




review article | UDC 632.4:632.95 | doi: 10.31210/visnyk2020.04.12

MODERN STRATEGY OF INTEGRATED PLANT PROTECTION


V. M. Pisarenko

 ORCID  [0000-0002-0184-3929](https://orcid.org/0000-0002-0184-3929)


N. P. Kovalenko

 ORCID  [0000-0001-5998-1745](https://orcid.org/0000-0001-5998-1745)


G. D. Pospelova*

 ORCID  [0000-0002-8030-1166](https://orcid.org/0000-0002-8030-1166)


M. A. Pischalenko

 ORCID  [0000-0001-8954-8256](https://orcid.org/0000-0001-8954-8256)

N. I. Nechyporenko

 ORCID  [0000-0003-2572-9095](https://orcid.org/0000-0003-2572-9095)

O. L. Sherstiuk

 ORCID  [0000-0003-0834-5663](https://orcid.org/0000-0003-0834-5663)

Poltava State Agrarian Academy, 1/3, Skovorody str., Poltava, 36003, Ukraine

*Corresponding author

 E-mail: ganna.pospelova@pdaa.edu.ua

How to Cite

 Pisarenko, V. M., Kovalenko, N. P., Pospelova, G. D., Pischalenko, M. A., Nechyporenko, N. I., & Sherstiuk, O. L. (2020). Modern strategy of integrated plant protection. *Bulletin of Poltava State Agrarian Academy*, (4), 104–111. doi: 10.31210/visnyk2020.04.12

The urgency of improving the condition of farm lands today is being solved by effective using fertilizers and environmentally friendly plant protection means, mechanical equipment, introducing the results of selection work and other scientific achievements. The purpose of the study is to determine the peculiarities of the system of integrated plant protection, taking into account their impact on yield environmental safety and soil fertility. As the global tendency favors the eco-balance of plant protection, there is a need for rational using agricultural technologies, which involve achieving a compromise between the desire to obtain a high environmentally friendly yield and preserve soil fertility. It is the system of organic farming, which is based on the specified complex of organizational, economic, and agro-technical measures and technologies. Peculiarities of this system's technologies, which provide optimization of crops' phyto-sanitary condition, were determined taking into account economic harmfulness levels of pests, diseases and weeds. The role of crop rotation as the main agro-technical measure in preventing crop damage by pests incapable of active movement and delaying the settlement of crops by insects, which damage seedlings and migrate from the previous year crop rotation fields, was substantiated. The role of tillage system in weed control was determined taking into account its impact on existing natural systems, creating favorable conditions for plant growth and development, restoration and preservation of soil fertility. The expediency and peculiarities of using biological (biocenotic) method in long-term pest control programs were substantiated. Methods were worked out in detail, which affect the conservation and increase the effectiveness of zoophages' natural resources: crop rotation, tillage, sowing time, fertilization, weed control, forest-protective belts, using attractive crops, creating favorable conditions for their vital functions, terms and methods of harvesting. The place of chemical method in the system of integrated plant protection and its negative impact on the environment was determined. Measures to optimize the application of chemicals in agro-ecosystems were presented in order to adapt farming systems to the requirements of environmentally friendly food production.

Key words: integrated plant protection, arable farming, agro-technologies, phyto-sanitary condition, plant diseases.

СУЧАСНА СТРАТЕГІЯ ІНТЕГРОВАНОГО ЗАХИСТУ РОСЛИН

В. М. Писаренко, Н. П. Коваленко, Г. Д. Поспелова, М. А. Піщаленко, Н. І. Нечипоренко, О. Л. Шерстюк

