). Significant expansion in the cultivated area structure of energy-intensive crops promotes their growing as monocultures, which reduces the yield and causes the use of additional plant protection products (Dankevich, 2012, p. 20-21). Moreover, these cultures take a significant amount of nutrients from the soil, destroying the organic reserves of humus.

Table 5.2

State of Agricultural Land Use in Polissia of Ukraine

Indicator	Year						2016 to 1990 +/-
	1990	1995	2000	2005	2010	2016	
Structure of sown area, %							
a) cereals and grain legumes cultures	45.0	48.5	50.2	56.0	56.8	55.6	10.6
b) technical cultures	11.6	13.2	15.4	27.1	26.9	28.3	16.7
of these: sugar beet	5.0	3.2	3.2	1.9	1.9	1.6	-3.4
sunflower	5.0	7.3	10.8	17.0	17.1	18.7	13.7
c) forage crops	37.0	30.1	26.0	9.6	9.0	8.9	-28.1
Reclamation level, %	69.6	69.5	69.3	68.9	68.9	68.8	-0.8
Ploughness level, %	79.5	78.1	77.9	78.1	78.2	78.3	-1.2

The tendency of development of the domestic agrarian sector is the increase in the level of land resources concentration by commodity producers in Polissia and Wooden steppe zones. Over the past 10 years, the integrated agricultural production in Ukraine has become an important and leading form of agribusiness. It partially replaced former collective farms and state farms of the post-Soviet period. The emergence of agrarian holdings has become a significant competitive advantage of the Ukrainian agrarian sector, which allowed to enter international markets for agricultural products.

In the context of growing demand for food in the world and the globalisation of agrarian markets in Ukrainian agriculture, processes of concentration of capital and the formation of agricultural holdings on this basis have begun. The activity of integrated enterprises in the studied region shows that with the integrated type of production, there is a decrease in the cost of production with an increase in the volume of sales of such products. Savings in scale enable integrated commodity producers to offer their products at more affordable prices, and thus cover new segments of the markets and be competitive, as evidenced by the indicators of production and economic activity of agricultural holdings (Dankevych, 2013, p. 34). Top results of agricultural holdings' economic activity have been achieved through the creation of modern production, own processing facilities, the introduction of new technologies and intensification of production.

Thanks to the activity of the holdings, being the leading exporters of agrarian products, it was possible to achieve improvement of economic performance in the Ukrainian economy. This was particularly evident in times of crisis, when agriculture became one of the driving forces of economic development. During the period of 2009-2016 Ukraine was one of the largest producers and exporters of grain: wheat - 6 million tons exported (No. 7 in the world); barley - 4 million tons exported (No. 3 in the world); corn - 5.5 million tons exported (No. 4 in the world); sunflower - 1.3 million tons exported (No. 3 in the world); rape - 0.2 million tons exported (No. 3 in the world). These positions were achieved on account of integrated organisations that are the leaders in land resources leased on a long-term basis. A significant amount of these enterprises is concentrated in the studied region - Ukrainian Polissia (Table 5. 3).

Unlike small and medium-sized operators of the agricultural market, the integrated organizations have a powerful material and technical base. The most active part of it is the machinery and tractor fleet. The scale of land resources allows the use of powerful and large farm machinery. Moreover, the machinery fleet is equipped with new facilities by international manufacturers, which allows the use of machines 24 hours a day.

Table 5.3

The Production Activity Area of Agricultural Holdings of Ukrainian Polissia

Company	Area of activity	Area, thousand hectares	Production line
Nibulon JV LLC	Chudniv, Zhytomyr	8.4	Crop production, animal breeding
ATK LLC	Lyubar, Chudniv	18.7	Crop production, storage and sale
Agricultural Company Svitanok Private Agricultural Enterprise	Ruzhyn, Andrushivka	21.4	Crop production
Ukrzernoprom-Berdychiv LLC	Zhytomyr, Berdychiv	6.5	Crop production
UkrAgro RT LLC	Andrushivka, Cherniakhiv	10.4	Crop production
TAKO PJSC	Ruzhin, Popilnia	15.8	Crop production
Stud Farm Agro-Region PJSC	Lyubar, Chudniv	7.0	Crop production
Landkom LLC	Korostyshiv, Radomyshl	5.5	Crop production
VV Agro LLC	Korostyshiv, Radomyshl	18.6	Crop production
RISE-MAKSYMKO PrJSC	Chudniv	5.0	Crop production, processing, storage and sale
Loture-Agro LLC	Baranivka	5.7	Crop production

In the holdings a system of creating stable competitive advantages by means of combination of production, processing and marketing of agricultural products. For agrarian sector, the integration associations are currently of particular importance, as they facilitate entering the world economic system, accelerating the achievement of the required level of competitiveness. In terms of tax optimisation, the association of several legal entities in a financial agro-industrial group is most effective and common in domestic practice. The core of the organisational model of integrated organisation is a managing company that controls and coordinates its activity. The components of such organisation are actually the agricultural and processing enterprises and organisations of wholesale and retail trade. Agro-industrial organisations take the form of "economy in the economy". Besides agricultural commodity producers, it necessarily includes at least one industrial enterprise, as well as trading, supply structures, banks, insurance companies, etc.

The conducted analysis of the activities of integrated organisations allowed to highlight their main strengths: the possibility of attracting credit funds, including from external investors (IPOs), better access to market information in comparison with small enterprises; high profitability of business; higher level of labour productivity; saving in tangible and operating costs per unit area; increased opportunities for rational organisation of production, use of technology, achievements of science and advanced practices. Their weaknesses are the impact on the social and environmental spheres.

While considering the cost efficiency of commodity producers' activity, it is important to mark the ecological component of economic activity. In the production process, it is necessary to pay considerable attention to preserving the soil fertility and the ecological balance in the countryside. However, the environmental performance of most agricultural holdings is not satisfactory. For a large number of agricultural holdings, the recent trend is characterised by extensive methods of farming, increased land use for cultivation, imperfect machinery and technology of land cultivation and agricultural production, neglecting scientifically sound farming systems and, in particular, failure to ensure crop rotation, introducing insufficient quantities of organic fertilisers, imperfect system of use and introduction of mineral fertilisers and failure to implement environmental protection measures.

The results of the survey show that a number of companies have not started production activities on leased land for various reasons, in whole or in part during the first year. The introduction of monoculture and non-compliance with scientifically sound standards of economic activity are characteristic of the agricultural producers. Much of investors pay taxes to the budgets of the territorial community at the place of their state registration, which leads to a reduction in revenues in local budgets. There are some cases of violation of the agronomic requirements for growing grain maize, soy, rape as a monoculture, sunflower, with a violation of the return to the previous place before the pre-set terms. The violation of the structure of sown areas is typical of them, as stipulated by the Resolution of the Cabinet of Ministers of Ukraine No. 164, as well as the introduction of monoculture by a number of enterprises. A rotational method of economic activity has become widespread.

Among the modern natural processes, resulting from irrational management of agricultural holdings in Polissia of Ukraine, the processes of gluing, oxidation and water- logging are observed. Thousands of hectares of agricultural land, large forest areas have been withdrawn from economic activities. Over the past few years there has been a significant environmental degradation, which has led to intensification of water erosion processes, significant environmental and economic losses and damages. Intensive agricultural land use has led to a decrease in soil fertility because of their overconsolidation, loss of lump and granular structure, water permeability and aerating capability with all environmental consequences. In their entirety, this has led to an environmental crisis in many areas and contributed to a change of attitude towards the production activities and the search for ways to introduce safe production systems.

While studying the basis of organic production, P.O. Stetsyshyn and V.V. Pindus prove that the main factors of destabilisation of natural, historically formed conditions within the Ukrainian Polissia are the agricultural and forestry industrial and production activities (Stetsyshyn, Pindus, 2011, p. 7). The former involves the use of all land suitable for agricultural production, as well as the drainage and cultivation of lands of a reclamation fund, consisting of mires, wetlands and water-logged agricultural lands that need to be improved. Implementation of the state program of large-scale amelioration of mires, wetlands and water- logged land has led to discrepancies between the volumes of introduction of additional ameliorated land and the possibilities of their reclamation in accordance with the design specifications. Due to the lack of material and technical resources, low level of agricultural engineering, insufficient training of personnel, gross violation of agronomic, technological and environmental requirements for the use of drained lands, the efficiency of their development have not reached the planned level, which has led to further extensive development of agricultural production.

These trends have led to intrinsic problems in exploiting reclamation systems and maintaining the ameliorated land condition at an optimal level. A complex of man-made unpredictable factors was created which, in spite of the forecast analysis, caused the development of negative processes on the drained and adjacent lands, such as depletion of soil fertility, their loss and loss of humus, wind and water erosion, or vice versa - secondary water-logging, flooding, negative impact on state of natural water reservoirs and others. Considerable reclamation of drainage basins at the existing level of operation of drainage systems and the cultivation of ameliorated lands has caused the challenging ecological situation in the region. The consequence of this effect is the degradation of soils, accompanied by loss of humus.

The level of agricultural land ploughness in Polissia is the highest among the similar indices of developed European countries. Erosion processes cover 104.8 thousand hectares of land. Transformations in the production structure of agricultural enterprises significantly influenced land cultivation. Currently, the use of agricultural land resources in Polissia natural zone is unsustainable and environmentally unbalanced. The current ratio between arable land and other types of land, both ecologically and economically, is unsatisfactory. While studying the prospects of development of organic production in the agricultural sector, T.O. Chaika states that extensive farming, unsustainable use of land and high ploughness of land reserves have led to a significant decrease in fertility of soil and its degradation (Chayka, 2012, p. 14-15). Over the course of 50 years, the soil of Polissia have lost almost 25% of humus. The increasing anthropogenic impact during the implementation of agricultural extensification policy did not so much ensure the achievement of the planned world levels of production as reduced the fertility of the land.

In view of the above, there is a need to find alternative ways of preserving soil fertility and replenishing its nutrient elements by improving the production structure taking into account the specialisation of the farm; to include large amounts of beans and leguminous high-protein crops in crop rotation; to improve fertilization program on account of green manure crop, vermicompost, organic crop residues; to carry out the measures ensuring preservation and reproduction of soil fertility.

According to L.F. Kozhushko, ecologization of agriculture involves combining and co- operating in the sectors of the innovative technology suit aimed at the economic growth of the industry, environmental protection as interdependent and complementary elements of the strategic development in the agrarian sector of the economy, which guarantees the high quality of food for the population, the value creation for the products manufacturer, and preservation of natural resources and population employment for the state (Kozhushko, Skrypchuk, 2007, p. 231). At the same time, four directions of ecologization can be distinguished.

The ecological and economic situation in the region can be improved through the management based on diversified production with a large set of agricultural crops and the restoration of soil fertility through the use of a significant amount of industrial products (mineral fertilizers, lime products, chemical plant protection products, etc.). At the same time, such systems turned out to be economically unviable in the market conditions. They are particularly ineffective in Polissia, where the natural and climatic conditions are favourable for agricultural production, however, external investment in production is negligible. Among the important measures for the region is the search and development of an effective zonal system of farming, based on the principles of biological highly-specialised production.

One of the key issues was the biologization of production through a system of agricultural production, which prohibits or significantly restricts the use of synthetic combined fertilizers, pesticides, growth regulators and food additives to fodder when feeding the animals. Such a system should be based, if possible, on crop rotation, the use of plant remains, manure and compost, legume grasses, organic waste products, mineral raw materials, biological pest control products in order to increase fertility and improve the soil structure, provide plant nutrition and fight against weeds and various agricultural crops pests.

The International Federation of Organic Agriculture Movements (IFOAM) formulated four basic principles of organic production: health, ecology, fairness, care (“The World of Organic Agriculture…”, p. 3). The Declaration of these principles means that in agricultural practice certain restrictions, prohibitions and requirements should be adhered to, first of all, it involves the use of synthetic fertilizers, pesticides, GMO, and requirements of minimum tillage. The basic guiding principles for the transition to organic farming are divided into four main groups: technological, social, economic and environmental.

Technological principles include: the complete refusal to use chemical products for the protection of plants and animals, mineral fertilizers, etc. in the process of production and processing of agricultural products; use renewable resources in the process of production and processing of agricultural products, prevention of their losses and pollution; creating the optimal balance between the production of crop and animal breeding products; the use of packaging materials that can be recycled or decomposed biologically.

The social principles of organic production require recognition of: the priority value of natural objects and human health; the need to preserve and recreate cultivated land; the importance of studying the practices and forms of management aimed at preserving the environment and production of environmentally friendly food products; providing the population with high-quality, environmentally safe food in sufficient quantities.

No least important are the economic principles of the production of organic products, namely: improving the economic viability of economic activities; stimulating local and regional production; ensuring each employee in organic production and its products processing a proper income level that meets the requirements of a healthy and safe living.

Environmental principles should include: harmonization of production processes with natural cycles and ecosystems of soils, flora and fauna; preservation and increase of soil fertility and biological activity through local cultural, biological and mechanical methods; promotion of responsible use and conservation of water resources with all living organisms. An important factor contributing to the development of organic agriculture in Polissia region is the reduction of the fertilizers and pesticides application in farming processes. Due to a difficult economic situation of most manufacturers, the introduction of nutritional elements for the main crops has decreased significantly. The analysis showed that while in 1990 83% of the area was fertilized and 141 kg of nutrients per hectare was applied, by 2001 there was a catastrophic decline in these indicators. Fertilizers were applied on every fifth hectare only, and the absolute amount of fertilizers was only 13 kg of active substance per hectare. This explains why the implementation of the genetic potential of wheat in the 80's was around 50% of the potential, and in 10 years decreased to 25-30%.

In post-reform years (2001-2015) there was a gradual increase in the area where fertilizers were applied from 19% to 69%, and the absolute amount of fertilizers - from 13 kg of nutrients to 57 kg per hectare ("Integrated program…", 2009). In 2013-2015, this trend was halted, there was a decrease in amount as compared to previous years, by 35% of the amount of mineral fertilizers applied by agricultural producers, and a decrease of the area of application of such fertilizers by 23%.

A similar situation, the reduction in application, is observed with the products of crops protection from weeds, diseases and pests. During the period of 2005-2015 there was an increase in the amount of crop protection agents - from 15.9% to 49% to technological needs. However, in 2015, only one-third of products required was applied. While the technology requirements to the means of protection for the fulfilment of genetic potential at the level of 70-80% varied from UAH 1,100 to 1,350 per hectare, depending on the technologies and conditions of cultivation, and in 2015, Ukrainian agricultural producers spent less than UAH 400 per 1 hectare. A similar situation exists for the cultivation of other crops.

Systematic failure to follow the main technological stages of cultivation of agricultural crops, primarily, the application of mineral and organic fertilizers and the use of plant protection products, leading to lower productivity. At the same time, it provides opportunities for the development of organic agriculture, the basis of which are the agroecological principles, according to which the agricultural enterprise is considered as an ecological and economic system based on rational and environmentally sound production methods, ensuring the quality of production and raw materials, the production efficiency, as well as the min

According to the studies by V.I. Vovk, conducted during the work related to the certification of organic agriculture, the main ecological and economic approaches were identified in terms of the rational use, reproduction and protection of agricultural land, namely: the predominance of environmental criteria and indicators over economic ones in land relations; the predominance of long-term social and economic programs and approaches over the short-term needs; integrity in solving ecological problems and tasks on recultivation of disturbed lands; investing in the agricultural land reclamation; integration and mutual harmonization of the natural and resource, and material and technical components of the overall resource and production potential of the agrarian sector; consistency in solving ecological problems of the agro-industrial sector; payment for the use of agricultural land, including penalties for their pollution (Vovk, 2004, p. 5).

Thus, summing up, it should be noted that the activation of ensuring the ecological orientation of agricultural production requires diversification of ways to increase the pace of production of green products, the use of environmentally safe and energy saving technologies in farming, a large-scale implementation of innovative developments that can minimize the negative impact of production and processing of products on the environment. The solution of the set tasks is possible by means of ecologization of agricultural production, which will help in land reclamation, create conditions for sustainable use of land and production of green products.

Increased level of production intensity maximizes the negative impact of agricultural activities on the environment. It is well-known that plants absorb only

40-45% of the total amount of mineral fertilizers introduced into the soil. The rest of the mineral fertilizers evaporate into the atmosphere, is transported to surface and water sources, is distributed through the food chains ("The World of Organic…", p. 6). Use of chemicals is no less harmful. Accumulation of chemical products accelerates the process of decomposition of humus, worsens agricultural properties of soils, their buffering, capacity and structure. It is likely that continuing intensive farming can further aggravate the environmental crisis, destroy ecosystems and damage people's health.

According to calculations, about 70% of all toxic substances get into the human body in food products. Pesticides used by domestic producers, cause pathological changes in the human body. As they get into the body, they can cause a variety of chronic diseases of the gastrointestinal tract, nervous system, dermatitis and respiratory disorders, adversely affect the reproductive function of humans.

Of particular concern is the use of genetic engineering, which involves the transfer of genes from one organism to another, resulting in changes to the characteristics of organisms that can not be acquired naturally. The consumers' diet, virtually without their knowledge, include a number of genetically modified products. The main benefits of genetically modified products are increased crop yields, reduced costs of using pesticides, and reduced morbidity in plants. However, the impact of GMOs on human health and the environment has not been studied in full yet and is not predictable.

Therefore, agricultural practice, which for half a century was focused on increasing production through its intensification and which in fact ignored environmental constraints, is currently subject to a certain revision by society. Significant pollution of the environment and food, reduced soil fertility, and the constant threats to human health are the factors requiring technological changes in agriculture. The need to preserve the natural environment and provide the population of the Earth with high-quality food leads to the search and use of new alternative agricultural models.

Alternative agriculture is a general name for different systems of management with non-traditional approaches to the production of environmentally friendly products. At the same time there are some differences from traditional technologies of management. The basis of alternative methods of farming is the concept of obtaining a yield without any harmful impacts on the environment due to studying and taking into account the processes in nature. Currently, the alternative methods of agriculture include: Organic Farming; Biointensive Mini-Farming; Biodynamic Agriculture; ecological agriculture; Effective Microorganism Technologies; Low Input Sustainable Agriculture (LISA); Precision Farming; Regenerative Agriculture ("The World of Organic…", p. 3).

Biointensive mini-farming, biodynamic agriculture and ecological agriculture are sometimes jointly referred to as biological agriculture. These alternative types of farming are commonly used in Europe. The difference in biological agriculture from organic is rather conditional. Biological agriculture is defined as a small size, economically viable, aesthetically and ethically attractive system of management that is ecologically self- regulated and does not require large investments (Kupinets, 2004, p. 52). Farmers creating such systems are trying to produce the optimal amount of products without causing harmful changes in the environment. The measures by which this is achieved include the introduction of a special crop rotation, the introduction of organic fertilizers, the inclusion of all bioproducts and waste in the biological cycle, the establishment of an appropriate pasture system and maintenance of an optimal balance between plants, animals and the number of workers. The peculiarity of this system is that the farming is in line with environmental laws and principles.

Sustainable farming with low resource intensity is characterized by the desire to reduce the amount of resources coming to the farm from external sources and reduce production costs as compared to the traditional methods of farming. This kind of farming can economically and environmentally maintain itself for a relatively long period, while maintaining and raising the living standard of the farmers.

Regenerative agriculture combines the elements of organic and traditional farming. Unlike organic farming, with the regenerative system of farming it is possible to apply chemicals as a temporary and emergency measure. The main feature of the regenerative system is its ability to reproduce the resources the farm needs. With this system, farmers try to improve the natural balance within the ecological system of the farm, find the domestic sources of organic fertilizers, replace the use of pesticides and herbicides with biological products.

Organic agriculture involves the reuse of organic substances (manure, compost, organic residues) and the refusal from pesticides, growth regulators, fertilizers and animal feed additives. Organic production is a system that supports the health of soils, ecosystems and people. Organic agriculture avoids the use of harmful resources that have adverse effects on the environment and people. Today, the term "organic production" is understood as a complex of agronomic measures for the production of products with health-improving properties, which are regulated by international and domestic standards and are aimed at achieving ecological, social and economic effects.

Understanding the essence of organic agriculture, understanding its basic principles and concepts is the first step in the transition to an alternative system of farming. In early 2016, 171 farms received organic status in Ukraine, while the total area of land under organic production amounted to 380 thousand hectares, which allowed Ukraine to rank number 16 among more than 100 countries of the world. Most organic farms are located in Odessa, Kherson, Chernivtsi, Ternopil and Poltava regions (“Materials…”, p. 2).

Despite the difficulties, the organic movement in Ukraine is gradually gaining strength and popularity, both among consumers and producers of green products. An important factor is that Ukraine managed to establish an organic certification system according to international standards.

Basically, organic production in the region under study is represented by the cultivation of organic grain, which is carried out on account of integrated companies, and is exported abroad (Boyko, 2003). It should be noted that the on largest areas under organic production rye is grown. The reasons for this are that the culture is traditional for the Polissia area, it does not require a significant amount of fertilizer and is adapted to local soil and climatic conditions.

In the conditions of Ukrainian Polissia, commodity producers, whose ideology is to adhere to the system of sustainable development and the integral system of organic farming, and industrial organic producers, has nowadays failed to come to a single concept about what organic farming is. Industrial organic farmers with large volumes of production of organic products and with the use of technologies minimizing the role of humans in the process of farming, obtain a lower cost of production, and on account of the scale effect they reach the best financial results of farming. As a result, they are more competitive and actually do not provide any prospects for the creation of a market for agricultural producers, who practice a holistic approach to the production of organic products.

The main producers following the production processes of organic farming in the region under study are as follows: Vertokyivka LLC, Myroliubivske Enterprise, VO Agro-Prom- Service LLC, Stavriv Farm, Galeks-Agro Enterprise in the Nov.-Volynsk district, Ukraina Agricultural Limited Liability Company, Agrofirm Symony Agricultural Enterprise, V. Yablunetske Private-Lease Agricultural Enterprise, Michurin Farm Enterprise, Kulishivske Farm Enterprise, State Enterprise Rykhalske Research Farm, Raiagrokhim State Farm Enterprise and others.

One of the most famous "organic" integrated corporate farms in Polissia is Galeks-Agro Private Enterprise in Novohrad-Volynskyi district in Zhytomyr region, specializing in the cultivation of cereals and industrial crops, as well as the production of milk and meat. Galeks- Agro PE is the basic farm for the production testing soil-protection technologies of growing crops, measures for enhanced reclamation and manufacture of environmentally safe food.

The enterprise was founded in 2008 in the village of Stryeva, Novohrad-Volynsk district in Zhytomyr region. In 2009, the land was examined by inspectors of

IMO and Organik Standard certification companies. The main task of the enterprise in introducing organic farming was the development of natural fallows and the control of weeds, especially with perennial weeds. John Deere tractor, with a capacity of 260 hp, was purchased, as well as Kuhn plough, with which almost 500 hectares of fallows were ploughed, where then 110 hectares were sown with vetch and oats mixture and 108 hectares - with filed pea and oats mixture. Almost 270 hectares of white mustard and oil radish were also sown. The seeds of mustard and oil radish during flowering were ploughed for green manure. Thus, perennial weeds control was carried out. The seeds of vetch and oat and field pea and oat mixtures were mainly destroyed by perennial weeds. In addition, 2 tons of seeds of these crops were received from a hectare, and thus, the farm was provided with seed material.

Weeds control was carried out in the following way: ploughing on the arable layer depth and two-four-fold disc ploughing with BDT-6 disc harrow as the couch-grass and Canada thistle germinates. On the forest areas the undergrowth was cut down, and in the areas overgrown with bushes, these were unrooted and removed. The Claas tractor of 230 hp, six- meter pneumatic seeder by Amazone and the six-meter Lemken compactor were purchased. Before the harvesting of crops, a grain- and seed-cleaning complex was installed at the enterprise, with a capacity of 50 tons per hour, and warehouse facilities for storing 5000 tons of grain were prepared. Two John Deere harvesters with six-meter cutters were purchased before harvesting. The measures taken have contributed to the increase of gross output.

The basis of the enterprise farming is the Drevlianska system with four-year crop rotation: a field pea and oat mixture for grain; rye; vetch and oat mixture; winter crops. The Drevlianska system of farming is based on the principles of biological specialized production. It is zonally specialized, alternative to the traditional agricultural systems of Polissia, and consists in creating a structure of crop areas covered with up to 66% of winter crops and up to 50% of annual bean crops (Ivanyuk, 2002, p. 5-7). At the same time, non-perennial beans, such as spring vetch and field peas, are grown both in pure sowing and in mix with other crops and are used depending on economic needs for grain and green feed. In case no green fodder is required or in the event of significant distances from farms, leguminous crops can be fully used for grain, that is 100% of the crop area can be used for grain production.

The advantages of the Drevlianska farming system for the Galeks-Agro PE are as follows: the possibility of efficient farming of low-yielding and low-cultivated soils with insufficient amounts of organic and mineral fertilizers introduced; the possibility of rapid change in the cropping structure; low cost (direct expenditures in Drevlianska system amount to UAH 400-600 per ha, that is 2-3.5 times less than in traditional systems); production of environmentally safe products.

The use of the Drevlianska system allows producers to effectively produce specialized grain at the minimum use of mineral fertilizers and chemical plant protection products. In addition, crops and leguminous crops occupy 70-80% of the crops area, with yields amount to 25-33 centners per hectare in the structure of the crops area of farms, which have familiarised with the Drevlianska system (Volyn, Peremoha, Novohrad-Volynskyi food processing and feeding cooperative).

The peculiarity of organic farming and one of its main advantages is lower cost. At operational determination of the standard cost of crop production in Galeks-Agro PE, the following items of expenditure are applied: payment for labour (direct and indirect), deductions for social measures, seeds (planting material), organic fertilizers, electricity, depreciation, current repairs of fixed assets, payment for the lease of property or a property share, rent for land plots or shares, other expenses, costs for by-products, selling expenses.

It should be noted that there are not expenditures on mineral fertilizers and plant protection products, since they are not used in the cultivation of environmentally safe products. The list and composition of items when using such a classification of costs are specified by the company itself, depending on the specifics of the industry, the nature of the manufactured products, and the process of production. This makes it possible to control the intended use of funds and to identify reserves for reducing the cost of production.

The activity of Galeks-Agro PE evidences that the use of organic technologies in agriculture enables the farm to increase the natural biological activity in the soil and restore the balance of natural nutrients. Under conditions of organic farming, the restorative properties of the soil are enhanced, the functioning of living organisms is improved, humus is enriched, which results in an increase in the productivity of agricultural crops and the improvement of the quality of crop production.

Organic farming uses fertile soils, where sustainable crop yields can be grown without the use of mineral fertilizers. For the area of Polissia, these are grey (light grey, dark grey) forest (ashen-grey), turf and meadow non-clay soils, turf ash-grey sandy loam and loamy soils with average and high agrochemical support and optimal parameters of the water and air regime ("Scientific fundamentals…", 2010, p. 141). Farms producing organic produce must adhere to crop rotation, include leguminous crops and perennial legumes in the crop area in order to ensure sufficient amount of nutrients and humus recovery in the soil.

For organic farming, agricultural land must meet certain requirements regarding the level of their contamination with harmful substances: pesticides, heavy metals and radionuclides. The specialists of the Institute of Agrochemistry and Soil Science of UAAS analysed the ecological and toxicological state of arable land of Ukraine and identified the areas suitable for the cultivation of environmentally safe products. According to the study, most of the land in Polissia region is suitable for the development of organic agriculture ("Scientific fundamentals…", 2010,, p. 721). At the same time, it should be clearly seen that the transition from conventional (intensive) agricultural production technologies to organic farming (the so- called conversion period) is a rather long process (according to some data - from 2 to 5 years), and it is accompanied by certain risks and the need to solve a number of problems. At the same time, the main process operations under conditions of introducing organic production have their own specifics. It mainly manifests itself in the following technological processes: soil cultivation, plant protection, weed control, fertilization, preplant treatment of soil, sowing, plant care, harvesting.

Soil cultivation includes a complex of agrotechnical, biological, ecological, agro- physiological and other measures aimed at improving the water and nutrient regimes of the soil, photosynthesis, minimizing the amount of weeds in the fields and damage to plants due to diseases and pests. The soil cultivating system is selected depending on the climatic zone and the mechanical composition and impurity of soil. In conditions of organic farming it is best to apply surface cultivation of soil to a depth of 4-6 cm.

The process of first ploughing has its peculiarities. The main purpose of this production step is soil tillage to a depth of 4-6 cm, the destruction of the capillary system of moisture evaporation from the soil, the destruction of weeds. It is most effective when weeds begin to sprout. The value of this production step consists in the fact that the after-harvest residues on the surface of the field form the mulch, which prevents the evaporation of moisture from the soil and creates favourable conditions for the development of effective microorganisms. The organic farming system strictly forbids burning the after-harvest remains on the fields.

In the traditional farming system, the main process operation is ploughing to a depth of 25-27 cm. When the arable layer is turned, the conditions for the development of effective microorganisms are destroyed and the soil loses its natural properties. That is why the subsoil tillage is introduced in organic farming system, that is, a deep loosening of the soil without its overturning. Depending on the mechanical composition, the soil is loosened to a depth of 8-10 cm. In the process of loosening, favourable conditions for the development of microorganisms are created, conditions for air and water aeration are improved, conditions for growth and development of the root system of plants are created. The main feature of this process operation is that the after-harvest remains are not conserved at the depth of 25-27 cm, but are left on the soil surface as mulch.

To ensure crop protection from pests and diseases, the agricultural crops seeds are treated with biological preparations only. One of the main methods of weeds control in the organic farming system is the mechanical destruction of weeds. In early spring, to ensure mulching and destruction of weeds it is necessary to use tractor harrows. Cultivators and combined aggregates are used for general cultivation in the preparation of soil for sowing and destruction of weeds. In addition, the rescheduling of sowing such crops as corn, millet, and buckwheat for later period of time can be effective for weeds control, with the aim of eliminating of weeds sprouting by cutting and cultivating. In weeds control a special care is taken to the purity of the sowing material.

In the organic farming system, the main fertilizer is manure. The source of organic matter are the plants themselves. Under the influence of organic fertilizers, the mass of root and after-harvest remains considerably increases. However, humus accumulates in soil on account of fertilizers in the most effective way. Humus is an important indicator of soil fertility. It characterizes the nutritional regime, the physical, physical and chemical and biological properties of the soil.

The content of humus in soil is determined by the zonal, mechanical composition of soil, as well as the effectiveness of water and wind erosion control. The steady humus content is achieved solely by adhering to a complex of agrotechnical measures, increasing the accumulation of organic matter in soil in the form of root, after-harvest remains and organic fertilizers.

The main task of pre-sowing soil cultivation is the creation of best conditions for germination of crop seeds and their development. Due to pre-sowing tillage, the moisture accumulated during the autumn and winter period is kept, a loose layer on the surface is formed and favourable conditions for high-quality seeding of the seeds, as well as clearing the field from the weeds are created.

The system of pre-seeding soil treatment includes: early spring loosening of soil, pre- sowing cultivation, compaction, etc. In the organic farming system, it is necessary to minimize the number of process steps in preparing the soil for sowing. After all, under the influence of drive systems of agricultural machinery the soil is compacted, the soil and air exchange is imbalanced, its permeability and activity of microbiological processes decreases, nutrient reserves are reduced. Therefore, to carry out such process operations, it is necessary to use wide-level agricultural equipment.

The crucial factor in obtaining high yields is the correct timing of sowing. When scheduling the sowing terms, it is necessary to take into account the specific local conditions and characteristics of cultivating breeds and the duration of the growing season. There are different ways of sowing: ordinary-row, narrow-row, cross-sowing, broad-row, brand, single- seed, hole-sowing, ridge sowing and others. The method is chosen depending on the biological characteristics of the crops and the cultivation technology. The main requirements for the methods of sowing are the uniform distribution of seeds in the area, sowing seeds in a relatively compacted soil, seeds covering at the same depth.

Seeds of different crops, depending on biological characteristics, are sown to different depths so that during its germination it is provided with sufficient air and moisture. Too thick layer covering the seeds worsens the conditions of aeration, and temperature conditions are changed. With shallow seeding - the supply of humidity for the seeds deteriorates. The depth of seeding depends on the timing of sowing. When sowing is delayed, if the top layer of soil dries, it is necessary to sow deeper. A constant monitoring of the quality of sowing must be ensured during sowing and all the defects should be immediately eliminated, since they cannot be corrected later.

