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SCIENTIFICALLY INNOVATIVE ASPECTS ARE IN DEVELOPMENT AND IMPLEMENTATION OF CROP ROTATIONS IN UKRAINE

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The strategy of development and innovation of crop rotations with different durations, the satisfying structure of sown areas regarding soil and climatic conditions and farms specialization in Ukraine are examined. There are shown some effective principle crop rotation schemes of different duration met the modern agricultural systems and introduced in the farms which had achieved the most effective productive parameters. The prospects of further studies are determined on the direction of deepening the researches of crop rotations development.

Keywords: *modern farming systems, crop rotations with different duration, structure of acreage, crop rotation, innovation, forms of management.*

Introduction. Changes of farming systems in the historical context of their development and improvement were determined by changes in industrial relations and hydrothermal conditions of those periods [2]. The extensive farming system is ineffective and does not prevent the degradation of soil fertility and enhancing both water and wind erosion.

Taking into account all positive achievements of old farming systems the development of modern farming systems need to be based on the new approaches to land use. In particular, it is essential to take into account its specific agricultural and environmental features in the production of agricultural products depended to its quality and quantity for environmentally and economically effectiveness in accordance with market requirements, logistical and natural resources, agricultural landscapes [6]. Each subsequent farming system characterized by the increased energy consumption, which is also characteristic for modern farming systems, with their high scientific and technical level. Recently, in the science and practice many terms have appered that determine the characteristics of agriculture systems. The modern farming systems include industrial (intensive), soil protective, environmental, biological (organic), no-till system and so on.

Modern farming systems provide growth of crops productivity, restoring, preserving and improving of soil fertility by means of measures and intensification of agriculture – rational use of crop acreage structure and intensive crop rotation, high-productive crops and their varieties, advanced methods of soil cultivation, use of fertilizers, weeds, diseases and pests control preparations, the implementation of soil and the environment protection from destruction and pollution, introduction of new equipment and technologies, intensive cultivation techniqes of crops [7]. The main task of modern agriculture is to provide the population with quality and safe human food, animal – feed, and industry – with raw materials. Therefore, farming systems should be energy-efficient, low-cost, environmentally safe, soil protective and high productive.

At the end of the second and beginning of the third millennium in most countries more and more attention is paid to the development of alternative environmentally friendly farming [1]. It's strategy requires the development,

improvement, further development and innovation of individual units zonal farming systems. Among them, one of the major components are crop rotation.

The role of crop rotation in modern agriculture due to the biological characteristics of field crops. Various plants or group of similar crops require varying conditions of water or soil nutrient regimes, while affecting the properties of the latters [3]. The technological importance of crop rotation is correct alternation of different biological requirements of its plants, in which the best conditions are created for growth of each culture, it's development and high productivity.

Crop rotation provides a dual impact. Due to the rotation the crop can better used not only nutrients but also moisture, because plant roots penetrate to different depths. In addition, some cultures, for example beans, are able to provide the soil with nitrogen – after these crops the soil is not depleted, and vice versa – fertile. One of the major objectives of the rotation – to provide a particular crop the best conditions for growth and development and establish the conditions for growing the next culture [4].

At the same time the permanent crop growing dramatically reduces productivity, soil fertility, affects the phytosanitary status of soils and crops when comparing with the inclusion of crops into rotation. Introduction to rotation the crops, which differ in terms of sowing and harvesting, development character, different ways of care techniques, promotes uniform distribution during the year and rational use of means and labor [5]. Properly prepared and introduced crop rotation is important for improving the farming culture, increasing crop yields and profitability of agriculture.

Materials and methods of research. The purpose of research is the development, improvement and innovation of agro-ecological and biological basis of efficiency increase of scientifically based crop rotations with different duration depending on soil and climatic conditions with different saturation, ratio and placement of cereals, industrial and forage crops. These principles would promote to increase and stabilize soil fertility; increase the level of quality, diversified crop production by reducing the cost of its production and achieving ecological safety of the environment.