Полтавська державна аграрна академія, м. Полтава, Україна

Актуальність поліпшення стану сільськогосподарських земель на сьогодні вирішується шляхом ефективного використання добрив та екологічно безпечних засобів захисту рослин, застосування засобів механізації, впровадження результатів селекційної роботи та інших наукових досягнень. Метою дослідження є визначення особливостей системи інтегрованого захисту рослин, взявши до уваги їх вплив на екологічну безпечність урожаю та родючість ґрунту. Оскільки загальносвітова тенденція надає перевагу екологізації захисту рослин, то виникає потреба в раціональному використанні агротехнологій, які передбачають досягнення компромісу між прагненням одержати високий екологічно безпечний урожай і збереження родючості ґрунту. Саме система органічного землеробства і ґрунтується на зазначеному комплексі організаційно-господарських та агротехнічних заходів і технологій. Визначено особливості технологій цієї системи, які забезпечують оптимізацію фітосанітарного стану посівів, зважаючи на економічні пороги шкідливості шкідників, хвороб і бур'янів. Обґрунтовано роль сівозміни як основного агротехнічного заходу у запобіганні пошкодженню культур шкідниками, не здатними до активного переміщення, та затримці заселення посівів комахами, які пошкоджують сходи і мігрують з торішніх полів сівозміни. Визначено роль системи обробітку ґрунту в боротьбі з бур'янами, взявши до уваги його вплив на існуючі природні системи, створення сприятливих умов для росту і розвитку рослин, відновлення та збереження родючості ґрунтів. Обґрунтовано доцільність та особливості використання біологічного (біоценотичного) методу в довгострокових програмах боротьби зі шкідливими організмами. Деталізовано методи, які впливають на збереження та підвищення ефективності природних ресурсів зоофагів: сівозміна, обробіток ґрунту, строки сівби, удобрення, знищення бур'янів, лісові смуги використання приваблювальних посівів, створення сприятливих умов для їхньої життєдіяльності, строки і способи збирання врожаю. Визначено місце хімічного методу в системі інтегрованого захисту рослин та його негативний вплив на навколишнє середовище. Наведено заходи з оптимізації застосування хімічних засобів в агробіоценозах з метою адаптації системи землеробства до вимог виробництва екологічно безпечних продуктів харчування.

Ключові слова: інтегрований захист рослин, землеробство, агротехнології, фітосанітарний стан, хвороби рослин.

The strategy of modern arable farming does not envisage the expansion of sown areas, but the improvement of their using by the application of mechanical equipment, fertilizers, highly effective and environmentally friendly plant protection products, improving selection work and other scientific achievements. Thus, the relevance of our study is not doubtful and involves determining the features of integrated plant protection system, taking into account their impact on the environmental safety of harvest and soil fertility.

For the effective using of soil fertility and plant genetic potential, scientists have developed and recommended agro-technologies for growing crops, which can significantly increase the using of bioclimatic potential to increase yields and improve product quality [26]. One of the important technological factors is the optimization of phyto-sanitary condition of sown areas based on using methods of integrated plant protection. Modern protection system includes agro-technical, biological, chemical, physical, mechanical measures and plant quarantine. The importance of these methods varies depending on crops, rotation system, fruit and berry plantations. For field crops, agro-technical method has always been the main one and its role is growing due to the global trend of eco-balancing plant protection [24].

The strategy of integrated plant protection is based on agro-technologies, which are based on an attempt to reach a compromise between the desire to obtain a high environmentally friendly yield and preserve soil fertility. They are the foundation of organic farming system, based on a complex of organizational, economic and agro-technical measures and technologies [16], which include: the structure of sown areas; the using of perennial and annual legumes; scientifically substantiated crop rotations; shallow tillage; applying organic fertilizers; green manure crops; high quality seed preparation; optimal terms of conducted work; applying microbiological preparations; controlling economic injury levels of pests, diseases and weeds [25].

The system stipulates complete refusal to use pesticides and mineral fertilizers, except some cases: seed incrustation and the application of macro- and microelements to improve the properties of organic fertilizers while processing manure into compost [6].