The main task of plants handling in the organic farming system is the weeds control, which is exercised during the process of soil loosening. In addition, during the soil treatment after sowing, the conditions for plant growing are created, the air and water regime in the upper layer is regulated. Soil treatment in the process of handling plants consists of the following techniques: harrowing, compaction, cultivation. Harrowing is carried out immediately after sowing. This technological operation makes it possible to create the best contact of seed with the soil, levelling the soil surface. To increase the moisture income to the seed, which accelerates the germination ability, the soil is compacted. Cultivation is carried out for surface soil loosening, which helps to provide plants with moisture, air and nutrients. During cultivation, the weeds in row spacings are destroyed. The soil nutrients are introduced in soil during the period of vegetation of plants. The plants are protected from pests and diseases and adverse climatic conditions (dry winds, ground frost). Cultivation is carried out using cultivators for inter-row tillage of soil.

Harvesting in organic farming can be done in two ways: by separate or direct combine harvesting. Separate harvesting method is used for leguminous, cereal crops, lain down and covered with weeds. For separate harvesting, rotary windrowers and combined harvesters are used for picking rolls. Direct harvesting is carried out with combine harvesters. Grain- harvesting machines used in farms producing organic products impose the following requirements: grain-harvesting machines must be technically fit (no leakage of fuel and lubricants is allowed; engines must have smokeless exhaust); the operative parts should not hurt the output material (grain); during the process the grain should not be lost, as well as the weed seeds; combined harvesters must be equipped with straw shredders, spread the shredded stems in the field (mulch); grain-harvesting machines that move to another field or come from other regions or areas must be cleaned.

To sum up, it should be noted that, according to international standards, the farming is considered organic if it does not use synthetic chemicals, provides for minimal tillage of soil and does not use genetically modified organisms. The basic principles of organic farming are as follows: soil cultivation by surface tillage to a depth of not more than 5 cm; non-use of chemical fertilizers and pesticides in production; scientifically grounded use of crop rotation; sowing green manure crops; widespread use of plant residues and organic waste from processing enterprises. The basis of organic farming is virtually the return of primary sources of agriculture, which results in an increase in natural biological activity in the soil, the restoration of the balance of nutrients, increase in amount of humus, and the enhancement of functioning of living organisms.

In Ukraine, organic products are gaining in popularity, because domestic consumers become more cautious and more serious when choosing food. Nowadays there is a trend among the Ukrainians towards a healthy lifestyle, a significant part of which is healthy eating. An alternative to dainties, made with the addition of taste boosters and other harmful preserving agents, is the organic food.

The experience of organic farming development evidences the creation of additional jobs, the emergence of new prospects for farms, increasing the viability of rural communities and other social benefits, which is extremely relevant for the region of Polissia. In the long run, organic farming will allow to partially optimize the production structure of agricultural enterprises, coordinate and harmonize the economic, environmental and social aspects of farming in the agricultural sector of the region.

In order to study the prospects of organic production in Ukrainian Polissia, a sociological survey was conducted. The survey was aimed to identify the domestic market capacity and the readiness and ability of consumers to buy organic products. 476 respondents from Zhytomyr, Volyn and Rivne regions were interviewed.

To ascertain the views of Polissia region inhabitants regarding the quality of agricultural products of plant origin, which is the basis of their diets, the question was asked as follows: "Are you satisfied with the quality of agricultural products that you buy?" The analysis of the answers to this question has shown that almost 60% of consumers believe that the quality of agricultural products they consume is low.

Moreover, for consumers, the safety of products (that is, the absence of chemicals and harmful substances in it) is the most important factor when deciding on the purchase of agricultural products (Table 5.5.). This factor is considered "very important" by 74.3% of respondents. Other factors determining the demand for food products were recognized as the price - 37.4% of respondents identified it as "very important", and the visual appearance of the product (52.9% of respondents identified this factor as "important"). The availability of a food quality certificate is "important" for 26.8 respondents.

Given that the basis of dietary structure of the region residents is the food of vegetable origin, and up to 80% of the harmful substances enter the body with food

(“Agro- ecological…”, 2003), it is especially important that agricultural production be of high quality and contain no harmful substances. According to the results of the study, it was discovered that when choosing the food products, consumers want them to be safe in the first place. Therefore, to study the needs of consumers in environmentally safe food, it was necessary to establish to what extent the foods sold in the investigated area meet the customers' requirements.

Table 5.5

Priorities of consumers regarding the characteristics of agricultural products

Characteristics of agricultural products	Points	Rating
Safety	371	1
Price	600	2
Appearance	622	3
Availability of a quality certificate	670	4
Trademark awareness	955	5

Consumers' concerns about the poor quality of food products to some extent are due to the fact that this is what they see as the reason for their health deterioration (Fig. 8. Our society has already faced the consequences of the increasing man-made impact on the ecological state of the environment and human health. The results of epidemiological observations and statistical surveys conducted in recent years have shown a reduction in life and an increase in the number of cases of diseases that were much less frequent 30-40 years ago. The number of people with tuberculosis, anemia, immunodeficiency, cardiovascular diseases and others is increasing. Medically fragile children are born. The longevity is reduced. In our country these indices, unfortunately, exceed the average European ones.

Domestic agrarian sector plays a significant role in these processes. As you know, various chemicals approved for use are applied in agriculture. Many of them, after use, decompose into safe compounds for 3-4 weeks, but some of them turn into metabolites that can remain in soil for 5-7 years and are absorbed by plants. Thus, with the "traditional" technologies of agricultural production, cereals, vegetables, fruits, animal and fowl feeds contain residues of pesticides, herbicides, fungicides, zoocides, and others. The average conventional meat and milk, in turn, contain antibiotics, hormones, growth-promoting agents. All these substances enter the human body with the food products of plant and animal origin and deteriorate health and reduce life.

According to a study conducted by Ukrainian scientists, who during the year examined a group of people, in 80-90% of cases vitamin C deficiency was discovered, in 40-60% cases results showed low levels of B1, B2, B6 and E vitamins. Approximately 60% of the examined experienced a deficiency of β-carotene. Vitamins and minerals regulate the biochemical processes of the body. Their shortage is accompanied by a reduction in the adaptive capabilities of a person, leads to the development of chronic fatigue syndrome, a decrease in physical and mental ability. Among the causes of deterioration are the general environmental problems, vicious habits, nervous and emotional stress and poor-quality food (Yarova, 2013, p. 84-84).

Instead, according to scientists from different countries, organic foods contain 50% more nutrients, minerals and vitamins (vitamin C, iron, magnesium, phosphorus) than similar products from industrial farms. Organic products are particularly good for children, as their body is more vulnerable to the impact of residues of pesticides, nitrates, heavy metals and antibiotics in food. The production of organic products involves the rejection of the use of harmful technologies, the application of chemical fertilizers, pesticides, genetically modified organisms (GMOs), preserving agents, etc., and at all stages of production (growing, processing) the methods, principles and rules for obtaining natural (green) products, as well as for the conservation and restoration of natural resources are applied.

During the study, it is assumed that consumers have a certain rating of products that they think are questionable in quality and dangerous to health. In order to verify the assumption, respondents have to answer the question as follows: "What agricultural products, in your opinion, are most ecologically dangerous?" The analysis of answers to this question shows that agricultural crops, in relation to their quality in consumers' view, can be rated as follows: the respondents consider vegetables, fruits and berries, melons, potatoes, cereals to be the most contaminated. Consequently, it can be argued that, according to consumers, there are no crops and their derivative products, which fully meet the requirements for quality and safety.

Pollutants get into agricultural products through the soil, packaging, as a result of technological processing and storage, in the process of transportation of products, etc. As for sources of pollution of agricultural products consumed by respondents, in their view, the most dangerous is the pollution of soil. After all, 50% of respondents believe that the state of soils greatly affects the quality of agricultural products. According to consumers, other significant factors influencing the safety of agricultural products include water sources pollution, agricultural production technology, and atmospheric air pollution.

The analysis of the sociological survey data and statistical information allowed to establish the degree of consumers' satisfaction with the agricultural products available to them in the outlets of Polissia region. The respondents' desire to buy better and environmentally safer products is obvious. The confirmation of this thesis is given providing the results of the analysis of respondents' answers to the question: "What is your opinion about environmentally safe agricultural products?" Indeed, the absolute majority of respondents (85%) have chosen the answer "Positive, would like to buy it", and nearly 11% have confirmed their "positive" attitude towards such products, however, have not been willing to spend on it.

The social studies allows you to assert that consumers of the region under study need vegetables, fruits and berries, potatoes, grain and cereals, which should be environmentally safe and sold in retail outlets of the city. In this case, ecologically safe food products should be non-toxic and contain no harmful impurities, produced using energy-saving and resource- saving technologies, and the process of their production should not damage the environment. The existing unsatisfied need in safe plant products could be met by the agricultural producers of Polissia region, offering organic products.

The results of sociological research allowed to identify the problems of introduction of organic farming technologies in Polissia area. The social and psychological problems of implementation of organic farming technology in Polissia include the low awareness level of the population and manufacturers of organic farming (understanding of key features and peculiarities of the technology, the benefits of its application and potential problems in the process of implementation).

Another significant problem is the low level of ecological consciousness of the population and the poor technological culture of agricultural production on all levels, from private farms to large agricultural associations. The lack of appropriate training courses on the theory and practice of organic farming should also be included in this group of problems. In addition to the lack of education and environmental awareness there is a reluctance to overcome the persistent stereotypes that have developed over a long period of intensification of agriculture, and the low level of innovative activity of managers and management structures. A complex demographic situation in Polissia countryside (depopulation, age structure) and low living standards of the population should also be mentioned.

The institutional and legal problems of introducing organic farming in Polissia include: the absence of an appropriate legislative and regulatory framework, particularly, of the basic law on organic farming and certification of organic products, consistent with the requirements of international law; the absence of an effective national system of certification and control of organic farms and products manufactured by them; the absence of proper internal infrastructure (associations, unions and departments of manufacturers of organic products); the need for integration into international structures (EU, IFOAM) and access to external markets for organic products.

Currently, there are the issues related to agrarian reform and sharing land reserves: the need to conserve large areas of farm territories, the inadmissibility of combining field and soil protection crop rotations or dividing the latter. Land sharing should be carried out in the areas, where contour strip pre-structuring has been performed in kind in its safety runoff draining modification, and the sharing should be planned in accordance with the projects of such a structuring.

The financial and economic problems of organic farming implementation include the following: lack of marketing research of organic products markets; the risks associated with possible changes of organic products market environment for quite a long period of conversion; financial losses related to the decrease in production (this is particularly relevant for farms, applying the intensive technologies); the financial costs associated with the need to purchase special equipment and machinery; lack of effective mechanism of insurance against risks in agricultural production; the lack of financial support from the state during the period of conversion and of incentives or subsidies for the production of organic products.

There is the national regulatory framework to ensure organic production development, allowing to work over the mechanisms of control of ecological products production process to provide quality assurance for its end user. National regulatory documents should be harmonized with the international standards in order to create conditions for domestic producers to operate on international markets of green products.

One of the most important issues is the marketing and promotion of eco-products, informing the consumer about the benefits of such products and creating a steady demand for this product. This is the most complicated issue in Polissia due to the absence of eco-products consumption tradition. Therefore, it is the development of a mechanism for the environmentally safe products promotion to the consumer that is a priority task for today. Small organic producers are trying to sell their products to consumers mainly through traditional production markets. Unlike the EU member states, a network of specialized stores of organic and healthy products is beginning to emerge in Ukraine, and large supermarkets need commercial batches and relevant product documentation. The processing infrastructure is also not developed.

However, in spite of certain obstacles, in the studied region there is a significant potential for increasing the area under ecological production, since during a fairly long period the Polissia lands have been undergoing forced rehabilitation: due to a shortage of funds for the purchase of chemical agents of plant protection and mineral fertilizers, there are large areas of fertile land, which can easily be transferred into organic farming.

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CHAPTER 6. ESTIMATION OF THE SPATIAL NONSTATIONARITY OF THE RELATIONSHIP BETWEEN THE MORPHOMETRIC CHARACTERISTICS OF MAIZE (*ZEA MAYS* L.) BY MEANS OF GEOGRAPHICALLY WEIGHTED ANALYSIS OF THE PRINCIPAL COMPONENTS

The methods of analysis of the principal components are widely used in the study of plant morphology (Zobin et al., 2008). Principal component analysis showed significant differences in the covariance structures of morphological characteristics of maize, which was grown in conditions of soil humidity of 40 and 100% (Hafiz et al., 2015). The geographically different populations of maize were classified according to morphological features through the analysis of the principal components in France (Gouesnard et al., 1997), Spain (Llaurado, Moreno-Gonzalez, 1993; Ordas et al., 1994), Italy (Camussi, 1979) and Argentina (Melchiorre, 1992). Classical statistical approaches focused on the characteristic of relationship between phenomena or processes that proceed from the assumption of stationarity, i.e. regardless of the location of this connection in space (Kumar et. Al., 2012). The analysis of the principal components is used to reduce the dimensionality of the attribute space and to identify a combination of characteristics that describe a multidimensional array of data (Lloyd, 2010). It is believed that the covariance structure of the data in the analysis of the principal components is constant within the studied spatial range (Charlton et al., 2010). However, for spatial data, any standard non-spatial statistics provides in the aggregate a result, but does not provide an opportunity to describe the geographical variability of observed values or the relationship between them (Lloyd, 2010). In addition, the standard analysis of the principal components explicitly does not take into account spatial relationships, since it was not specifically created for the identification of spatial structures (Arrouays et al., 2011).

The analysis of the principal components can be expanded by applying geographically weighted correlation coefficients in which the weights are determined for each observation point, which allows for separate analyses of the principal components for each sampling point - a geographically weighted analysis of the principal components (geographically weighted PCA - GWPCA) (Lloyd, 2010). GWPCA takes into account spatial heterogeneity and enables evaluation of spatial characteristics of data (Kumar et al., 2012). Geographically weighted analysis of the principal components has the ability to reveal hidden spatial structures and provides the necessary information, indicating that local correlation structures are the result of non-random processes (Charlton et al., 2010). The use of GWPCA reflects the trend in the analysis of spatial data, associated with a shift in focus from global similarity to local differences (Lloyd, 2011).

The spatial heterogeneity and spatial dependence are singled out as the types of spatial processes. Spatial heterogeneity emerges when observations made in proximity to each other are similar as a result of existence of a common cause that affects them. In this case, no interaction between the spatial points is assumed. Spatial dependence arises as a consequence of a functional connection due to spatial proximity. A wrong understanding of the nature of the spatial process can be the reason for generating information about the availability of a process where none exists, or to hide the factual process.

The purpose of this paper is to identify spatial patterns of variability in the relationship between the morphometric characteristics of maize using the methods of geographically weighted analysis of the principal components at a large-scale level.

Study materials and methods. On the agricultural field (Dnipropetrovsk region, Synelnykove district, village of Vesele, 48°21'27.25"C, 35°31'53.88"B) a test site was established, which is represented by 7 transects with 15 sample areas in each. The distance between sample areas is 2 m. Within each area, 6 plants to be measured were randomly selected. The coordinates of these plants were recorded relative to the local coordinate system. The height of the stem, the number of leaves, the length and width of the leaves, the width of the stem at a plant half height were measured in plants. The median leaves (counting from the first one) were measured in each plant. Accuracy of measurement of plant height was 1 cm, the diameter of the stem, the length and width of the leaf – 1 mm.

In a row of maize plants of 1 m long, the quantity of plants N was counted, and taking into account the distance between the rows d (in meters), the density of planting was calculated:

$PD = N / d$,

where PD is the density of planting, specimen/m2, N is the number of plants in a row of 1 m long; distance between the rows, m.

The surface area of the maize leaves was calculated using the formula as follows:

$S = k \times W \times L$,

where W is the maximum width of the leaf; L is the leaf length; k is the shape factor, which varies between 0.67-0.71 (Bos et al., 2000).

The specific area of the leaf surface was calculated as follows:

$LS = S \times Nm \times PD$,

where LS is the specific area of leaf surface, m2/m2; Nm is the number of leaves on one plant; PD is the density of planting.

The volume of the maize stalk was calculated as follows [Maddonni, Otegui, 2004]:

$St\_V = \pi \cdot St\_L \cdot (0.5 \cdot St\_D)2$,

where St_V is the volume of the stalk, St_L is the height of the stalk, St_D is the height of the stalk at a level of a half height of the stalk.

On the basis of measurements of the morphological characteristics of maize plants, derivative indices were calculated. The indices are the ratios of the logarithms of the values, which name the indices. Thus, the St_D / St_L index is equal to log(St_D) /log(St_L). The formulas of other indices are similar to the one mentioned above.

Moran's I statistics was calculated using the GeoDa program (Anselin et al., 2006; Zhukov 2015). Descriptive statistics were obtained using the Statistica 7.0 program. The spatial variation of features was imaged using the ArcMap 10.0 and Surfer 11.0 software programs. A spatially weighted analysis of the principal components was carried out using the GWmodel library (Gollini et al., 2013) within R environment (R Core Team, 2013).

Data on the density of corn planting and its morphological features is provided in Table 6.1.

The density of planting was 10.26 specimens/m2. This index within the studied test site varies within a wide range of 2-18 specimens/m2 (CV = 26.37%). It should be noted that the data on the density of plant sowing are often provided in he studies. Our results show that such an important indicator, as the density of planting, which determines the state of seeds, is subject to considerable variability even in a relatively limited area of the field.

The number of leaves on the plant is also a very variable factor. It should be noted that the number of emerging leaves in maize linearly depends on the amount of the effective temperatures with an average speed of 0.03 leaves/°C·day and night [Boon et al., 2008]. Our data indicate that there is a statistically significant correlation between the number of leaves and the 5-7 cm top soil temperature ($r = 0.18$, $p = 0.00$). It was discovered that there is no statistically significant relationship between the different irrigation regimes and the number of leaves in maize (Hajibabaee et al., 2012). The identification of the relationship between morphological features and environmental factors was not included in the tasks of this study, but the data presented suggest a cause of the considerable variability in the number of leaves of maize in space. Most likely, the spatial variability of the thermal properties of the soil influences the dynamics of maize growth processes.

As a first stage of the analysis, a standard analysis of the principal components was carried out. The first five principal components, the eigenvalues of which exceed 1, account for 94.70% of the variability of the characteristic space of ecological and morphometric features of maize.

Table 6.1

Ecological and morphometric features of maize (N = 630) and the results of the principal components analysis

Feature		Average ± st. error	CV, %	Analysis of principal components *				
				PC1	PC2	PC3	PC4	PC5
1	Density of planting, specimen/m^2 (PD)	10.26±0.11	26.37	–	–	–	–0.50	0.64
2	Height of stalk, cm (St_L)	144.68±0.89	15.40	–0.35	–	–	0.33	0.21
3	Stem width, cm (St_D)	7.59±0.02	7.17	–0.22	–	0.48	–	–
4	Number of leaves, pcs. (Nm)	12.26±0.07	13.75	–0.34	0.15	–0.10	–0.15	–0.25
5	Leaf length, cm (L)	68.47±0.27	9.95	–0.21	–0.29	–0.12	–	–
6	Leaf width, cm (W)	7.15±0.03	11.48	–0.32	–0.29	–	–	–
7	Specific area of leaf surface, m^2/m^2 (LS)	4.40±0.07	38.35	–0.29	–0.11	–0.11	–0.40	0.34
8	St_D/St_L	0.41±0.07	4.16	0.16	–0.14	0.43	–0.35	–0.18
9	Num/St_L	0.50±0.10	5.13	–0.21	0.21	–0.17	–0.37	–0.43
10	L/St_L	0.85±0.14	4.01	0.24	–0.31	–	–0.30	–0.20

11	L/St_D	2.09±0.32	3.83	–	–0.17	–0.54	–	–
12	L/Nm	1.70±0.60	8.92	0.28	–0.31	–	–	0.16
13	W/St_L	0.40±0.08	5.34		–0.43	–	–0.15	–0.20
14	W/St_D	0.97±0.21	5.48	–0.21	–0.31	–0.30	0.12	–
15	W/Nm	0.79±0.28	9.01	0.11	–0.42	0.14	0.14	0.13
16	W/L	0.46±0.08	4.57	–0.31	–0.24	–	–	–
17	Stalk volume, m^3 (St_V)	0.66±0.01	24.15	–0.33	–	0.30	0.14	0.11
Moran's *I*		Index		0.14	0.07	0.13	0.16	0.12
		p-level**		0.01	0.01	0.01	0.01	0.01

Component 1 describes 35.16% of the variability of the attribute space. The maximum absolute value of the load on the principal component 1 is characterises such features as stalk height (-0.35), number (-0.34) and width (-0.32) of leaves, as well as stalk size (-0.33). Thus, the principal component 1 can be interpreted as the size of the maize plants. The principal component 2 describes 26.42% of the variability of the feature space. The indices W/St_L (-0.43) and W/L (-0.42) are characterised by the maximum absolute loads on this component, which gives grounds for interpreting this component as a measure of the leaf shape - elongated or widened. The principal component 3 describes 16.32% of the variability of the attribute space. The maximum absolute load values for this component describe the stalk width (0.48), as well as the L/St_D (-0.54) and St_D/St_L (0.43) indices. This component reflects the variability of the thickness of the maize stalk. The principal component 4 describes 8.77% of the variability of the attribute space. The maximum absolute values of load on this component describe the density of planting (-0.50) and the specific surface area of the leaves (-0.40), as well as indices St_D/St_L (-0.35), Num/St_L (-0.37) and L/St_L (-0.30). This component reflects the inverse relation between the density of planting and the height of stalks. The principal component 5 describes 8.03% of the variability of the attribute space. The maximum absolute values of load on this component describe the density of planting (-0.64) and the specific surface area of the leaves (-0.34), as well as indices St_D/St_L (-0.18), Num/St_L (-0.43) and L/St_L (-0.20). This component reflects the positive relation between the density of planting and the height of stalks.

The Moran's index indicates the availability of a spatial aspect of the variability of the principal components singled out.

To perform a geographically weighted analysis of the principal components (GWPCA), it is necessary to determine the optimum bandwidth value. This task can be performed automatically through a cross-validation procedure (Harris et al., 2011). To perform the procedure, you must a priori choose the number of components for which the optimum bandwidth value will be determined, since for the whole number of principal components there is no optimal solution. In our case, the first three components were selected and the selection was made on the basis of a bi-square kernel. There are two choice strategies - adaptive and non-adaptive. Adaptive strategy is applied in case of irregular location of sampling points and the target value is the number of the nearest locations for a given point. A non-adaptive strategy is applied to regular or quasi-regular data and the distance is to be identified. We found that the optimal bandwidth is 7.23 m.

It should be noted that the standard version of the analysis of the principal components allows describing 77.90% of the variability of the attribute space using the first three components. In 91.91% of cases the first three components of GWPCA describe a greater percentage of variability than in the case of the standard analysis scenario. This indicator is characterized by a high level Moran's I (0.79, R = 0.001), which indicates a high degree of its spatial conditionality.

In the largest number of cases, the leaf width, and in a somewhat smaller number of cases - the L/Nm and L/St_L indices, are characterized by the predominant load (Table 6.2). It should be noted that in the standard analysis scenario these variables are not among the numbers with the predominant load. Areas with a predominant factor load of a particular indicator are spatially defined and compact. Moreover, the compactness of the spatial location is also characteristic for the areas with predominant feature loads for the principal component 2. In most cases, the maximum absolute load on the principal component 2 is the characteristic of the L/St_D index, somewhat less often, the maximum is set for L/St_L and the density of planting. It is noteworthy that for the standard scenario of the principal components analysis, the latter indicator generally does not fall in the number of the features that are characterized by a statistically significant loading on the principal component 2.

Table 6.2

The number of locations where the variables have the highest loading on the principal component 1 (GWPC1) or 2 (GWPC2) (the bandwidth is 7.23 m)

No.	Variable	GWPC1	GWPC2
1	Density of planting, specimen/m^2 (PD)	–	75
2	Height of stalk, cm (St_L)	17	–
3	Stem width, cm (St_D)	–	20
4	Number of leaves, pcs. (Nm)	17	–
5	Leaf length, cm (L)	6	–
6	Leaf width, cm (W)	317	44
7	Specific area of leaf surface, m^2/m^2	12	–
10	L/St_L	58	98
11	L/St_D	–	223
12	L/Nm	103	21
13	W/St_L	1	66
14	W/St_D	19	83
15	W/Nm	25	–
16	W/L	55	

The standard scenario of the analysis of the principal components allowed distinguishing five main trends in the variability of the morphological characteristics of maize and its density of planting in the field. These trends can be meaningfully interpreted. The interpretation of multidimensional principal components is at first glance somewhat trivial: it is the size of the plants, the shape of the leaves, the thickness of the stalk, and the change in plant height at different levels of density of planting. Two fact should be noted at this point. This is a set of indicators that form a related group of characteristics, described by each principal component. And the orthogonality of the principal components, or the independence of the processes, with which the principal components are identified at the interpretation. Thus, the specificity of the principal component 1 indicates that the size of plants does not depend on their density of planting. In addition, the length of the maize sheet increases slower than the length of the plant.

In general, the density of planting is characterised by a statistically significant load on the principal components 4 and 5, being the last ones on the list of components, the eigenvalues of which exceed one and thus can be taken for analysis. At the same time the coefficient of variation in density of planting is 26.37%, which is second only to the specific area of the leaf surface (by the way, this is the calculated index, which also depends on the density of planting). Thus, at a sufficiently high level of variability of density, the average level of this indicator is 10.26 ± 0.11 specimen/m2 does not have a significant influence on such morphological features of maize as dimensions, form of the leaf surface and width of stalk. In this case, the influence of density of planting on the stalk height is ambiguous. The opposite relationship between the density of planting and the stalk height is revealed by the principal components 4 and 5. This situation can be the result of the horseshoe effect: analysis of the principal components is a linear process that is unable to describe nonlinear effects. The nonlinear connection (bell-shaped, or horseshoe-like) is divided by this analysis into several components rather than into only one, in the simplest case, into two, which correspond to the ascending and descending sides of the "horseshoe".

A geographically weighted analysis of the principal components made it possible to establish the spatial variability of the covariance structure, which describes the relationship between morphometric characteristics and the density of planting of maize. The established global pattern of interconnection by means of classical analysis of principal components is not identical to local covariance structures. Local covariance structures, which are opened by analysing the principal components within the optimal bandwidth, are generally characterized by a much higher level of non-random variability, which is described by the first three principal components. Variability, which is referred to the subsequent principal components (especially if the corresponding eigenvalues are less than 1), is determined by the random noise, or factors, which cannot be described within the framework of the principal component analysis models. Thus, the percentage of the variance, which is described by the first three principal components, indicates the consistency of the morphological structures. This consistency is characterised by regular spatial variation trends.

Local covariance structures form spatially regular patterns of their location. A peculiarity of these structures is the quantitative redistribution of the values of any given characteristics within the framework of sufficiently invariant configurations. In this case, configuration means an agreed set of morphological features, which, if possible, can be meaningfully interpreted. One may talk of the succession of covariance structures in qualitative terms at various levels of scale (global and local), but with local quantitative specificity. This specificity is manifested in the predominance of one or another indicator as the main marker of the principal component at the local level.

The identification of spatial patterns of covariance structures sets the problem of understanding the nature of this spatial regularity. The nature of these patterns can be endogenous or exogenous. The endogenous nature is understood as the formation of coherence of morphological processes as a result of interorganism interactions of plant organisms. The exogenous nature means, first of all, the edaphically conditioned processes of synchronisation of morphological processes.

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CHAPTER 7. EVALUATION OF GAMMA-RAYS CUTE IRRADIATED CONSEQUENCES ON PLANT AND CELL LEVEL BY PARAMETERS OF DEVELOPMENT, GROWTH AND CHROMOSOMAL REARRANGEMENTS

In this part we report about results our investigation of several cytogenetic parameters of mutation induction variability of the modern winter wheat varieties and some connections amid means of cytogenetic indexes and different doses of gamma-rays.

Experimental mutagenesis studies the effects of any mutagen on living organisms. This includes radiation across the electromagnetic spectrum including X-rays, ultra- violet radiation, visible light, microwaves, radio waves, emissions due to radioactive decay, low-frequency radiation such as ultrasound, heat waves and related modalities, chemical and biological agents. In radiobiology, most of the biological systems such as mammalian cells and bacteria generally are exposed to X-rays, γ -rays and electron beams for the investigation of radiation effects. Ion beams with high energy are utilized in some researches. In traditional radiobiology, most of the irradiated biological samples, such as cells or tissues, are in atmosphere or even in soil (Shu et al, 2011, Nazarenko, 2017).

Mutation has been described as a sudden change in the genetic material of living cells. However, at the beginning of mutation research, over 100 years ago, these sudden changes were observed and detected by the phenotypes they affected. The “sudden phenotypic changes” were heritable and therefore had a genetic base and mutation detection and monitoring in research and plant breeding were based entirely on phenotyping. Later, in the mid-1950s onward, light microscopy provided a means of observing aberrations at the ploidy, karyotype and chromosome levels.

Besides gene mutations, chromosomal aberrations in the form of deletions, inversions and translocations were produced (Shu et al, 2011).

Translocations are most impotent for mutation breeding type of chromosome aberration, which may result from the rejoining of broken chromosomes. Irradiation tends to induce chromosome breaks, which can rejoin at random, resulting in translocations. These are likely to be deleterious. Ionizing radiation produces cytological aberrations and defects in chromosome segregation. Cytological aberrations observed in mitosis include the production of micro-nuclei and chromosomal abnormalities The cytogenetic effects of a gamma ray in the root tips of many plant species were measured previously. The specific localization of the radiation induced chromosome aberrations using traditional chromosome staining has been the subject of studies in barley and other plant species. A gamma ray, causing breaks in one or two chains of DNA, is routinely used in plant mutagenesis and most barley mutant varieties were developed by applying this type of radiation. Recently, the genetic effects and the influence of heavy ions (neon, argon, iron, carbon) on plant development in maize, rice, wheat and Arabidopsis thaliana were analyzed (Shi et al, 2011). Complex effects of sparsely and densely ionizing radiation in plants were evaluated. The data showed that densely ionizing radiation was a more efficient damage inducer Various types of chromosome aberrations both in anaphase and metaphase were observed in root apical meristem after exposure of wheat dry seeds to carbon ion beams (Natarjan, 2005).

Genotoxic impacts of environmental mutagens on eukaryotic organisms may be determined at different levels: at the level of genes by counting the phenotypes corresponding to mutant alleles; at the level of chromosomes by counting chromosome/chromatid type aberrations, sister chromatid exchanges, chromosome mal-segregation or micronuclei (MN); or at the level of DNA by measuring adducts, crosslinks, breakage of DNA or repair of the corresponding damage using diverse assays (e.g. comet assay, unscheduled Abbreviations: CA: chromatid aberrations; MN: micronuclei; FISH: fluorescent in situ hybridization; MNU: N-methyl-N-nitrosourea, DNA synthesis, immuno-slot blot, etc. The different levels of genotoxicity testing have specific advantages/disadvantages with respect to the necessary efforts and skills as well as to their sensitivity and meaningfulness. Usually, data resulting from several levels of genotoxicity testing are required to arrive at a reliable estimation of risk. Analysis of chromosomal aberrations after mutagen action of any kind of mutagen by anaphases method is one of the more investigated and most precision methods which we can used for determine fact of mutagen action on plants, identify nature of mutagen. We combined in our investigation both sensitivity of genotype to mutagen using cytological analysis of mutagen treated wheat populations with the corresponding different varieties by breeding methods to reveal its connections and differences, specific sensitive to mutagens action on cell level. Dry seeds of 8 varieties of winter wheat were subjected to 100,150, 200, 250 Gy gamma irradiation, which are trivial for winter wheat mutation breeding. We investigated rates and spectra of chromosomal aberrations in winter wheat primary roots tips cells. The coefficient of correlations amid the rate of chromosomal aberrations and the dose of gamma-rays were on 0.8 – 0.9 level. Fragments/bridges ratio is clear and sufficient index for determine mutagen agent nature. We distinguished the following types of chromosomal rearrangements: chromatid and chromosome bridges, single and double fragments, micronuclei, and delayed chromosomes. The ratio of chromosomal aberrations changes with the change in mutagen; note that bridge-type are characteristic of irradiation. Radiomutants are more resistance to gamma rays. It is appeared in less rate of chromosomal aberrations. Varieties, obtained by used chemical mutagenesis (varieties Sonechko, Kalinova) are more sensitive to gamma-irradiated than other. We proposed these varieties as object for mutation breeding program and radiation mutants for planting in areas under gamma-rays action.

There are three reasons for the study of plant mutant generation M1 after mutagenic effect. The first one is the definition of the agriculture lands after mutagen pollution suitability for grows main crops. More than 70% of soil in Ukraine used for agriculture is constantly exposed to chemical and physical mutagens. The second reason is the fact that the amount of material, obtained from the first generation, limits the opportunities of mutation breeding programmes (especially using the lethal doses). The third reason is the use of obtained M1 population to extract valuable mutant strains in further generations.