Many years – researches were performed in the field of long stationary experiments on typical chernozem on zone of unstable humidity at former Drabiv experimental station and Panfyly experimental station NSC «Institute of Agriculture NAAS». In addition, due to the land reform and the creation of new groups in the agricultural sector of Ukraine (public, rent and private) in the late twentieth and early twenty-first century. Scientific institutions were focused on keeping fixed research, the focus of which was to study on different soil and climatic zones efficiency of crop rotations with different duration, including specialized crop rotations with short rotations and impact on soil fertility and efficient use of arable land.

Implementation of research programs took place in accordance with the methods [3], making it possible to obtain reliable data and depending on the crop acreage in rotation structure, their type and kind, soil fertility, phytosanitary soil and crop conditions and productivity of crops and some agrophytocenoses and rotation.

Results of research. For farms with different directions of specialization there are developed 7–10-field crop rotation saturated by grain crop to 60–100%, providing a yield of cereals 5,0–6,1 tons are from a 1 hectare, 2,3–3,2 thousand UAH are from a 1 hectare net profit and 87–112% profitability. In rotations with short duration 3–4–5-field with 40–100% saturation by cereals yield of grain is 6,0–6,5 tons are from a 1 hectare, net profit 2,5–2,9 thousand USH are from a 1 hectare, rate of profitability

88,3–137,4%. Food units yield reaches 10,5–11,0 tons are from a 1 hectare, digestible protein – 0,75–0,90 tons are from a 1 hectare. Saturation of rotation to 40% maize on grain, 20% sunflower, rape and soybeans both – 20% increased energy efficiency ratio to 5,3–5,5 units. Among rotations with short duration on typical chernozem the advantage remains at 4–5-fields of crop rotations where 80–100% is maize and 3-field crop rotation with soybeans and maize.

Placing crops after the best predecessors is complicated in specialized crop rotations, which are characterized by a high concentration of certain cultures. In such cases, it is appropriate reasonable compromise that will provide stable agrosystem productivity: limited saturation, guaranteeing acceptable rotation frequency of demanding crops, the right mix for their compatibility, additional techniques that improve alternation (intermediate crops, mineral fertilizers, green manure and others). When the need for rotation we can have 75–100% cereals, properly combining of winter crops (20–30%), maize, barley, oats, soybeans, canola and other crops without reducing their productivity. Illegal is over-saturation of crop rotations by self-incompatible sensitive crops such as sunflower, flax, lupine, which demand for optimal return period.

The optimal level of saturation crop rotation by cereals, considering the need for growing another crops (technical – sugar beet, sunflower, oil – canola, flax, soybean, forage – perennial and annual grasses etc.) in the Steppe and Forest-steppe is to 60% (30% of winter wheat and 30% of spring cereals, legumes and maize), in Polyssya – 50–55% (30–35% of winter cereals, 20% of spring cereals, legumes and maize). In Steppe and Forest-steppe saturation by specialized crop rotation crops can reach 70–80–100% due to an increase in the Steppe area of maize, soybeans, barley, the Forest-steppe – maize, barley and soybeans. The share of crop rotations in winter is 20-30%; maize – 30–40, legumes – 20–30, barley 20–30%). In the Steppe rotation saturation by wheat to 40% is possible if there is it's placement after the best precursors (black and full fallows, legumes), and 50% with the presence in rotation of two black fallow fields and one field of full fallow.

Based on years of researches there were recommended for industrial and farm production scientifically based principles of rotations constructing of both types, and different types and sorts of crop rotations (from 3–5 to 6–10-fields). They respond appropriately to account for land reform and consider zoning areas: Steppe, Forest-steppe, Polyssya, areas of the Carpathians, Transcarpathia, Crimea lowlands, including irrigation and drained lands. They paid enough attention to crop rotation with vegetable crops, soil and crop protective rotations, optimizing structure of crop acreage and crop rotation system through mathematical designing. Developed and recommended rotations with different duration types and systems for appropriate crop rotation systems and structure of crop acreage, a different set, and placement ratio that produces high quality products (grain, oil, raw material of sugar beet, fodder) and leads to high productivity of arable land. There are recommended cereal – fallow – row tilled crops rotation for farms in Steppe and north-east Forest-steppe of grain specialization; cereal, cereal-row tilled crops, crop interchanging, row tilled crops rotations – for farms with livestock and grain developed specialization in all areas of Ukraine.