Based on our many-year research at private enterprise “Agro-ecology” in Shyshaky district of Poltava region, it has been established that the optimization of phyto-sanitary crop condition in organic farming is based on taking into account economic injury levels of pests, diseases and weeds, as well as peculiarities of technologies characteristic of this system and can be formulated as follows [14, 15, 21, 22]:

- the application of sufficient amounts of organic fertilizers, cultivation of perennial legume grasses and green manure crops ensures optimal crop nutrition increasing their ability to compete with weeds, as well as resistance to damage by certain pests and diseases’ causative agents;
- the structure of sown areas, active using of agro-phytocenology principles based on the expansion of species and varietal composition of cultivated plants, refusing to use pesticides make it possible to increase the effectiveness of natural entomophages and fungistasis of biocenosis, which reduces the number of pests and in some cases inhibits diseases’ causative agents;
- an important factor in optimizing phyto-sanitary condition is using the effect of auto-inhibitors in the process of growing green manure crops and wide introducing the principles of poly-crop in farming;
- farm fields are covered with plants inhibiting weed growth throughout the vegetation period;
- many-year shallow tillage (to a depth of 5 cm), in the layer of which most annual weeds germinate, constantly reduces their number, which helps to clean up fields;
- harvesting most crops for green fodder, silage, haylage or hay in mowing ripeness phase, as well as planting green manure crops contribute to the destruction of weeds, which do not have enough time to form seeds, and also disrupt the life cycle of many pests (e. g., corn borer) and diseases of corn (root and stem rots), alfalfa, sainfoin, cruciferous (cabbage) crops, and others;
- since weed infestation poses the greatest threat to row crops, the only proceeding crop for them on a farm is winter wheat, which is usually grown after perennial grasses, occupied or green manure crops’ fallow land, which are highly effective in cleaning-up fields from weeds;
- complying with regulations of following all technological measures in the process of crop cultivation increases their effectiveness in weed control, which also restrains the amount of weeds on the verge of their economic injury levels, as well as reduces plant damage by many pests and diseases;
- reducing the number of many leaf beetles, as well as decreasing the intensity of disease development are ensured by timely treatment of plants with microbiological preparations;
- manure storage technology makes it possible to clean decomposed manure from weed seeds as much as possible, interrupting their circulation on the farm;
- applying tillage units, which meet technological requirements of organic farming in terms of work quality and weed control facilitates the decreasing of weed infestation.

Thus, the optimization of crops’ phyto-sanitary condition in organic farming is based on forming heterogeneous species and varietal structures of agro-ecosystems and placing the diversity (harmonious combination of crop growing and livestock farming) in the farm’s activity, when a favorable biocenotic state is created, which stipulates conservation, increase in the number, and effectiveness of useful arthropods and microorganisms species and carrying out agro-technical measures, which are included in the technologies of cultivating crops and limit the activity of harmful organisms of agro-ecosystem [17, 18].

On the whole, according to the well-known scientist on plant protection M. S. Kornichuk [23], in intensive technologies, timely and high quality agro-technical measures for 4-5 years under their proper interaction enables to reduce the species diversity and amount of pests and pathogens to economic injury level, eliminating the necessity to apply chemicals.

Agro-technical method of plant protection has more than a century long history, which began with the work of provincial entomologist Y. K. Pachosky: “Mechanical tillage, as the best means of cereals pests’ control” (1900). Later, this method was developed by the scholars of Poltava State Agricultural Experimental Station M. V. Kurdiunov and V. V. Znamensky, and in the former USSR – by V. M. Shchogolev [30], I. F. Pavlov [13], and others. Since then, the complex of agro-technical measures has hardly changed, but it has been supplemented with new materials obtained on the basis of scientific research.

So, one of the main agro-technical measures is crop rotation, the role of which is to spatially remove crop location from pests’ reservation in previous year fields of its cultivation. Such measure is important in preventing damage

by pests, which are unable to active movement (nematodes, larvae of bread beetles, larvae of beet root aphids, soil microorganisms – the causal agents of plant root rots, etc.). This measure also delays the infestation of crops by insects damaging sprouts and migrating from the previous year crop rotation fields [1, 19].

The distancing of each year winter crops from the fields where they were grown the previous year makes it possible to prevent the spreading of cereal flies, cicadas, brown leaf rust causative agent, and other pests from drops to new crops.

Post-mowing, post-harvesting and green manure crops are also important preventive measures in rotation. Along with this, more and more binary crops are sown, which creates a more favorable phyto-sanitary situation in agro-biocenoses. For example, sowing oats with spring vetch inhibits the development of annual and perennial weeds, and post-harvesting soil loosening also depletes rootstock weeds, which significantly reduces their amount [2, 3].

