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TECHNOLOGICAL METHODS OF ORGANIC FARMING AS A BASIS FOR REGULATING THE DEVELOPMENT OF HARMFUL ORGANISMS

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Organic farming is the concept of harmonious development in the field of agricultural production which ensures the preservation of soil fertility, its protection from xenobiotic contamination and the production of environmentally friendly food products. One of the main principles of organic farming is strict compliance with the requirements for each stage of agricultural production. That is why it is important to find effective technologies. The influence of technological methods of organic farming on the regulation of pests' development is studied based on many-year experience at the private enterprise "Agroecology" in Shyshaky district of Poltava region. It has been found that the optimization of phytosanitary conditions of crops in organic farming is based on the formation of heterogeneous species and varietal structure of agro-ecosystems, taking into account the economic thresholds of pests, pathogens and weeds, and the peculiarities of technologies inherent in this system. It has been proven that due to application of sufficient amounts of organic fertilizers, growing perennial legumes and green manure crops at the private enterprise "Agroecology" provides optimal nutrition for crops, which helps to increase their competitiveness with weeds and resistance to damage by some pests and diseases. The microbiological activity of soil in organic farming is 28.4–31.6% higher than in intensive agricultural production. In addition, changes in the species composition of entomofauna have been noted. There has been an increase in the number of carnivorous turuns species in the fields of the farm by 20 % compared to crops of cereals with the use of intensive technologies. During the years of research (2012–2019), the dynamic carnivorous carabids' density, depending on the species composition and weather conditions in organic farming, exceeded this indicator in fields with intensive technology by 32.6–51.2 %. It was found that the reduction of weediness of crops was associated with compliance with the regulations of technological measures provided for organic farming such as long-term shallow tillage, use of green manure, harvesting of some crops for green fodder, silage, haylage or hay in the phase of mowing ripeness. Widespread use of the principles of agro-phytocenology based on the expansion of species and varietal composition of cultivated plants, lack of pesticides and adherence to the principles of poly-culture contribute to the increase in efficiency of natural entomophagous and fungistasis biocenosis, which in turn

allows to control pests on the farm.

***Key words**: agro-ecology, organic farming, harmful organisms, technological methods, phytosanitary conditions, agro-ecosystems, green manure crops.*

ТЕХНОЛОГІЧНІ ПРИЙОМИ ОРГАНІЧНОГО ЗЕМЛЕРОБСТВА ЯК ОСНОВА РЕГУЛЮВАННЯ РОЗВИТКУ ШКІДЛИВИХ ОРГАНІЗМІВ

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Концепцією гармонійного розвитку у сфері сільськогосподарського виробництва є органічне землеробство, яке забезпечує збереження родючості ґрунту, його захист від забруднення ксенобіотиками та виробництво екологічно безпечних продуктів харчування. Одним із головних принципів органічного землеробства є чітке дотримання вимог, що висуваються до кожного етапу виробництва сільськогосподарської продукції. Саме тому важливим є пошук ефективних технологій. Досліджено вплив технологічних прийомів органічного землеробства на регулювання розвитку шкідливих організмів на основі багаторічного досвіду роботи ПП «Агроекологія» Шишацького району Полтавської області. З'ясовано, що оптимізація фітосанітарного стану посівів сільськогосподарських культур за умови органічного землеробства базується на формуванні гетерогенної видової та сортової структури агроекосистем, урахуванні економічних порогів шкідливості шкідників, збудників хвороб і бур'янів, особливостях технологій, притаманних цій системі. Доведено, що за умови внесення достатніх норм органічних добрив, вирощування багаторічних бобових трав та сидеральних культур у ПП «Агроекологія» забезпечується оптимальний режим живлення сільськогосподарських культур, що сприяє підвищенню їхньої конкурентоспроможності з бур'янами та стійкості до пошкодження деякими шкідниками і ураження хворобами. Встановлено підвищену на 28,4–31,6 % мікробіологічну активність ґрунту за умови органічного землеробства порівняно з інтенсивним веденням сільськогосподарського виробництва. Крім того, відзначено зміни у видовому складі ентомофауни. Спостерігається збільшення кількості видів хижих турунів на полях господарства на 20 % порівняно з посівами зернових колосових культур у разі застосування інтенсивних технологій. Динамічна щільність хижих карабід за роки досліджень (2012–2019 рр.) залежно від видового складу і погодних умов за умови органічного землеробства перевищувала цей показник на полях з інтенсивною технологією на 32,6–51,2 %. Визначено, що зменшення забур'яненості посівів пов'язане з дотриманням регламентів технологічних заходів, передбачених органічним землеробством (багаторічний мілкий обробіток ґрунту, застосування сидератів, збирання деяких культур на зелений корм, силос, сінаж або сіно у фазі укісної стиглості). Широке використання принципів агрофітоценології, що базуються на розширенні видового та сортового складу культурних рослин, відсутність використання пестицидів та дотримання принципів полікультури сприяють підвищенню ефективності природних ентомофагів та фунгістазису біоценозу, що своєю чергою дає змогу контролювати чисельність шкідливих організмів у господарстві.