It should be noted that considering the soil and climatic conditions of Ukraine zoning, adaptive farming systems have to be developed and implemented, which provide not only efficient use of arable land, but any and all farmland. A characteristic

feature of such farming systems is their high technological level, the widespread use of intensive crop rotation, high productive crops and their varieties, advanced tillage technologies, fertilization, weed control measures, plant protection of diseases and pests, environment protection from destruction and pollution, soil conservation, introduction of new equipment and techniques of intensive crops cultivation.

Today in world agriculture several directions of alternative agriculture are simultaneously developed, studied and implemented. The combination of agronomic, environmental and economic characteristics of the branch creates conditions for the development and implementation of zonal and adaptive systems with different levels of intensification. Such farming systems can be implemented in farm formations depending on the specialization, environmental conditions of agro-landscapes and technical capabilities. The priority of ecological farming system is the use of biological agents as a source of natural resources, widely use of organic fertilizers by introducing «green manure» cultures use to fertilize the soil with stubble after-harvest residues and non-tradable harvest, microbiological processes along with the fertilizer application for regulations in soil fertility.

Crop rotations for ecological farming systems determine the impact on quantitative parameters of the cycle of nutrients in agrocenoses by alternation of crops in time and space, the use of non-tradable crop stubble, after-harvest and root remains, green manure. The introduction of long (7–8 fields) or short (3–5 fields) rotations or their parts must necessarily provide planting legume crops (legumes and grasses). For ecological farming system the most effective measures are introduction and development crop-interchange rotation with perennial legumes. An example of such rotation is as follows: 1 – perennial legumes, 2 – winter wheat plus stubble on green manure, 3 – sugar beets, 4 – buckwheat, 5 – maize, 6 – peas, soybeans, 7 – winter wheat plus stubble on green manure, 8 – barley and sowing of perennial legumes; or 1 – peas, 2 – winter wheat, 3 – rape, 4 – winter wheat + green manure legumes, 5 – maize, 6 – soy, 7 – barley+ buckwheat in green manure.

In households with low livestock density or without them circumstances encouraged to focus on the production of grain. Cereal crops can be up to 70% of arable land. Wheat, corn and barley dominate in the structure of grains. Crop rotation is as follows: 1 – always green manure fallow (lupine, mustard, rape, oil radish, etc.), 2 – winter wheat, 3 – sugar beets, 4 – barley, 5 – peas, 6 – winter wheat, 7 – maize grain, 8 – barley. As can be seen there are 75% of cereals in crop rotation and ear-forming cultures are not sown after stubble of ear-forming predecessors. As the fertilizer, in addition to green manure, including sugar beet tops, straw, all post-harvest remains, are used and provide a yield increase of 1 ton of barley per hectare.

Green manure fallow cultures in rotation help to improve the phytosanitary status of fields, the main indicators of soil fertility and are a good precursor for winter crops. A strong root system of rape, oil radish, white mustard, penetrating to a depth of more than 1,5 m, well drain soil enriched with organic matter; root and stubble slow down the development of diseases, pathogens which are stored in the soil. Growing of basic and intermediate green manure crop as fertilizer is particularly important in light sandy low humus soils for putting abandoned land in agricultural use or as replacement of farmyard manure under row tilled crops.

In the production introduction of crop rotations is decided by the proper organization of the economy, which provides rational relationship between the different branches of agricultural production. The more developed some industries, the

more varied composition by type of crop plants. Depending on their structure and economic purpose field, fodder and specialized rotations are distinguished. In field crop rotations placing cereals and technical field crops are placed, forage crop is allocating in limited area. Food crop rotation is rich for forage crops, and cereals and technical crops occupy a small area. Farm specialization often determines the need for saturation of rotation with special crops. Hence the name - specialized rotation. They can be saturated only with such cultures, which are not affected by their frequent sowing at one and the same field. The specialized rotation includes some grain or vegetable crop rotation. In all cases, they should take into account the scientific basis of crop rotation.