Sowing peas with white mustard creates unfavorable conditions for the development of pea aphids and pea grain moth. Harvest separation is technically quite effective.

Binary mixtures of typhon with rye or triticale, oil radish with oats, strip sown areas of buckwheat with millet and rye, and others are also promising. Post-harvesting, post-mowing, and binary crops in some cases have unfavorable auto-inhibiting effect on weed development [9].

One of the leading places in modern integrated systems is occupied by tillage system. Its main components are: main (autumn), pre-sowing, post-sowing and post-harvesting tillage, which provide high effectiveness of weed control [7]. Under-winter plowing with stubble pre-peeling in autumn significantly inhibits the reproduction of cereal flies, wheat thrips and cereal stalk sawfly, reducing their amount by 90 %. Moreover, a large amount of leaf – horned beetles, *Stenodiplosis panici*, beet webworms, cutworms die; the amount of causal agents of powdery mildew, rust, leaf spot diseases also decreases [13].

In the system of post-sowing tillage, rolling, pre-emergence and post-emergence harrowing and loosening between rows at row crops cultivation remain effective methods of weed control. Moreover, harrowing is the most effective measure at its carrying out during a “white thread” phase. By its timely conducting (usually with light, and recently – spring-tined harrows), 90–95 % of weed seedlings is destroyed both between rows and in protective zones [12].

Recently, in connection with the crisis phenomena (droughts) in moisture supply, tillage tools loosening the topsoil less, without upsetting the balance of useful soil microorganisms, increasing organic matter content in the topsoil and retaining more moisture in arable land layer, are becoming more important, as their application improves plant development and their resistance to pests [20, 27].

Therefore, the task of modern tillage system is to intensify production and simultaneously preserve the existing natural systems. High yields, despite natural disasters, are obtained by those farms, which take into account climate changes on the planet in their agricultural technologies. Instead of deep plowing, deep loosening of the soil or surface tillage is carried out, at which the plant root system is not removed from the soil, and after its death passages remain loosening the soil and creating favorable conditions for plant growth and development [19].

At present, the working model in the theory and practice of arable farming is that for over 150 recent years, black soils have constantly been degrading and losing fertility as a result of mass using shelf plows. Many-year experiments of the Institute of Grain Economy of the National Academy of Agrarian Sciences of Ukraine [29] have shown that deep plowing is still effectively mobilizing fertility potential and ensures a higher yield (5–11 %) of grain crops than the methods of minimal tillage. But the future of restored land is more important.

In integrated plant protection systems in the world and in Ukraine, in particular, there is a tendency to use biological method. Biological preparations do not pollute the environment, manifest a high selective effect, they are convenient for production and have inexhaustible resources for constant increasing volumes. Therefore, the introduction of biological (biocenotic) method is a priority in long-term pest control programs [10].

The directions in biological plant protection can be summarized in the following scheme [8]:

- using natural resources of zoophages;
- replenishing agro-biocenoses with useful species of zoophages, which are absent there, or their density is insufficient;
- using microbiological preparations against both pests and diseases causative agents;
- using pheromones to break the links between pest sexes;
- using hormonal preparations, in particular juvenoids, and other biologically active substances, which

disrupt the metamorphosis of harmful species.

No doubt, the using of resistant varieties is also an important element of bio-method.

The using of natural resources of zoophages is based on methods of preserving and increasing the effectiveness of natural populations of useful organisms. The following methods should be mentioned [21–26, 28]:

Crop rotation. Periodic crop change in rotation system limits the accumulation of plant diseases causative agents, pests and weeds, increases its bio-cenotic functions.

Tillage. Most diseases causative agents, pests and all weeds are connected with the soil in their development. Tillage stimulates the activity of a number of natural entomophages and useful microbes.

Terms of sowing. In each case, they should be determined in such a way that harmfulness of phytophages, diseases causative agents and the development of weeds on sown areas were minimal.

Fertilization. Ensuring optimal plant nutrition, as a rule, increases the endurance of plants to damage and diseases.