***Ключові слова**: агроекологія, органічне землеробство, шкідливі організми, технологічні прийоми, фітосанітарний стан, агроекосистеми, сидерати.*

ТЕХНОЛОГИЧЕСКИЕ ПРИЕМЫ ОРГАНИЧЕСКОГО ЗЕМЛЕДЕЛИЯ КАК ОСНОВА РЕГУЛИРОВАНИЯ РАЗВИТИЯ ВРЕДНЫХ ОРГАНИЗМОВ

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Концепцией гармонического развития в области сельскохозяйственного производства является органическое земледелие, которое предусматривает сохранение плодородия почвы, ее защиту от загрязнения ксенобиотиками и производство экологически безопасных продуктов питания. Одним из главных принципов органического земледелия является точное соблюдение требований, которые вы-

двигаются к каждому этапу производства сельскохозяйственной продукции. Именно поэтому важным является поиск ефективных технологий. Исследовано влияние технологических приемов органического земледелия на регулирование развития вредных организмов на основе многолетнего опыта работы ЧП «Агроэкология» Шишацкого района Полтавской области. Выяснено, что оптимизация фитосанитарного состояния посевов сельскохозяйственных культур при органическом земледелии основывается на формировании гетерогенной видовой и сортовой структуры агроэкосистем, учитывании экономических порогов вредоносности вредителей, возбудителей болезней и сорняков, особенностях технологий, ствойственных этой системе. Определены приемы обработки почвы, которые эффективно контролируют количество сорняков в посевах сельскохозяйственных культур. Доказано, что за счет внесения достаточных норм органических удобрений, выращивания многолетних бобовых трав и сидеральных культур в ЧП «Агроэкология» обеспечивается оптимальный режим питания сельскохозяйственных культур, что способствует повышению их конкурентноспособности с сорняками и устойчивости к повреждению некоторыми вредителями и поражения болезнями. Определена повышенная на 28,4–31,6 % микробиологическая активность почвы при органическом земледелии сравнительно с интенсивным ведением сельскохозяйственного производства. Кроме того, отмечены изменения в видовом составе энтомофауны. Наблюдается увеличение количества видов хищных жужелиц на полях хозяйства на 20 % сравнительно с посевами зерновых колосовых культур при интенсивных технологиях. Динамическая плотность хищных карабид за годы исследований (2012–2019 гг.) в зависимости от видового состава и погодных условий при органическом земледелии превышала этой показатель на полях с интенсивной технологией на 32,6–51,2 %. Определено, что уменьшение засоренности посевов связано с соблюдением регламентов технологических мероприятий, предусмотренных органическим земледелием (многолетняя мелкая обработка почвы, применение сидератов, уборка некоторых культур на зеленый корм, силос, сенаж или сено в фазе укосной зрелости). Широкое использование принципов аргофитоценологии, основанных на расширении видового и сортового состава культурных растений, невнесение пестицидов и соблюдение принципов поликультуры способствуют повышению эффективности природных энтомофагов и фунгистазису биоценоза, что в свою очередь позволяет контролировать численность вредных организмов в хозяйстве.

Ключевые слова: *агроэкология, органическое земледелие, вредные организмы, технологические приемы, фитосанитарное состояние, агроэкосистемы, сидераты.*

Introduction

Organic farming is the concept of harmonious development in the field of agricultural production which ensures the preservation of soil fertility, its protection from xenobiotic contamination and the production of environmentally friendly food products [6, 15].