Bread wheat (Triticum aestivum L.) is one of the most important agricultural products, accounting for 20% of global human caloric intake. However, artificial selection and domestication of wheat breeding programs tend to decrease the biological diversity, thereby decreasing the resistance of varieties to various biotic and abiotic stresses and leading to heavy losses in yield. Therefore, broadening the biological diversity of current wheat varieties is necessary to increase their resistance to agricultural stresses. Determination of the mutagen- polluted area suitability for agriculture. More than 70% of soil in Ukraine used for agriculture is constantly exposed to chemical and physical mutagens. Ukrainian government planned to use some areas with high level of pollution for forestry and production of grain. However, data on the negative consequences in form of reduced grain productivity of plants cultivated on such soil (effects of mutagenic depression in the first generation) have been obtained (Nazarenko, Kharytonov, 2016).

The second reason is the fact that the amount of material, obtained from the first generation, limits the opportunities of mutation breeding programmes (especially using the lethal doses). Induce of mutations in crop plants contribute by increasing genetic variability and enrich plants germplasm for direct selection and cross-breeding [18; 35]. More than 3000 mutant varieties have been directly or indirectly derived through mutation induction, including 200 bread wheat varieties (Nazarenko, Kharytonov, 2016). Induced mutations have been applied to produce mutant varieties by changing the plant characteristic for a significant increase in production and improve quality (Shu et al, 2011). Wheat is the top food crop in Ukraine as well as in the whole world and the biggest part of grain is obtained primarily from winter wheat. Wheat is the stable food of millions of people globally. This crop is widely adapted to wide range of climatic conditions. A large variety of food that include bread, cakes, noodles, crackers, breakfast food, biscuits, cookies and many other confectionary items are prepared from wheat. The total area for winter wheat cultivation in Ukraine covers 6.8 mln. he with actual productivity of 24 mln. tons and average capacity of 2.8 t/ha (Nazarenko, 2017).

The third reason is the use of obtained M1 population to extract valuable mutant strains in further generations. The study is devoted to the survival ability and productivity of plants exposed to mutagenic effect at different doses, concentrations and mutagen nature. Mutagenesis reduces plant growth and other crop yield structure components, increases the pollen sterility and cuts the germination and survival abilities of plants by means of chemical agents and gamma rays; sometimes the great part of population is killed with the critical doses. Depression increases with the increase of dose. But sometimes we observe stimulating effect (in case of low doses) or absence of depression (at medium concentrations of some chemical mutagens) (Nazarenko, 2017)].

Thus, there is a contradiction between the mutagen efficiency (for breeding purposes) in the induction of valuable mutations, which often occur at high doses and small population of M1 plants obtained when applying such doses (Shu et al, 2011).

High doses are more successful in obtaining large quantity and a wide range of mutations. Some genotypes have total or partial resistance to mutagenic effect. These genotypes are important both for obtaining new varieties of plants and cultivation in case of mutagenic pollution.

Mutagenic effects of chemicals or ionizing radiation have been assessed by analysis of chromosomal aberrations.Chromosomal abnormalities in irradiated mitotic cells range from breaks, through exchanges, laggards and anaphase bridges, dicentric and centric ring formations, terminal fragments with telomeric signal at only one end and interstitial fragments that appear as double minutes without any telomeric signals. Mutated plants typically show reduced fertility, mainly caused by chromosomal rearrangements and genomic mutations during meiosis. For crops like wheat, individual tillers (side branches) originate from different cells of the embryo of the treated seeds. If an aberration occurs in one of these cells, it will be carried in the tiller developed from that cell (Shu et al, 2011).

Analysis of chromosomal aberrations after mutagen action of any kind of mutagen by meto-anaphases method is one of the more investigated and most precision methods which we can used for determine fact of mutagen action on plants, identify nature of mutagen factor. Usually, analysis are widely used as for radionuclide’s pollution of environment and its level, danger of this pollution as for determine optimal doses of radiation and chemical agents in breeding work with plant material]. In the past 80 years, physical mutagens, mostly ionizing radiations, have been used widely for inducing hereditary aberrations and more than 70% mutant varieties were developed using physical mutagenesis. However, this compound exhibits high mutagenic, clastogenic and recombinational activity in plants, frequently stronger than that of the most powerful alkylating agents. Gamma irradiation is an effective way to induce mutations and to broaden crop genetic variability. Since 1956, Sears transferred gene from Aegilops umbellulata (Zhuk.) to wheat genetic background, genetic transfer has been widely used in wheat breeding programs and for the creation of translocations to develop novel wheat genetic resources. To date, some wheat cultivars have been successfully bred by incorporating 60Co-γ-induced mutations. Many beneficial traits have been transferred from the genomes of alien species to those of wheat by 60Co-γ. Moreover, translocations and deletions induced by gamma rays have been useful in mapping and cloning target genes. Most previous studies mainly focused on alien chromosomes that were studied using cytological procedures such as C–banding and genomic in situ hybridization methods. However, cytogenetic detection is generally time-consuming and labor-intensive. Given that non-denaturing florescence in situ hybridization (ND-FISH) involves the use of oligonucleotides as probes, it is a novel and efficient technique to identify chromosomes. A correlation between “clastogenic adaptation” expressed as a reduction of chromatid type aberrations, micro-nuclei and aneuploid cells, and the “clastogenic adaptation” has been shown (Natarjan, 2002). Advantages of the method are promptness, objectivity of the results, the reliability and the ability to assess the impact of integrated wide variety of mutagens by nature (Nazarenko, Kharytonov, 2016).

Mutation induction activities had peaks in the 1950s, 60s, 70s and 80s and enjoyed major successes in terms of mutant variety releases. However, mutation induction declined towards the end of the 20th century. There were various reasons for this, the negative arguments of Stadler still posed problems and there was a general concern that mutation induction and mutation breeding were non-scientific. Another major drawback was that all mutation detection and selection was done (painstakingly) at the phenotypic level. The early years of the 21st century witnessed a resurgence in mutation technologies due to a rapid and greater understanding of mutagenesis and related disciplines, which led to more applications. The understanding of the molecular basis of mutagenesis (transformed mutation induction from chance events into science- based techniques. The use of molecular and genomic tools for mutant screening and characterization also enabled mutation breeding to embrace and utilize the very event findings and technological innovations in plant genomics and molecular biology research. And last but not the east, induced mutants are regarded as valuable tools in bridging the gap between phenotype and genotype, an important issue in plant breeding and plant genomics (Shu et al, 2011).

Gamma rays, nitrosomethiureas, methylsulphat and diazoatsetilbutan are the most important and frequently used mutagens well known for their effect on the plant growth and development and the appearance of morphological, cytological and physiological changes in cells and tissues; they are also traditional in breeding. Most commercial varieties are obtained by means of gamma irradiation (Zhang et al, 2015). The development of direct mutants into commercial varieties is still a common practice in seed propagated crops (Shu et al, 2011). In first generations for wheat as cultivar composed from three genomes we observed only some dominant mutations in our investigations, but we continued our experiments on next generations (M2 –

M6).

Positive desirable mutant will be selected and be incorporated in future breeding programs.

Plant genera and species and, to a lesser extent, genotypes and varieties differ in their radio-sensitivity. These differences are accounted for genetic, physiological, morphological and other biological modifying factors (such as ontology). These combine with environmental factors (such as oxygen and water content) to assert marked influences on the response of seeds (and other plant propagules) to ionizing radiation and chemical mutagens. Mutagen effects on cell and whole plant level are the key factors which limited either winter wheat productivity for agricultural purpose or number of families for breeding program in obtaining next generation material for identification and selection of mutants. Consequences of mutagen action on cell level (chromosomal aberrations) are closely connected with future mutation rate. Influence of mutagen factors action is depended on next parameter: physiological parameter of mutagen action object, genotype of object, type of mutagen action (acute, chronicle), nature of mutagen, doses or concentration of mutagen, fractional of dose or concentration, time of exposure, concentration or appearance of free active oxygen, temperature and other environmental conditions (Zhang et al, 2015; Nazarenko, Kharytonov, 2016).

Mutagenesis reduces plant growth and other crop yield structure components, increases the pollen sterility and cuts the germination and survival abilities of plants by means of chemical agents and gamma rays; sometimes the great part of population is killed with the critical doses (Solanki, Sharma, 2000). Depression increases with the increase of dose (Yilmaz, Erkan, 2006). But sometimes we observe stimulating effect (in case of low doses) or absence of depression (at medium concentrations of some chemical mutagens). In first generations for wheat as cultivar composed from three genomes we observed only some dominant. Positive desirable mutant will be selected and be incorporated in future breeding programs (Ali Sakin et al, 2005).

Recurrent mutagenesis includes the exposure to mutagen action of progeny of plants that had been treated in previous generation. The strategy of treating the progeny of previously treated plants is well-known as recurrent action. Investigators studied a wide range of mutagens including different types of physical mutagens (different types of radiation) and the chemical mutagen (EMS); the alternation of EMS with irradiation was also studied. The results of these experiments did not bear out the expected results and were at best mixed. In most cases, radiosensitivity, mutation rate and spectra remained unaffected with repeated irradiation of subsequent generations. In our investigations we used other types of chemical mutation factors (nitrosoalkylureas, DAB) and alteration these mutagens with gamma-rays. We obtained new results according to reduce radiosensetivity, mutagen depression after recurrent mutagenesis and determined some new laws for recurrent mutagen action. In case of mutagen alteration we ran on with trivial, normal reaction on mutagen action (Chaima et al, 2012, Nazaenko, 2017b).

Gamma-rays are related to special group of mutagens “supermutagens” (as classified by Rapoport). Special ability of this group is induction mutations on level of comparable mutagen without high damages, which influence on survival ability of plant material (Jovtcheva et al, 2002; Özel et al, 2015). Supermutagens induct 50-60 times more mutations than relevant by their consequences for surviving and plant development doses of gamma rays or fast neutrons (Albokari, 2014). But DAB in spite of previous chemical mutagens (nitrosoalkylureas), by its action more similar to physical mutagens (like as gamma-rays) than for other chemical mutagens and don’t so site-specific.

Other feature (general for all chemical mutagens) is induction of gen mutations on peculiar DNA-sequence rather than structural changes. It is depends on chemical nature of specific mutagen. That’s why chemical mutagenesis is one of the important methods for modern genetics investigations (as for example for reverse genetics, for different types of tilling’s methods). We can predict (in certain limits) more probably types of future mutations with higher rates (according to preferable DNA sequences for mutagen action) (Juchimiuk-Kwasniewska, 2002; Natarajan, 2005).

Mutagenic effects of chemicals have been assessed by both analysis of chromosomal aberrations (Rakhmatullina and Sanamyan, 2007) and investigation plant development and grows at first generation under field conditions.

Parameters traditionally used to estimate the degree of plant injury in the M1 generation are: 1. Seedling height, determined at a particularly stage soon after germination. 2. Root length, determined soon after germination in controlled environment conditions. 3. Emergence under field conditions or germination. 4. Survival under field or controlled environment conditions. 5. Number of florets, flowers or inflorescences per plant. 6. Number of florets or flower parts per inflorescence. 7. Number of seed set. 8. Number of seeds per plant (Khaled et al, 2016).

Irradiation, for the purposes of inducing mutations in plants, is normally carried out in either of three ways: continuous exposure, usually of growing plants, over extended periods of time, ranging from weeks to months, to relatively low doses of irradiation; this is known as chronic irradiation. Gamma glasshouses and fields are particularly suited for this extended exposure of growing plants to irradiation. The single exposure of plant propagules at higher doses over a short period of time (minutes) is known as acute irradiation. Recurrent irradiation involves the exposure to radiation of progeny of plants that had been irradiated in previous generation(s). Dose fractionation or split dose irradiation, somewhat akin to chronic irradiation, refers to the practice of exposing the plant propagule to more than one regimen of irradiation with the treatments separated by time intervals. It used to be believed that acute irradiation resulted in relatively greater mutation frequencies. This does not appear to be supported by empirical data, but currently, most mutation induction exercises are of the acute type. Mutated plants typically show reduced fertility, mainly caused by chromosomal changes during meiosis. Plant surviving, pollen fertility and yield structure were studied for identification of mutagen depression evident at first generation (Karthika and Subba, 2006; Nazarenko, 2017b).

Most of the observed effects in the M1 generation are physiological. Plant injuries in the M1 generation are indicative of the degree of the effects of mutagens on plants and can be determined quantitatively in various ways. Physical injury is commonly measured using such parameters as reductions in germinability of seeds, growth rates of seedlings, vigor, sterility and even lethality of plants.

Chromosomal abnormalities in irradiated mitotic cells range from breaks, through exchanges, laggards and anaphase bridges, dicentric and centric ring formations, terminal fragments with telomeric signal at only one end and interstitial fragments that appear as double minutes without any telomeric signals (Rakhmatullina and Sanamyan, 2007). The process of radiation affecting plants involves physical, chemical and biological stages. The biological consequences of radiation depend on its effect on cellular components such as proteins and organelles but more importantly on the plant's genetic material. For crops like wheat, individual tillers (side branches) originate from different cells of the embryo of the treated seeds. Radiation acts on living cells by the releasing of energy raising electrons to a higher energy state (excitation), ejecting electrons from target molecules (ionization), and other reactions (such as mass deposition and charge exchange). It involves both physical and chemical processesIf an aberration occurs in one of these cells, it will be carried in the tiller developed from that cell (Bolzarn and Bianchi, 2006; Huaili et al, 2005; Shu et al, 2011).

Influence of different types of chemical mutagens or any type ionizing radiation of can be analyzed by calculated number and kinds of chromosomal aberrations (Rakhmatullina, 2007). Chromosome aberrations have long been recognized to be an important biomarker of living organisms exposure to ionizing radiation and genotoxic chemicals. Both structural and change in number aberrations have been associated with problems in growth and development, e.g. congenital incorrectness in new-borns living organisms. The rate of spontaneous chromosome aberrations is about 0.6% of plants. Both structural and numerical aberrations occur spontaneously due to intraneous and extraneous factors (Nikolova et al 2015).

Chromosomal rearrangements tend to visible mutations or modifications were firstly described in plants by de Vries (de Vries, 1918). Unlike other living organisms, plant systems offer an opportunity to detect the types and rates of chromosome changes in the first cell division following gamma-irradiation. It should be pointed out that these investigatings were connected long before the structure of DNA and chromosomes were known. Conventional direct damage to DNA results in transversions (purines to pyrimidines and vice versa) and transitions (purine to purine and pyrimidine to pyrimidine) through the activities of different DNA repair mechanisms. Single and double-strand breaks (SSBs and DSBs) by ionizing radiation are believed to be induced by electrons with sufficient energy to ionize DNA and produce chemically reactive macromolecules that interact with the cellular molecular environment. More recent findings (Boudaïffa et al. 2000) challenge this conventional view by suggesting that damage to the genome by ionizing radiation is only induced by electrons with sufficient energy to ionize DNA. A break in either single (resting stage) or divided (prophase) chromosomes are the consecutives of direct action on the chromosome by the ionization produced by any elementary particle. Such a break may remain as such to give rise to terminal deletion, rejoin in the original position (restitution) or join with an indigenous break in the same or different chromosome to produce various types of rearrangements (Natarajan, 2002).

A third of the in vivo damage to the genome caused by light ionizing radiation, such as X-rays, can be attributed to energy deposited directly in the DNA and its closely bound water molecules. The remaining two thirds can be indirectly attributed to free radicals produced by energy deposited in water molecules and other biomolecules surrounding the DNA. Since the reducing counterparts of -OH , principally the hydrated electron, aqare relatively ineffective (especially at inducing DNA strand breaks, almost all of the indirect damage to DNA is due to attacks by the highly reactive hydroxyl radical -OH. Thus, the induction of a double strand break by a single burst of radiation is the result of a localized attack by two or more -OH radicals. This presents a challenge to the DNA repair machinery, and has vital consequences for biological effects of the cell, such as the development of a complex lesion through concomitant damage in close proximity by -OH or by direct effects on the DNA. One strand could be attacked by an •OH radical whereas the other strand may sustain direct damage within a 10 base-pair range of the •OH attack. Clusters of such hybrid damage are known to be generated by the closely spaced depositions of energy along the radiation tracks. Low-energy electrons, might induce single strand breaks on each strand of the DNA as a single electron interaction. The quantitative relationship amid a doses of radiation and the rate of aberrations depends on both the type of rearrangements and the kind of radiation. With any type of radiation, elementary breaks are linearly related to the dose. Interchanges ascend with increasing of the dose, greater than one, showing that two separate breaks are included. If an one-time dose of gamma-radiation is obtained, all the initial breaks are present simultaneously, reunion is disable and the exchange produce is proportional to the dose in square. If the dose is given chronically restitution is disabled over the act of reunion and the exchange produce is decreased (Bolzarn, Bianchi, 2006).

Changes in chromosome number and structure in mitotic cells after irradiated. Chromosomal changes rank from breaks, through exchanges, laggards and anaphase bridges, dicentric and centric ring formations, terminal fragments with telomeric signal at only one end and interstitial fragments that appear as double minutes without any telomeric signals changes in irradiated mitotic cells (Rakhmatullina, 2007).

Joining with gene mutations, chromosomal aberrations in the form of different structure rebuilding (deletions, inversions, translocations, etc) were generates (Shu et al, 2011). Translocations are the most impotent for mutation breeding kind of changes on chromosome level, which are possibly result from the rejoining of broken chromosomes districts. Gamma-irradiation leads to generate of chromosome breaks, which can reunite in random manner, result of this process is translocation. Deletions are produced in the same way. Ionizing radiation generates cytogenetic aberrations and large number of mistakes in chromosome segregation.

Cytological aberrations observed in cells mitosis include the production of micronuclei and other types of chromosomal changes (Ukai, 2006; Shu et al, 2011).

Analysis of variability of chromosomal changes after mutagen treatment of any type of mutation factor by anaphases method is one of the well-investigated and most precision methods which we can used for determine fact of mutagen action on plants, identify nature of mutagen (Lifang et al; 2001, Adlera et al, 2004; Ukai, 2006, Waugha. 2006). Moreover, this method is widely exploited as for determine of radionuclide's pollution of lands and water, its level, danger of this pollution as for definition optimal doses of radiation and concentrations of chemical supermutagens in breeding work with plant material (Ahloowalia et al, 2004; Nazarenko, 2015). Therefore, radiation mutation is a compound of high mutagenic, clastogenic and recombination activity in plants on cell level, frequently stronger than that of the most powerful nitrosoalkylating agents (Grant and Owens, 2001). A relation amid clastogenic adaptation shown in descending of chromatid type of changes, micronuclei and changes in number of chromosomes in cells, and the clastogenic effect has been appeared (Bignold, 2005). Preferences of this trivial approach are simplicity, objectivity of the results, the reliableness and the ability to assessment the impulse of integrated wide variety of mutagens by nature (Karthika and Subba, 2006; Albokari, 2014).

The main purposes of investigations are definition of cytogenetic variability of mutation induction chromosomal aberrations of the modern wheat varieties and connections amid means of cytogenetic characteristics and different doses of gamma-rays.

Plant mutagen depression at first generation. Dried seeds (approx. 14% moisture content) of (in brackets method of obtaining varieties or used mutagens) Favoritka, Lasunya, Hurtovina (irradiation of initial material by gamma rays), line 418, Kolos Mironovschiny (field hybridization), Sonechko (chemical mutagenesis, nitrosodimethilurea (NDMU) 0.005%) and Kalinova (chemical mutagenesis, DAB 0.1%), Voloshkova (termomutagenesis – low plus temperature under vernalizaion has been used as mutagen factor) of winter wheat (Triticum aestivum L.) were subjected to 100,150, 200, 250 Gy gamma irradiation. Each treatment was comprised of 1000 wheat seeds. These doses are optimal for the breeding process that has been repeatedly established earlier (Ahloowalia et al, 2004; Nazarenko, 2015). Non-treated varieties were used as a check.

Treated seeds were grown in rows with inter and intra-row spacing of 50 and 30 cm, respectively, to raise the M1 population. The untreated seeds of mother varieties (parental line/variety) were also planted after every ten rows as control for comparison with the M1 population. M1 plant rows were grown in three replications with check- rows of untreated varieties in every ten-row interval. Data on seed germination and surviving plants were recorded considering whole plots of M1 population. Data on yield structure components (plant height, general number of culms, number of productive culms, spike length, spikelets per spike, number of grain per spike, grain weight per spike and plant, 1000 grains weight) were taken from 50 randomly selected plants of each treatment representing more or less all types of morphological plants.

The seeds used in this study were of the M0 generation. After mutagen treatment dry seeds were germinated in Petri dishes under 24 – 72 hours (depends on presoaking and mutagen action), temperature +250C. Afterwards central primary roots were cut and fixed in solution of alcohol and acetic acid (in proportion 3:1) for 24 hours. Fixation material was stored in 70% alcohol solution under temperature 2 0C (20 – 25 roots per variant). Cytological analysis was carried out by the standard method at temporary press-time preparations of root tips (1 – 1.5 mm) stained with acetocarmine (has been prepared by Remsderh). Tissue maceration (if it needs for analysis) was carried out at 45% solution of acetic acid (during 5 minutes on bane-marie under 600C). Anaphase of cell division was observed by light microscope JNAVAL. No less than 800 cells in proper phases of mitosis were observed in each variant (Lifang et al, 2001; Rank et al, 2002, Natarajan, 2005).

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Chromosomal aberrations. Winter wheat seeds (Triticum aestivum L.) (approx. 14% moisture content) of (in brackets method of obtaining varieties or used mutagens) Favoritka, Lasunya, Hurtovina (irradiation by gamma rays), line 418, Kolos Mironovschiny (field hybridization), Sonechko and Kalinova (chemical mutagenesis), Voloshkova (termomutagenesis – low plus temperature under vernalizaion has been used as mutagen factor) were subjected to 100,150, 200, 250 Gy gamma rays. Each treatment was comprised of 1000 wheat seeds. These differences of doses are trivial for the winter wheat mutation breeding (Ahloowalia et al, 2004; Nazarenko, 2015). Non-treated varieties were used as a check for each variety.

The seeds used in this study were of the M0 generation. After mutagen treatment dry seeds were germinated in Petri dishes under 24 – 48 hours (depends on presoaking and mutagen action), temperature +250C. Afterwards central primary roots were cut (if these length were 10 – 15 mm.) and fixed in solution of alcohol and acetic acid (in proportion 3:1) for 24 hours. Fixation material was stored in 70% alcohol solution under temperature 2 0C (30 – 35 roots per variant). We conducted cytological analysis in trivial way at temporary press-time preparations of primary roots tips (1 – 1.5 mm. length) stained with acetocarmine (has been prepared by

Remsderh). Tissue maceration was conducted at 45% solution of acetic acid (during 5 minutes under 600C). Anaphase of cell division was observed by light microscope JNAVAL. No less than 800 cells in proper phases of mitosis were observed in each variant (Lifang et al, 2001; Rank et al, 2002, Natarajan, 2005).

Mathematical processing of the results was performed by the method of analysis of variance, the variability of the mean difference was evaluated by ANOVA, the grouping by the nature of mutagens was performed by cluster analysis (Euclidian distance) (Klekka, 1989). Used the standard tools of the program Statistica 8.0 for cluster analysis (Multivariate Exploratory Techniques, cluster analysis, single linkage, Euclidian distance), factor analysis (Statistics 8.0, ANOVA module).

Analysis of grows and development of plants. In M1 population, observations were recorded seed germination and plant surviving, pollen fertility, plant height, spikes/plant, spike length, kernels/spike, 1000-grain weight, yield/plant. Standard error (±SE) values of the treated populations are at tables too.

The results on germination of seeds, survival rate of plants derived from treated and untreated seeds are tabulated (Table 7.1).

Mutagens can completely prevent the germination of seeds at high doses. Lethality, when seeds germinate but are unable to grow and subsequently wither and die off, is also common at high doses. High mutagen doses can also reduce the fertility of M1 plants and in extreme cases can result in total sterility. Since there are direct relationships between plant responses and mutagen dose, germination and survival rates as well as reductions in fertility can be used in determining optimal doses of mutagens for treating plant propagules. Whereas germination rates are computed at an appropriate interval shortly after sowing, survival rates are determined at maturity (at harvest time) of the M1 population. Survivors of the treatment may be defined as those plants that complete their life cycle and produce at least one floret, flower or inflorescence, regardless of whether seeds are produced.

Table 7.1

Main parameters of grown of winter wheat plants at M_1 generation.

Trial	Germination,%	Survival after winter, %	Germination,%	Survival after winter, %
Variety	Kolos Mironivschini		Kalinova	
Check	98±0,57	91±0,93	94±0,94	88±0,98
Gamma-rays, 100 Gy.	79±0,76*	76±1,01*	75±1,07*	70±1,11*
Gamma-rays, 150 Gy	69±1,09*	66±1,13*	71±1,15*	66±1,18*
Gamma-rays, 200 Gy	58±1,48*	54±1,71*	47±1,24*	44±1,43*
Gamma-rays, 250 Gy	38±1,26*	36±1,34*	37±0,83*	35±1,10*
Variety	Voloshkova		Sonechko	
Check	92±0,57	87±0,93	94±0,94	89±0,98
Gamma-rays, 100 Gy.	73±0,76*	69±1,01*	65±0,57*	62±0,93*
Gamma-rays, 150 Gy	64±1,09*	60±1,13*	43±0,57*	40±0,93*
Gamma-rays, 200 Gy	55±1,26*	52±1,34*	31±1,14*	29±1,72*
Gamma-rays, 250 Gy	55±1,48	51±1,71	5,6±1,07*	5,3±1,39*
Variety	Favoritka		Hurtovina	
Check	98±0,57	91±0,93	92±0,94	84±0,98
Gamma-rays, 100 Gy.	82±0,76*	76±1,01*	73±1,07*	67±1,11*
Gamma-rays, 150 Gy	58±1,09*	54±1,13*	52±1,15*	48±1,18*
Gamma-rays, 200 Gy	49±1,26*	45±1,34*	55±0,83*	50±1,10*
Gamma-rays, 250 Gy	39±1,48*	36±1,71*	36±1,24*	33±1,43*
Variety	Lasunya		Line 418	
Check	98±0,57	94±0,93	93±0,94	92±0,98
Gamma-rays, 100 Gy.	54±0,76*	52±1,01*	74±1,07*	67±1,11*
Gamma-rays, 150 Gy	48±1,09*	46±1,13*	70±1,15*	55±1,18*
Gamma-rays, 200 Gy	42±1,26*	41±1,34*	48±1,24*	36±1,43*
Gamma-rays, 250 Gy	37±1,48*	35±1,71*	39±0,83*	35±1,10

* - difference is statistically significance from check at $P_{0.05}$

Actual plant death may occur at any time between the onset of germination and ripening. Survival rate determined in controlled environments can be significantly different from field tests, particularly if adverse conditions occur. Germination and survival abilities of seeds reduce compared to untreated seeds of the initial variety in all cases. Plant survival ability ranges from 55 (Voloshkova) to 5.3% (Sonechko) at 250 Gy, while it ranged from 98 to 92% under untreated control. As for the impact of gamma rays on the germination and survival abilities, it is the usual effect in plants for most crops previously observed by many researchers in wheat as well. However, we can see that some varieties were statistically more successful in survivals ability. Seedlings are particularly sensitive to mutagens and provide an easy means of measuring treatment effects. Seedling height and root length are simple parameters. Seedling height is typically used as an indicator of genotype response to a mutagen and various methods can be devised depending on the species.

Fertility reduction in M1 plants can be manifest in various forms. The degree of M1 sterility varies greatly from plant to plant and from inflorescence to inflorescence even within the population treated with the same dose. Seed set is the most commonly used criterion in quantifying sterility. Due to the wide range of variations among plants, sufficient number of inflorescences should be used to estimate this parameter.

It is well documented that effects of mutagens are dose dependence. However, the dose effect is not linear. With the increase of mutagen dose, the effect on plant growth and reproduction increases. Low doses can have a stimulatory effect on pollen and seed germination rate, seedling height and root length and on in vitro cultures. Prior to initiating any mutagen treatment, the most important step is to determine the effective dose. In the absence of detailed data, it is sometimes necessary to estimate the optimum dose in the M_1 population by estimating the LD_{50} or by RD_{50} via a small scale test.

The LD_{50} is the dose that results in a 50 % reduction in germinating seeds or viable plants. The RD_{50} represents the dose which reduces the growth and seed production of an M_1 population by 50%. It should be noted that the relationship between the effect on an M_1 trait and mutation rate in the subsequent M_2 varies between chemical mutagens and between radiations, especially between sparsely and densely ionizing radiations. For instance, the relative biological effectiveness (RBE) of neutrons often differs with M1 traits. In general, the correlation between the dose value and survival abilities of plants is at the level of -0.9 for gamma rays. Sonechko was extremely sensitive to gamma rays. Plants of all varieties showed higher level of depression being processed with highest dose of gamma rays.

Table 7.2.

Pollen fertility after mutagen action, %.

Trial	Kolos Mironivschini	Kalinova	Voloshkova	Sonechko	Favoritka	Hurtovina	Lasunya	Line 418
Check	95,0	93,1	89,7	96,7	95,7	98,6	96,8	93,0
Gamma-rays, 100 Gy.	91,2*	82,9*	81,3*	84,5*	79,9*	82,3*	84,8*	89,1*
Gamma-rays, 150 Gy	82,7*	74,6*	74,5*	70,9*	64,7*	67,8*	71,2*	81,6*
Gamma-rays, 200 Gy	71,2*	69,8*	69,2*	64,5*	50,7*	59,9*	61,3*	73,4*
Gamma-rays, 250 Gy	64,6*	52,5*	61,6*	42,3*	42,5*	47,9*	43,8*	66,1*

* - difference is statistically significance from check at $P_{0.05}$

Correlation between the dose value and pollen fertility was -0.9. As we can see, the highest level of this indicator was observed after the mutagenic effect on Kolos Mironivschini seeds. Frequency of pollen sterility was on the highest level after gamma irradiation, primarily, in the varieties obtained by processing with gamma rays. Only these varieties showed extremely low fertility at a dose of 250. Pollen sterility is the more reliable parameter for monitoring depressive consequences compared to germination and survival rates. The Table 2 shows that resistance to mutagenic effect directly depends on the genotype of processed material.

All parameters of the crop yield structure have been studied. Components such as plant height, 1000 grain weight, grain weight per plant, number of grains per spike, grain weight per spike, general number of culms, number of productive culms, spike lengths have been developed. But only three (plant height, grain weight per spike and 1000 grain weight) showed statistically difference level of mutagen depression under any dose action.

Regarding the plant height, correlation between the dose and the indicator constituted -0.89, (high invert correlation). This parameter decreases if the dose increases. However, the differences between versions can be statistically unreliable. Gradual decrease in height is a tendency. We have not observed any differences between the varieties.

The indicator of grain weight per spike was more informative, weight was falling statistically valid with every increase in dose. Here we have the same situation with the varietal specificity by depression as in the previous case. Sonechko responded to mutagenic effect in the worst manner. The correlation coefficient was -0.92.

The thousand grain weight is the most informative indicator. Depression value at each dose is clear and statistically valid. The correlation coefficient was -0.96.

The most informative parameters to determine the degree of mutagenic depression in the first generation for plant growth and development were germination and survival rates, pollen fertility rate, indicators such yield structure parameters as plant height, grain weight per spike, thousand grains weight.

Factor analysis showed that the formation of all crop yield structure values primarily depends on the genotype factor and secondly on the mutagen dose and nature for chemical agents, and on the dose, genotype and mutagen nature for gamma rays respectively.

46 mutant forms have been developed in M_1 populations (21 sterility or semi-sterility, 11 by changes in plant height, 14 by early maturity, predominantly by 200-

250 Gy). All these forms were sown in next generations.

Chromosomal aberrations analysis. At table 7.3 we represent dates of the results of our analyze with next parameters: general number of observing mitosis in primary roots tips, number of cells in appreciate phase with visible chromosomal aberrations, total rate of changes. Standard error (± SE) values of the treated variants are appeared at table 4 too. As we can see from table 4 frequencies of aberrations were changed from 7,1 % (Favoritka, gamma-rays 200 Gy) to 47,5 % (Voloshkova, gamma-rays 200 Gr.) percent from total number of cells divisions. All the variants are statistically substantially dissimilar from each other and from the check (excluded 250 Gy).

The effectiveness and efficiency of any induced mutagenesis experiment (estimates of mutation density and ability of the mutagen to induce desirable changes with minimal unintended effects) are direct results of the choice of appropriate mutagen dosage.

Higher frequency of aberrations in any cases characteristic for varieties obtained by chemical mutation breeding (Sonechko, Kalinova) and we can predict more rate of visible mutations (regarding previous investigations).The higher frequency of aberrations has been obtained by used 200 Gy dose.