Weed control. Traditionally, weeds are considered to be the reservoirs of harmful phytophages. They feed on weeds at a time when cultivated plants have not yet emerged or have already been harvested.

Forest-protective belts and using attractive crops. In general, forest protective belts formed around fields have a positive effect on phyto-sanitary situation on sown areas.

Creating favorable conditions for the activity of useful organisms. For this purpose, special agro-technical measures have been developed. Among them there are the sowing of plants - nectar plants (phacelia, coriander, buckwheat, and others), on which these insects find additional nutrition.

Terms and methods of harvesting. Optimal harvest time allows to preserve the crop as much as possible and to affect harmful and useful organisms, regulating the former and activating the latter ones.

The peculiarities of the tactics of applying toxic substances, which ensure the maximum preservation of useful organisms, consists in the treatment of farm and forest plantations in terms, the least dangerous for parasites and predators. These are twilight pesticide treatments, edge and strip treatments, etc. [11].

At present, in order to replenish agro-biocenoses with useful species of zoophages, the technologies of breeding and using 30 species of insect-eaters are applied in the world practice as a real achievement of the classical bio-method [10].

Seasonal colonization of trichogramma has become effective on field crops, and in protected soil – phyto-seiulus mite, encarsia, galica afidomiza, and ambiseiulus mite.

Microbiological preparations are created on the basis of other bacteria, fungi or viruses. These biological products, which are now used against crop pests, are divided into three groups by their action [27]:

- the first – preparations of entobacterin type (dendrobacillin, BTB, lepidocide);
- the second – preparations of boverin type (ashersonia, trichodermin, and others);
- the third – preparations made on the basis of obligatoty parasitic microorganisms – viruses, microsporidia (ENSh virin, KSh virin, and others).

Among biological preparations to fight diseases causative agents, trichothecin, phyto-bacteriomycin (FBM), and phytoflavin 100 are used most often.

The expansion of agro-technical methods to increase the activity of entomophages' natural populations, as well as the range of biological means and the scale of their application is becoming an important factor in improving the environmental security of agricultural technologies [4–5].

Chemical method has been remaining an integral part of integrated plant protection system in our time and in the future. Extensive applying pesticides led to a number of serious negative consequences. Environmental and economic justification of the feasibility of using chemical plant protection means is one of the requirements for the eco-balancing integrated plant protection. In the process of farming system adaptation to the requirements of environmentally friendly food products, the optimization of applying chemicals in agro-biocenoses will be carried out in the following way [14–16, 20–24]:

1. Improving integrated protection involves reducing the application of chemicals by increasing the scale other techniques, taking into account the economic injury levels of using forecast and control over spreading harmful organisms.

2. Improving the assortment of pesticides having less toxicity, greater effectiveness and often more selective. In the future, preference will be given to insecticides-regulators of insects' growth and development, which have not a biocide but a regulatory effect on pests. Concerning pathogens causing plant diseases, preference is given to highly effective complex preparations including several active substances. A great achievement is the creation of preparations for seed incrustation, followed by seedlings' toxication, which

are effective against both pathogens and pests. Thus, new generation pesticides make it possible to implement more completely the genetic potential of varieties and hybrids, to obtain the maximum yield with greater environmental safety.

3. Improving the ways of applying pesticides. To protect field crops, pre-sowing seed incrustation and spraying plants during the growing season will remain dominant.

Spraying plants against pests should be conducted, first of all on the basis of inspections and treatment of field edge belts, without waiting till all area will be populated by them. When using pesticides against diseases and weeds, tape application is more appropriate. Applying a mixture of different action pesticides is promising, as it increases the toxicity of the mixture due to synergism, expands the spectrum and increases the duration of action on harmful object, prevents the formation of resistance and reduces the number of treatments [9]. Applying nitrogen mineral fertilizers in working solutions of pesticides makes it possible to reduce the consumption amounts of pesticides by increasing the effectiveness of their action with nitrogen fertilizers.

4. To increase the effectiveness of pesticide using and reduce their consumption amounts, it is expedient to use adhesives and surfactants. Using pheromones can reduce the number of treatments by 2–3 times.