The system of organic farming is designed to: increase biological diversity within the entire system of organization of agricultural production; increase of biological activity and preservation of soil fertility; reuse of plant and animal waste in order to return nutrients to the soil which leads to minimal use of non-renewable resources; use of renewable resources in agricultural systems on the ground; promoting the protection of soil, water and air, as well as to minimize all forms of pollution due to agricultural activities; and compliance with such processing of agricultural products that would contribute to the preservation of its organic integrity and vital properties [7, 8, 17].

One of the main principles of organic farming is strict compliance with the requirements for each stage of agricultural production. That is why it is important to find effective technologies. In most cases, approaches in the production of organic products are the subject of agricultural consulting. Farmers, as a rule, can use the main recommendations offered by the specialty organizations. However, a creative (more flexible and variable compared to the traditional) approach to the cultivation of agricultural products by the producer is considered positive. This approach is based on the prevention of possible problems associated with the development and spreading of pests which is achieved by constant monitoring [1, 19].

An important part of the system of organic farming is ecologically sound optimization of phytosanitary conditions of crops, which is implemented through the ecologization of integrated plant protection measures, which is a component of organic farming technologies. This provides for the complete abandonment of the use of pesticides and mineral fertilizers, possibly with the exception of seed inlay and the use of macro-and micronutrients to improve the properties of organic fertilizers [16, 18].

Technological methods of the system of optimization of phytosanitary condition of crops are based on a complex of organizational, economic and agrotechnical measures inherent in technologies of organic agriculture. These include:

- scientifically substantiated structure of sown areas in specialized crop rotations with saturation of perennial legumes up to 25–27 %;
- shallow tillage which preserves the natural structure of the arable layer without destroying the vertical orientation of the aeration pores;
- the use of perennial legumes, greens and the introduction of scientifically sound standards of organic fertilizers which provides plants with nutrients and forms a positive balance of humus;
- application of ecologically safe agrotechnical and biocenotic measures in technologies of cultivation of agricultural crops;
- use of modern machines and mechanisms for tillage and plant care [1, 2, 5, 4, 12].

The aim of our research was to establish the correlation between the number of harmful organisms and the technological methods of organic farming.

The task of the research was to determine the efficiency of agrotechnical methods in optimization of the phytosanitary conditions of agroecosystems.

Materials and methods of research

The study of the impact of technological methods of organic farming on regulation of development of harmful organisms was conducted from 2012 to 2019 at PE "Agroecology" of Shishatsky district of Poltava region where the system of organic farming has been utilized for almost 40 years [18]. Systematic observations were conducted in the fields of this establishment during different phases of crop development. Accounts for the number of phytophages, their entomophages as well as the prevalence of diseases were performed in accordance with the methods of research [14].

Results of the study and their discussion

The most environmentally sound method of reducing the impact of negative factors on the growth and development of cultivated plants is to create an optimal regime for the development of crops, growing viable and competitive plants.

Many years of experience in organic farming show that the cultivation of legumes and green manure and the use of humus, taking into account their aftereffects, practically provide the recommended mineral nutrition of main crops which promotes their growth and development, has a positive effect on resistance to pests and especially diseases.

The optimal conditions for crop development are provided by preserving and improving soil fertility in the fields of the establishment. This is achieved by introducing green manure into crop rotation every four years and applying humus in the same sequence. As a result, good seedlings, vigorous growth and development, and large leaf surfaces of many crops inhibit the growth of weeds, making them less susceptible to damage by wireworms, fleas, weevils, leaf-eating caterpillars, and root rot. Thus, at the private enterprise “Agroecology”, the incidence of winter wheat seedlings during the years of research did not exceed 3.7 % with a threshold of 5 %.

Increased microbiological activity of the soil has a positive effect on agricultural plants. According to our data, it is 28.4–31.6 % higher in the fields of this establishment compared to the soil of farms with intensive use of pesticides.

Bio-diversity of crops in crop rotations is an important factor in optimization of the phytosanitary conditions. The botanical diversity of agrocenoses is facilitated by the siltation of ditches and slopes, the sowing of buckwheat for grain, sunflower, green manure crops and especially buckwheat for green manure which blooms two or three times a season.