Frequency was statistically lower when we used gamma-rays for varieties Favoritka, Lasunya, Hurtovina obtained with gamma-irradiation. The same situation we observed in case of varieties Kalinova and Sonechko, when NMU and NEU have been used in our previous investigations, but decreasing stronger in case of gamma-rays. Thereby, varieties Favoritka, Lasunya, Hurtovina are less sensitive to gamma-rays. Gamma-rays initiated more rates of chromosome aberrations than nitrosoalkylureas) (Nazarenko, 2016). From the Table 7.3 we can see that the higher rates of chromosomal changes in any cases characteristic for varieties obtained by mutation breeding with using of chemical mutagens (Sonechko, Kalinova). Gamma-rays were effective in aberration induction in case of chemical mutation varieties. According to this fact re-exposure of mutagens is acceptable as a method if we exploit other mutagen by nature than first time (for example gamma-rays after nitrosoalkylureas in our pattern).

Table 7.3.

Rate of chromosomal aberrations in winter wheat primary roots cells

Variant	Mitosis, number	Chromosomal aberrations		Mitosis, number	Chromosomal aberrations	
		number	percent		number	percent
	Favoritka			418		
Check	984	19	1.9 ± 0.3	962	11	1.1 ± 0.1
Gamma-rays, 100 Gy.	1006	71	7.1±0.7*	992	161	16.2±1,1*
Gamma-rays, 150 Gy	1004	139	13.9±1.1*	1056	245	23.2±1,2*
Gamma-rays, 200 Gy	943	230	24.4±1.5*	747	228	30.5±1.6*
Gamma-rays, 250 Gy	466	126	27.1±1.5*	586	247	42.2±1.9*
Variety	Lasunya			Hurtovina		
Check	1056	15	1.4 ± 0.2	1034	12	1.2 ± 0.1
Gamma-rays, 100 Gy.	979	88	9.0±0.8*	1012	100	9.9±0.9*
Gamma-rays, 150 Gy	1012	158	15.6±1.1*	981	147	15.0±1.0*
Gamma-rays, 200 Gy	810	198	24.5±1.5*	1011	228	22.6±1.5*
Gamma-rays, 250 Gy	399	98	24.6±1.5	742	193	26.0±1.6*
Variety	Sonechko			Voloshkova		
Check	1026	8	0.8 ± 0.1	1003	31	3.1 ± 0.3
Gamma-rays, 100 Gy.	1010	194	19.2±1.1*	1000	213	21.3±1.2*
Gamma-rays, 150 Gy	1003	288	28.7±1.3*	1007	332	33.0±1.4*
Gamma-rays, 200 Gy	888	342	38.5±1.9*	560	266	47.5±2.0*
Gamma-rays, 250 Gy	411	190	46.2±2.0*	478	198	41.4±1.8*
Variety	Kalinova			Kolos Mironivschini		
Check	1047	9	0.9 ± 0.1	909	10	1.1 ± 0.1
Gamma-rays, 100 Gy.	1000	192	19.2±1.1*	1019	179	17.6±1.0*
Gamma-rays, 150 Gy	937	269	28.7±1.3*	890	215	24.2±1.2*
Gamma-rays, 200 Gy	817	315	38.5±1.9*	738	243	32.9±1.7*
Gamma-rays, 250 Gy	459	212	46.2±2.0*	510	196	38.4±1.8*

* – difference statistically significant on $P_{0,01}$

We developed next types of aberrations of chromosomes after spectra investigation of: chromosomal bridges and double-bridges, fragments of chromosomes and double-fragments, micronucleus, lagging chromosomes. Cases with complicated aberrations (two or more kinds of changes in one mitosis) and ratio amid fragments and bridges were counted up singly (Table 5). After this date has been analyzed we identified some correlations between mutagen doses or concentrations and parameters of spectra. Number of any type of chromosomal changes was ascended with dose heightened (correlation coefficients is on 0,8 – 0,9 level). Previously we observed this evident in our investigations, when more bridges than fragments have been induced with gamma-rays (fragments-bridges ratio lower than 1) too (Nazarenko, 2016).

However, more fragments and double-fragments were caused by chemical supermutagens (fragments-bridges ratio more than 1) (Nazarenko, 2015; Nazarenko, 2016). We will be able to use this parameter for identify gamma-rays action as like for chemical mutagens but in opposite sense of parameter.

According to the results of cluster analysis (was generated by number of chromosomal aberrations) it was found a clear determine between the method of variety obtaining and the nature of the mutagenic factor. Identified four different groups of varieties – by using gamma rays Favoritka, Lasunya, Hurtovyna, by the action of chemical mutagens Kalinova, Sonechko and obtained using recombinant breeding – Kolos Mironovschiny, line 418, and is entirely separate – variety Voloshkova (termomutagenesis). Thus, this method of grouping finally confirmed the conclusion that the effect of mutagenic factor is largely determined sensibility for mutagen action if these factors have used for obtained initial material.

In general, when dose or concentration of mutagen was increased the frequency also has increased. Also increases the proportion of complex aberrations. In the transition from a dose of 200 Gy. to 250 Gy dose it broken linear dependence and the frequency of chromosomal aberrations even drop to a lower level than in the previous dose. It is more typical for the varieties

created by gamma rays (Favoritka, Lasunya, Hurtovina) and termomutagenesis (Voloshkova) (also for these varieties are characterized by high frequency of spontaneous mutations in control - a consequence of lower stability resulting genotype, for example variety Voloshkova with frequency 3,09 % at control). Analyzed the results of three-factor analysis (“genotype”, "dose" or "concentration", "nature of mutagen") it has been shown that, primarily on the frequency of chromosome aberrations affects factor "dose", then "genotype", then the "nature of mutagen" factor. But second and third factors characterized more part of dispersion than first. Identified effect of frequency decrease belongs to genotype-mutagen nature interaction. Thus seen that re-exposure to the same nature of the mutagen (for example, gamma-rays on the variety obtained by the action of this mutagenic factor) leads to a significant decrease in the frequency of aberrations. The overall correlations between the frequency of chromosomal aberrations and the value of a dose were on 0,7 – 0,8 level.

In general, when dose of mutagen was increased the frequency also has increased. Also ascend the persent of complex (double and more changes in one cell) aberrations. On the other hand, complicated aberration more occurs after NMU and NEU than gamma-rays. The results of three-factor analysis ("genotype", "dose" and "mutagen"; in general scheme of analyze we include our date from previous investigation of chemical mutagens action (Nazarenko, 2016) shown us that, prevalently, on the rate of chromosome aberrations factor "dose" influenced, then "genotype", then the "mutagen". But second and third factors involved more part of dispersion than first. Developed evident of rate descending belongs to genotype-mutagen interaction (which exist as part of interaction amid second and third factors). Thereby, we developed that repeated exposure to the similar mutagen (for example, gamma-rays on the variety obtained by the action of this mutagenic factor) tends to a substantially lower rate of chromosomal aberrations.

Thereby, we propose this parameter (prevalence of fragments under bridges as fragments-bridges ratio) for mutagen nature identification. Complicated (or combined) aberrations are more typical for chemical mutagens than for physical. Genotype, obtained with gamma-rays is less sensitive for repeated action of the same mutagen. Previous rule for chemical supermutagens was confirmed for gamma-rays too. Gamma-rays will successful in mutation induction in case of applying for chemical mutations varieties.

Finally, the most informative parameters to determine the degree of mutagenic depression in the first generation for plant growth and development were germination and survival rates. Thus, the greatest depression among all varieties was observed in Sonechko under all parameters (except thousand grains weight). Kolos Mironivschini was the most resistant to mutagenic effect. Varieties obtained by action of mutagenesis show specificity in demonstration of mutagenic depression based on the some indicators of crop yield structure.

Radiomutants are more resistance to gamma rays. It is appeared in less rate of chromosomal aberrations.. We can predict less quantity of mutations if we will exploit these varieties as mutation breeding objects.

Varieties, which obtained with chemical mutagenesis (varieties Sonechko, Kalinova) are more sensitive to gamma- irradiated than other (rates of chromosomal changes are higher).

Comparing between bridges and fragments is a reliable index for identification of mutagen nature (chemical or gamma-rays). In case of gamma-irradiation more number of any type of fragments were observed, on other way – bridges. In general, the rate of any kind of chromosomal aberrations is linearly increased with increase dose of the mutagen. Complicated (or combined) aberrations are more typical for chemical mutagens than for physical. In general, the frequency chromosomal aberrations is linearly dependent on the dose or concentration of the mutagen (except 250 Gy dose for some varieties), which is consistent with previous studies.

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CHAPTER 8. ECOLOGICAL-GYGYENIC ASPECTS OF EXPOSE OF XENOBIOTICS WITH ESTROGEN ACTIVITY

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Many contaminants are associated with their potential estrogenic effect and classified as endocrine disrupting compounds including many classes of organic compounds. Substances depleted endocrine systems are a compound changing the hormonal and homeostatic system and acting through different mechanisms (Darbre, Charles, 2010). Numerous environmentally sustainable compounds are estrogen agonists and / or androgen antagonists. Since 1970, there has been a worldwide debate on the potential consequences of the influence of such substances on the environment and human health:

Estrogens are biologically active hormones that are derived from cholesterol and secreted by the adrenal cortex, testes, ovaries and placenta in humans and animals. Estrogen compounds were found in plants. Steroid estrogens are classified as natural or synthetic hormones and can act as chemical substances caused endocrine disorders.

Natural steroidal estrogens (also known as the C18 steroidal group) share the same tetracyclic molecular framework comprising four rings, one phenolic group, two cyclohexane and one cyclo-pentane ring. Structural differences within the C18 group lie in the configuration of the D-ring at positions C16 and C17. For example, estrone (E1) has a carbonyl group on C17, 17β-estradiol (E2) has a hydroxyl group on C17, whilst estriol (E3) has two alcohol groups on C16 and C17. The C17 hydroxyl group of the E2 can either point downward or upward on the molecular plane, forming either the α- or β-compound. Conjugated estrogens, which are also potential environmental hazards, are formed by esterification of free estrogens by glucuronide and sulfate groups at the position(s) of C3 and/or C17.

The estrogen system in vertebrate animals includes steroidogenic enzymes involved in the synthesis of estrogen; estrone, estriol and 17β-estradiol (E2, the most common and potent natural estrogen) and estrogen receptors. Estrogen hormones are crucial for human biology and physiology. Estrogens are the main regulators of physiological changes associated with the reproduction of both sexes, and also adjust many other important physiological processes, including immune function and mineral homeostasis. They help regulate reproduction, cardiovascular function, bone strength, cognitive behavior, successful pregnancy and gastrointestinal systems. Arguably, the most widely discussed issue concerning estrogens and human health is hormonal therapy (HRT). Menopausal women can be administered estrogens to replace endogenous hormones that are no longer produced in adequate quantities to maintain normal health. The Joint FAO/WHO Expert Committee on Food Additives, evaluated 17β-E2 in relation to the HRT treatment in menopausal women. They found that adverse hormonal effects occurred at much lower than expected concentrations and subsequently established an acceptable daily intake (ADI) of 0–50 ng/kg body weight (bw). A no-observed-adverse-effect for humans of 0,3 mg/day (equivalent to 5 μg/kg bw/day) has been calculated ut estrogens are capable of affecting human health as soon as above this safe level (von Goetz et al., 2017).

Clearly, estrogens are essential for normal human physiology but can have serious adverse effects if allowed to accumulate in the environment and enter the human food chain. If consumed at levels above the safe thresholds they can increase the risk of cancer and induce cardiovascular diseases in humans. Indeed supraoptimal levels of estrogens have been linked with increased incidences of breast cancer in females and prostate cancer in men. Estrogens preferentially bind with receptor cells in breast tissues leading to cell proliferation and decrease apoptosis (cell death) that can ultimately form tumours. Whatever the exact link is between estrogens in the environment and breast cancer, water authorities world-wide include, or should include routine screening of estrogen concentrations (together with all EDCs) as part of their aim to deliver clean and wholesome water (von Goetz et al., 2017).

Substances depleted endocrine systems are a compound changing the hormonal and homeostatic system and acting through different mechanisms There is a variety of receptors, mechanisms and signaling pathways involved in the cellular activity of estrogens, which are also targets for EDCs. These are mechanisms dependending on the estrogen receptors, as well as their genotoxic metabolites, acting through nuclear receptors, non-nuclear steroid hormones (for example, estrogen membrane receptors), non-steroid receptors (eg, neurotransmitter receptors such as the serotonin receptor, dopamine receptor, noradrenaline receptor), specific receptors (eg, arylhydrogen receptor), enzymatic pathways involved in the steroid biosynthesis and / or their metabolism, and many other mechanisms converged on the endocrine and reproductive systems (Darbre, Charles, 2010).

Xenoestrogens can act on several mechanisms simultaneously. Although most environmental estrogen activity was recognized as "weak" for many years because of their inability to cause transcriptional effects, at present it is proved that they are quite powerful initiators of signal cascades out of membranes (Rubin, 2011; De Coster, van Larebeke, 2012).

Since the inception of global industrialization, steroidal estrogens have become an emerging and serious concern. Worldwide, steroid estrogens including estrone, estradiol and estriol, pose serious threats to soil, plants, water resources and humans. Indeed, estrogens have gained notable attention in recent years, due to their rapidly increasing concentrations in soil and water all over the world. Concern has been expressed regarding the entry of estrogens into the human food chain which in turn relates to how plants, farm animals and aquatic organisms consumed as food, take up and metabolism estrogens.

The potential risk of estrogens emission in the environment and their effects on human health are of intensive modern agriculture, waste management system, the absorption and metabolism of these compounds by plants.

Estrogens at polluting levels have been detected at sites close to waste water treatment facilities and in groundwater at various sites globally. Estrogens also perturb fish physiology and can affect reproductive development in both domestic and wild animals. Treatment of plants with steroid estrogen hormones or their precursors can affect root and shoot development, flowering and germination. However, estrogens can ameliorate the effects of other environmental stresses on the plant (Adeel et al., 2017). The sources of estrogenic EDCs include natural estrogens produced by plants (phytoestrogens), fungi (mycoestrogens) and cyanobacteria, synthetic therapeutic agents (eg raloxifene), personal hygiene products, and numerous synthetic compounds, mainly used in industry and agriculture (for example, polychlorinated biphenyls (PCBs), organochlorine pesticides, plasticizer phthalates or dioxins, antimicrobial agents (zearalenone)) (Wielogórska et al., 2015).

Many man-made chemical compounds are recognized as endocrine disruptors and once released into the environment are likely to spread and bioaccumulate in wild species. Due to their lipophilic nature, these substances pass through the cell membrane or bind to specific receptors activating physiological responses that in the long run can cause reproductive impairment, physiological disorders, including the occurrence of metabolic syndromes. One significant source of contamination is represented by the consumption of polluted food. As a consequence, different environmental pollutants, with similar or different modes of action, can accumulate in organisms and biomagnify along the food web, finally targeting humans (Carnevali et al., 2017).

Since the initial “estrogenic hypothesis” proposed by Sharpe and Skakkebaek, several findings have suggested a link between deterioration of reproductive health and environmental factors, particularly endocrine disruptors (EDs), that have been quantitatively and qualitatively increasing in our environment during the last (N'Tumba-Byn et al., 2012).

During critical periods in fetal life, e.g. fetal or pubertal periods, there is an increased vulnerability to perturbations in endocrine function due to environmental factors. Small shifts in concentrations of hormones that regulate the differentiation of organs, such as estradiol and testosterone, can have permanent effects on morphology, enzymatic activity, and hormone receptors in tissues as well as neurobehavioral effects. These changes can lead to effects throughout life, including impacting the risk for various diseases. Research with mice subsequently demonstrated that a very small experimental change in fetal serum estradiol levels altered organogenesis and caused permanent changes in organ function. Taken together, these findings led to the hypothesis that environmental chemicals that mimic or antagonize hormone action (e.g., endocrine disrupting chemicals) could also be causing harm at very low exposures (the "low dose" hypothesis) within the range of exposure of humans, domesticated animals, and wildlife (Vom Saal, 2016).

EDCs are defined in drinking and bottled water (Pereira R.O. et al., 2011; Jiang W. et al., 2012; Dhaini H. R., Nassif R. M., 2014; Li L. et al., 2014), present in food

- cereals, vegetables and fruits (Massart, Saggese, 2010; Kim, 2014), animal products

- meat, milk, eggs (Ganmaa, Sato, 2005; Kolf-Clauw et al., 2008; Wielogorska E. et al., 2014), and also products containing phytoestrogens (Tomar, Shiao, 2008; Wang J. et al., 2014; He X. et al., 2014).

In recent decades the world manifests environmental concern due to contaminants difficult elimination by conventional water and wastewater treatment processes. The number of contaminants present in the aquatic environment both alone (in different concentrations) or in complex mixtures that may have an estrogenic disrupting action (Pinto et al., 2014). Present technologies for wastewater treatment do not sufficiently address the increasing pollution situation of receiving water bodies, especially with the growing use of personal care products and pharmaceuticals (PPCP) in the private household and health sector. The relevance of addressing this problem of organic pollutants was taken into account by the Directive 2013/39/EU. In addition, a watch list of 10 other substances was recently defined by Decision 2015/495 on March 20, 2015. This list contains, among several recalcitrant chemicals, the painkiller diclofenac and the hormones 17β-estradiol and 17α-ethinylestradiol. Additionally, by-product and transformation product formation has to be considered. Still, most of the presently applied methods are incapable of removing critical compounds completely (Schröder et al., 2016).

Estrogens have been classified as group 1 carcinogens by the World Health Organization and represent a significant concern given that they are found in surface waters worldwide, and long-term exposure to estrogen-contaminated water can disrupt sexual development in animals (Chen et al., 2017).

Wastewaters from various industries are a main source of the contaminants in aquatic environments. It have been evaluated the hormonal activities (estrogenic/anti-estrogenic activities, androgenic/anti-androgenic activities) and genotoxicity of various effluents from textile and dyeing plants, electronic and electroplate factories, pulp and paper mills, fine chemical factories, and municipal wastewater treatment plants. The results demonstrated the presence of estrogenic, anti-estrogenic, and anti-androgenic activity in most industrial effluents. In terms of estrogenic activities and genotoxicity, discharge of these effluents could pose high risks to aquatic organisms in the receiving environments (Fang et al., 2012).

Natural and synthetic estrogens are one of the most potent endocrine disrupting compounds found in urban wastewater. Municipal discharges, the pharmaceutical industry and hospitals are the main sources of steroid estrogens. Municipal landfills are also sources of organic contaminants and may contain leachate with significant amounts of dissolved organic matter partly consisting of steroid hormones and other contaminants. Hospitals have been identified as yet another major source of steroidal estrogen pollution. Indeed, a few investigations revealed that steroidal estrogens, especially high levels of estriol, were found in all hospital effluent samples (von Goetz et al., 2017).

Regulatory aspects implementing a screening program and is actively involved in endocrine disruptor testing and assessment related to steroid estrogens are established, especially in the European Union and Japan (Ting, Praveena, 2017).

Sorption and biodegradation are the primary removal mechanisms for estrogens in activated sludge systems, which are widely used biological treatment techniques for municipal wastewater treatment. However, when removal of estrogens in a wastewater treatment plant is incomplete, these compounds enter the environment through wastewater discharges or waste activated sludge at concentrations that can cause endocrine-reproductive system alterations in birds, reptiles and mammals (Racz, Goel, 2010).

Endocrine disrupting compounds (EDCs) are pollutants with estrogenic or androgenic activities at very low concentrations and are emerging as a major concern for water quality. For sewage of municipal wastewater treatment plants in cities, one of the most important sources of EDCs are natural estrogens and natural androgens excreted from humans. To evaluate their estrogenic activities, their excretion rates of estrogen equivalent or testosterone equivalent were also calculated.The total excretion rates of estrone (E1), 17β-estradiol (E2), and estriol (E3) only accounted for 66–82 % of the total excretion rate of the compounds among four different groups, and the other corresponding natural estrogens contributed 18–34 %, which meant that some of the other natural estrogens may also exist in wastewater with high estrogenic activities (Liu et al., 2009).

Natural steroidal estrogen hormones, e.g., estrone (E1), 17beta-estradiol (E2), estriol (E3), and 17alpha-estradiol (17alpha), are released by humans and livestock in the environment and are the most potent endocrine disrupters even at nanogram per liter levels. Published studies broadly conclude that conventional wastewater treatment is efficient in the removal of 17beta-estradiol (85-99 %), but estrone removal is relatively poor (25-80 %). The removal occurs mainly through sorption by sludge and subsequent biodegradation. In spite of the treatment, the effluent from conventional biological wastewater treatment systems still contains estrogenic compounds at a level that may cause disruption of endocrine systems in some species (Khanal et al., 2006). The long-term ecological risk of micropollutants, especially endocrine disrupting chemicals (EDCs) has threatened reclaimed water quality. Estrogenic activity and ecological risk of eight typical estrogenic EDCs in effluents from sewage plants were evaluated. The estrogenic activity analysis showed that steroidal estrogens had the highest estrogenic activity (ranged from 10^{-1} to 10^{3}ng-E2/L), phenolic compounds showed weaker estrogenic activity (mainly ranged from 10^{-3} to 10 ng- E2/L), and phthalate esters were negligible. Suggesting that 17α-ethynylestradiol (EE2), estrone (E1) and estradiol (E2) should be the priority EDCs to control in municipal sewage plants (Silva et al., 2012; Sun Y et al., 2013).

Phytoestrogens are plant compounds with estrogenic activities. Many edible plants, some of which are common in the human diet, are rich in phytoestrogens. Almost all phytoestrogens eaten daily by people were reported partly recovered in urine or feces, which can be regarded as one of the main sources of their occurrence in municipal wastewaters. As they may act as one part of the endocrine disrupting compounds (EDCs) in water systems, some phytoestrogens have been monitored and detected in wastewater and other various environments (Liu et al., 2010).

A pan-European monitoring campaign of the wastewater treatment plant (WWTP) effluents was conducted to obtain a concise picture on a broad range of pollutants including estrogenic compounds. Snapshot samples from 75 WWTP effluents were collected and analysed for concentrations of 150 polar organic and 20 inorganic compounds as well as estrogenicity. The effect-based assessment determined estrogenicity in 27 of 75 samples tested with the concentrations ranging from 0.53 to 17.9 ng/L of 17-beta-estradiol equivalents (EEQ). It’s confirmed the importance of cities as the major contamination source. Beside municipal WWTPs, some treated industrial wastewaters also exhibited detectable phytoestrogens. The study demonstrates the need of effect-based monitoring to assess certain classes of contaminants such as estrogens, which are known to occur at low concentrations being of serious toxicological concern for aquatic biota (Gunatilake et al., 2013; Jarošová B. et al., 2014).

The presence of organic pollutants in the aquatic environment, usually found at trace concentrations (i.e., between ng L^{-1} and μg L^{-1} or even lower, known as micropollutants), has been highlighted. (Gorito et al., 2017). Although steroid concentrations are low in the rivers, the possibility of additive effects may be of concern (Zhang et al., 2017).

The world's human population of about 7 billion discharges approximately 30,000 kg/yr. of natural steroidal estrogens (E1, E2, and E3) and an additional 700 kg/yr. of synthetic estrogens (EE2) solely from birth control pill practices. However, the possible release of estrogens to the environment from livestock is much higher. For example, in the United States and European Union, the annual estrogen discharge by livestock, at 83,000 kg/yr., is more than twice the rate of human discharge. Indeed, possible causal relationships have been established between concentrated animal feeding operations (CAFOs) and the detection of estrogens in the aquatic environment. Clearly, natural estrogens in animal and human waste pose a serious risk to the environment. This risk is heightened by the application of animal manure or sludge bio-solids to agriculture lands, being an alternative nutrient source for organic farming, a widely adopted practice in modern agriculture. Indeed, application of animal manure to agricultural land has been identified as a main source of estrogens in the environment (von Goetz et al., 2017).

Another major source, which accounts for 90 % of the estrogen load, is animal manure from concentrated animal-feeding operations. Manure is not required to be treated as long as it is not discharged directly into water bodies. Thus, there is an urgent need to study the fate of animal-borne estrogens from these facilities into the environment. A number of studies have reported the feminization of male aquatic species in water bodies receiving the effluents from wastewater treatment plants or surface runoff from fields amended with livestock manure and municipal biosolids.

Estrogenicity monitoring studies have been conducted in more than 30 countries. Worldwide, water has been polluted with steroid hormones with many released from sewage treatment plants and effluent from livestock feedlots (Khanal et al., 2006).

The dairy livestock industry has long-used a variety of growth-regulating steroids to enhance cattle growth rates, feed efficiency and to procure lean muscle mass. Natural and synthetic steroids have a knock-on effect as animal manure has seeped into the aquatic environment. Steroidal estrogens have been detected in faeces, liquid manure and solid waste collected from cattle, lagoon effluent, and in fertilizers applied directly to agricultural land. Arguably, animal manure is the largest source of estrogen hormones in the natural environment. Certainly, poultry, cow and horse manure may contain the greatest amount of steroidal estrogens. About 49 tons of estrogens were excreted by farm animals in the USA in 2002. In the UK, total excretion of estrone (E1) and estradiol (E2) from the farm animal populations was 1315 and 570 kg/yr., respectively.

Hence, it is increasingly clear that these estrogens, as part of feed programmes associated with intensive animal husbandry, find their way into excreted products easily. There is report about 68.1 ng/L of E1 in deep groundwater, which is sufficiently close to drinking water to cause alarm. According to a National Sewage Sludge Survey of the US EPA, approximately 1,014,724,000 tons of solid waste, especially animal manure, contained an estimated 76 tons of estrogens. One clearly identified route for estrogens into the terrestrial environment is through the application of manure to agricultural land as fertilizer for crops. In manures, 17α-estradiol, 17β-estradiol and estrone concentrations range from 6 to 462 ng/g of dry solids (von Goetz et al., 2017). A widespread practice is to convert manure into renewable energy such as biogas. In biogas digestate, estrogenic steroid levels were observed up to 1478 ng/g. A liquid or sold bi-product can be used as fertilizer clearly representing another potential source of estrogen pollution. Livestock excreta are also a source of natural estrogens in the aquatic environment. In rivers and fresh water in North America were 1–22 ng/L and 0–4.5 ng/L, respectively. Also, in a study based in California, USA, steroidal estrogens were observed in 86 % samples from surface water in pastures with a maximum 44 ng/L recorded. In rivers and sources of fresh water on European sites, estrone ranges from 1-5 to 12.4 ng / L, respectively (von Goetz et al., 2017).

Understanding the physiochemical properties of steroidal estrogens compounds is crucial in order to resolve their fate in soil and water systems. The distribution of organic pollutants between water and other natural solids are often considered as a partitioning process between the aqueous and organic phase. All steroidal estrogens are moderately hydrophobic, nonvolatile, weak acids.

Generally, unconjugated estrogens or free estrogens are not very soluble in water. However, solubility can be pH-dependent because, for example, at pH 10, relative solubility of estrogens is higher.

The half-life of an estrogen will depend on its rate of degradation, reflecting its initial quantity and that remaining after a measured period of time. Clearly, the longer the half-life of a pollutant, the more persistent it will be in the environment. Steroidal estrogens that are excreted by humans and animals have short half-lives. Because they are hydrophobic, their concentrations decrease significantly in the aqueous phase. However, synthetic estrogens are more resistant in this environment than natural estrogens.

Estrogens such as E2 and EE2 in aquatic environments are also susceptible to breakdown by photocatalysis and photolysis. The extent of degradation by photolysis and photocatalysis depends upon an estrogen's chemical structure (von Goetz et al., 2017).

Numerous EDCs are of anthropogenic origin and have been accumulating in the aquatic environment for decades, and their lipophilic and persistent nature means that they bioaccumulate and/or biomagnify in marine organisms. Three estrogens (i.e., estrone, 17β-estradiol, and 17α-ethinylestradiol) were simultaneously analyzed. The method was applied to determine concentrations of target analytes in four invertebrates (i.e., Orconectes virilis, Procambarus clarkii, Crassostrea virginica, and Ischadium recurvum). All eight target analytes were detected at least once in the tissue samples, with the highest concentration being 399 ng/g of homosalate in O. virilis. These results highlight the ubiquitous bioaccumulation of estrogens in aquatic and marine invertebrates (He et al., 2017).

The ability to impair female reproduction at very low concentrations makes the progestins arguably the most important pharmaceutical group of concern after ethinylestradiol (Kumar et al., 2015).

A wide range of structurally diverse compounds from natural and anthropogenic sources have been shown to interact with and disrupt the normal functions of the estrogen system, and fish are particularly vulnerable to endocrine disruption, as these compounds are frequently discharged or run-off into waterways. In aquatic ecosystems, progesterone and synthetic progestins (gestagens) originate from excretion by humans and livestock. Synthetic progestins are used for contraception and as progesterone for medical treatments as well. Despite significant use, their ecotoxicological implications are poorly understood. Only about 50 % of the progestins in use have been analyzed for their environmental occurrence and effects in aquatic organisms. In animal farm waste and runoff, they reached up to several μg/L. Progesterone and synthetic progestins act through progesterone receptors but they also interact with other steroid hormone receptors. They act on the hypothalamus-pituitary-gonad axis, lead to oocyte maturation in female and sperm motility in male fish. Additionally, other pathways are affected as well, including the circadian rhythm. Transcriptional effects were found at highest environmental levels. Reproductive effects occurred at higher levels. However, norethindrone, levonorgestrel and norgestrel compromised reproduction at environmental (ng/L) concentrations. Thus, some of the progestins are very active endocrine disrupters (Fent K., 2015).

Aquatic vertebrates, such as fish, are particularly affected by aquatic anthropogenic contaminants; exposure can be lifelong and through multiple routes, including the skin and gills or through feeding on contaminated sediments or organisms and bioaccumulation is frequent. Aquatic contaminants can compromise reproduction, development, immune response and other physiological processes, which can ultimately affect the survival of fish. In addition to the direct impact of aquatic contaminants on fish populations, the ecological importance of fish means that they also indirectly affect the environment and, when eaten by humans and wildlife, pose a health risk and negatively impact the economics of fisheries and aquaculture (Pinto et al., 2014).

Elevated concentrations of natural and synthetic estrogens feminize male fish e.g. reduce testes size, affect reproductive fitness, lower sperm count, induce the production of vitellogenin (VTG) and alter other reproductive characteristics. Additionally, EE2 caused a considerable reduction in fish biomass and interrupted the aquatic food chain. On the other hand, EE2 does have severe deleterious effects on other forms of aquatic life. For example, in a recent study, EE2 at 10 ng/L directly affected the heart function of bullfrog tadpoles (von Goetz et al., 2017).

Results suggest that some EDCs can have an impact on skeletal development, morphology and anomalies in fish, including the environmental contaminants, 17 alpha-ethynylestradiol (EE_2), bisphenol A (BPA), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), PCB 77 and the estrogen antagonist, ZM189,154 (ZM)] (Pinto et al., 2014). These results support that the mineralized tissue turnover of fish (sea bass (Dicentrarchus labrax) and tilapia (Oreochromis mossambicus)) is regulated by estrogens and reveals that the mineralization of estrogen-responsive may be affected by some EDCs (Pinto et al., 2017).

The study of EDC effects represents an endless, but necessary task to prevent future damage to fish species, wildlife and human welfare in general. More specifically, estrogenic disruption of mineralized tissues may have a wide range of consequences, since an increase in skeleton anomalies, modified bone density and mineral homeostasis may impact on swimming and capacity to capture prey and escape from predators. In addition, homeostasis violation may be compromised and affect wild and cultured fish fitness and productivity in aquaculture units (Pinto et al., 2014).

Soybeans and other legumes investigated as fishmeal replacements in aquafeeds contain phytoestrogens capable of binding to and activating estrogen receptors. Estradiol has catabolic effects in salmonid white muscle, partially through increases in protein turnover. The current study determines whether phytoestrogens promote similar effects. In rainbow trout (Oncorhynchus mykiss) the phytoestrogens genistein, daidzein, glycitein, and R- and S-equol reduced rates of protein synthesis and genistein, the phytoestrogen of greatest abundance in soy, also increased rates of protein degradation. Phytoestrogens reduced cell proliferation, indicating that effects of phytoestrogens extend from metabolic to mitogenic processes (Cleveland, 2014).

The responsiveness to estradiol and the phytoestrogen genistein, was compared between the scales and the liver, a classical estrogenic target, in sea bass (Dicentrarchus labrax). In scales changes in gene expression mainly consisted of small rapid increases, while in liver strong, sustained increases/decreases in gene expression occurred. Similar but not overlapping gene expression changes were observed in response to both estradiol and genistein. This study demonstrates that estrogens and phytoestrogens, to which fish may be exposed in the wild or in aquaculture, both affect liver and mineralized tissues in a tissue-specific manner (Pinto et al., 2016).