5. To prevent the resistance of phytophages and pathogens to plant protection means, it is necessary to change preparations, use mixtures of fungicides having different chemical composition and mechanism of action.

6. Expanding the use of intra-herbal therapy, or temporary toxication of seedlings, achieved by seed incrustation.

7. Using new effective pesticides with improved sanitary, toxicological and ecological characteristics (pyrethroid and nicotinoid insecticides, chitin synthesis inhibitors, and others).

8. Applying selective action pesticides (pyrimor, and others), which destroy phytophages and are low-toxic to entomophages.

9. Twilight pesticide treatments are environmentally important, at which the quality of plant covering with pesticide solutions is improved and their negative impact on entomophages is reduced.

10. Improving technical equipment and complying with regulations for pesticides' application. Thus, chamber, auger-type and rotary-type mechanisms are promising for pre-sowing treatment (incrustation). Fan and boot sprayers are used to spray plants during the growing season. Reducing pesticide consumption amounts at low-volume spraying reaches 25–30 %.

11. Strengthening environmental requirements to pesticides by creating effective legislative acts to prevent applying preparations having unfavorable sanitary, toxicological and environmental properties. Legislation in many countries allows selling, storing, and using pesticides only to professionals who have the appropriate qualifications and licenses giving the right to work with pesticides.

Conclusions

Recently, taking into account harmful effect of pesticides on the environment and human health, there is a tendency in the world to reduce their application. The connection of human with nature will increase in the future. Therefore, in the XXI century, the using of chemicals in integrated plant protection will decrease. The using of the latest and already well-known agro-technical and biological measures, resistant crop varieties, mechanical equipment, and other effective environmentally friendly methods of pest control in agrobiocenoses will increase. The system of integrated protection will be further developed to increase effectiveness and environmental safety. The application of pesticides is already prohibited in organic farming completely.

References

1. Chaika, T. O. (2011). Zemelno-resursnyi potentsial orhanichnoho vyrobnytstva v Ukraini. *VISNYK Kharkivskoho Natsionalnoho Ahrarnoho Universytetu im. V. V. Dokuchaieva: Seriya Ekonomichni NAUKY*, 12, 323–330 [In Ukrainian].
2. Chaika, T. O. (2018). Rol minimalnoho obrobitku gruntu v orhanichnomu zemlerobstvi. *Inzheneriia Pryrodokorystuvannia*, 2(10), 37–44. Retrieved from: <https://drive.google.com/file/d/1edJXNTAezpYjEp75JK0CHtXFHpbuwfkO/view?usp=sharing> [In Ukrainian].
3. Chaika, T. O., & Lotysh, I. I. (2020). Zberezheniia rodiuchosti gruntiv za suchasnykh system zemlerobstva. *Orhanichne vyrobnytstvo i prodovolcha bezpeka : VIII Mizhnarodnoi naukovopraktychnoi kon-*

ferentsii. Zhytomyr: ZhNAEU. Retrieved from: <http://dspace.pdaa.edu.ua:8080/handle/123456789/7856> [In Ukrainian].

4. Chaika, T. O. (2019). The Influence of Conventional Agriculture to Sustainable Development of the Agricultural Sector of Economy. *Orhanichne vyrobnytstvo i prodovolcha bezpeka: materialy VII Mizhnarodnoi naukovo-praktychnoi konferentsii*. Zhytomyr: Vyd-vo ZhNAEU [In Ukrainian].

5. Chaika, T. A. (2019). Predposy`lki sokhraneniya i vosstanovleniya ustojchivosti ekosistem. *E`kologicheskoe sostoyanie prirodnoj sredy` i nauchno-prakticheskie aspekty sovremenny`kh agrotekhnologij: materialy` III mezhdunarodnoj nauchnoj-prakticheskoy konferenczii*. Ryazan: IP Zhukov [In Russian].