Based on the experimental results of scientifical research institutes the recommendations were worked out for rational crop rotations for large farms, where possible introduction of many-field crop rotations, and for farmers with a limited acreage of land under cultivation, which requires the use of a small set of crops and short rotation. In view of the present indicative most common crop rotation schemes with different duration for various soil and climatic zones of Ukraine.

Steppe. I. 1 – clean or ordinary fallow; 2 – winter wheat, 3 – rape or soy, 4 – maize, 5 – barley, 6 – maize for silage and green fodder, 7 – winter wheat or winter barley, 8 – soybeans, 9 – winter wheat or winter barley, 10 – sunflower; II.1 – black fallow, legumes, 2 – winter wheat, 3 – sugar beets, maize for grain or silage, 4 – spring cereals, sunflower; III. 1 – black fallow, 2 – winter wheat, 3 - rape, 4 - winter wheat; IV. 1 – legumes, 2 - winter wheat, 3 - maize, 4 - maize and spring crops.

For sunflower we can allocate half of the field in the rotation: 1 – black fallow, 2 – winter wheat, 3 – barley, 4 – 0,5 of field sunflower plus 0,5 of field maize. Changing of one rotation of sunflower and corn should be interchanged to keep the return period to the previous field.

Rice crop rotation: 1, 2 alfalfa; 3, 4, 5 – rice; 6 – land improvement field; 7, 8 – rice.

Forest-steppe. I. 1 – perennial legumes grasses, 2 – winter wheat + after harvest crops for green manure, 3 – sugar beets, 4 – maize for silage, 5 – winter wheat + after harvest crops for green manure, 6 – maize, 7 – peas or soybeans, 8 – winter wheat + after harvest crops for green manure, 9 – sugar beets and sunflowers, 10 – barley + overseeding with perennial legumes grasses; II. 1 – perennial and annual grasses, 2 – winter wheat, 3 – sugar beets, 4 – maize for grain and silage, buckwheat or barley, oats; III. 1 – legumes, 2 – winter wheat, 3 – sugar beets, 4 – maize, soybean, 5 – spring cereals (barley, oats, cereals); V. 1 – black or full fallow, 2 – winter wheat, 3 – rape, 4 – winter wheat+ after harvest crops for green manure, 5 – maize, buckwheat, millet or barley; V. 1 – legumes, 2 – winter wheat, 3 – maize, 4 – barley and oats.

Polyssya. I. 1 – clover, 2 – winter wheat+ after harvest crops for green manure, 3 – potatoes, 4 – flax, 5 – winter rye, 6 – maize for silage and green fodder, 7 – peas, lupines, 8 – winter wheat, 9 – winter or spring rape, 10 – barley + sowing clover; II. 1 – legumes, 2 – winter wheat, 3 – winter rape, 4 – winter wheat, 5 – potatoes; III.1 – legumes, 2 – winter wheat, 3 – early potatoes, flax, 4 – winter wheat, 5 – spring cereals; on sandy soils: 1 – lupine for grain, 2 – winter rye, 3 - potatoes, oats, 4 – winter rye, 5 – oats.

Undoubtedly, crop rotation schemes are to be regarded as fundamental in their construction. They can not cover the whole variety of schemes and set rotation, which occurs in theory and in practice of modern agriculture. The need for implementation of

short crop rotation caused by the emergence of new forms of land ownership, land sharing, increasing of number of households with a small area of land, crops and limited set of crops and narrow economy specialization. After all, modern agriculture with rational parameters rejects practice only when grown grains and oilseeds, which is widely practiced across the state. None other than the desire of today's rapid gain prevents many farmers to realize and to object the brutal violations of rotation.

In Ukraine there is a strategy of crop rotation development in nearby and distant future. The owners of farms must pay more attention to the advices of scientists to keep rotation structure to maintain soil fertility. It is necessary to restore classic crop rotation, which would provide in its structure optimal set, ratio and location of field crops.