The study determined whether estradiol (E2) or the phytoestrogens genistein and daidzein regulate expression of growth-related and lipogenic genes in rainbow trout. Juvenile fish (5 mon, 65.8±1.8 g) received intraperitoneal injections of E2, genistein, or daidzein (5 μg/g body weight) or a higher dose of genistein (50 μg/g body weight). Liver and white muscle were harvested 24h post-injection. Estradiol and genistein (50 μg/g) reduced components of the growth hormone (GH)/insulin-like growth factor (IGF) axis in liver. These data indicate that genistein and daidzein affect expression of genes in rainbow trout that regulate physiological mechanisms central to growth and nutrient retention (Cleveland, Manor, 2015).

It's analyzed the effects induced by the consumption of contaminated diets. Fish were fed for 21days a diet enriched with different combinations of pollutants, nonylphenol, tert-octylphenol and bisphenol A (BPA). The results obtained at hepatic level pinpointed the steatotic effect of all the administered diets, associated to a modulation of the expression of genes involved in lipid metabolism (Carnevali et al., 2017).

Estrogens have other both positive and negative concentration-dependent effects on plant growth. A recent study in Sweden highlighted the negative effects of EE2 (at 7μM) on growth and photosynthesis in the green alga, *Chlamydomonas reinhardtii*. They concluded that the discharge of EE2 in the waste water stream posed a deleterious effect not only by removing atmospheric CO_2, but also in inhibiting algal growth (von Goetz et al., 2017).

The human health affects a lot of factors, one of which is food. Food is considered to be safe, which does not create harmful effects on health, directly or indirectly, under the conditions of its production and turnover in compliance with sanitation and consumption (use) by appointment (Arditsoglou, Voutsa, 2008).

In modern agriculture (agriculture, livestock, poultry and fish farming) under intensive technologies of products cultivation for a significant increase in productivity technological regulations can disrupt and dangerous agronomic and veterinary drugs (hormonal growth promoters, antibiotics etc.) and pesticides are used illegally. Many of these compounds by the action are similar to steroid hormones, particularly estrogen. Products containing such substances are extremely dangerous to human health because of steroid activity manifestation with the following carcinogenic effects, causes a disruption of puberty and reproductive capacity. Food is one of the main routes of estrogens exposure on the human from the environment. Hormones aren't completely destroyed at cooked products. Therefore, similar compounds naturally presenting in meat, milk, eggs, fruits and vegetables, and there are, at least sometimes, and in smaller doses. Steroid hormones are destroyed by heat processing less (Berrino et al., 2006; Papaioannou et al., 2014).

Male and female hormones are contained in meat (beef, pork, chicken), only female ones are in milk and eggs, fruits and vegetables include phytohormones, for example soy. All the hormones used in the agricultural sector, can affect the human body. Animal sex hormones are identical to human hormones. Getting into to the human body with food, hormones are perceived by them as their own (Brinkman et al., 2010).

In 1988, the FAO /WHO experts Committee on food additives declared that the steroid hormones remnants, usually presented in agricultural products were safe for human consumption. However, the risks associated with nutritional influence of exogenous hormones aren't yet fully characterized, and publications give conflicting reports about long-term consequences of such products using (Larrea, Chirinos, 2007; Omoruyi, 2013).

In animal experiments, it has been proved that anabolics regulate various biochemical pathways, significantly affecting the receptors of steroids and growth factors, angiogenesis and tissue remodeling factors, steroid synthesis, proliferation, apoptosis, and others. Some genes are regulated in opposite directions in animals in post-pubertal compared with the adolescent period. Anabolics change the hormonal sensitivity and synthesis of steroids, cause proliferative changes in the reproductive tract (uterus and ovaries), and also perform anti-angiogenic effects in the ovaries, the severity and direction of which depends on the stage of development of animals (Becker et al., 2011).

Estrogens regulate reproductive functions in vertebrates and are present in all tissues of animals. The theoretical maximum daily dose of estradiol-17бета (as growth promoter) for the consumption of cattle meat is calculated as 4,3 ng. After use of the products containing growth factors estradiol-17бета level increases from 4,6 to 20 ng, suggesting that a single dose and "good animal husbandry" aren't observed. Pork and poultry probably include the same amount of estrogen as untreated cattle. In whole milk estradiol-17бета average concentration is estimated as 6,4 pg / ml. the Few data report about 200 pg/g of estradiol-17бета in eggs (Courant, 2007; Stephany, 2010).

Despite the prohibition by the European Union, the use of anabolic steroids and derivatives agents for cattle are still there. Due to the continuous improvement of analytical methods, very low detection limits for individual compounds have been achieved. In response to these events, mixtures consisting of several steroids are often used illegally, thereby impeding detection by lower levels of certain compounds (Blankvoort, 2003).

Estrogens and androgens are determined in concentrations as ng / kg (-1) at the range of 10-100 in the analyzed muscle tissues and milk samples. The same compounds are found approximately 10 times higher concentrations (100-1000 ng / kg (-1) range) in eggs and kidney samples. Eggs and milk are minor sources of estradiol (2.2 +/- 0.8 and 3.1 +/- 2.0 ng day, respectively), while testosterone exposure is due to the intake of meat and / or eggs (12.2 +/- 48.2 and 5.2 +/- 2.3 ng day, respectively) (Courant et al., 2008).

There are reported cases of determination of these compounds in beer (Maragou et al., 2008).

In maize seedlings, uptake of two natural steroidal estrogens, 17β-E2 and E3 and two synthetic estrogens was measured. All four were detected in roots at concentrations up to 0.19 µM but only 17β-E2 was transported to the shoot In Japan, one hundred different garden plant species were tested for phenolics and EDCs; *Portulaca oleracea* was the only effective phytoremediator. It removed EDCs having a phenol group, including 17β-estradiol (E2) Vegetables obtained from local markets in Fort Pierce, FL, USA. Significant concentrations of estrogens were observed in the vegetables especially in lettuce. 17β-E2 in vegetables and fruits was 1.3 to 2.2 µg/kg. According to the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the toxic level for daily intake (ADI) of 17β-estradiol for a 60 kg adult is 3.0 µg/day and that for a 10 kg baby is 0.5 µg/day. Clearly, in this study 17β-E2 exceeded this limit for infants (von Goetz, 2017).

Zearalenone (ZEA) is a mycotoxin produced by some Fusarium species in food and feed. Zearalenone (ZEN), a mycotoxin with high estrogenic activity, is a widespread food contaminant that is commonly detected in maize, wheat, barley, sorghum, rye and other grains (Mally, 2016). According to preliminary data, the remains of mycoestrogen - beta-resorcilic acid lactones, such as zearalenone and its metabolites, are grain pollutants, but have been found to be safe (Lindsay, 1985)._In more recent studies residual antimicrobials in food is established to be a risk to human health (Bogialli, Di Corcia, 2009). ZEA and its metabolites related to the chemical structure of the mycotoxins toxicity is proved to be similar to natural estrogens (Gromadzka, 2009). ZEA is the cause of reproductive disorders, genotoxicity and testicular toxicity in animals (Wang et al., 2014). As an endocrine "disruptor" zearalenone and its metabolites are involved in carcinogenic mutations (Kwaśniewska et al., 2015).

The tolerable daily intake of 0.25 μg ZEA/kg body weight. At a daily basket of animal foodstuffs and associated carry over factors are assumed at reported ZEN contamination levels of complete feed. ZEN residue analysis in biological samples does not only enable evaluation of ZEN exposure but also allows the risk for the consumer arising from contaminated foodstuffs of animal origin to be assessed (Dänicke, Winkler, 2015).

Zeranol - a metabolite of zearalenone is an estrogen agonist in mammals. Zeranol is potent estradiol, used as growth hormone in the production of beef in many countries, including Canada, Australia, New Zealand, South Africa, Mexico, Chile, Japan and the United States. In the US, it is used under the trade name Ralgro as an anabolic agent for more efficient conversion of feed into meat. The use of synthetic growth promoters, such as zeranol, is controversial because of their ability to mimic the actions of endohormones in animal organisms, potentially leading to abnormal results (Mukherjee, 2014). The first reports identified zeranol as an anabolic agent that is commercially available for use for cattle and sheep intended for human consumption and is not a carcinogen, a teratogen-like mutagen. Toxicity tests (acute, subacute and chronic) with several different routes of administration showed very low toxicity, LD50 orally for rats is greater than 40 g / kg (Baldwin, 1983). Therefore, zeranol was widely used as an anabolic promoter, which could lead to very low residues in the edible tissues of farm animals. Most often, zeranol was detected in adipose tissue, liver and kidneys (Dixon, Russell, 1986). At the moment, zeranol is officially banned in Europe for safety reasons because of its potential carcinogenic and endocrine biological activity (Wang, Wang, 2007).

Also in livestock production zeranol lactone of resorcilic acid, taleranol and zearalanone and stilben anabolic steroids as diethylstilbestrol and dienestrol, the natural precursors of zeranol (zearalenone, alpha zearalenone and beta zearalenone) can be present (Zhang et al., 2006; Erbs M. et al., 2007; Dickson et al, 2009). Fruit vegetable as an important source of vitamins, minerals and fiber has taken up a large proportion in dietary consumption with a constant increasing tendency since the last decades In spite of the compensation of yield loss, food safety issues and ecological risks conversely caused by the excessive application of fungicides in vegetables have been raised as public concerns recently worldwide. However, fruit vegetables are generally cultivated in the greenhouse and the well-controlled environments with relatively high temperature and humidity always lead to severe suffering from fungal pathogens such as Deuteromycotina and Ascomycotina. Besides, in contrast to the open ground, the favorable condition of greenhouse provides a more profitable hotbed not only for the indigenous rhizomicroflora but also for epiphytes and endophytes, which were considered to dominant biological factors contributing to synergic effect on agrochemical degradation. Various chemical fungicides have been thus applied to reduce the yield loss caused by fungal diseases, particularly those with broad-spectrum antifungal activities. Fluopyram, a typical phenylamide fungicide with the broad-spectrum activity has been widely applied to eliminate fungal pathogens from fruit and vegetables.

Fluopyram was classified as a low toxic compound due to the relatively low LD_{50} towards mammals (for rats, >2000mg/kg bw), but it was also known to act as an endocrine disrupting compound (EDC) to exert side effects on the endocrine systems of human beings and wildlife at trace level. For instance, it could induce tumor formation in the liver and thyroid of the rat by activation nuclear receptor. More recently, it was also found that this fungicide was capable of altering the microbial diversity in soil ecosystem, leading to depraved soil health. It seems that constant and excessive application of fluopyram may pose a risk towards human health through the imbalance of the associated agricultural ecosystem.

The edible parts of the three vegetables were collected after the foliar application. Analysis showed that initial deposits of fluopyram followed the decreasing order of pepper>tomato>cucumber. It was attributed to that majority of the fluopyram were deposited on the surface of the fruit and leaf rather than the soil owing to the foliar application and high leaf area index. The residual fluopyram persisted in three vegetables for an extended period of time (Wei, 2016).

Pesticides are widely used at various stages of cultivation and during assembly storage to protect plants against pests and / or to ensure the preservation of quality. Pesticide residue methods have been developed for a wide variety of food products including cereal-based foods, nutraceuticals and related plant products, and baby foods. These cereal, fruit, vegetable, and plant-based products provide the basis for many processed consumer products (Raina-Fulton, 2015).

Through international trade in fruits and vegetables, as well as the lack of consistent worldwide rules for the use of pesticides, including those with estrogenic properties, the risk of consumption of contaminated products is quite high (Mezcua et al., 2009).

So, in Japan, Spain and China, of 88 pesticides 63 were determined in the range from 50 to 150 % at a level of 0.1 μg / g in 12 cultures (asparagus, cauliflower, burdock, carrots, broccoli, spinach, matsutake mushrooms, oranges, soybean, sesame, prose, and tea) (Hirahara et al., 2006; Hernandez et al., 2006 Lu et al., 2007), in Spain 81 samples of olive oil contained pesticides at a concentration of 1 to 10 μg / kg (Hernando et al., 2007).

Despite the strict legislation of the European Union (EU) on the need to ensure security of supply, taking into account the low levels of residual pesticide content, there is a threat of pesticide residues in baby food (Hercegová et al., 2007).

When poisoning with some insecticides and pesticides (organophosphorus compounds and carbamates) that are used in agriculture, the activity of acetylcholinesterase is inhibited: pesticides reduced the acetylcholinesterase activity of neurons in rats of the PC12 cell line, depending on the dose to 100 μM (Cabello et al., 2003; Isoda et al., 2005). In the developing brain the rlevated levels have the ability to directly disturb a number of processes in the nervous system, including proliferation and differentiation of neurons, gliogenesis and apoptosis (Flaskos, 2012).

Organophosphate pesticides cause changes in the epithelium of the mammary gland affected the process of carcinogenesis, and such changes occur at the level of the nervous system due to an increase in cholinergic stimulation. Through the inhibition of AChE with pesticides, changes occur as manifestation of increased cholinergic stimulation, changes in molecular pathways proliferation and leading to carcinogenesis of the mammary gland. Young animals are more susceptible to the action of organophosphorus pesticides, proving that age is another factor in the exposure of pesticides (Cabello et al., 2001).

The content of five representatives of plant growth regulators (ppp) [gibberellic acid, 2,4-dichlorophenoxyacetic acid (2,4-d), thidiazuron, forchlorfenuron, and another retardant-paclobutrazole] in fruits was analyzed. 2,4-dichlorophenoxyacetic acid in concentrations (5.1-1503 μg / kg) and paclobutrazole (1-1381 μg / kg) was found in oranges and peaches, respectively, suggesting that the use of these compounds for processing these fruit crops should be regulated (Shu H. et al. 2012).

Bisphenol A (BPA) is an endocrine disrupting chemical that is ubiquitous in wild and built environments. BPA is a widely used and produced organic compound (about

3.5 million tons manufactured worldwide in 2008). Currently, it is used as monomer for the industrial production by polymerization of polycarbonate plastic (72%) and epoxy resins (21%), and as anti-oxidant or inhibitor of polymerization in some plasticizers and PVC (7%). BPA is used in the manufacture of polycarbonate plastics, epoxy resins, food packaging and coatings, dental sealants, rubber chemical products and fire retardants. Exposure to BPA is through air inhalation, consumption of food and drinking water and direct route through products containing this compound (Fenichel et al., 2013). Although the toxicity of BPA has been intensively studied since 1970 and its low estrogenic activity is shown (Keri et al., 2007), BPA is defined in the body of almost 90 % of Americans (Calafat et al., 2008). It is not a mutagen, but can exhibit genotoxic activity and cause oxidative stress (Wu et al., 2011; Jain et al., 2011; Tiwari et al., 2012).

Among such EDs, the estrogenic activity of bisphenol A has been the focus of considerable research effort and discussion about its toxicity at low doses. BPA exposure can occur when the residual monomer migrates into packaged food and beverages: BPA can leach into the content of food containers made of polycarbonate plastic or coated with epoxy resins and it is then ingested (N'Tumba-Byn et al., 2012).

According to the European Food Safety Authority opinion, diet is considered to be the main source of exposure, especially canned food; moreover, among non-canned food, meat and fish products have the highest levels of BPA contamination. The canned seafood is more contaminated than the non-canned one (Repossi et al., 2016). Monitoring of food contamination from bisphenols is a necessary process for the consumers' risk assessment. Bisphenols was performed and validated for their determination in 33 samples of tuna fish, canned in either oil or aqueous medium. Detected levels of bisphenols ranged from 19.1 to 187.0 ng/g in tuna matrix and from 6.3 to 66.9 ng/mL in oil medium. No bisphenols were found in aqueous medium. At least one of the analytes was found in 83 % of the tuna samples in oil medium, whereas tuna samples in aqueous medium showed bisphenol a alone in 67 % of samples (Fattore et al., 2015). Bisphenol was detected in 17 out of 40 samples (42.5%) of canned energy drinks of different brands, collected from the market in Naples (Gallo et al., 2017).

As the concern over the safety of bisphenol A (BPA) continues to grow, this compound is gradually being replaced, in industrial applications, with compounds such as bisphenol F and bisphenol S (BPS). Foodstuffs were divided into nine categories of beverages, dairy products, fats and oils, fish and seafood, cereals, meat and meat products, fruits, vegetables, and "others". Bisphenols were found in the majority (75 %) of the food samples. The highest overall mean concentration of ΣBPs (ΣBPs: sum of eight bisphenols) was found in the "others" category, which included condiments (preserved, ready-to-serve foods). The predominant bisphenol analogues found in foodstuffs were BPA and BPF, which accounted for 42 and 17 % of the total BP concentrations, respectively. Canned foods contained higher concentrations of individual and total bisphenols in comparison to foods sold in glass, paper, or plastic containers (Liao, Kannan, 2013).

This is the main source of contamination, although its ubiquitous distribution leads also to contamination from dermal exposure and inhalation of household dusts (N'Tumba-Byn et al., 2012). Moreover, due to the ubiquitous presence of this compound, the general population can be exposed to environmental sources such as water, air and soil. Many studies have investigated the potential health hazards associated with BPA, which can elicit toxic and cancerogenic effects on humans.(Ćwiek-Ludwicka, 2015; Repossi A et al., 2016)

Among the non-food sources, BPA exposures through dust, thermal paper, dental materials, and medical devices were summarized. Bisphenols have been reported to be a ubiquitous contaminanst in indoor dust, and human is exposured to this compound. The estimated median daily intake of ∑BPs (∑BPs; sum of eight bisphenols) through dust ingestion in the U.S., China, Japan, and Korea was 12.6, 4.61, 15.8, and 18.6 ng/kg body weight (bw)/day, respectively, for toddlers and 1.72, 0.78, 2.65, and 3.13 ng/kg bw/day, respectively, for adults (Liao et al., 2012).

Based on the available data for these exposure sources, it was concluded that the exposure to BPA from non-food sources is generally lower than that from exposure from food by at least one order of magnitude for most studied subgroups (Geens et al., 2012; Lorber et al., 2015).

Current exposure levels in Europe are below the temporary Tolerable Daily Intake of 4 μg/kg_bw/d proposed by the European Food Safety Authority. Taking into account age-dependent bioavailability differences, internal exposure of premature neonates hosted in intensive care units was reckoned close to the biologically effective dose, resulted in increased margins of safety compared to the conventional exposure/risk characterization scheme (Sarigiannis et al., 2016).

The conclusions are consistent with the large number of hazards and adverse effects identified in laboratory animals exposed to low doses of BPA (Vandenberg et al., 2013). For example, exposure of bisphenol A and 17α-ethinyl-estradiol causes no dose-related changes in body weight. Heart weight was increased only in females exposed to estradiol. Decreased collagen and cardiomyopathy incidence were observed in hearts of bisphenol A and 17α-ethinyl-estradiol exposed females. Myocardial degeneration was observed in both exposed males and females (Gear et al., 2017).

It was found that the influence of xenoestrogens, e.g. bisphenol A, caused oxidative stress due to lipid peroxidation and the generation of hydroxyl radicals. Hydroxyl radicals with a half-life in nanoseconds can initiate lipid peroxidation in membrane phospholipids, affecting the cell membrane structure and functions, provoking the next generation of free radicals attacking and damaging all cellular components and DNA. At the membrane level lipid peroxidation products covalently modify other bimolecular components and enhance cell damage. Lipid peroxidation is associated with liver and kidney damage (Kovacic, 2010; Negre-Salvayre, 2010), which accounts for the toxic effects of BPA in these organs. Exposure of xenoestrogens results in increased generation of hydroxyl radicals with the following histopathological changes in the liver and kidneys, which can be explained by both estrogenic activity and the inclusion of various pathways, caused oxidative stress (Rashid et al., 2009; Korkmaz et al., 2010, 2011; Lazalde-Ramos et al., 2010; Hassan, 2012). In 4-5 week old rats, chronic exposure to bisphenol A resulted in edema and degeneration of liver parenchyma and tubular degeneration in the kidney (Popa et al., 2014).

There are reports that BPA initiates intraprostatic epithelial proliferation and mammary hyperplasia with the formation of new milk ducts, stimulates some cell responses like estradiol and affects multiple endocrine pathways that are predictors of breast cancer. The specific estrogen stimulating effects observed in the mammary gland, which are enhanced by exposure to BPA and parabens, have confirmed that patients with breast cancer should avoid exposure to synthetic xenoestrogens (Murray et al., 2007; Rubin, 2011; Rochester, 2013).

Parabens are esters of 4-hydroxybenzoic acid used as preservatives and antibacterial agents in numerous food products, cosmetics and pharmaceuticals (Boberg et al., 2010). The methyl ester of p-hydroxybenzoic acid is a stable and non-volatile compound that is considered to be safe, exhibits estrogenic activity due to its main metabolite, p-hydroxybenzoic acid (Soni et al., 2002). There are reports that parabens contribute to abnormal signaling of estrogens in the human mammary gland and negatively affect the incidence of breast cancer (Darbre, 2006).

Phenolic compounds of natural or anthropogenic origin may be present in the environment, as well as in food products. They include a large and diverse group of compounds that can be harmful to consumers, causing toxicological and / or possibly endocrine disorders (Goodson et al., 2011).

Phthalate esters are widely used in chemical synthesis and are added during the manufacture of many items used in daily life, including food packaging, cosmetics, pharmaceuticals, insecticides, polyvinyl chloride (PVC) products, construction materials, and medical products. Phthalate esters are not chemically bound to the polymer and therefore easily evaporate, migrate, or release into air, foodstuffs, and related materials. Exposure to phthalate occurs by ingestion, dermal absorption, inhalation, or contact with medical devices.

The hypothalamus–anterior pituitary–gonadal (HPG) axis regulates and controls the balance of reproductive hormone levels in the body. Environmental phthalate diesters are endocrine disruptors that may interfere with the normal function of the HPG axis, resulting in distorted levels of reproductive hormones and potentially producing reproductive and developmental toxicity.

Phthalate diesters are reported to have antiandrogenic and weak estrogenic effects. Among phthalate diesters, di-(2-ethylhexyl) phthalate (DEHP) is the most widely used. Animal studies have shown that DEHP exposure is associated with decreased testosterone concentration, lowered sperm counts, and abnormal testicular development due to its adverse effect on Leydig cells. DEHP may also contribute to a decline in semen quality due to the increased production of semen with abnormal heads. Higher E2 levels and elevated E2/ testosterone ratios were also found in male PVC workers who were exposed to higher urinary DEHP metabolite concentrations (Wen et al., 2017).

Such nutritional factors as phytoestrogens are also found in food, especially on legumes. Phytoestrogens have a similar chemical structure when compared with estrogen and estradiol in mammals. They are able to bind to estrogen receptors (ER) with the advantage of ER-beta. Most of the available data on the absorption and metabolism of food phytoestrogens is of a qualitative nature: it is known that food phytoestrogens are metabolized by intestinal bacteria, absorbed, conjugated in the liver, circulated in the blood plasma and excreted in the urine.

The analysis of a group of 22 estrogenic compounds including eight phytoestrogens (i.e. daidzein, enterodiol, glycitein, enterolactone, genistein, formononetin, prunetin, biochanin A), six mycotoxins (β-zearalanol, β-zearalenol, α-zearalanol, α-zearalenol, zearalanone, zearalenone) as well as four synthetic (i.e. ethynylestradiol, diethylstilbestrol, dienestrol, hexestrol) and four natural estrogens (i.e. estriol, 17β-estradiol, 17α-estradiol, estrone) in different dairy products with relevant interest for the population including skimmed and whole cheese and goat and cow kefir has been validated. Finally, the analysis of commercially available products was carried out finding the presence of daidzein, glycitein enterolactone and genistein in some of the studied samples (Socas-Rodríguez et al., 2017).

A new method of analyze four naturalestrogens, four syntheticestrogens, five mycoestrogens, and nine phytoestrogens for the investigation of estrogenic compounds in 11 milk samples and 13 yogurt samples from a Czech retail market was proposed. Mainly phytoestrogens were found in the studied samples. The most abundant compounds were equol and enterolactone representing 40-90 % of all estrogens. The total content of phytoestrogens (free and bound) was in the range of 149-3870 μg/kg dry weight. This amount is approximately 20 times higher compared to non-bound estrogens (Cavaliere et al., 2015; Socas-Rodríguez et al., 2017).

Phytoestrogens are able to suppress the stimulation of proliferative effects at exostergens expose. It has been proved that phytoestrogens can activate the estrogen receptor and mimic endogenous estrogens, affecting cell growth and proliferation. Phytoestrogens, like estrogens that promote cell growth, can stimulate the growth of already existing tumors. Many phytoestrogens perform a two-phase effect on cell proliferation, stimulating growth at low concentrations and inhibiting growth at high concentrations. When ingested, phytoestrogens interact with many enzymes as endogenous estrogens and interfere with the metabolism of estrogens. They can also inhibit enzymes involved in the generation and removal of endogenous steroid hormones. Among the most powerful biological effects of phytoestrogens, their ability to inhibit sulfotransferase is revealed, which sulfates estrogenic steroids and various chemicals from the environment, including dietary procancerogens. So, inhibition of sulfotransferase by dietary phytoestrogens can have a complex effect on a person and lead to a predisposition for the occurrence of breast cancer (Han et al., 2002; Cassidy, 2003; Mense et al., 2008; Tomar, Shiao, 2008).

Phytoestrogens (isoflavones, which are structurally and functionally similar to 17β-E2) cause developmental abnormalities in domestic animals. These effects are manifest morphologically with cows. Some plants also contain sufficient concentrations of estrogens to cause reproductive alterations in domestic animals. For example, sheep grazed on the clover plant, which contains potent levels of phytoestrogens, develop permanent infertility, so called “clover disease”. The effect of estrogens can also impair vision. Intraocular eye pressure (IOP) varies from species to species in domestic animals but progesterone can increase the IOP in lions, and estrogen similarly in cats (von Goetz et al., 2017).

Neuroendocrine systems function as a link between the brain and peripheral endocrine systems and are responsible for controlling homeostatic processes, including reproduction, growth, metabolism, energy balance and response to stress. Neurotoxicity is one of the most serious toxicological problems, since even a small number of neurons can have unpredictable consequences for the whole organism. One of the most important aspects of the integral functioning of the body is the presence of molecular mechanisms of signaling systems providing the realization of the physiological and biochemical effects of hormones and neurotransmitters. Violation of neuroendocrine homeostasis in the endocrine system by chemicals can lead to a series of shifts (De Coster, van Larebeke, 2012). In particular, there is some evidence of an increased risk of progesterone receptor-positive meningiomas associated with the use of contraceptives and other hormonal contraceptive means (Korhonen et al., 2010).

Steroidal estrogens in food and water can also induce premature menopause and affect reproductive development, also causing virilization in young women. Several studies also revealed that estrogens were involved in the decline of sperm counts and disorders of the male reproductive system and feminization of men. Steroidal estrogens singly or in combination with progesterone also reduce intraocular eye pressure after menopause in humans which might increase the risk of developing glaucoma. Besides phytoestrogens can also affect reproduction, the immune system and metabolism. Accumulative evidence points clearly to serious health concerns regarding estrogens making it crucial to ensure that both estrogens from human and animal waste and phytoestrogens are not consumed in food and water at levels above the accepted (von Goetz et al., 2017).

There is good reason to believe that consuming large amounts of animal fats (with meat and dairy products) can contribute to the development of diseases, including cancer, possibly as a result of increased levels of estrogen circulated in the body (Baena, Salinas, 2014). Consumers are exposed to low levels of such substances throughout life. The effect of these compounds is currently assessed with an emphasis on mutagenicity and genotoxicity. However, this approach does not take into account the integration of the latest new toxicological studies, for example, in endocrine disorders, toxicant mixtures and toxicity in the development (Muncke, 2011).

Age-related aspects of EDCs impact. In mammals, exposure to EDCs during the perinatal period may have an impact during adult life, while other effects may be a consequence of exposure at any time during life.

There is now extensive evidence from experimental laboratory animals, sheep, and humans that fetal exposure to very low (presumably safe) doses of the endocrine chemical disruptur e.g. bisphenol A, which exhibits estrogenic activity, can cause permanent changes that can increase the risk of a wide array of diseases (Vom Saal, 2016).

Concerns about the increasing incidence of abnormalities in human and animal male reproductive function, such as cryptorchidism, hypospadias, low sperm count and testicular germ cell cancer, have been steadily increasing. These disorders have been hypothesized to be the expression of one common underlying disorder, the testicular dysgenesis syndrome arised during fetal life. Specifically, the higher occurrence of cryptorchidism and hypospadias might be the result of increasing alterations of the function of fetal Leydig cells. Indeed, Leydig cells produce testosterone that is responsible for the masculinization of the male urogenital system and external genitalia. Moreover, fetal testis migration into the scrotum is dependent on testosterone and insulin-like hormone produced by Leydig cells. It were investigated the effects of small BPA concentrations on fetal Leydig cell function, as fetal life is a critical period of sensitivity to EDCs effects on male reproductive function.The results evidenced a deleterious effect of BPA on fetal Leydig cells function in human (N'Tumba-Byn et al., 2012).

Different effects have been reported for different bone types. Several *in vivo* and *in vitro* EDC exposure studies carried out in mammals, amphibians and reptiles support the hypothesis that the disruption of cellular actions involved in bone formation and remodeling may have consequences for bone architecture, strength, density (mineral content) and characteristics (hardness and elasticity) (Pinto et al., 2014).

Excess estrogen exposure of avian embryos perturbs reproductive organ development in both sexes and demasculinizes the reproductive behaviors of adult males. Furthermore, anomalous retention and malformations of the Müllerian ducts/oviducts were seen in embryos and juveniles of both sexes. The reproductive organs become sexually differentiated consequent to activation of ERα by endogenous estrogens; excessive activation of ERα during embryonic development may disrupt this process. The results also suggest that the demasculinizing effect of estrogens on male copulatory behavior is only partly mediated by ERα and ERβ, and may rather involve other estrogen-responsive pathways (Mattsson A., Brunström B., 2017).

Pregnant and lactating mice were exposed to either BPA or diethylstilbestrol at low, environmentally relevant doses via their diet. Studies of leptin function and neurobiology were conducted on offspring at several time points. The findings suggest that BPA may exert its effects through developmental programming of the hypothalamic melanocortin circuitry, permanently altering the neurobiology of metabolic homeostasis (Ćwiek-Ludwicka K, .2015; MacKay et al., 2017).

Parental CD1 mice were acclimated to defined diet containing BPA or 17α-ethinyl estradiol (EE) and bred to produce progeny (F1) that were maintained through adulthood on the same diet as the parents. In F1 females, uterine weights were increased in all EE and the BPA-exposure groups, demonstrating model sensitivity and estrogen-like actions of BPA. At postnatal day 21 increase of prolactin and sperm counts and increased circulating testosterone levels, balanopreputial separation was increased in males by BPA. The effects were nonmonotonic and not predictable (Kendig et al., 2012).

Children are in a critical stage of development and are more sensitive than adults to environmental pollutant exposure. Children exposed to endocrine disruptors may have long-term and stronger effects on their health compared to adults. It is crucial for reproductive hormones to be well regulated for normal pubertal development in children. EDCs effects can be harmful to humans, especially with regard to behavioral and other effects in children (Rochester, 2013).

In human studies, Di-(2-ethylhexyl) phthalate influence has been linked with decreased testosterone levels in children. Moreover, prenatal DEHP exposure is reportedly associated with a shorter anogenital distance in boys and a lower sperm volume in adolescent males that perhaps is associated with subsequent infertility in adulthood.

In May 2011, a major incident involving phthalates-contaminated foodstuffs occurred in Taiwan. Di-(2-ethylhexyl) phthalate was added to foodstuffs, mainly juice, jelly, tea, sports drink, and dietary supplements. Concerns arose that normal pubertal development, especially reproductive hormone regulation in children, could be disrupted by phthalate exposure. As conclusion, phthalate exposure was associated with alterations of reproductive hormone levels in girls (Wen et al., 2017).

The most important period of postnatal ontogeny is the pubertal period, characterized by a significant increase in the synthesis of estrogens. The increased level of estrogen circulating in the blood affects many systems in the maiden's body, leading to various physiological changes. In different age periods hormones influence differently, and not only on the age hormonal homeostasis, but also the state of the hormone-dependent organs (Lykholat et al., 2014).

The experiments were conducted on Wistar rats exposed to exogenous estrogen for 45 days. At the beginning of the experiment 3-month-old pubertant animals (group

II) and 6-month-old sexually mature rats(group IV) were involved. The control group consisted of intact appropriate age animals (groups I and III).

For modeling exogenous estrogen impact rat' meal is treated with the drug "Sinestrol" as stilbene derivative differing from steroid hormones estrogen on chemical structure, but by biological and medicinal properties similar to them in the rate of 2 mg per kg.