6. Chaika, T. A., & Lotysh, I. I. (2019). Organicheskoe sel`skoe khozyajstvo kak e`lement ustojchivogo razvitiya sel`skikh territorij. *Kompleksnoe razvitie sel`skikh territorij i innovacionny`e tekhnologii v agropromy`shlennom komplekse: sb. IV Mezhdunarodnoj nauchno-metodicheskoy i prakticheskoy*. Novosibirsk Retrieved from: <https://www.elibrary.ru/item.asp?id=41405412> [In Russian].

7. Chesalin, G. A. (1979). *Agrotekhnicheskie mery` bor`by` s sornyakami. Sorny`e rasteniya i bor`ba s nimi*. Moskva: Kolos [In Russian].

8. Diadechko, M. P., Padii, M. M., & Shelestova, V. S. (2001). *Biologichnyi zakhyst roslyn*. Bila Tserkva [In Ukrainian].

9. Fedorenko, V. P., Sekun, M. P., Retman, S. V., Korniihuk, Ye. M., & Vinnichuk, T. S. (2010). *Intehrovanyi zakhyst roslyn vid shkidnykiv i khvorob. Naukovi osnovy ahropromyslovoho vyrobnytstva v zoni Lisostepu Ukrainy*. Kyiv: Naukova dumka [In Ukrainian].

10. Kaminskyi, V. F., Hadzalo, Ya. M., Saiko, V. F., & Korniihuk, M. S. (2015). *Zemlerobstvo XXI stolittia – problemy ta shliakhy vyrishennia*. Kyiv [In Ukrainian].

11. Korniihuk, M. S. (1999). Shliakhy pokrashchennia fitosanitarnoho stanu igruntu i posiviv silskohospodarskykh kultur. *Zbirnyk Naukovykh Prats Instytutu Zemlerobstva UAAN*, 4, 67–76 [In Ukrainian].

12. Pashchenko, Yu. M., Borysov, V. M., & Shyshkina, O. Yu. (2009). *Adaptyvni i resursozberezhni tekhnolohii vyroshchuvannia hibrydiv kukurudzy : monohrafiia*. Dnipropetrovsk: ART-PRES [In Ukrainian].

13. Pavlov, Y. F. (1976). *Agrotekhnicheskie i biologicheskie metody` zashhity` rastenij*. Moskva: Ros-sel`khozizdat [In Russian].

14. Pisarenko, V. M., & Pisarenko, P. V. (2014). Ekologicheskie usloviya formirovaniya fitosanitarnogo sostoyaniya posevov sel`skokhozyajstvenny`kh kul`tur pri organicheskom zemledelii. *Zerno*, 12 (105), 52–60 [In Russian].

15. Pisarenko, V. M., Kovalenko, N. P., Pospelova, G. D., Gorb, O. O., Pischalenko, M. A., & Sherstiuk, O. L. (2020). Technological methods of organic farming as a basis for regulating the development of harmful organisms. *Visnyk Poltavskoi Derzhavnoi Ahrarnoi Akademii*, 3, 46–54. doi: 10.31210/visnyk2020.03.12

16. Pysarenko, P. V., & Chaika, T. O. (2014). Yakist gruntiv v orhanichnomu zemlerobstvi. *Dim. Sad. Horod*, 9, 22–23 [In Ukrainian].

17. Pysarenko, P. V., & Chaika, T. O. (2015). Otsinka ekonomichnoi efektyvnosti orhanichnoho silskoho gospodarstva. In S. A. Baliuk, & A. V. Kucher (Red.), *Ratsionalne vykorystannia gruntovykh resursiv i vidtvorennia rodiuchosti gruntiv : orhanizatsiino-ekonomichni, ekolohichni y normatyvno-pravovi aspekty : kolektyvna monohrafiia* (p. 311–318). Kharkiv: Smuhasta typohrafiia. Retrieved from: <http://dspace.pdaa.edu.ua:8080/handle/123456789/4743> [In Ukrainian].

18. Pysarenko, V. M., & Pysarenko, P. V. (2007). *Zakhyst roslyn: fitosanitarnyi monitorynh, metody zakhystu roslyn, intehrovanyi zakhyst roslyn*. Poltava [In Ukrainian].

19. Pysarenko, V. M., Antonets, A. S., & Pysarenko, P. V. (2017). *Systema orhanichnoho zemlerobstva ahroekoloha Semena Antontsia*. Poltava [In Ukrainian].