There are flowering plants that attract beneficial (entomophagous) insects in the fields of this establishment throughout the growing season. Our research has confirmed the reduction of pests due to natural regulation by beneficial organisms [19]. Thus, the incidence of cereal aphids in spring barley crops with sainfoin was 46.8–54.2 %, while it did not exceed 18.3 % in spring barley crops under intensive agriculture where mostly three or four crops are grown. During the study, the number of cereal aphids in spring barley crops at this establishment did not exceed the economic threshold of harmfulness – 25 cereal aphids per ear for 50 % of the plant population.

The lack of pesticide use, introduction of shallow tillage and botanical diversity of plants in organic farming stimulate an increase in the species composition and number of carnivorous turuns. We found that the number of species of carnivorous turuns (carbides) in the fields of this establishment was 20 % higher than in cereal crops where intensive technologies were utilized. The dynamic density of carnivorous carbides over the years of research (2012–2019), depending on the species composition and weather conditions in organic farming, exceeded this indicator in fields with intensive technology by 32.6–51.2 %. That's why it is clear why the number of larvae of wireworms and false wireworms before sowing corn and sunflower, whose main predators are carnivorous turuns, usually did not exceed the economic thresholds of harmfulness of 3–5 insects per 1 m^2.

The positive impact of organic farming is evident by the research focused on determination of the intensity of development of powdery mildew on winter wheat and spring barley plants. During the earing phase, the actual values did not exceed the threshold of intensity of the disease – 15–20 % of the affected leaf apparatus of plants.

The development of the disease is constrained by the microclimate of stems, especially in crops of spring barley with sainfoin, when the sowing rate of barley is reduced by 20–30 %. This determines the lower plant density and better ventilation of crops. It should be noted that polyculture helps to decrease the infestation of cultivated plants with pathogens due to lower rates of accumulation and spread of the infection in the crops under the influence of microclimate (changes in humidity, temperature and light).

Thus, the optimization of phytosanitary conditions in organic farming is based on the formation of heterogeneous and varietal structure of agroecosystems that creates a favorable biocentric state which leads to the preservation and increase in the number and efficiency of beneficial species of arthropods and microorganisms. This reduces crop loss from pests and diseases due to the natural regulation by beneficial organisms.

The interaction between plants, also called an effect of allelopathy, is an important factor of phytosanitary conditions in the multicultural environment. Allelopathy is the mutual influence of plants through the release of physiologically active substances into the environment [3, 9, 11]. This phenomenon explains the effectiveness of the use of greens, intermediate crops, and fodder mixtures as measures to diminish weeds and reduce the incidence of plant pathogens. The main factors in plant interactions that affect soil health are root secretions, plant mass above the ground and nutrient residues of green manures, intermediate crops and fodder mixtures. The sources of allelopathically active substances mentioned above stimulate the development of crops, inhibit development of segetal plants and phytopathogenic microorganisms [13]. The research conducted by Rakhmetov, D. B. and Gorobets, S. O. proves that a number of green manure crops are effective in suppressing pathogenic microflora; root secretions and cell juice of many green manures significantly inhibit the development of the pathogen Fusarium (Fusarium oxysporum). It is known that the introduction of cruciferous (cabbage) crops, in particular tyfon, into agrobiocenoses saturated with cereals reduces the incidence of root rot by 15–25 % [20].

The results of our research confirmed the positive effect of polycultures on plant resistance to disease. Thus, the cultivation of winter wheat following oilseed radish and oats grown for green fodder reduced the intensity of root rot development at the beginning of the growing season to the economic threshold of harmfulness of 5 %.

Allelopathy is also a factor in reducing weed infestation, so recently much attention has been paid to the scientific search for allelopathically active crops capable of counteracting weed infestation of crops. The most effective and real use of allelopathic properties of plants in agrophytocenoses is the use of compatible crops, phytosanitary plants, intermediate and cover crops of allelopathic plants [13]. This is especially evident in cruciferous crops and their mixtures with cereals. V. Giska notes that the introduction of cruciferous plants to crop rotations gives a unique opportunity to reduce the clogging of the field with weeds during the growing season [10]. Thus, introduction of tyfon to crop rotations reduces the amount of weeds in subsequent crops by 40–50 %. Similar data were obtained from growing a mixture of oilseed radish with oats and a mixture of rye with tyfon.