The aim of the work was the study of lipid peroxidation, antioxidant system components and cholinergic neurotransmitter system in the organs of experimental animals of different ages for exposure of alimentary synthetic estrogen.

Thus, alimentary exogenous estrogenic exposure caused amplification of lipid peroxidation in pubertal animals and mature females. There was a different degree of peroxidation intensification depending on age and research organs. In younger females organs reaction of oxidative system exceeded the power of response in the organs of sexually mature animals.

In the kidneys of research female groups marked decrease of restored glutathione demonstrates the risk of the detoxification system violations. This can lead to the accumulation of free radicals, which are the triggering factors of various diseases in the future.

Organ discreteness of changes of antioxidant enzymes activity depending on the animal age was observed. This indicates the imbalance of enzymes of glutathione system. Given the involvement of glutathione system to the estrogen inactivation by conjugation in their reactions catalyzed by glutathione transferase, reducing its activity can result in the accumulation of intermediate metabolites and damage of intracellular structures mainly DNA.

An imbalance of SOD - glutathione peroxidase links leads to the accumulation of peroxides, which is a measure of endogenous intoxication more pronounced in younger females

Admission to the organism food hormones caused changes of prooxidant-antioxidant system in the brain and may be followed by a lesion of signal transmission of information. Therefore, reducing the peptide in the pubertal rat brain is a negative prognostic criterion of afferent integrated system destruction. The estrogen effect concerns the entire central nervous system and includes signaling pathways that intersect with the other mediators, such as neurotransmitters and neuromodulator, consequently, affecting the processes associated with autonomic regulation, neuroprotection and more. The accumulation of toxic metabolites can cause damage both the cellular and organ levels.

Table 8.1.

Indexes of brain tissue experimental groups, M + m

Indexes	Experiment variants			
	I group, n=6	II group, n=6	III group, n=6	IV group, n=6
Reductive glutathione,	221,13+11,05	154,75+7,40*	190,31+9,50	203,25+10,16
mM/g tissue				
Glutathione reductase mkM/g protein	195,24+9,76	168,25+8,41*	174,25+8,70	200,51+10,03*
Glutathione transferase, mkM/ min. /g protein	51,14+2,56	45,77+2,29*	61,06 ± 3,05	57,27+ 2,86
TBA-active products, nM/g protein	28,61+ 1,40	38,26+ 1,90*	24,26+0,12	31,42 + 1,57*
Total antioxidant activity, standard units	34,35+ 1,71	21,98+1,10*	27,52+1,38	17,17+0,85*
Superoxide dismutase optic unit/min. g protein	888,46+44,40	764,08+38,23*	543,91+27,22	660,85+ 33,43*
Glutatione peroxidase, mkM/ min. g protein	26,94+1,35	28,02+1,40	32,75+1,64	38,97+1,95*

* Significant differences between the indexes of control and experimental groups , p ≤ 0,05.

In AChE study in the brain of younger rats its activity was higher by 22 % compared to the control index. In the older group of experimental females the enzyme activation by 15 % was observed. When comparing enzyme index of 3-month and 6- month-old animals the activity increase by 5,3% has been shown (tabl.8.2)

Table 8.2.

The impact of nutritional effect of estrogen on the activity of acetylcholinesterase, M + m

Investigated organ	I group, n=6	II group, n=6	III group, n=6	IV group, n=6
Blood serum, mM/mg protein/L	4,52 + 0,31	4,07 + 0,28*	4,74 + 0,36	4,40 + 0,33
Brain, mM/ mg protein/ min	13,35+ 0,80	16,23 + 0,92*	14,06 + 0,95	16,17+ 1,03*
Liver, mM/ mg protein/ min	2,77 + 0,21	2,53 + 0,25*	2,91 + 0,18	2,73 + 0,22

For nutritional effect of estrogen reduced AChE activity were fixed in the serum and liver that could be caused by deterioration of liver synthesizing function and particular stagnation in the liver and kidneys. Enzyme activity was lower in pubertal females than in mature rats, indicating a lower efficiency of neurotransmitter transmission in the corresponding cholinergic neurons in rats from younger group. In the future, it can result in serious disturbances in the functioning of the body and trigger the emergence of new pathological states.

Thus, in the model experiment the effect of alimentary exogenous estrogen that can be presented in agricultural products on the condition antioxidant and prooxidant systems, the cholinergic neurotransmitter system in the tissues of the experimental different age animals has been studied. It was established that the severity of the effects had been higher in females in puberty compared to sexually mature animals, which indicates the existence of specific age-related physiological conditions defined high sensitivity to exogenous estrogen-like compounds. Due to changes in the rate of reactions of the detoxification pathway, and not in the metabolism of estrogens that were ingested, in particular with food, animals became less sensitive to the effects of these substances with age (Lykholat et al., 2016).

Since there is a risk of contaminating the diet of adolescent children, as a particularly sensitive population to endocrine chemicals, an analysis of the risks of future health problems is needed (Courant et al., 2007; Hu J et al., 2013; Hulin et al., 2014). At present, the relevance of the potential of acyl esters of estradiol, the current production rate of estradiol in adolescent children is unclear. The presence of various subtypes of cytoplasmic estrogen receptors and potential effects of estradiol not associated with reproductive functions require further study (Daxenberger et al., 2001).

Conclusion. Based on the analysis of information on the effect of exogenous estrogens obtained from literature sources and the results of our own studies, we can conclude:

- Sewage treatment plants, wastewater treatment plants and sewage constituents used in manure constitute major potential sources of estrogen pollution;
- Half-lives of E1 and E2 are short and both can be biodegraded relatively rapidly but EE2 is more persistent in the environment;

- E1, E2, E3 and EE2 are easily transformable into each other by aerobic organisms but transformation rates are positively related to moisture content of soils;
- Human, domestic and wild animal together with fish health can be disrupted by rising levels of estrogens;
- There is a link between environmental estrogens and breast cancer,
- Plants synthesise phytoestrogens and take up mammalian-derived estrogens both actively and passively. Estrogens' hydrophobicity and lipophilic properties facilitates relatively easy passage through plant membranes;
- Plants can accumulate estrogens in both roots and shoots (von Goetz et al., 2017).

Thus, there is published evidence to establish a causal relationship between estrogens in the environment and breast cancer. However, there are serious gaps in our knowledge about estrogen levels in the environment and a call is required for a world wide effort to provide more data on many more samples sites. Of the data available, the synthetic estrogens are more persistent in the environment than natural estrogens and may be a greater cause for environmental concern. Finally, we believe that there is an urgent requirement for inter-disciplinary studies of estrogens in order to better understand their ecological and environmental impact (Adeel et al., 2017).

As a matter of fact, ecological and dietary risks caused by agrochemical residues were deemed to be highly linked to its side effects on the living creatures, and spectrum approaches-based disclosure of the residual profiles of agrochemical thus became an essential component and powerful tool in risk assessment. Therefore, the further elucidation of the toxicological effect on human beings needs to be focused through the short-term and long-term toxicological tests (Wei et al, 2017).

Further investigation of the action of EDCs is required and should include, amongst other things:

- Substances with estrogenic activity should be listed as toxic organic pollutants;

- Screening of a far greater number of EDCs, including endpoints, such as the assessment of enzyme activities, gene expression, proteome changes and gene networks and cellular pathways;
- In study tests that model the accumulation of natural as opposed to synthetic estrogens in the environment and in particular at those sites close to water treatment and sewage disposal systems should enable;
- Clarification is required about safe threshold levels of estrogens in the terrestrial, aquatic and human environments;
- Characterization of tissue-specific responses;
- Establishment of species-specific, season-specific and age-specific responses;
- Further studies are also required to determine tolerance, because still the impact of estrogen-toxicity in many ecosystems is not clear (Pinto et al., 2014; von Goetz et al., 2017).

Despite the steady growth of agricultural production, development of agro-industrial pollution drugs like compounds of food and drinking water is very likely. This phenomenon is of concern and requires increased control of both the responsible organizations and public associations that will enable to avoid the negative effects of dietary factors on the population health. Particular attention should be paid to the safety and quality of children's food, because this population is extremely sensitive to the influence of previously alimentary factors (Lykholat et al., 2016).

Combinations of different conventional and advanced technologies including biological and plant-based strategies seem to be most promising to solve the burning problem of polluting our environment with hazardous emerging xenobiotics with estrogenic activity (Schröder et al., 2016).

The study of EDCs impact is a difficult but necessary task to prevent future damage to the species of plants, fish, domestic and wild animal together human health and wealth as a whole.

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CHAPTER 9. HERBICIDES IN AGRO-SPHERE OF UKRAINIAN STEPPE DNIEPER: ACTION AND AFTEREFFECT

Herbicides treatment has been the most widely used method for controlling weeds in crops over the past decades in majority of the developed countries (Busi et al., 2014; Vencill er al., 2012), since the herbicides are the most effective and economical among the weed management practices (Duary, 2008).

In Ukraine, the costs associated with the use of herbicides can reach 15 – 20% of the expenses of growing crops. Nevertheless, the application of the herbicides remains an inevitable necessity, since the yield losses can reach 20 – 50% in the close- growing crops, and 40 – 80% in the row crops due to competition created by weeds (Ivashchenko, 2001). Moreover, favor of the herbicides is evidenced by the fact that in Ukraine over 80% of the sown areas have high weed contaminations. In particular, the chernozems of the steppe zone contain about 550 million pieces / ha of the weed seeds in the surface soil (Tsikov, Matyukha, 2006).

However, the long-term use of herbicides in large areas has led to the emergence of numerous resistant populations of weeds (Délye et al., 2015; Yu, Powles, 2014). According to the latest data, resistance against various herbicides has been reported for 319 biotypes belonging to 185 species (111 dicots and 74 monocots) in 60 countries. Largest numbers were found in the USA (139 biotypes), Australia (60 biotypes), Canada (52 biotypes) and some European countries (Vencill er al., 2012).

In Ukrainian steppe Dnieper, an alien species Ambrosia artemisiifolia L. (common ragweed) has become one of the first weeds which showed tolerance or resistance to the herbicides. It was established (Matyukha et al., 2003) that against the background of the annual herbicides application during 1991-2001, the total topsoil contamination with the weed seeds increased by 1.5 times, while contamination with the seeds of common ragweed by 2.4 times.

In our study, most of the field research of the herbicides influence on common ragweed was carried out in the maize crops. The objective of the study was to identify the metabolic resistance of A. artemisiifolia to different modes of herbicides action by revealing effects and after-effects of herbicides on the common ragweed plants, seeds and seedlings of the following generation.

It was established that the annual herbicides application during 2002-2006 caused the development of the resistance to the herbicides MaysTer (inhibitor of ALS) and Merlin (inhibitor of carotenoids biosynthesis). However, Harness and Frontier herbicides belonging to the chloracetanilide class have shown the ability to control A. artemisiifolia in the maize crops for several years with slight loss of efficiency. Recommended approaches and methods for controlling A. artemisiifolia infestation in the corn crops are given in this paper.

The study of the properties of viable common ragweed seeds harvested from the parental plants which survived the various herbicide action led to conclusion that population of A. artemisiifolia acquired simultaneous resistance to different modes of herbicide action. Weight variability of the common ragweed seeds together with the seeds vital differentiation can contribute to *A. artemisiifolia* population survival in the adverse conditions of the agrocenosis.

Greenhouse experiments were carried out to identify the aftereffects of herbicide action in the metabolic features of the common ragweed plants of the following generation. The significant activation of the antioxidant enzymes (SOD, POD, and PPO) and GST as well was established in the untreated next-generation common ragweed plants. Given the simultaneous enhancement of ability to protect against the oxidative stress action, and to degrade xenobiotic through the activation of GST, it can be assumed that each of these processes contribute to the emergence of metabolic resistance within the population of *A. artemisiifolia*.

So, studies have shown the herbicide-induced activation of toxin degradation processes as well as antioxidant protection in the treated common ragweed plants, inherited by the weed seeds and untreated plants of the next generation. Thereby, long- term herbicidal treatment carried out the selection of the herbicide-resistant biotypes within the population of *A. artemisiifolia*.

Special attention was paid to analysis of the herbicide influence on the ontogeny of cultivated plants. Although herbicide manufacturers declare absolute selectivity for the non-target plant species, many studies have identified the negative effects and after- effects of the herbicides. Violation of chlorophyll fluorescence in wheat leaves (Ekmerci, Terrioglu, 2005), growths of sorghum pollen sterility (Oginova, 2006), and antioxidant enzymes activation in maize leaves (Grygoryuk et al., 2016) were caused by herbicide action.

In our study, the decrease in maize 1000 grains mass as well as in protein content was found due to the treatment of corn crops with new selective herbicides Harness, MaysTer, and Stellar. Electrophoretic analysis revealed the herbicide-induced quantitative and qualitative changes in the soluble proteins composition of corn grain. The control number of protein zones was sharply decreased due to the treatment with herbicides Harness and Stellar. Significant disruption in the antioxidant and glutathione-dependent systems of maize seeds was established, indicating decline of the protective properties and the deterioration in grain quality due to the herbicidal treatment of parent plants.

The after-effects of herbicidal treatment of winter wheat crops were manifested in growth of the grain vigor together with the deterioration of germination index. The notable deviations of the grain antioxidant enzymes activity were associated with the after-effects of treatment with the tank mixtures of herbicides. So, the combined action of two or more the phytotoxic components was not neutral for winter wheat plants, even in the presence of an antidote in herbicides composition.

The study results showed that the morphometric parameters should not be considered an exhaustive characteristic of the quality of cereals mature grain. Physiological and biochemical parameters should be taken into account in order to ascertain all the aftereffects of the herbicides action and argue the choice of an optimal variant of the crops herbicide treatment.

Resistance of the weed plants to the action of the herbicides is a worldwide phenomenon and number of resistant biotypes of weeds is increasing at catastrophic rate (Duary, 2008). Herbicide resistance should be interpreted as the ability of the weed biotype to survive the action of the herbicide, to which the original population was sensitive.

Insensitivity of weed plants to herbicide 2, 4-D was noted back in 1957, and however the first scientific publications date back to the early 1970s. The publications were devoted to the resistance of common groundsel (Senecio vulgaris L.) to the herbicides triazine (Ryan, 1970) and simazine (Radosevich, Appleby, 1973), which were used for several years in the nurseries of coniferous plants. For decades, since the discovery of the first herbicide-resistant weed, the number of such reports has increased so many times that the phenomenon of herbicide resistance has reached the level of a global problem.

Judging by the data of Tharayil-Santhakumar (2003), the growth curve of the number of resistant biotypes has an exponential character. So, in the early 1980s, about 50 herbicide-resistant weed species were identified, in the early 1990s about

100, whereas by 2002 their number exceeded 260 species. Further, Cummins and Eswards (2010) reported more than 300 herbicide-resistant biotypes of weeds which have been identified in more than 270 thousand fields in 56 countries. In accordance with the data of Duary (2008), till July 10, 2008, 319 biotypes belonging to 185 species (111 dicots and 74 monocots) have been reported resistance against various herbicides in 60 countries. It is known (Vencill er al., 2012) the largest number of them was found in the USA (139 of all biotypes), Australia (60 biotypes), Canada (52 biotypes) and some European countries.

So, current situation makes us acknowledge that the herbicide-resistant weeds can significantly weaken the stability of agriculture (Yuan et al., 2007), which threatens global food security (Matzrafi et al., 2014). Therefore, it is not surprising that the efforts of a large number of researchers for many years have been aimed at studying the mechanisms of the emergence of herbicide resistance of weeds and the search for ways to overcome this undesirable phenomenon. It was possible to establish that spontaneous resistance within weed populations manifests itself due to such reasons as uniformity of control methods, use of persistent herbicides, and reduction of crop rotation, use of herbicides with identical mechanism of action (Ganie, Jhala, 2017; Délye et al., 2005; Tranel, Wright, 2002; Morderer, 2001).

However, the herbicide does not change the genotype of the weeds, but only selects plants with some level of existing genetic resistance to a certain mechanism of action of the herbicides (Vencill er al., 2012). As Duary (2008) noted, weed herbicide resistance is simply an altered response by a plant species which was earlier susceptible and it is the naturally occurring and inheritable ability of some weed biotypes within a population. Thus, resistance to herbicides occurs in populations of weed plants as a result of evolutionary adaptation under the action of rigid selective pressure (Délye et al., 2015).

To date, it has been established that weeds can quickly acquire resistance to some relatively new herbicides. An example is the resistance to sulfonylurea herbicides, which was found in the populations of prickly letture (Lactuca serriola L.)

and burning bush (Kochia scoparia (L.) Schrad.) only four years after the start of herbicides application (Mallori-Smith et al., 1990).

Herbicide-resistant weed biotypes can be emerging from only one or a few plants that are already present in a population. Tharayil-Santhakumar (2003) suggests that for the emergence of a resistant biotype, 0.001% of insensitive plants in the weed population are sufficient. Such a minute number of resistant plants continue to grow and expand by generation over time. Getting resistance, the individuals of weed plants do not change, instead populations change.

Although insensitive plants look morphologically identical, minor invisible genetic differences do exist among them that confer inherent resistance against the herbicides (Duary, 2008). Due to applying an herbicide continuously for some years, the number of the susceptible weed plants decrease drastically and those resistant biotypes increase gradually to the extent that the herbicide appears to be ineffective. At this stage the weed has developed resistance against an herbicide or in other words called selection pressure of herbicides reached to maximum. Vigueira et al (2013) consider the herbicide resistance of weeds as an example of convergent evolution, when both the same and different mutations present in plants lead to the emergence of a resistant phenotype in a group of species.

As for the molecular basis of herbicide resistance of weeds, they can be represented by two types of mechanisms. At first, herbicide resistance of the weeds can be caused by changes in the three-dimensional structure of the target protein (target- site resistance, TSR) which reduces the bond to the herbicide (Yuan et al., 2007). In such cases, mutations in the site of action lead to the emergence of resistance to herbicides that inhibit among others enzymes Acetolactate synthase (ALS) and Acetyl- Coenzyme A-carboxylase (ACoAC). It is known (Duary, 2008), that besides 101 species demonstrated resistance to herbicides inhibitors of ALS or acetohydroxy acetone synthase (AHAS), there are more than 200 species surfaced resistant to 18 other classes of herbicides.

From investigations of numerous resistant weed biotypes, five conserved amino acids have been identified in ALS that, on substitution, can confer resistance to ALS inhibitors. In most cases, resistance to ALS-inhibiting herbicides is caused by an altered ALS enzyme. For example, Tranel and Wright (2002) showed that several point mutations within the gene encoding ALS can result in an herbicide-resistant ALS. Delye et al (2005) established that the resistance of the weeds to the herbicides – inhibitors of ACoAC is associated with the replacement of the amino acids tryptophan, asparagine and glycine in the site of action of the herbicides. It was revealed (Marion et al., 2017) that a tryptophan-to-leucine substitution at amino acid position caused the resistance to Cloransulam (ALS inhibitor) in population of giant ragweed (Ambrosia trifida).

Alternative mechanism of the weeds herbicide resistance does not involve the target protein (non-target-site resistance, NTSR), and includes such mechanisms as declining penetration and/or translocation herbicides in plants, as well as biochemical modification and / or compartmentalization of the herbicide and its metabolites (Délye et al., 2015; Yuan et al., 2007).

For example, the reduced ability for the translocation of glyphosate into the meristem zone of plants is responsible for the resistance of populations of annual ryegrass (Lolium rigidum L.) to glyphosate treatment (Wakelin et al., 2004). At the same time, resistance of this species to the herbicide atrazine and its analogies as well is associated with increasing processes of metabolism or isolation of herbicides within plant cells (Burnet et al., 1991). Further, the resistance of the velvetleaf (Abutilon theophrasti Medicus) to atrazine was found to be due to the induced increase in the activity of the specific isoforms of the enzyme glutathione S-transferase (GST) which is one of the most effective enzyme for xenobiotic detoxification including the herbicides (DeRidder et al., 2002).

Admittedly, the non-target-site resistance of the weeds can create additional unexpected problems for humanity. The fact is that the recent studies have shown (Matzrafi et al., 2016) that the climatic changes in last decades have increased the risk of herbicide resistance precisely because of the increased herbicides detoxification by the treated plants.

In Ukraine, about 300 of the most widespread species of weed plants were found in crops. According with data of Ivashchenko (2001), a decrease in the sensitivity to herbicide 2,4-D was observed in different regions of Ukraine in such weeds as Matricaria perforata Merat., Centaurea cyanus L., Galium aparine L., Papaver rhoeas L., Equisetum arvense L., and Cirsium arvense (L.) Scop. The resistance to triazine herbicides has increased in such weed species as Echinochloa crusgalli (L.) Pal. Beauv., Setaria glauca (L.) Pal. Beauv., Sonchus asper (L.) Hill, and Convolvulus arvensis L. A decrease in sensitivity to chloroacetanilide herbicides was found in weed species Chenopodium album L.

As for the zone of the steppe Dnieper, the predominant part of agricultural land in the region is reserved for cereals, including maize, spring and winter wheat, barley, and sunflower. Accordingly, annual and perennial weeds both monocotyledonous and dicotyledonous are present in crops of different cultures, forming a mixed type of contamination of the fields during the crops rotation. The group of the most common weed plants in all crops includes such species as Amaranthus retroflexus L., Amaranthus blitoides L., Ambrosia artemisiifolia L., S. glauca, C. arvense, Ch. album, and some others (Table 9.1).

Table 9.1

The most abundant dicotyledonous weeds in maize crops in the steppe Dnieper (averaged data for 2007-2009)

Weed species	Plants number, pcs / m^2	Share of the total number of weeds,%
Amaranthus retroflexus	1.29±0.09	20.8
Ambrosia artemisiifolia	1.08±0.12	17.4
Chenopodium album	0.77±0.07	12.4
Iva xantifolia	0.64±0.12	10.3

In these conditions, the use of herbicides is an indispensable way to protect crops and reduce the yield losses. However, the effectiveness of the herbicides action can often be decline due to decrease in sensitivity of weeds to the herbicides action. For example, according to the data of Matyukha et al (2003), in the steppe Dnieper, A. artemisiifolia (common ragweed) has become one of the first places in terms of control problems in row crops in the past two decades.

At the same time, numerous confirmations of the emergence of resistant common ragweed populations in different regions (Ganie, Jhala, 2017; Heap, 2014; Zheng et al., 2005; Taylor et al., 2002; Patzoldt et al., 2001) indicate the global nature of the problem. Today it is known that the mutations in the enzymes structure are the basis for resistance of A. artemisiifolia to herbicides – inhibitors of acetolactate synthase (ALS) (VanWely et al., 2015; Patzoldt et al., 2001) as well as of protoporphyrinogen oxidase (Rousonelos et al., 2012). Unfortunately, the mechanisms of non-target-site resistance of common ragweed as well as many other weeds have been studied extremely little, including due to the complexity of the metabolic processes (Yuan et al., 2007).

Field experiments were performed in the corn sowings, where the treatment with the herbicides of different modes of action has been used for many previous years. The need for annual application of the herbicides is caused by the fact that the common ragweed can dramatically reduce maize yield due to the low competitiveness of culture in the early stage of ontogeny. The results of the field experiments conducted in the different years during the period 2002-2015 together with their analysis are given in this work.

In the first experiments (during the period 2002-2006), the soil-applied herbicides (Harness at a dose 2.5 L/ha, Frontier at a dose 1.5 L/ha, and Merlin at a dose 130 g/ha) were applied 2-3 days before planting crop and used as pre-emergence (PRE) herbicides. Foliar-applied herbicides (2,4-D at a dose 1.0 L/ha, Dialen at a dose 2.5 L/ha, MaysTer at a dose 150 g/ha, and Serto at a dose 200 g/ha) were introduced as POST herbicides in the phase 5-7 leaves of the culture.

It was established that the sensitivity of A. artemisiifolia plants to the herbicides action has changed during the interval 2002-2006 (Table 9.2).

Compared to control levels in the corresponding years, herbicide Harness action caused a decrease in the number of common ragweed shoots to 34% and 37%, and generative plants number to 29% and 37% respectively in 2002 and 2006. At the same time, generative plant density in the plots changed insignificantly during the experiment. Considering that acetochlor-containing herbicides (Atsenit and Trofi) were previously repeatedly introduced into maize crops, the stability of density of weed generative plants can be regarded as decrease in sensitivity of *A. artemisiifolia* population to this mechanism of herbicidal action.

Table 9.2

Herbicides influence on the germination and development of the common ragweed plants in the field experiments

Herbicides	Number of the shoots, pcs / m^2		Number of the generative plants, pcs / m^2	
	2002	2006	2002	2006
Harness (PRE)	2.03±0.06	1.59±0.04	0.81±0.02	0.89±0.02
Frontier (PRE)	3.15±0.08	2.23±0.06	0.94±0.02	0.96±0.04
Merlin (PRE)	2.43±0.06	2.29±0.07	0.87±0.02	1.30±0.07
MaysTer (POST)	5.83±0.11	4.15±0.09	0.17±0.01	1.04±0.06

Herbicide Frontier declined the number of the common ragweed shoots only to 53% and 51% of the control respectively in 2002 and 2006. Low effectiveness of the herbicide Frontier, first applied in 2002, can be explained by similarity of the mechanisms of action of this herbicide and acetochlor-containing herbicides which were used many times before in maize crops. However, the number of the generative weed plants increased insignificantly during the period 2002-2006. Thus, herbicides of the chloracetanilide class have shown the ability to control *A. artemisiifolia* in the corn crops for several years with a gradual decrease in efficiency.

The effectiveness of herbicide Merlin was manifested only with respect to a decrease in the number of weed shoots (up to 41% and 53% of control), while the number of surviving generative plants of common ragweed increased 1.5 times between 2002 and 2006. Thus, the herbicide Merlin proved to be unsuitable for control of the common ragweed with repeated application in corn crops.

As for the foliar-applied herbicide MaysTer, its effectiveness in controlling the number of generative weed plants decreased catastrophically (more than 6 times) during the period of the experiments. Consequently, the herbicide MaysTer cannot be used for re-treatment of *A. artemisiifolia* in the maize crops.

Thus, already the results of the first experiments have shown that the annual use of the same herbicides in maize crops marked a clear tendency to reduce the effectiveness of herbicide treatment. The basis for this conclusion was the lack of a reduction in the number of the generative common ragweed plants. The lowest loss of efficacy was associated with the repeated application of the herbicides Harness and Frontier, while the application of the herbicides Merlin and MaysTer led to significant efficacy declining.

In our opinion, the effectiveness of the herbicide action should be assessed by the number both of the seedlings and generative weed plants that survived after herbicide application. So, relying on the patterns of change in the number of common ragweed generative plants, we can assume that the repeated herbicides introduction for 4 years (during the period from2002 to 2006) caused the tendency to the formation of the resistance to herbicide – inhibitor of ALS (MaysTer) and inhibitor of carotenoids biosynthesis (Merlin).

At the same time the annual repeated use of the chloracetanilide herbicides Harness and Frontier in the corn crops was accompanied by a slight decrease in the sensitivity of the population of *A. artemisiifolia*.

In addition, experiments conducted during the period 2002-2006 revealed the ability of plants of *A. artemisiifolia* to significant activation of glutathione S-transferase under the influence of the herbicides, which have a different chemical structure (Table 9.3).

Furthermore, activation of glutathione S-transferase together with the changes in the reduced glutathione content were revealed in the leaves of other dicotyledonous weeds in the response to the action of herbicide Harness (Table 9.4).

A high level of enzyme activation together with a slight decrease in reduced glutathione content was observed in the leaves of A. retroflexus, A. artemisiifolia, and Ch. album, which indirectly confirms the activation of glutathione biosynthesis in response to the Harness action. The changes revealed testify to the functioning of the xenobiotic detoxification mechanism by the conjugation with glutathione catalyzed by the glutathione S-transferase (DeRidder et al., 2002). So, the coordinated activation of different units of the glutathione-dependent defensive system indicates the intensive detoxification of the herbicide Harness in the leaf cells of weed species A. retroflexus, A. artemisiifolia, and Ch. album (Khromykh, 2011a). Probably, the degree of glutathione S-transferase activation can correlate with the level of resistance of the weed species to the herbicide Harness, as well as to the mechanism of action of acetochlor-containing herbicides in general (Khromykh, 2013a).

Table 9.3

Change in the glutathione S-transferase activity in leaves of juvenile common ragweed plants due to the herbicides action (averaged data for 2004-2005)

Herbicides	GST activity, % of control	P
Harness (PRE)	273.6	0.0002
Frontier (PRE)	155.2	0.0029
Merlin (PRE)	137.4	0.0033
MaysTer (POST)	366.1	0.0009
2,4-D (POST)	140.1	0.0114
Dialen (POST)	165.3	0.0068
Serto (POST)	196.0	0.0006
Harness (PRE) + MaysTer (POST)	146.4	0.0062

Experiments carried out in the following years revealed a gradual decrease in the sensitivity of the weeds in the maize crops to the herbicides, the effectiveness of which was previously quite high. For his reason, new herbicides and their combined action have been applied to counteract the undesirable increase in the resistance of weeds. In a field experiment conducted in 2011-2012, a high abundance of dicotyledonous weeds was found in the plots where herbicide treatments were used previously for many years (Table 9.5).

Table 9.4

Response of the glutathione-dependent system of dicotyledonous weeds to the herbicide Harness action (averaged data for 2007-2009)

Weed species	GST activity, % of control	Glutathione (GSH) content, % of control
Amaranthus retroflexus	397.8*	89.5
Ambrosia artemisiifolia	277.4*	92.6
Chenopodium album	194.3*	88.9

Significance of the differences (P<0.05) was indicated by an asterisk (*).

Table 9.5

Action of the herbicides on the dicotyledonous weeds in maize crops (averaged data for 2011-2012)

Herbicides	Generative plants, pcs / m^2		GST activity, % of control	
	A. artemisiifolia	*A. retroflexus*	*A. artemisiifolia*	*A. retroflexus*
Adengo (PRE)	1.46±0.26	1.22±0.21	140.3	83.1
Stellar (POST)	1,35±0.16	1.61±0.18	250.6	95.1
Harness (PRE) + Esteron (POST)	1.16±0.39	1.21±0.42	155.4	119.3
Harness (PRE)	1.95±0.31	2.12±0.37	172.3	214.4

In comparison with the control plots, the herbicides of the new generation have reduced the number of the weed plants on average to 18-24%. The number of the generative plants of A. artemisiifolia was reduced the least due to the influence of herbicide Adengo, as well as the smallest GST activation. Adengo includes the isoxaflutol (an inhibitor of the carotenoid biosynthesis), and earlier we found low response of the common ragweed plants to this component, which was the part of

Merlin herbicide. The most increase in glutathione S-transferase activity in A. artemisiifolia leaves was caused by the action of herbicide Stellar containing dicamba, which confirmed the previously established activation of the enzyme in response to the action of other auxin-like herbicides.

In the leaves of A. retroflexus, decrease in GST activity due to action of the herbicides Adengo and Stellar indicated the inhibiting herbicides effect. In the leaves of both weed species the maximum phytotoxic effect was achieved with the successive application of herbicides Harness (PRE) + Esteron (POST). However, the increase in activity of GST both in A. artemisiifolia and A. retroflexus leaves due to action of Harness alone was higher than under the combined herbicides action, which is probably due to the additive phytotoxic effect of acetochlor-containing and auxin-like herbicides (Khromykh, 2010).

In 2015, the soil-applied herbicides (Harness at a dose 2.5 L/ha and Guardian-Tetra at a dose 3.5 L/ha) were used as pre-emergence (PRE) herbicides. Foliar-applied herbicides (Starane-Premium at a dose 2.5 L/ha, Guardian-Tetra at a dose 3.5 L/ha, Stellar at a dose 1.25 L/ha, Milagro at a dose 0.18 L/ha, Lancelot at a dose 100 g/ha, and Pic at a dose 100 g/ha) were used after crop emergence as POST herbicides. Any herbicide was introduced on the control plots.

In the field experiment, the number of juvenile plants of *A. artemisiifolia* and level of the glutathione S-transferase (GST) activity in common ragweed leaves differed significantly depending on herbicide classes, mechanisms of action, and variants of herbicide treatment (Table 9.6).

The PRE-herbicides Harness and Guardian-Tetra reduced the number of juvenile common ragweed plants by no more than 60% of the control level. The active substance in these herbicides is acetochlor belonging to the chloroacetanalides and inhibiting the synthesis of the fatty acids as one of modes of action. Herbicides with this mechanism of action have been used for many years on the experimental plots, which may explain their low effectiveness.