20. Pysarenko, V. M., Antonets, A. S., Lukianenko, H. V., & Pysarenko, P. V. (2019). Zmina klimatu: tekhnolohichni aspekty system zemlerobstva. *Zerno*, 10, 62–71 [In Ukrainian].

21. Pysarenko, V. M., Antonets, S. S., Antonets, A. S., & Pysarenko, P. V. (2011). *Syderalni kultury: praktychni rekomendatsii*. Poltava «Symon» [In Ukrainian].

22. Pysarenko, V. M., Kovalenko, N. P., Pospelova, H. D., Pishchalenko, M. A., Sherstiuk, O. L., Melnychuk, V. V. (2020). Ekolohizatsiia zemlerobstva, yak pershyi krok do orhanichnoho zemlerobstva. *Visnyk Poltavskoi Derzhavnoi Ahrarnoi Akademii*, 3, 109–118. doi: 10.31210/visnyk2020.03.05 [In Ukrainian].

23. Pysarenko, V. M., Pishchalenko, M. A., & Pospelova, H. D. (2020). *Intehrovanyi zakhyst roslyn: navchalnyi posibnyk*. Poltava [In Ukrainian].

24. Pysarenko, V. M., Pysarenko, P. V., Pysarenko, V. V., Horb, O. O., & Chaika, T. O. (2019). Posukhy v konteksti zmin klimatu Ukrainy. *Visnyk Poltavskoi Derzhavnoi Ahrarnoi Akademii*, 1, 139–146. doi: 10.31210/visnyk2019.01.18 [In Ukrainian].
25. Pysarenko, V. M., Pysarenko, P. V., Pysarenko, V. V., Horb, O. O., & Chaika T. O. (2019). Formuvannia pozhyvnoho rezhymu roslyn v orhanichnomu zemlerobstvi. *Visnyk Poltavskoi Derzhavnoi Ahrarnoi Akademii*, 3, 85–91. doi: 10.31210/visnyk2019.03.11 [In Ukrainian].
26. Pysarenko, V. M., Pysarenko, P. V., Pysarenko, V. V., Horb, O. O., & Chaika, T. O. (2019). Formuvannia pozhyvnoho rezhymu hruntu v orhanichnomu zemlerobstvi. In I. O. Yasnolob, T. O. Chaika, & O. O. Horb (Eds.), *Alternatyvni dzherela enerhii u pidvyshchenni enerhoefektyvnosti ta enerhonzalezhnosti silskykh terytorii: kolektyvna monohrafiia*. Poltava : PP «Astraiia» [In Ukrainian].
27. Pysarenko, V. M., Pysarenko, V. V., & Pysarenko, P. V. (2020). *Upravlinnia ahrotekhnolohiiamy za umov posukh: monohrafiia*. Poltava: FOP Smirnov A. L. [In Ukrainian].
28. Saiko, V. F. (2003). Problemy zabezpechennia gruntiv orhanichnoiu rechovynoiu. *Visnyk Ahrarnoi Nauky*, 5 (601), 5–8 [In Ukrainian].
29. Shevchenko, M. (2019). Pozbutysia gruntovoi erozii. *Fermer*, 2 (110), 48–52 [In Ukrainian].
30. Shhegolev, V. N. (1960). *Sel'skokhozyajstvennaya entomologiya*. Moskva-Leningrad: Sel'khozgiz [In Russian].

Стаття надійшла до редакції 29.10.2020 р.

Бібліографічний опис для цитування:

Писаренко В. М., Коваленко Н. П., Поспелова Г. Д., Піщаленко М. А., Нечипоренко Н. І., Шерстюк О. Л. Сучасна стратегія інтегрованого захисту рослин. *Вісник ПДАА*. № 4. С. 104–111.

© Писаренко Віктор Микитович, Коваленко Нінель Павлівна, Поспелова Ганна Дмитрівна, Піщаленко Марина Анатоліївна, Нечипоренко Наталія Іванівна, Шерстюк Олена Леонідівна, 2020