Green manure and intermediate crops are important factors in reducing crop weeds on the farm. In such fields, the growth of some weeds is suppressed by shading or reduction of their reproductive function by mowing before the seeds reach maturity. It is known that the use of green manure decreases the amount of weeds in crops by 32–39 % [9].

We have found that winter rye is a good green manure for clearing the field of weeds. Thus, in the field where maize was sown after rye disking, the number of weed seedlings during maize germination reached 0,7 plants per 1 m^2, while the economic threshold of annual weed infestation in this phase of maize development is 5–10 plants per 1 m^2.

According to D. Rakhmetov, the number of weeds after growing winter and spring rapeseeds decreased by 60.2 % and 51.3 % respectively compared to autumn plowing.

Weeds pose the greatest threat to row crops. That's why the only precursor to them on the farm is winter wheat which is grown after occupied fields, green manure or perennial grasses that are the best precursors for this crop in terms of nutrition and low degree of weed infestation.

According to M. S. Korniychuk [13], timely and high-quality application of agrotechnical measures for 4–5 years, in terms of their full interaction, allows to reduce the species diversity and number of populations of pests and pathogens to the threshold and eliminates the need for chemicals. These studies became the basis of the principles of ecologization of agriculture which stimulated the development of organic farming.

The results of the research showed a higher level of weed infestation in organic farming compared to intensive farming. Therefore, the strategy of weed control on the verge of economic thresholds of weed infestation at PE "Agroecology" is based on agronomic measures that are elements of technologies for growing field crops.

With the alternation of different crops in crop rotations, weed control measures consist of biological suppression through the use of different biotypes of cultivated plants. Thus, sowing of winter rye, triticale, oats, buckwheat, oat mixture and a mixture of oats with oilseed radish, winter wheat, a mixture of triticale or rye with tyfon, and perennial grasses is a significant means of reducing weeds in the fields of this establishment. These crops dominate in crop rotations at the farm. In general, the share of continuous crops that are most suppressed by weeds reaches 80 % in organic farming, while this figure does not exceed 20 % in intensive agriculture.

A positive trend of clearing the soil of weeds is created by fodder crops, most of which are harvested for green fodder in the phases of oblique maturity. At the same time weeds are destroyed, not having time to form seeds.

Tillage techniques are also quite effective for control of the number of weeds in crops. Thus, high-quality shallow tillage, the main and only approach at the farm, creates a well-leveled, provided with moisture and weed-free topsoil. During sowing, the seeds are placed to the required depth on a solid bed. The seeds grow together and young plants begin to grow rapidly which increases their resistance to damage by pests and diseases, and increases their competitiveness against weeds.

Stubble husking is effective in weed control especially if the grain is harvested with simultaneous grinding and scattering of straw in the field. If the straw remains in the field for baling, then "Agroecology" carries out tape peeling of stubble between rolls. Early peeling retains moisture in the soil and creates conditions for the germination of weeds, which are destroyed by a cultivator with flat-cutting working bodies "Skorpion" before the generative organs are formed. In the spring, when the soil is physically ripe, cultivation is carried out to a depth of 3–5 cm or 6–8 cm for maize. This technique is not used before sowing sunflowers.

Crops are rolled with ring-spur rollers. It promotes better weed germination and minimizes plant loss during post-emergence harrowing, which reduces the damage to seedlings by phytopathogenic microflora [15].

Pre-emergence harrowing is carried out when the majority of weeds are in the phase of "white thread". This allows for the destruction of up to 90-95 % of weeds. The efficiency of harrowing of seedlings in the phase of 1-2 leaves on a plant is 65–75 % and only 15–20 % in the phase of 3–5 leaves and more.

The first inter-row tillage is carried out with a cultivator with pointed paws to a depth of 6-8 cm. The second inter-row tillage is carried out after 12-15 days with cultivators with paws-dumps to a depth of 4–6 cm. This provides for coverage of weed seedlings in rows.

In the case of the emergence of amaranth seedlings in maize crops, the second inter-row cultivation is not carried out. The presence of amaranth improves the quality of silage enriching it with protein. It was found that the green mass of maize for silage contains 3.5 % of crude protein in the milk-wax phase of grain ripening and 11.7 % in the green mass of amaranth in this period. Accordingly, the amount of crude protein in the silage is 4.9–5.1 %.