Table 9.6

Effect of the herbicides on juvenile plants of *A. artemisiifolia* in the field experiment of 2015 (20 days after the treatment)

Herbicides	Number of common ragweed plants, pcs / m^2	GST activity in leaves, nkat/g WW
Control (without treatment)	9.3±0.43	19.3±0.56
Harness (PRE)	3.6±0.33	29.8±0.68*
Harness (PRE)+Starane (POST)	0.9±0.14	21.1±0.53
Harness (PRE)+Lancelot (POST)	1.4±0.13	21.7±0.41*
Guardian-Tetra (PRE)	3.7±0.51	25.8±0.54*
Guardian-Tetra (POST)	1.3±0.24	17.4±0.38*
Stellar (POST)	0.8±0.14	21.4±0.63

Significance of the differences (P<0.05) was indicated by an asterisk (*).

However, the activity of glutathione S-transferase was the greatest in the plants treated with PRE-herbicides Harness and Guardian-Tetra, exceeding the control level by 1.5 and 1.4 times. Catalyzing the glutathione conjugation with xenobiotic, GTS provides one of the key ways of their detoxification (Cummins et al, 2013).

Since the intensive biochemical herbicides modification indicates the formation of a metabolic (non-target-site) resistance in the treated plants (Délye et al., 2015; Cummins, Eswards, 2010; Yuan et al., 2007), activation of glutathione S-transferase in leaves of common ragweed plants can testify to similar processes due to acetochlor-containing herbicides action (Khromykh, 2007).

In comparison with Harness individual action, sequential treatment with Harness and the POST-herbicides Starane and Lancelot was accompanied by a decrease in weed number 4.2 and 2.5 times respectively, and decrease in GST activity 1.5 times in both variants. Herbicides Starane and Lancelot have a different structure, but are combined by auxin-like mechanism of action. So, the use of the auxin-like POST herbicides can be an effective method of controlling *A. artemisiifolia* at the plots with long-lasting application of acetochlor.

As for the herbicide Guardian-Tetra, its foliar applying, in comparison with soil applying, was almost 3 times more effective in reducing the weed number. On the contrary, GST activity in the ragweed leaves was reduced due to POST treatment, amounting to about 90% of the control. It seems that terbutylazine (auxin-like component of the herbicide) did not affect the juvenile weed plants in the cause of soil-applying, which could be due to a decrease in the penetration and translocation of the herbicide, and also contribute to the development of resistance.

The polycomponent herbicide Stellar provided the greatest decrease in the number of the juvenile common ragweed plants together with the relatively low glutathione S-transferase activation, if compared with the first application on the experimental plots in 2012 (see Table 9.5). Obviously, the combined action of topramesone inhibiting the growth point of the weed plants and auxin-like component dicamba caused an irreversible imbalance of phytohormones and subsequent common ragweed elimination.

In our study, variability was established in the properties of seeds collected from control and herbicides-treated parent plants of *A. artemisiifolia* (Table 9.7).

Table 9.7

Effect of the herbicides on seed weight (average for 100 seeds) and glutathione S- transferase activity of common ragweed seeds in the field experiment

Herbicides	Seed weight, mg (M±SD)	GST activity in seeds, nkat/g DW
Control (without treatment)	4.11±0.46	55.3±0.50
Harness (PRE)+Starane (POST)	4.00±0.20	71.8±3.00*
Guardian-Tetra (PRE)	2.42±0.33*	63.8±2.50*
Guardian-Tetra (POST)	2.37±048*	59.6±0.31*
Milagro+Pic (tank mixture)	3.92±0.06	53.2±0.71*
Milagro+Lancelot (tank mixture)	4.70±0.42	54.6±2.12

Significance of the differences (P<0.05) was indicated by an asterisk (*).

Seed weight was declined on most plots, especially due to effect of the herbicide Guardian-Tetra: more than 40% below control both with the soil and foliar applying. An increase in seed weight of 14% was founded only on the plots where a tank mixture of the herbicides Milagro (inhibitor of ALS) and Lancelot (ALS-inhibiting together with auxin-like action) was applied.

Since seed size polymorphism is of adaptive importance (Harrison et al., 2007), variability of common ragweed seed weight like the previously revealed by Khromykh (2005; 2009a) the vital differentiation of the common ragweed seeds can contribute to

A. artemisiifolia population survival under the herbicide action. This conclusion is confirmed by the data of Matyukha et al (2003) that in the steppe Dnieper area during 1991 – 2001, with the annual herbicide application, the total number of weed seed germs in topsoil increased 1.5 times, while common ragweed seeds increased 2.4 times. Glutathione S-transferase activity in the common ragweed seeds from plants treated with herbicides Harness (PRE) + Starane (POST) and Guardian-Tetra (PRE and POST) exceeded the control level by 30%, 15% and 8%, respectively, indicating an increase in metabolic detoxification of different herbicide molecules in weed cells. The results are in agreement with the data of Yu and Powles (2014), according to which metabolic resistance is often manifested to the herbicides of various chemical classes and mechanisms of action. GST activation in the seeds of common ragweed can also be combined with the biosynthesis of specific isoforms which play a key role in the multiple herbicidal resistances (MHR), as Cummins et al (2013) noted.

Thus, the formation of the seeds by the annually herbicides-treated common ragweed plants in the actual field experiment obviously can indicate that the population of *A. artemisiifolia* is likely to have simultaneous resistance to several different modes of herbicide action, including auxin-like, inhibition of the fatty acids synthesis, and ALS inhibition.

Electrophoretic analysis showed that herbicidal treatment of the *A.*

artemisiifolia parent plants in the corn crops was accompanied by quantitative and qualitative changes in the protein compositions of the common ragweed seeds. Generally, the protein spectra of common ragweed seeds were represented by 15 components in the molecular weight range of 17.0 – 68.0 kD. Six constant zones with molecular weights of 21.9, 24.5, 33.9, 36.3, 45.7, and 56.2 kD were found in the polypeptide spectrum of seeds both from control and treated plants. Control common ragweed seeds contained polypeptides with 30.9 and 55.0 kD in addition to the constant protein components.

Combined action of the herbicides Harness and Starane led to the emergence of the components with 25.4, 28.8, and 43.7 kD, which were absent in the control spectrum, and to a sharp increase in the intensity of the constant bands.

Soil applying of herbicide Guardian-Tetra was accompanied by a noticeable weakening protein bands and even loss of components 30.9 and 55.0 kD, as well as the appearance of a component 67.7 kD which was absent in control common ragweed seeds. Foliar-applied Guardian-Tetra caused the disappearance of the proteins 30.9 and 45.7 kD, and the appearance of components with 37.2 and 53.7 kD.

The effect of tank mixtures of the herbicides Milagro+Pic and Milagro+Lancelot on the common ragweed plants was expressed in the intensification of the constant zones, together with the elimination of component 55.0 kD. Instead, the biosynthesis of proteins with molecular weights 25.4 and 53.7 kD was induced by the action of both tank mixtures. In addition, the mixture Milagro+Pic caused the appearance of the 43.7 kD component, whereas the second tank mixtures induced the accumulation of polypeptides 17.0, 28.8, and 37.2 kD.

Thus, the reduction of the zones in the protein spectra of seeds from herbicide- treated common ragweed plants was associated with components of 30.9, 45.7 and 55.0 kD. New zones appeared throughout the range of the protein spectra, but more often they were components with 25.4, 28.8, 43.7 and 53.7 kD.

The given data are in agreement with the results obtained by us earlier (Khromykh, 2005). When studying aftereffect of herbicides Frontier, Merlin, 2,4-D, Dialen, Cambio, and MaysTer used at that time to protect maize crops, it was also noted the appearance of new herbicide-specific polypeptide components in the protein spectra of the common ragweed seeds.

Summarizing all the results, electrophoretic analysis revealed some proteins which were inherent in the common ragweed seeds collected from the treated plants only, indicating an adaptive directionality of the changes in the polypeptide spectra of seeds of *A. artemisiifolia* due to herbicide action of parent plants.

Common ragweed seeds collected both from the herbicides-treated and control parent plants were prepared for germination. Seeds were kept for 2 months in wet sand at 4°C. After that, seeds were germinated in plastic cups filled with a mixture of soil and sand (1:1) in a greenhouse with a 12-h photoperiod at 22°C. In order to reveal whether the changes identified in the seeds can manifest themselves in next-generation plants, we germinated in a greenhouse the common ragweed seeds harvested from herbicides treated plants.

In an experiment conducted in 2005, we investigated the next generation plants from seeds harvested from plants treated with herbicides Trophy (PRE) + 2.4-D (POST), Merlin (PRE), Frontier (PRE)+ Cambio (POST), and Milagro (POST). A significant difference in the growth and development of juvenile common ragweed plants was established.

Control plants of common ragweed have from two to three pairs of true leaves. At the same time, the juvenile plants of next generation from treated parent plants have three to four pairs of true leaves (aftereffect of the herbicides Trophy + 2.4-D, Merlin, and Frontier + Cambio), and even five to six pairs of true leaves (aftereffect of the herbicide Milagro).

Moreover, an unexpected feature was discovered in the next generation from the herbicides-treated plants. It turned out that the juvenile plants of the next generation from parent plants that survived the treatment with herbicides Frontier + Cambio, and Milagro as well entered the budding stage. Thus, the descendants of herbicide-treated common ragweed plants developed faster than the control plants and were able to bloom while staying in a juvenile state. It is obvious that the accelerated transition to the reproductive stage of ontogenesis, found in the juvenile common ragweed plants, is the evidence of the adaptation of *A. artemisiifolia* population to the unfavorable annual effects of the herbicides.

Another greenhouse experiment was conducted in 2016, and a significant difference in the growth and development of 21-day common ragweed seedlings was established. While seedlings from control seeds had 1 pair of true leaves, the next generation plants from weeds that survived successive treatment with the herbicides Harness + Starane were able to form 3 pairs of true leaves. At the same time, seedlings grown from seeds harvested on plots treated with the tank mixture (Milagro+Lancelot) had the seed leaves only.

Thus, intensive herbicidal treatment increased the differentiation of common ragweed seeds and seedlings, which is consistent with the data of Vencill et al (2012) on the increase in weed population diversity due to herbicidal pressure. In our opinion, similar variability of *A. artemisiifolia* seeds germination are able to provide more opportunities for the survival of weed population in the agrocenosis where a set of weed control methods with a clear timeframe is applied.

In order to evaluate the susceptibility of the common ragweed seeds from the herbicides-treated and control parent plants to the soil herbicides action, the model experiment was conducted. The seeds (100 pcs in 3 replicates) were germinated during 8 days in the Petri dishes in the solutions of the herbicides Harness and Frontier, and the differences in effectiveness of germination were revealed.

So, the decrease in sensitivity to both chloracetanilide herbicides was found in the germinating seeds harvested from the herbicide-treated common ragweed plants. In comparison with the control, seeds from the plants that survived the treatment with herbicides Trophy (PRE) + 2.4-D (POST) and Frontier (PRE)+Cambio (POST) showed less sensitivity to Harness at 12 and 11 times, and to Frontier 4 and 5 times respectively. Given the fact that chloracetanilide herbicides were introduced into crops for several consecutive years, a decrease in the sensitivity of germinating seeds to this mechanism of herbicide action can be considered as a natural result of adaptive changes in the population of *A. artemisiifolia*.

In the greenhouse experiments with the seeds collected from the herbicide-treated plants, the significant differences in the antioxidant enzymes activity were established in the leaves of the common ragweed plants of future generation grown without the herbicide treatment. Activity of superoxide dismutase (SOD), peroxidase (POD), polyphenol oxidase (PPO), and glutathione S-transferase (GST) in leaves of all seedlings grown from the seeds collected from the herbicides-treated plants exceeds the control level (Table 9.9).

Table 9.9

Aftereffect of the herbicides treatment of the parent plants on the enzyme activity of the untreated future generation plants of *A. artemisiifolia*

Herbicides	SOD activity, % of control	POD activity, % of control	PPO activity, % of control	GST activity, % of control
Harness	110.7	147.2*	254.7*	186.8*
Frontier	198.5*	140.5*	255.6*	129.4*
Merlin	229.3*	122.8*	219.5*	109.1
MaysTer	146.5*	132.5*	240.7*	240.3*

Significance of the differences ($P<0.05$) was indicated by an asterisk (*).

In particular, superoxide dismutase and peroxidase activities were above control by 11 – 129 % and 23 – 47% respectively. The increase in polyphenol oxidase activity was more significant and reached 256% above the control level. The activation of GST was in the interval 29 – 140% above the control level. It must be noted that the increase in activity of the antioxidant enzymes and glutathione S-transferase was induced by the after-action of the herbicides having different mechanisms of action.

It is likely that the activation of the antioxidant system in next-generation common ragweed plant cells is intended to enhance the protection against the oxidative action of the toxic compounds. Given the simultaneous enhancement of the ability of plants to degrade xenobiotics through the activation of GST, it can be assumed that each of these processes contribute to the emergence of metabolic resistance of *A. artemisiifolia*. Our assumption coincides with the opinion of Cummins and Edwards (2010) that the mechanisms of detoxification, underlying the metabolic resistance of the weeds, also extend to protecting the cell from secondary oxidative damage caused by the herbicides. Such damage can be eliminated by degradation of the toxins formed in the plant cells due to the oxidation and destruction of cell membranes.

In general, a high level of enzymatic antioxidant activity is characteristic for the plants with a high degree of sustainability to the adverse environmental conditions. Consequently, the results obtained suggest that due to the higher activity of antioxidant enzymes, the plants of the next generation of *A. artemisiifolia* have increased tolerance to stress factors, including herbicides.

Isoelectric focusing method was used to investigate the changes of composition of the peroxidase molecular forms in seedlings grown in a greenhouse from the common ragweed seeds harvested in the field experiment. Components having isoelectric points (pI) of 4.35 and 4.87 were constant for the composition of peroxidase molecular forms of seedlings grown from seeds collected both from the herbicides- treated and control parent plants of common ragweed. The after-action of herbicides Harness (PRE) + Starane (POST), and tank mixture (Milagro+Pic) as well was manifested in a significant increase in the expressiveness of isoform with pI 4.35. In addition, peroxidase isoforms with pI 4.42, 4.50 and 4.55 were found in the next generation of common ragweed plants from all treated plots, whereas these isoforms were absent in control seedlings. So, the next generation plants of *A. artemisiifolia* have a specific composition of peroxidase isoforms determined by the herbicides modes of action on the parent plants of common ragweed in the field experiment. Given the key role of peroxidases in antioxidant plant protection, it can be assumed that the next generation of common ragweed plants inherited high antioxidant activity induced by the herbicidal treatment of common ragweed parent plants.

Gas chromatographic analysis showed a significant increase in the fraction of long-chain hydrocarbons in cuticular waxes composition of the next-generation common ragweed plants (Khromykh et al., 2009b). Thus, the annual herbicide treatment of *A. artemisiifolia* L. population caused physiological and biochemical changes in parent weed plants that had a manifestation in the properties of next generation common ragweed plants even without herbicide action. Such changes obviously reflect the increased metabolic herbicide resistance of common ragweed population and can serve to illustrate the process of evolution of weeds, which was noted by Powles and Yu (2010).

The herbicides with new modes of action have not been developed for the last 30 years (Heap, 2014), so weakening herbicide resistance of *A. artemisiifolia* and other dicotyledonous weeds as well can be achieved by combining known mechanisms of action. In addition, the herbicide treatment of the sown fields should be integrated into a set of weed management in crops, as shown in Table 9.10.

Table 9.10

Recommended approaches and methods for controlling common ragweed infestation in the corn crops

Option	Required level for effective weeds control
Cultural control	Full rotation, including black fallow Cleaning of seed grain from weed seeds
Mechanical control	Stubble ploughing at 8-10 cm, and repeated at 10-12cm Spring harrowing, inter-row cultivation
Herbicide rotation	Annual using another mode of action
Combined application of the herbicides	Two or more modes of herbicide action including the use of PRE (chloracetanilide) and POST (auxin-like) herbicides
Herbicides mix	Use of the tank mixtures (ALS-inhibiting herbicide together with auxin-like herbicide)

Cultural plants do not belong to the target objects of the action of herbicides, but under the conditions of agrocenosis they are exposed to their toxic effects. The effect of the herbicides on crops can be accompanied by the changes in linear growth and the development of plants, the manifestation of the chlorosis, and various violations of the physiological functions, including the functioning of the photosynthetic apparatus (Kopsell et al., 2011). Regardless of a wide range of the active substances and the mechanisms of herbicides action, their penetration into the plant cells causes the development of oxidative stress.

In the recent years, sufficient evidence has been obtained for the existence of the herbicides-induced oxidative stress in a number of the cultivated plants. For example, the oxidative stress accompanied the action of herbicide 2,4-D on the pea leaves (MeCarthy-Suarez et al., 2001) as well as the action of herbicide Granstar on the leaves of wheat, rye and corn (Gar'kova et al., 2011).

Oxidative stress was manifested in the meristem cells of maize roots under the action of the herbicide Galoxyfopmethyl (Palanytsa et al., 2009), as well as in maize leaves under the action of the herbicides Norflurazon (Jung, 2003) and Rimsulfuron (Hassan, Alla, 2005).

The action of the herbicide Glyphosate caused the oxidative stress in the seedlings of corn (Sergiev et al., 2006) and peas (Miteva et al., 2010).

The treatment with the Paraquat herbicide led to the development of oxidative stress in the wheat plants (Ekmekci, Terzioglu, 2005).

In our work, we set out to identify the long-term consequences of herbicide treatment of cereals. For this purpose, the features of metabolic processes were investigated in the plants of the following generation grown from the seeds collected from the plants which were treated with herbicides in the field.

In the model experiment, the features of the antioxidant system and the photosynthetic apparatus were studied in the winter wheat seedlings (*Triticum aestivum* L., Zemlyachka cultivar), grown from the seeds harvested in crops from the herbicides-treated parental plants. The herbicide-induced changes in the activity of the antioxidant enzymes superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD) were revealed (Table 9.11).

The most significant (1.8 – 4.1 times higher the control level) were the changes in the activity of SOD in the seedlings from seeds collected on the herbicide-treated plots. Activation of the enzyme indicates an intensification of the process of the superoxide anion dismutation and the formation of hydrogen peroxide in the cells of the second-generation winter wheat plants.

At the same time, the changes in the activity of the enzymes that must utilize the excess hydrogen peroxide were much less pronounced. In particular, catalase activity increased by an average of 9 – 13% above the control level. The greatest activation of catalase was due to the aftereffect of the two-component herbicide Ellay-Super, as well as the combined action of the herbicides Esteron + Puma-Super.

Table 9.11

After-action of the herbicides on the functioning of the antioxidant system in the winter wheat seedlings (Zemlyachka cultivar)

Herbicides	Enzyme activity, % of control		
	SOD	POD	CAT
Granstar (POST)	210.2*	97.8	110.2
Grodil-Maxi (POST)	296.3*	116.4*	109.3
Ellay-Super (POST)	390.2*	69.8*	113.2*
Esteron (POST)	179.5*	84.7*	113.4*
Esteron (POST) + Puma-Super (POST) (tank mixture)	406.4*	71.2*	112.7*
Mastac (POST)	182.0*	73.1*	111.0*

Significance of the differences ($P<0.05$) was indicated by an asterisk (*).

Peroxidase activity in the leaves of wheat plants of the next generation varied in different directions relative to the control level. The POD activity exceeded the control by 8% in the case of the aftereffect of the Grodil-Maxi multicomponent herbicide, equaled the control in the case of the aftereffect of the Granstar herbicide, and in all other cases the enzyme activity was below the control level by 12-34%.

The correlation analysis of the study results made it possible to establish a high degree of interconnection of activity of the SOD, CAT, and POD in the leaves of the control wheat plants of the next generation (r =

0.99).

The effects of the after-action of the herbicides Granstar, Esteron and Mastac were expressed in a slight violation of the coordinated functioning of the antioxidant system in seedlings, which is confirmed by high correlation coefficients (r = 0.92, r = 0.96, and r = 0.91 respectively).

At the same time, a more significant change in the correlation coefficients between the activities of the antioxidant enzymes was revealed due to the aftereffect of the polycomponent herbicides. In these cases, the correlation coefficients were reduced (r = 0.71 due to the aftereffect of the herbicide) or they acquired negative values (r = -

0.13 and r = -0.08 respectively due to the aftereffect of the herbicide Ellay-Super, and the tank mixture of the herbicides Esteron and Puma-Super).

That is, the aftereffects of herbicide treatment of wheat crops manifested in the violation of the coordination of antioxidant protection enzymes (SOD, CAT, and POD) in the leaves of the next generation plants, with the most pronounced changes followed by the influence of polycomponent herbicides and combined herbicides treatment of the parent plants.

In addition, it was established that in the leaves of all wheat seedlings grown from the seeds collected from the herbicides-treated wheat plants, the content of chlorophyll *a* (Chl *a*) and chlorophyll *b* (Chl *b*) and their ratios significantly differed from the control values (Table 9.12).

The total content of the chlorophylls in the control seedlings was exceeded in all the experimental variants (by 6 – 40%), except for the aftereffect of the combined action of the herbicides Esteron and Puma-Super, which caused a decrease in the chlorophylls total content by 6.2%.

The greatest increase in the content of chlorophyll *a* was observed as a result of the after-effects of the herbicides Granstar, Ellay-Super, and Mastac (by 42.4%, 36.2%, and 41.0%, respectively).

The after-action of the herbicides Grodil-Maxi and Esterone caused a less pronounced increase in the content of chlorophyll *a* (respectively by 8% and 14% above control). An insignificant decrease (near 6%) in the content of chlorophyll *a* was caused by the aftereffect of the combined action of the herbicides Esteron and Puma-Super used as the tank mixture.

The content of chlorophyll *b* in the leaves of the experimental seedlings was reduced insignificantly compared with the control in the case of the aftereffects of the herbicides Granstar and Ellay-Super. The effects of the after-action of the herbicides Esteron and Mastac were more significant and caused the decrease in chlorophyll *b* content respectively by 11% and 30% below the control level.

Table 9.12

After-action of the herbicides on the content of chlorophyll in the winter wheat seedlings (Zemlyachka cultivar)

Herbicides	Chl *a*, mg/L	Chl *b*, mg/L	Total chlorophyll content, % of control	Ratio Chl *a*/ Chl *b*
Control	4.08±0.13	0.22±0.01	-	18.2
Granstar (POST)	5,81±0.17*	0.21±0.01	140.0	27.3
Grodil-Maxi (POST)	4.43±0.13	0.12±0.01*	105.7	36.6
Ellay-Super (POST)	5.56±0.14*	0.22±0.01	134.2	25.5
Esteron (POST)	4.65±0.14*	0.16±0.01*	111.7	29.4
Esteron + Puma-Super (POST, tank mixture)	3.94±0.12	0.10±0.01*	93.8	40.2
Mastac (POST)	5.75±0.17*	0.20±0.01*	138.4	28.9

Significance of the differences ($P<0.05$) was indicated by an asterisk (*).

The after-action of the multicomponent herbicide Grodil-Maxi as well as the after-effect of the combined influence of the herbicides Esteron and Puma-Super were accompanied by the largest decrease in the content of chlorophyll *b* in the leaves of the experimental seedlings (by 46% and 56% of control respectively).

It must be noted that the both last variants of the herbicides treatment provided for the presence of an antidote Mephenyr-Diethyl, which is designed to protect the cultural plants from the toxic effects of the herbicides. The results obtained showed that the protective effect of the antidote does not extend to the possibility of the aftereffect of herbicide treatment of crops in the properties of the wheat plants of the following generation.

Further, the excess of the control ratio of the chlorophyll forms (Chl *a*/ Chl *b*) in

1.4 – 2.2 times was revealed in the leaves of all the next-generation wheat plants. It should be noted that the greatest increase in the ratio of chlorophylls was also established in the case of the after-action of the multi-component herbicides containing the antidote (Khromykh et al., 2013b).

The observed deviations cannot be unambiguously assessed within the framework of the study due to the complexity of the interpretation. The increase in the ratio of Chl *a*/ Chl *b,* on the one hand, can serve as a sign of a high potential intensity of photosynthesis (Saglam et al., 2011), but on the other hand, the increase in the content of chlorophyll *b* is associated with the protective function of a pigment that can shield photosynthetic active chlorophyll *a* from adverse effects (Havaux, 1998). Therefore additional studies are needed to correctly assess the identified changes of the ratio of the chlorophyll forms (Chl *a*/ Chl *b*) in the leaves of the wheat plants of the following generation.

In general, the study results confirmed the previously established influence of the herbicides on the cultivated plants, manifesting themselves in the properties of the ripe seeds or the plants of the next generation. Thus, the increase in the activity of superoxide dismutase together with decrease in the activity of peroxidase, catalase and the content of reduced glutathione were observed in maize grain (Khromykh et al., 2011). In addition, the significant changes in the activity of the antioxidant enzymes were revealed in the wheat grains indicating the presence of oxidative stress in the seed cells (Matyukha et al., 2012).

In the field experiment the dynamic of the antioxidant enzymes activity was observed both in roots and leaves of maize (*Zea mays* L., cult. Kadr 267 MV) plants from the plots treated with the soil-applied herbicides Harness at a dose 2.5 L/ha, Frontier at a dose 1.5 L/ha, and Merlin at a dose 0.13 kg/ha. The objective of this study was to investigate whether the soil herbicides cause the activation of maize antioxidant enzymes superoxide dismutase (SOD), peroxidase (POD), and catalase (CAT) during early stage of ontogenesis only, or the herbicides treatment has a prolonged effect on the defense system of plants.

The activity of the antioxidant enzymes both in maize roots and leaves exceeds control level significantly ($P < 0.05$) during early ontogenetic phase (Table 9.13).

Table 9.13

Effect of herbicides on the enzymes activity in maize (cultivar Kadr 267 MV) vegetative organs during phase of shoots emergence

Herbicide	Activity of the antioxidant enzymes, % of control					
	SOD		POD		CAT	
	root	leaves	root	leaves	root	leaves
Harness	138.9	154.3	135.7	149.1	137.7	152.1
Frontier	152.2	158.6	139.1	141.8	139.2	155.2
Merlin	145.6	160.4	142.9	145.3	138.3	155.8

Increase in activity of all antioxidant enzymes was more notable in the leaves of the plants due to the action of each of the herbicides which indicates the oxidative stress development in the maize shoots.

Into the phase of 3-5 leaves, the antioxidant activity in herbicide-treated maize plants continued to exceed the control (Table 9.14). It is obvious the tendency towards a greater degree of enzymes activation in maize leaves was observed in the developmental phase of 3-5 leaves, which indicates herbicide-induced oxidative stress in photosynthetic organs of plants.

In florescence, the excess of the control activity of enzymes was revealed both in maize roots and leaves (Table 9.15).

In our study, the prolonged soil herbicides action on the maize antioxidant enzymes activity was confirmed. The prevail enhancing each enzyme activity was observed under the Merlin action both in maize roots and leaves. This effect should be attributed to the specificity of Merlin mode of action with the ability to reactivation in the soil. Maize plants adaptation to the stressful herbicides treatment was accompanied by the antioxidant system up-regulation during shoots emergence, 3–5 leaves phase, and plant florescence.

Table 9.14

Effect of herbicides on the enzymes activity in maize (cultivar Kadr 267 MV) vegetative organs during phase of 3-5 leaves

Herbicide	Activity of the antioxidant enzymes, % of control					
	SOD		POD		CAT	
	root	leaves	root	leaves	root	leaves
Harness	152.0	160.3	149.2	162.5	149.2	161.4
Frontier	153.1	161.0	153.1	163.4	151.2	162.5
Merlin	159.4	161.6	154.8	165.0	153.2	163.3

Acetochlor is an active ingredient of the several widely used herbicides, including the Harness. These herbicides cause the disruption of the growth and development of dicotyledonous weeds, but also can have the toxic effects on the non-target species, including the cultivated plants. Harness is used as a pre-sowing (PRE) herbicide in the corn crops, so the maize grains undergo contact with the herbicide during germination. It is known that plants of the species Zea mays L. have the ability to biodegrade the herbicides through the activation of the glutathione-dependent system (Neuefeind et al., 1977; DeRidder et al., 2002).

In our study, high-performance liquid chromatography (HPLC) method was used to determine the content of acetochlor and its metabolites in organs of the maize seedlings in early stage of ontogeny. In model experiment, the maize grains of hybrid

Dneprovsky-310 were exposed to the action of herbicide Harness 0.01% solution in the Petri dishes during 12 days.

Table 9.15

Effect of herbicides on the enzymes activity in maize (cultivar Kadr 267 MV) vegetative organs during phase of florescence

Herbicide	Activity of the antioxidant enzymes, % of control					
	SOD		POD		CAT	
	root	leaves	root	leaves	root	leaves
Harness	155.7	164.0	161.7	170.7	160.1	169.1
Frontier	150.2	164.9	160.2	172.3	156.3	171.9
Merlin	162.5	166.1	162.3	173.4	162.8	174.6

Sampling was carried out daily, separating the roots and shoots from grain and drying the samples. Then the content of acetochlor was measured in organs of the maize seedlings along the experiment (Table 9.16).

Table 9.16

Dynamics of the accumulation and utilization of acetochlor in the organs of maize seedlings of the Dneprovsky-310 hybrid

Organ of the seedlings	Content of acetochlor, mcg/100g DW							
	Day of the experiment							
	II	III	IV	V	VI	VII	VIII	IX
Grown grain	0.46	0.31	0.20	0.11	trace	-	-	-
Roots	-	9.73	6.31	2.00	7.82	6.62	0.70	trace
Shoots	-	trace	3.83	0.88	5.94	8.43	7.30	3.90

It was found out that the processes of accumulation and metabolism of acetochlor were different in different organs of seedlings. It was established, that in the grown grains herbicide was revealed already on the second day of the experiment, and then its content gradually decreased and was not detected after the sixth day.

The maximum amount of acetochlor was determined in the roots and the shoots of maize seedlings. However the accumulation of herbicide in the shoots was less significant than in the roots, and maximum content in the shoots reached only 87% of the herbicide content in the roots.

In the roots, the highest content of herbicide was found on the third day of the experiment, and then it fell sharply until the fifth day (up to 21% of the maximum), after which it again increased up to 80% of the maximum, and decreased again.

In the shoots, acetochlor was detected only on the third day of the experiment, the accumulation increased markedly on the fourth day, but on the fifth day the herbicide content dropped sharply. Maximum content of acetochlor in the shoots was revealed on the seventh day of the experiment, while at the end of the experiment, there was a gradual decrease in the herbicide content in shoots of maize seedlings.

The results obtained showed that the dynamics of herbicide accumulation in the roots and the shoots of maize seedlings was biphasic in nature. It is possible that such dynamics of the content of acetochlor in the roots and shoots of seedlings is due to the intensification of the herbicide detoxification processes in plants upon their transition to autotrophic nutrition.

In addition, two metabolites of acetochlor, designated M1 and M2, were identified in the experiment. Metabolites had a shorter retention time in chromatography, and probably represented different stages of the destruction of the herbicide in plant cells. Metabolites were detected in different organs of the seedlings: metabolite M1 was contained in the roots and shoots, while metabolite M2 was revealed in the grown grains only.

So, the active process of detoxification of acetochlor took place in all organs of maize seedlings, therefore the accumulation of herbicide was short-lived in plant tissues. Nevertheless, the metabolic changes induced by acetochlor in the plant cells had a negative impact on the rate of the growth and development of the maize seedlings in the early stage of ontogenesis (Khromykh, Vinnichenko, 2000).

Herbicide treatment of crops occupies a leading place among methods of weed control in modern agrarian sector in Ukraine. The costs associated with the use of herbicides can reach 15 – 20% of the cost of growing crops. Despite the long period of use of herbicides, the issue of environmental safety has not received an unequivocal assessment of specialists to date.

The need for herbicide treatment is dictated by the fact that the decline in crop yields due to competition created by weeds can reach 20 – 50% in continuous crops and 40 – 80% in row crops (Ivashchenko, 2001). In addition, in favor of herbicides is evidence a high contamination of 80% of sown areas in Ukraine with seed germs of weeds, reaching 1.14 - 1.47 billion pieces / ha.

On the other hand, the herbicide method of weed control is often not sufficiently effective. For example, it was established (Matyukha et al., 2003) that in the steppe Dnieper, against the background of the annual application of the herbicides in the period 1991-2001, the total ccontamination of the soil arable layer by seed germs of weeds increased by 1.5 times, while contamination with common ragweed (*Ambrosia artemisiifolia* L.) seeds by 2.4 times.

Special analysis is required to be devoted to the problem of the herbicide influence on the ontogeny of cultivated plants, despite the fact that the companies producing herbicides invariably point to the absence of toxic effects of herbicides on non-target plant species. Meanwhile, in recent years, many studies have identified the negative effects of action of the herbicides, widely used in the previous period (2,4-D, Atrazine, Acenite and others). It should be noted a decrease in plants height, leaf surface area and seed productivity of maize; increase in sterility of pollen of sorghum (Oginova, 2006); accumulation of a residual amount of herbicides and their metabolites in the cultivated plants (Khromykh, Vinnichenko, 2000).