In justifying crop alternation in rotation reasons of lowing of yield and quality in repeated and permanent crops is not considered, also biological characteristics of plants, their allelopathic activity and effect on phytosanitary condition of the soil and crops. Based on years of comprehensive research we found soil and environmental factors of soil exhausting under various field crops impact. It is necessary to take into account their allelopathic activity, phytonematodes and pathogenic states of soil. In different farming systems, including biological (organic) agriculture, there is no alternative for crop rotation as a powerful source of effective land use in Ukraine.

The strategic objective of the study of crop rotation is caused by rotation realization that it would be a mistake to assume that modern agriculture in market conditions should only go to innovation with rotations of short duration. At least that fact must be considered that Ukrainian Forest-steppe and Steppe are large-scale grain production regions, sugar beets, sunflowers and more, and here, too, the main producers of large agricultural enterprises. Such diversified enterprises, of course, should introduce and develop rotations with long duration (7–10 fields). So, have a right to exist both types of rotations – with long and short durations too. But which one to implement – the owner decides.

It should also be remembered that the basic unit of technology growing crops is correct placing them in rotation, to the same crop rotation are the basis of all farming systems. Therefore stationary experiments to study the rotation of research institutions were conducted for a long time since the 20s of XX century. The main objective of these experiments was to determine the role of perennial grasses and legume-grass mixtures grass to improve soil fertility, increase yields. In the 1961–1962 experiments' schemes were replaced towards expanding areas of high productive cultures, their optimal alternation in rotation. Results of researches are widely used in agriculture, as evidenced by the experience of the development of crop rotations production workers.

However, with increasing intensification of agricultural production, introduction of new technologies, high-performance varieties and hybrids of crops that have high demands on soil fertility, crop allocation issues arise anew. In addition, until recently, not enough attention was paid to overcome incompatibilities and self-incompatibility of some cultures, the term of their return to the previous field that limits the ability to design reasonably rotation of varying duration for farms of different ownership forms and areas of specialization.

In view of these challenges for the future research are:

- Conducting experiments in the field of stationary lyzimetre researches to solve such issues: environmental safety of agriculture, crop rotation and environment

(agricultural landscapes); reconstruction of existing experiments with the requirements of the time;

- Developing ways of dealing with allelopathic soil exhausting when saturation at specialized crop rotations with cultures those are close in biological characteristics. For crops with long return period of the previous growing place in the rotation– agricultural methods development for its reduction are needed. Learning of means to overcome incompatibility and self incompatibility of some main crops of rotation (ear-forming cereals, pulses, oilseeds, etc.) in recurrent crops. Specialization of rotations with short duration due to crops sensitive for this factor requires the development and application of countervailing measures to improve the phytosanitary condition of the soil and crops;

- Deepening the study of systems of crop rotation and farming in multifactor experiments determining influence of the intensification of crop rotation (the use of different methods of cultivation, doses of fertilizers, growth regulators, herbicides, pesticides, fungicides) on the productivity of certain crops and crop rotation as a whole;

- Increasing researches to develop rotations for alternative agriculture based on the principles of biologization (use of organic fertilizers and non-tradables production on fertilizer efficiency green manure, legumes and role of intermediate crops due to the increasing requirements for organic farming under different fertilization systems and cultivation in crop rotation);

- Deepening the study of energy-saving environmental crop rotations with different saturation of individual crops on soils of ecological and technological groups of lands at Polyssya, Forest-steppe and Steppe to the development of this direction of rotation;

- Continuation of the study of a new type of crop rotations with different duration – maize-legumes, including maize-soybean and maize-alfalfa rotations;

- Summarizing the results of research to develop models and automated management by structures of sown areas, the basic principles of set and crop interchanging and their technological processes in the rotations, to create computerized data banks;

- Initiating a problem to the Ministry of Agriculture and Food of Ukraine to restore the state of development of statistical accounting rotation of all categories (Form 17) and recovery "Books fields of history."