In order to maximally clear the fields of weeds, sowing of corn for grain on the farm is carried out at the end of the optimal period.

At the private enterprise "Agroecology", a mixture of vetch with oats for haylage or hay is used in the fields littered with perennial weeds. After harvesting the mixture, the stubble is disked and the field is treated with a flat-cut cultivator a week and a half later. In 5–7 days it is cultivated again. The purpose of these measures is to deplete the rhizomes of perennial weeds.

When growing buckwheat, taking into account its late sowing dates, it is possible to carry out two or three field treatments with harrows with segments for weeding sprouts of plants, followed by pre-sowing cultivation.

After many years of shallow tillage, the surface of the fields is covered with mulch that reduces the number of annual weeds.

Improving the phytosanitary conditions of crops is facilitated by carrying out technological measures in optimal agro-technical terms. In our production experiments, there were almost no signs of damage to the

seedlings by the larvae of the Swedish fly due to the intensive growth of corn seedlings.

Due to climate change and the extention of the warm period and in order to avoid mass damage to seedlings by cereal flies, cicadas, aphids and overgrowth of plants on the farm, the optimal sowing dates for winter wheat were moved to September 15–25. The number of puparia of the Swedish fly did not exceed 1.5–2.0 % of inhabited stems with a threshold of 6-10 %. Damage to plants by common and fusarium root rot was 0.7 % with a threshold of 5 %.

At the same time, it should be noted that the system of agriculture implemented in the farm cannot exclude damage to crops by polyphagous or actively migrating pests whose increasing numbers are determined by climatic factors.

Thus, there was an outbreak of meadow butterflies in 2013. They fed on crops of perennial legumes (sainfoin) which caused a significant destruction of the leaf surface of the crop that grew after the first mowing. Observations showed that the vegetative mass began to grow only in September-October, its growth continued and the optimal plant density was formed in the spring.

Most fodder crops are harvested during the period of mowing maturity when the weeds present in the crop do not have time to form generative organs; thus, the number of seeds in the soil, as a rule, does not increase. This is confirmed by analyzes of the number of seeds in fresh manure. So, previously we established the presence of approximately 200.000 weed seeds in one ton of the inspected manure. If such organic matter is used, approximately 70.000 to 142.800 weed seeds are supplied for each hectare. It should be noted that manure is considered to have satisfactory purity if it contains less than 100.000 weed seeds per one ton. This is achieved by storing it in burts in a dense “hot” way for at least a year.

The experience of “Agroecology” shows that the greatest return of manure can be obtained by applying it in the spring after the first mowing of perennial grasses (medick and sainfoin). After scattering the organic matter, the field is first treated with light disc harrows to mix the manure with the soil. Perennial grasses will grow within 2–3 weeks. All processes of reproduction of soil fertility are activated under their protective cover.

Other weed control measures include mowing wild vegetation on pastures, roadsides and uncultivated land to prevent weed seeds from spreading to fields. The effectiveness of the measure depends on the phase of weed development. Therefore, annual plants are mowed before flowering and perennials are mowed between the appearance of a rosette of leaves and flowering (with the smallest reserves of nutrients in plants).

The phytosanitary role of modern machines and mechanisms used in organic farming remains significant.

Conclusions

Optimization of phytosanitary conditions of crops in organic farming is based on taking into account the economic thresholds of pests, diseases and weeds, and the peculiarities of the technologies inherent in this system. It has been proven that the introduction of sufficient amounts of organic fertilizers and cultivation of perennial legumes and green manure crops at the private enterprise “Agroecology” provides optimal nutrition for crops that increases their competitiveness with weeds and resistance to damage by certain pests and diseases. Widespread use of the principles of agro-phytocenology based on the expansion of species and varietal composition of cultivated plants, lack of pesticides and adherence to the principles of poly-culture contribute to the increase in efficiency of natural entomophagous and fungistasis biocenosis, which in turn allows to control pests on the farm. It has been proven that the reduction of weed infestation at “Agroecology” is associated with compliance to regulations of technological measures provided for organic farming (long-term shallow tillage, use of green manure, harvesting some crops for green fodder, silage, haylage or hay in the phase of moving maturity).

Prospects for further research are to study the economic feasibility of using biological plant protection products in organic farming. It is important to continue the study of the impact of agronomic techniques on the phytosanitary conditions of agrocenoses.

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