In our study, some properties of corn seeds were studied in order to identify the aftereffects of crop treatment with the new selective herbicides Harness, Proponite, MaysTer, and Stellar. The object of the study was a ripe corn (*Zea mays* L.) seeds of the hybrid of Orzhitsa 237 MW. A field experiment was conducted in 2010 at the experimental plots of Institute of Grain Crops (Dnipro, Ukraine). The soil cover on the plots was represented by ordinary chernozem containing 4-5% humus.

Herbicides were applied in regulated doses: Harness – 2.5 l/ ha, MaysTer and Stellar – at 1.25 l / ha, and Proponite – 2.0 l / ha.

A decrease in the mass of 1000 grains of maize, as well as a decrease in grain protein content, was revealed (Table 9.17).

The lowest decrease in the weight of seeds (2.4% below control) and protein content (by 7.6%) was detected due to the action of Harness, while the largest decrease (respectively, 4.2% and 13.1%) – because of the action of herbicide MaysTer. The results obtained are in agreement with the known data on the negative effects of herbicides, including glyphosate, which caused a decrease in germination and weight of pea seedlings (Baig et al., 2003), as well as a damage in growth and micronutrient status of soybean (Bott et al., 2008).

Table 9.17

Influence of the herbicides treatment of corn sowings on mature seed of the hybrid Orzhitsa 237 MW

Herbicides	Mass of 1000 grains, g (M±SD)	P	Water-soluble rotein content, g/100g (M±SD)	P
Control	205.6±2.6	-	1.72±0.01	-
Harness (PRE)	200.8±2.4	0.435	1.58±0.01	0.010
MaysTer (POST)	197.1±2.5	0.002	1.49±0.01	0.002
Stellar (POST)	198.3±2.4	0.006	1.58±0.01	0.006
Proponite (PRE)	199.3±2.4	0.010	1.57±0.01	0.003

Electrophoretic analysis revealed herbicide-induced quantitative and qualitative changes in the soluble proteins composition of corn grain from treated parent plants. The number of protein zones, characteristic for control seeds (31 polypeptides), did not change under the influence of herbicide MaysTer, increased to 37 zones due to the influence of Proponite, and sharply decreased due to the treatment with herbicides Harness and Stellar (respectively, up to 13 and 6 zones). The treatment with two last herbicides resulted in a decrease in the content or disappearance of proteins in the range from 30 to 74 kD. On the contrary, under the Proponite influence, new polypeptides were found in the range of 59 – 74 kD. The effect of MaysTer herbicide was reflected in the proteins with medium and low molecular weight: polypeptide 35.5 kD appeared, but proteins 34.7 and 40.7 kD disappeared. These changes in the expression of seed proteins indicate a significant rearrangement of the metabolism of herbicide-treated maize plants in response to the stresses of herbicides.

The adaptive plants potential to the action of any stressor can be realized under the condition of coordinated functioning of protective enzyme systems, including superoxide dismutase (SOD), peroxidase and catalase.

In maize seeds from herbicide-treated plants, the SOD activity exceeded the control by 2.0 – 5.6 times (Table 9.18), which is accompanied as is known (Minibaeva, Gordon, 2003) by the accumulation of excess hydrogen peroxide in plant cells.

Table 9.18

Effect of herbicide treatment of corn crops on the antioxidant activity (M ± SD) of the seeds of hybrid Orzhitsa 237MB

Herbicides	SOD activity, Unit/g min	CAT activity, mM H_2O_2/g min	POD activity, Unit/g min
Control	3.7±0.09	3.4±0.01	2.6±0.01
Harness (PRE)	9.7±0.05	1.3±0.06	1.9±0.01
MaysTer (POST)	7.3±0.03	1.4±0.01	2.1±0.01
Stellar (POST)	20.8±0.29	1.2±0.01	1.2±0.01
Proponite (PRE)	7.3±0.07	1.4±0.03	1.2±0.01

At the same time, the activity of enzymes capable of reducing the content of the toxic metabolite was reliably ($P < 0.05$ in all cases) declined in comparison with the control: peroxidase activity was 1.3 – 2.3 times, and catalase activity 2.4 – 2.9 times.

The results are in agreement with the data of other authors who found multidirectional changes in the activity of antioxidant enzymes in maize leaves due to the effects of the herbicide Norflurazon (Jung, 2003) and also in 8-day old wheat sprouts after treatment with herbicide Paraquat (Ekmerkci et al., 2005).

The significant disruptions in the functioning of the antioxidant system of maize seeds can be the cause of a weakening of the protective properties of the grain and the deterioration in its quality due to the herbicidal treatment of parent (Khromykh et al., 2011b).

Plants of *Zea mays* species are capable of biodegrading herbicides that have penetrated into cells by activating a glutathione-dependent enzyme system (Neuefeind et al., 1977). Therefore, the level of activity of this protective system in the grain reflects the degree of detoxification of herbicides in maize plants during seed formation.

In our study, a significant decrease in the efficiency of the glutathione-dependent system functioning in the seeds from herbicides-treated plant was established (Table 9.19).

Table 9.19

Effect of herbicide treatment of corn sowings on GSH content and GST activity in the seeds of the hybrid Orzhitsa 237 MW

Herbicides	GSH content, nM/g (M±SD)	P	GST activity, nkat/g (M±SD)	P
Control	863.2±36.3	-	5.3±0.05	-
Harness (PRE)	505.4±48.1	0.015	3.5±0.11	0.001
MaysTer (POST)	605.3±20.8	0.029	4.5±0.11	0.026
Stellar (POST)	635.9±12.4	0.042	3.1±0.02	0.003
Proponite (PRE)	545.3±83.6	0.043	4.2±0.10	0.021

Compared with the control level, the content of reduced glutathione (GSH) in the seeds from the herbicide-treated maize plants was declined by 1.4 – 1.7 times, and the activity of glutathione S-transferase (GST) was reduced by 1.2 – 1.7 times, indicating serious deviations in the functioning of the glutathione-dependent plant protective system.

The most declines in the content of the reduced glutathione were caused by the after-action of the soil-applying herbicides Harness (up to 59% of the control level) and Proponite (up to 63% of the control level).

As for glutathione S-transferase, the enzyme activities were decreased mostly due to the aftereffects of the herbicide Harness (up to 66% of the control level) and the herbicide Stellar (up to 58% of the control level).

So, the glutathione-dependent system responsible for the biodegradation of the toxic components of various origins has been inhibited in the corn grain cells due to the action of the herbicides on the parent plants.

Reduction of the pool of reduced glutathione could be due to its conjugation with the herbicides, as well as disturbances in the process of its biosynthesis. In any case, a decrease in the content of this thiol compound results in a decline in the redox status of plant cells (Rausch et al., 2007; Szalai et al., 2009) and a weakening in plant resistance to stress factors.

Thus, the results of the study showed that the effects of the herbicide treatment of the corn sowings were reflected in the significant changes of the maize seeds properties, which indicate the sensitivity of the Orzhitsa 237 MB hybrid to the phytotoxic action of the herbicides.

In the State register of plant varieties suitable for distribution in Ukraine, the Orzhitsa 237MV hybrid was registered in 2010 as a promising hybrid for grain production. This means that the quality of the grain of this hybrid should meet the highest requirements and fully meet the standards.

Therefore, the deviations from the control indexes of the seeds caused by the action of the herbicides indicated the deterioration in the yield class of the studied maize hybrid. Orzhitsa 237 MV hybrid is characterized by high yield and resistance to lodging, cold, drought and pests.

The study results indicate the expediency of testing promising hybrids also for sensitivity to the herbicides with the different modes of action.

The aim of the work was to identify the aftereffects of the herbicidal treatment of crops of the cultivated plants. To this end, the physiological-biochemical properties of the mature wheat grain collected on the fields treated with the herbicides having the different mechanisms of phytotoxic action were carried out.

In the field experiments conducted in the winter wheat crops of the Zemlyachka cultivar, the herbicides were introduced at the plots for the post-emergence treatment (POST herbicides) in the phase of the tillering of the wheat plants in the following doses: Granstar in a dose 25 g/ha, Grodil-Maxi at a dose 100 mL/ha, tank mixture of the herbicides Esteron and Puma-Super at the equal doses 0.8 L/ha, and a tank mixture of the herbicides Granstar in a dose 15 g/ha and Esteron in a dose 0.6 L/ha. Any herbicides were applied at the control plots.

The reduction in the mass of 1000 grains was detected due to the effect of all the herbicides except Esteron (Table 9.20), while the total protein content of the grain increased slightly, excluding the effect of the tank mix.

Table 9. 20

Changes in the ripe grain quality of the winter wheat (Zemlyachka cultivar) due to the herbicidal treatment of the crops

Herbicides	1000 grains weight (M±SD), g	Water-soluble protein content, g/100g DW
Control	28.2±0.42	10.75±0.37
Granstar	27.5±0.13*	11.10±0.35
Granstar + Esteron (tank mix)	27.1±0.35*	10.21±0.32
Grodil-Maxi	26.4±0.23*	10.83±0.37
Esteron + Puma-Super (tank mix)	28.3±0.55	11.00±0.31

Significance of the differences ($P<0.05$) was indicated by an asterisk (*).

The obtained results are in accordance with the data about the increase in the total protein content (Suek et al., 2009; Grundy et al., 1996), the change in the weight of 1000 grains and the content of gluten (Mellado, Pedreros, 2005), and the sedimentation index of the ripe grain (Stankowski et al., 2010) which were detected in the seeds of winter and spring wheat varieties due to the action of the herbicides belonging to the different classes.

The after-effects of the herbicidal treatment of the winter wheat crops were manifested in the growth (relative to control) of the grain germination energy together with the deterioration of germination index (Table 9.21).

Table 9.21

Changes in the seed vigor and germination indexes of the ripe winter wheat grain (Zemlyachka cultivar) due to the herbicidal treatment of the crops

Herbicides	Seed vigor, %	Germination capacity, %
Control	68.7±3.9	89.3±3.1
Granstar	76.7±3.8*	84.7±3.6
Granstar + Esteron (tank mix)	68.9±4.6	76.7±4.4*
Grodil-Maxi	77.3±4.3*	86.7±4.2
Esteron + Puma-Super (tank mix)	79.3±3.6*	85.3±3.3

Significance of the differences ($P<0.05$) was indicated by an asterisk (*).

The especially noticeable shifts of the substantial vital indicators of the winter wheat seed were observed in the cases of the treatment of the crops by the tank mixture of the herbicides. Thus, the greatest increase in the seed vigor was caused due to the after-action of the tank mix of the herbicides Esteron + Puma-Super (15.4% above the control). However, the lowest level of the germinating ability of the winter wheat seeds was indicated due to the after-action of the herbicides tank mix Granstar + Esteron (14.1% below the control level). The presence of the Esteron herbicide in each of the tank mixtures suggests that the winter wheat plants showed sensitivity to the auxin-like mechanism of herbicidal action.

The state of the activity of the antioxidant enzymes in ripe grains indicated the functional changes caused by the influence of the herbicides on the parent winter wheat plants (Table 9.22).

The most notable deviations from the control level of the activity of antioxidant enzymes in the grains were associated with the after-effects of the treatment of the parental plants with both tank mixtures of the herbicides. So, the combined influence of two or more the phytotoxic components was not neutral for cultivated plants, even in the presence of an antidote in the composition of the herbicides. The sharp decrease in the activity of peroxidase due to treatment with the tank mix of the herbicides Esteron and Puma-Super as well as the sharp increase in the activity of glutathione peroxidase due to the treatment with the herbicides Granstar and Esteron (tank mix) both indicate the interruption of the flow of oxidation-reducing processes in the grain of winter wheat.

Table 9.22

After-effects of herbicidal treatment of crops on the activity of peroxidase and glutathione-peroxidase in the grain of winter wheat (Zemlyachka cultivar)

Herbicides	Peroxidase activity, % of control	Glutathione-peroxidase activity, % of control
Granstar	79.9*	111.6
Granstar + Esteron (tank mix)	114.5*	152.5*
Grodil-Maxi	83.9*	104.6
Esteron + Puma-Super (tank mix)	70.6*	118.2*

Significance of the differences (P<0.05) was indicated by an asterisk (*).

The results of the study indicate the need to make a conclusion that the morphometric parameters should not be considered an exhaustive characteristic of the quality of the ripe grain. Physiological and biochemical parameters should be taken into account in order to ascertain all the aspects of the aftereffects of herbicide influence and to argue the choice of a variant of the crops herbicide treatment.

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CHAPTER 10. ECOLOGICAL SIGNIFICANCE OF SOIL HARDNESS SPACIAL VARIABILITY IN NATURAL FARMING

The technology of natural agricultural production consists in the complete refusal to use genetically modified organisms, antibiotics, pesticides and mineral fertilizers. This leads to an increase in the natural biological activity of the soil, restoration of the nutrients balance, strengthening of the restoring properties of the soil, and normalization of the functioning of soil organisms. The content of humus increases, and as a result the agricultural crops yield increases as well. The result of natural agriculture is ecologically safe products, free of chemical elements foreign to food products (Lukianenko, 2000).

The idea of natural agriculture is currently popular in many countries around the world, especially in Europe. Ukraine possesses an extraordinary reserve of fertile soils, because it was in the past and it shall be in the future one of the world leaders in the production of high-quality, environmentally safe food (Medvedev, 2012). However, this requires complete information on the state of soils, their fertility and physical properties.

The soil hardness, apparently, is the most important indicator of soil properties (Medvedev, 2009). Its advantages are the high information content and efficiency, relative simplicity and high accuracy of measurement. The hardness is an indispensable index to assess the conditions of seed germination and its development in the early stages of ontogeny, including the assessment of the ability of root hairs to develop, not only in the interaggregate space, but also the space inside the aggregate (Zhukov, Kunah, 2011; Zadorozhna G.O., 2017). That is, using the index of hardness, not only the strength of the soil aggregates can be assessed, but also the quality of its composition can be rated. Moreover, such an estimate is almost impossible using the traditional index of structure density (Medvedev, 2009).

Based on the foregoing, the purpose of the study was to determine the spatial organization of ordinary black soil through the use of the technology of natural farming according to the soil hardness data.

The connection of arable soil heterogeneity with the soil fertility indicators was investigated using satellite images (Liadskaia et al., 2014). The data from the Enhanced Thematic Mapper Plus - ETM+ installed on the Landsat 7 satellite (http://glcf.umiacs.umd.edu/data) were used. Along with the direct Landsat channel values, the environmental properties are selectively represented through their ratio (indices) (Fassnacht., et al., 1998; Estimating the leaf …, 1998; Forest ecosystem processes …, 1993; Tieszen et al., 1996; Jakubauskas E. M. 1996; Paruelo, Lauenroth, 1998; Steininger, 2000).

The most known index - Normalized Difference Vegetation Index (NDVI): NDVI = (B4-B3)/(B4 + B3) - is sensitive to the availability of vegetation on the ground surface and can be used to determine its type, amount and status. The high correlation of this index with the value of net biological productivity defined the use of this index as the basis for regional and global maps of biological productivity (Kozlov, Sorokina, 2012).

The images taken on April 16, May 2 and 11, June 12 and 19, July 14 and 30 and September 6 and 22, 2012, were analysed in the paper. Thus, the images time range covers the most of the vegetation period. The snapshots obtained from the server (Earthexplorer http://earthexplorer.usgs.gov/).

During this study, soil hardness was studied on two adjacent fields. In each field, the measurement points were located in the form of 6 transects with 15-16 points in each one. The approximate distance between the points in the transect was 75 m. The exact coordinates of the sampling locations were fixed using the GPS navigator. The distance between the transects on the first field was approximately 50

– 70 m. Before the operations on the second field, a half of it was cleared, and this part of the field was ploughed, so at sampling the distance between the transects was reduced about by half – up to 30 – 40 m.

The soil hardness was determined using manual Eijkelkamp penetrometer (Cecilia, 2012; Hu et al., 2013; Moiseev, 2013; Zukov, Zadorojhna, 2016; Zadorojna, 2017). The average error of measurements of the device was ± 8%. The hardness of the soil was measured with a cone of a cross section of 2 cm^2 in each structure of the testing pattern.

The soil hardness on the two fields does not differ statistically significantly, therefore we presented summarised results throughout the territory (Table 10.1).

Table 10.1

Parameters of spatial variation of soil hardness

Distance from the surface, cm	Descriptive statistics		Geostatistical parameters	
	x ± SE, MPa	CV,%	SDL, %	R, m
0–5	1.96 ± 0.03	37.59	54.39	388.8
5–10	1.99 ± 0.02	35.36	66.67	353.7
10–15	1.96 ± 0.02	30.69	61.54	451.2
15–20	2.18 ± 0.03	29.01	77.50	145.4
20–25	2.36 ± 0.04	25.70	97.37	144.9
25–30	2.56 ± 0.03	22.80	97.22	114.9
30–35	2.81 ± 0.04	26.21	100.00	90.2
35–40	3.17 ± 0.05	27.61	96.20	42.7
40–45	3.55 ± 0.05	26.35	86.96	47.7
45–50	4.02 ± 0.04	21.32	55.70	45.3

Note. x is the mean value (MPa), SE is the standard error, SDL is the level of spatial data dependence (%), R is the radius of influence (m).

Mean values of hardness generally increase with depth, however, between the surface and the layer of 10-15 cm they are almost unchanged (1.96 ± 0.03 – 1.99 ± 0.02 MPa). Obviously, such values are the result of ploughing the farmland. The average data differs from that obtained in the study on a regular grid with a lag of 3 m (Table 3.10) due to the difference in time after the ploughing. The coefficient of variation of hardness data naturally decreases from 37.59% to 22.80% in a layer of 25-30 cm, and then there is some increase to 27.61% in a layer of 35-40 cm.

In layers of 0-5 ... 10-15 cm there was an average level of spacial heterogeneity discovered, which reduced at deepening and then averaged again in the layer of 45-50 cm. The autocorrelation impact radius is characterised by the general tendency to decrease with the deepening. At a depth of 0-15 cm, this index is at the level of 353.7-451.2 m. Starting from the depth of 15 cm, the radius of impact sharply decreases and is 42.7-47.7 m at a depth of 35-50 cm. Obviously, regular ploughing equates the mechanical properties of the soil. The mechanisms of creation of spatial relationships take effect, other than the mechanism functioning in the subsurface soil, where there is enough time for the soil structure to recover after another deep ploughing: at a depth of 35-50 cm the spatial structures of 45 – 100 m have been observed.

An attempt to describe the variability of hardness using geomorphological predictors with the linear regression produced no satisfactory results - a part of dispersion described was within 8-11%.

Application of regression by the method of reference vectors (the core of the function - ANOVA RBF) significantly improved the predictive capabilities of the model - up to 37-58%. Thus, it can be argued that the spatial variability of soil hardness depends on the geomorphological status, but the nature of this connection lies beyond the linear description.

Despite the differences in the absolute values of the descriptive abilities of regression models, the trend variability of described variations both in the linear model and the method of reference vectors is similar: hardness value on the depth of 5-10 and 10-15 cm depends mostly on a package of geomorphological characteristics. The second maximum of the values of the dispersion described is observed at a depth of 40-45 and 45-50 cm. Interestingly, the epipedons that are regularly ploughed at the end of the growing season are characterized by hardness, the variability of which in space is conditioned by geomorphological determinants. It is obvious that the dynamics of the water and thermal conditions, influenced by the regulatory effect of the relief, is reflected in the spatial variability of the soil. Thus, the Mantel test between the Mahalanobis distances matrices by hardness and geomorphological indices is 0.17 ($p = 0.001$). A private test between the same matrices with the matrix of geographical distances as a control variable is 0.16 ($p = 0.002$). This indicates that the geomorphological determinants influence the hardness of the soil, bypassing other factors of geographical nature.

When analysing the data in the table, it can be stated that the hardness of the soil at different depths within the studied fields basically does not defy spatial trend. The part of dispersion described by the regression model, is at the level of 5-10%, which is clearly not enough to recognize the role of the trend as being significant. However, the variability of the soil hardness includes a spatial component, which is conditioned by a local autocorrelation, i.e. the dimension of the spatial interactions is less than the interval of soil hardness measurements.

To single out relatively homogeneous territorial units on the basis of soil hardness, the coherence and synchronicity of the variability of hardness parameters of the soil profile can be chosen as a homogeneity criterion, which can be represented by the correlation coefficient. The Pearson correlation coefficient is an appropriate indicator of the similarity of the profiles. Formally, the profile is defined as the vector of the values of the object, graphically displayed as a jogged line. Sensitivity of Pearson correlation coefficient to form only means that two profiles can have a correlation of + 1.0 and still not be identical (that is, the profiles are not passing through are the same points).

To single out spatially homogeneous sites by soil hardness, the results of our research were processed using cluster analysis. As a cluster solution, we selected an option with 4 clusters. It should be noted that the hierarchical cluster procedure assumes the possibility of separating from 2 to N-1 clusters, where N is the scope of sampling. There are the procedures that allow according to a certain criterion to decide upon some intermediate version of a cluster solution (Calinski TA, Harabasz, 1974; Olden, Jackson, 2002). It is obvious that the "extremely small" number of clusters provides voluminous groups, the composition of which is artificially expanded. An "extremely large" number of clusters provides no solution for the main problem of classification - obtainment of a number of homogeneous objects available for examination, because instead of a typical number of objects we get a new set, a bit smaller in size, but still too much to understand its nature.

Obviously, a factual set of objects must act as a cluster in environmental studies, and this objects should be characterised by a certain uniformity of statistical parameters, as well as a uniformity of communications with other phenomena and processes of their ecological environment. Statistical uniformity is the criterion that logically arises from the properties of the cluster analysis, but sometimes between different cluster solutions there is no clear difference in homogeneity or in other statistical properties. Therefore, the clusters discreteness in relation to the external characteristics of the agricultural ecosystem was chosen as a decisive criterion. So, the solution of the 4 cluster is characterized by reliable difference between clusters of values of such geomorphological indices, as the angle of inclination, the roughness of the terrain, the curvature in the plan and the erosion factor, as well as the vegetation indices for different periods.

It should be noted that the cluster solution, obtained on the basis of the measures being not sensitive to the form of variability by profile, like Pearson correlation coefficient, but sensitive to absolute values, like, for example, the Euclidean metric, provided no clusters, which could be characterised by the specificity toward external characteristics in relation to the hardness of the soil. Thus, it can be stated that the nature of the profile distribution of soil hardness is geomorphologically deterministic, and not the absolute value of this property. Obviously, humidity conditions have a decisive influence on the dynamics of the absolute soil hardness value. And the character of the profile distribution of hardness reflects the local peculiarities of the soil-forming process, which is under the influence of such an important factor of soil formation as a relief. It can be assumed that the isolated clusters determine the agricultural ecosystem performance due to the peculiarities of the soil hardness profile change.

The assessment of ground biomass is necessary for the study of productivity, carbon cycle, distribution of nutrients in terrestrial ecosystems (Available fuel dynamics, ..., 2004). Methods of analysis of ground remote sensing data allow to assess the properties and processes in ecosystems and their annual dynamics at different scale levels, since the satellite observations are carried out with considerable spatial coverage, high spatial resolution and temporal periodicity (Liadskaia et al., 2014; Global terrestrial gross ..., 2000). Numerous studies show that such indices as the spectral vegetation index (SVI), a simple ratio (SR), normalised difference vegetation index (NDVI) and corrected normalised difference vegetation index (NDVIc), obtained using data from satellites, are good predictors of a leaf area index (LAI), biomass and productivity of forest and meadow ecosystems (Nettleton, Brasher, 1983; </ex> Jakubauskas, 1996; Tieszen, 1997; Estimating the leaf ..., 1997; Paruelo, Lauenroth, 1998; Steininger, 2000).

Both fields are characterized by a similar dynamics of vegetation during the growing season. It has been established that the active development of the vegetative mass of culture is observed from the end of May. This growth lasts until mid-July. After that there is a plateau, which ends with a decrease in the normalised difference vegetation index since the beginning of August.

Geostatistical analysis allows us to compare the peculiarities of the spatial distribution of the normalised difference vegetative index. The geostatistical procedure - kriging - should be carried out for the spatial and stationary process. Therefore, at first, the spatial trend should be extracted from the observed data. This can be done using regression analysis, if the spatial coordinates of objects are used as predictor variables.

Important information about the nature of the process is provided by the part of dispersion described by the regression model of a variable dependence on the spatial coordinates (a trend, in our case, of the 3rd degree) – R^2. This value indicates the significance of the spatial trend in the variability of the normalised difference vegetation index. The trend in general describes a set of factors, the action of which is continuous throughout the studied area.

The analysis of the obtained data suggests that the role of the trend increases with the increase in total phytomass in the fields (Table 10.2).

R^2 dynamics is synchronous with the dynamics of the value of the normalised difference vegetation index. The smallest R^2 value is observed in April, when there is almost no vegetation cover on the ground, and normalised difference vegetation index during this period reflects the heterogeneity of ground cover. With the exception of the local maximum of R^2 values on May 2 in the first test field (0.63), NDVI value grows due to the increasing role of the trend in spatial variability of the vegetation mass.

Table 10.2

Geostatistical characteristics of NDVI at various moments of the growing season

Date	Fields	Nugget * 10^4	Threshold * 10^4	R, m	100-SDL, %	R^2
April 16	1	1.87	7.30	104.39	79.61	0.22
	2	3.75	2.17	153.80	36.66	0.28
May 2	1	11.40	21.03	153.21	64.85	0.63
	2	17.06	27.82	166.72	61.99	0.37
May 11	1	4.44	32.34	87.69	87.92	0.45
	2	11.40	29.27	148.18	71.97	0.50
June 12	1	32.27	74.20	317.14	69.69	0.61
	2	12.20	28.09	176.93	69.71	0.39
June 19	1	6.83	45.41	183.87	86.93	0.57
	2	5.58	12.08	185.01	68.42	0.56
June 14	1	0.00	19.18	143.73	100.00	0.72
	2	2.14	14.91	171.44	87.46	0.76
July 30	1	1.31	31.61	149.66	96.03	0.71
	2	1.25	9.29	182.36	88.17	0.83
August 6	1	0.12	28.92	157.74	99.60	0.45
	2	3.09	6.28	172.19	67.02	0.75
August 22	1	6.54	9.81	167.31	59.99	0.68
	2	5.53	10.33	150.13	65.14	0.62

Characteristics of variograms provide important information about the spatial organisation of the phenomenon, or a process, at the local level. The ratio of the nugget-effect and the partial threshold indicates the role of space in the organisation of the variable, and the radius of autocorrelation shows the extent of the spatial interaction (Field scale variability, 1994).

The value of the magnitude effect and the partial threshold are used to calculate the spatial autocorrelation independence variable - SDL. Obviously, it is logical to consider spatial dependence, so we will review the complementary factor

- 100 - SDL. The autocorrelation component of spatial dependence is also synchronous with the phytomass. Factor 100 - SDL is the lowest at the beginning of the growing season, increases with the NDVI index advance, and when the plateau is reached, it decreases.

The radius of the autocorrelation of the normalised difference vegetation index is not inclined to regular changes during the growing season and does not vary statistically reliably between two fields (Wilcoxon test Z = 1.13, p = 0.26). For the first field, this figure equals, on average, 162.75 m, and for the second field - 167.42

m. This fact may indicate the nature of the occurrence of phytomass autocorrelation. Most likely, the action of local exogenous (in this case - edaphic) factors leads to spatial structuring of the vegetation cover. It can be stated that the spatial heterogeneity of soil properties is the reason for the formation of spatial patterns of vegetation.

An important feature is the increasing role of the trend and the local autocorrelation with increasing phytomass, which is indicated with the normalised difference vegetation index - denser vegetation groups become more spatially structured. This result is an obvious spatial consequence of the Liebig limiting factor. With the increase of phytomass in the process of vegetation, factors of different nature and different scale incrementally produce their own limiting effect.

It shows that the most favourable conditions for production are formed within the cluster 1. The worst conditions for primary products are indicated for cluster 2; clusters 3 and 4 occupy an intermediate position by NDVI value.

The features of the profile distribution of hardness, characteristic of each group. The analysis of the data shown in the figure indicates that the main difference between clusters is the speed at which the hardness increases with depth. For cluster 1, which is characterised by the highest level of normalised difference index, a gradual increase in hardness with depth is typical, due to which there is an exceedance of limit hardness levels (3 MPa) is observed with a very low probability in a root-occupied epipedon. It should be noted that the hardness of the soil at the depth of 0-20 cm within the cluster 1, in general, exceeds the similar values of other clusters. However the soil hardness value under analysis do not exceed the critical value, and due to that such a feature does not reduce the possibility of growth and development of the plants root system and the productivity of the plant cover.

Cluster 2, in which the worst conditions for the development of plants by the criterion of hardness are observed, is characterised by the combination of a high level of hardness in the upper epipedons (0-10 cm) and high hardness level at a depth of 40 – 50 cm. Clusters 3 and 4 are characterised by low hardness of the soil in the epipedon and high hardness - in the deeper epipedon. The differences between these clusters are in the depth at which hardness rises sharply. In cluster 3, a sharp increase in hardness was observed at the depth of 40-45 cm, and in cluster 4 - at the depthof 30-35 cm.

Obviously, the data on the dynamics of hardness in space and time can provide the most comprehensive and complete information about the effect of this important indicator on the productivity of agrocoenosis. The information on the spatial variability of soil hardness at the end of the growing season before harvesting indicates that not only the absolute value of hardness, but also the nature of the profile distribution (profile form by hardness) are important indicators allowing a description of spatial features of the normalised difference vegetation index over time.

In this case, the invariance means a similar nature of the profile distribution of hardness within each cluster. Absolute hardness values can change over time, especially as a result of the dynamics of soil humidity and mechanical effects on the soil of agricultural units. However, after significant fluctuations, within each cluster, the soil tends to some stationary state, which is characteristic for this cluster. The profile distribution of hardness, in its turn exercises an effect on the distribution of humidity and conditions of growth of plant roots and the life of soil fauna.

Cluster 1 takes 15.92% of the field area, cluster 2 - 46.87%, cluster 3 - 16.98%, cluster 4 - 20.24%. Thus, the land area with the most favourable hardness conditions is 15.92%, and the most unfavourable account for about a half - 46.87%. Cluster 1 is represented in the territory by fragmentary loci. Of these, the maximum is 37.79 % of the area taken by the cluster. Cluster 2 is a virtually integral entity - 90.37% of the cluster's area is occupied the largest locus. Similar indicators for clusters 3 and 4 are 44.28 and 63.78% respectively.

Thus, it has been established that clearly distinct soil formations, homogeneous in terms of formation of a profile by hardness, are united into clusters, the main difference between which is the speed at which the hardness increases with depth. Due to the characteristics of the profile change in soil hardness, the allocated clusters determine the agricultural ecosystem productivity and differ in NDVI value significantly.

Thus, the distribution of discrete units - clusters - within the field represents the basis for the establishment of "units of management". Units of management are the sites of the field, which are characterised by uniform technological requirements, which are quite different from the requirements of neighbouring control units within the field.

1. Mean values of soil hardness of the test fields are naturally increased at the depth from 1.96 MPa in the upper 15 cm layer to 4.02 at a depth of 45-50 cm. Distribution of indicators of hardness differs to a greater degree from the regular one at the depth of 15-30 cm from the surface.

2. Results of cluster analysis allowed to allocate four clusters of sites. In space, each cluster is represented by a number of clearly distinct entities, which are homogeneous in the formation of a profile by hardness. The main difference between clusters is the speed at which the hardness increases with depth.

3. The epipedons that are regularly ploughed (0-25 cm), at the end of the growing season are characterised by hardness, the variability of which in space is conditioned by geomorphological determinants. Regular ploughing levels the mechanical properties of the soil. In the underlying layer at a depth of 35-50 cm, there are spatial structures of 45-100 m in diameter.

4. The isolated clusters determine the agricultural ecosystem performance due to the peculiarities of the soil hardness profile change. The most favourable conditions for productivity are formed within cluster 1. The worst conditions for primary products are indicated for cluster 2; clusters 3 and 4 occupy an intermediate position by NDVI value.

5. The cluster 1 is represented on the territory by fragmentary loci - the maximum area of which is 37.79% of the territory occupied by the cluster. Cluster 2 is a virtually integral entity - 90.37% of the cluster area is occupied the largest locus. Similar indicators for clusters 3 and 4 are 44.28 and 63.78% respectively. The uniform character of the location of cluster 2, in which there are the adverse conditions for growing crops in terms of hardness, provides an option of local deep ploughing to optimize the physical properties of the soil.

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