Conclusions

In modern agriculture the leading factor in high productivity is the rotation of crops. High-effective crop rotations are those with different duration – 3–4–5-fields and with long rotation – 6–10-fields rotations their types and crop properly structured acreage and scientifically grounded ratio and placement. Theoretically and practically proved is the fact that with a decrease in the length of rotation, especially at simplified the 2–3-fields crop rotation, productivity of arable land use reduced.

Given the scientific potential problems with crop rotation, which has been preserved as a result of years of research in different soil-ecological zones of Ukraine, there is an opportunity to expand and deepen the scientific rationale and methodology for optimizing the structure of crop rotations with different duration to increase their productivity, conservation and restoration of soil fertility, improving its phytosanitary state and agrophytocenoses in agricultural landscapes. Strengthening of innovation into industrial production plays an important role and contribute to obtaining

competitive agricultural and livestock farming production through a combination of crop and livestock sectors.

References

1. Behey S.V. Ecological agriculture / S.V. Behey. - Lviv: New World, 2009. - 428 p. (In Ukrainian).

2. Boyko P.I. Historical and modern advances in the study and implementation of farming systems and crop rotation / P.I. Boyko, N.P. Kovalenko // Agronomist. - 2005. - №3 (9). - p.78-81.(In Ukrainian).

3. Boyko P.I. Method of current and future research in agriculture /P.I. Boyko, N.P. Kovalenko // Bulletin of Agricultural Science, 2008. - №2. - p.11-17. (In Ukrainian).

4. Boyko P.I. Efficiency of different rotational crop rotations in modern agriculture /P.I. Boyko, N.P. Kovalenko, N.N. Opara // Bulletin of Poltava State Agrarian Academy. - 2014. - №3. - p.20-32. (In Ukrainian).

5. Rotation in Ukraine agriculture / Ed. V.F. Saiko, P.I. Boyko. - K .: Agricultural Science, 2002. - 147 p. (In Ukrainian).

6. Shuvar I.A. Scientific bases rotation intense ecological agriculture / I.A. Shuvar. - Lviv: Mason, 1998. - 224 p. (In Ukrainian).

7. Jurkiewicz E.O .Agrobiological bases rotation southern steppe of Ukraine / E.A. Yurkevich, N.P. Kovalenko, A.V. Bakuma // Monograph. - Odessa: Odessa publishing house "VMV", 2011. - 240 p. (In Ukrainian).

Анотація

Бойко П.І. , Коваленко Н.П. ***Науково-інноваційні аспекти у розробленні та впровадженні сівозмін в Україні.*** *Розглянуто науково-інноваційні аспекти у розробленні та впровадженні сівозмін, обґрунтовано відповідну структуру посівних площ з урахуванням ґрунтово-кліматичних умов та спеціалізації господарств України. Наведено окремі ефективні принципові схеми сівозмін різної ротації, що відповідають сучасним системам землеробства і запроваджуються в господарствах, які стали найефективнішими за показниками виробництва. Визначено перспективи подальших досліджень у напрямі поглиблення основ розроблення сівозмін.*

Ключові слова: науково-інноваційні аспекти, сучасні системи землеробства, різноротаційні сівозміни, структура посівних площ, чергування культур, форми господарювання.

Аннотация

Бойко П.И. , Коваленко Н.П. ***Научно-инновационные аспекты при разработке и внедрении севооборотов в Украине.*** *Рассмотрено научно-инновационные аспекты при разработке и внедрении севооборотов, обосновано соответствующую структуру посевных площадей с учетом почвенно-климатических условий и специализации хозяйств Украины. Приведены некоторые эффективные принципиальные схемы севооборотов различных ротаций, соответствующих современным системам земледелия и внедряемых в хозяйствах, которые стали наиболее эффективными по всем производственным показателям. Определено перспективы дальнейших исследований, дано предложение по улучшению форм хозяйственной деятельности.*

Ключевые слова: научно-инновационные аспекты, современные системы земледелия, разноротационные севообороты, структура посевных площадей, чередование культур, формы хозяйствования.