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ANALYSIS OF CURRENT GLOBAL TRENDS IN THE DEVELOPMENT OF THE PLANT PROTECTION PRODUCTS MARKET

Current global trends in the development of the plant protection products market are analyzed. It was defined that global production of agricultural goods and services has increased significantly in recent decades. Crop protection products have played an important role in driving this growth, as have other technological innovations. We argue that pesticides are widely used in modern agriculture as they are an efficient and cost-effective way to improve the quality and quantity of crops, which contributes to the food security of the world's growing population. Although pesticides are useful for crop production, their widespread use can have serious consequences for the ecosystem, as they directly or indirectly pollute the air, water, soil and the overall ecosystem, which threatens the health of living beings.

We consider that in the current market conditions of socio-economic and financial-economic development of the state, the basic goal of forming the future model of Ukraine's economy is an active and targeted policy on the state of the agricultural market, organizational and functional relations between market entities, pricing policy for agricultural products, the state of the world market for plant protection products in agriculture. According to foreign experts, one third of the world's agricultural products are produced in Ukraine. Other researchers also point out that without the use of plant protection products, losses of fruits, vegetables and grains from pests, diseases and weeds would reach 78%, 54% and 32%, respectively. It was defined that in the period 1990-2024, there was a tendency to increase the use of pesticides in agriculture. The regions showing the highest growth rates in terms of total pesticide use are the Americas and Oceania, with 2.2 and 3.2 times the increase in use respectively. The only region where countries have reduced their pesticide use is Europe, where the total decrease was 12106 t, or 2.5%. In Ukraine, the use of pesticides in agriculture has significantly decreased by 42447 t (63.6%) over the period 1992-2024.

Keywords: global market of plant protection products (PPPs), exports, imports, government regulation, agriculture, supply, demand.

2 table, 1 fig., 38 ref.

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АНАЛІЗ СУЧАСНИХ СВІТОВИХ ТРЕНДІВ РОЗВИТКУ РИНКУ ЗАСОБІВ ЗАХИСТУ РОСЛИН

Проаналізовано сучасні світові тенденції розвитку ринку засобів захисту рослин. Визначено, що за останні десятиліття світове виробництво сільськогосподарських товарів та послуг значно зросло. Засоби захисту рослин відіграли важливу роль у стимулюванні цього зростання, як і інші технологічні інновації. Зазначено, що пестициди широко використовуються в сучасному сільському господарстві, оскільки вони є ефективним і економічно вигідним способом поліпшення якості та кількості врожаю, що сприяє забезпеченню продовольчої безпеки зростаючого населення світу. Хоча пестициди є корисними для рослинництва, їх широке використання може мати серйозні наслідки для екосистеми, оскільки вони прямо чи опосередковано забруднюють повітря, воду, ґрунт та екосистему в цілому, що загрожує здоров'ю живих істот.

Зазначено, що в сучасних ринкових умовах соціально-економічного та фінансово-економічного розвитку держави основною метою формування майбутньої моделі економіки України є активна і цілеспрямована політика щодо стану аграрного ринку, організаційно-функціональних відносин між суб'єктами ринку, цінової політики на сільськогосподарську продукцію, стану світового ринку засобів захисту рослин у сільському господарстві. За оцінками іноземних експертів, третина світової сільськогосподарської продукції виробляється в Україні. Інші дослідники також зазначають, що без застосування засобів захисту рослин втрати фруктів, овочів і зернових від шкідників, хвороб і бур'янів досягли б 78%, 54% і 32% відповідно. Визначено, що в період 1990-2024 рр. спостерігалася тенденція до збільшення використання пестицидів у сільському господарстві. Регіонами, що демонструють найвищі темпи зростання загального обсягу використання пестицидів, є Америка та Океанія - у 2,2 та 3,2 рази відповідно. Єдиним регіоном, де країни скоротили використання пестицидів, є Європа, де загальне скорочення склало 12106 т, або 2,5%. В Україні використання пестицидів у сільському господарстві значно скоротилося - на 42447 т (63,6%) за період 1992-2024 років.

Ключові слова: світовий ринок засобів захисту рослин (ЗЗР), експорт, імпорт, державне регулювання, сільське господарство, попит, пропозиція.

2 табл., 1 рис., 38 літ.

Problem statement. At a meeting of the Bureau of the Presidium of the National Academy of Agrarian Sciences of Ukraine (NAAS) in December 2021, it was noted that the implementation of the European Union (EU) European Green Deal programme necessitates a review of existing approaches to the organisation and management of agriculture, including in terms of agrochemical plant protection practices [1]. The need to apply scientific approaches to form a vision of the future of the industry that can successfully compete in the world requires scientists to conduct research on the development of the crop protection market, taking into account global trends. It is also important to propose technological solutions that will prevent economic and environmental losses and contribute to the development of Ukrainian agriculture [1].

Global production of agricultural goods and services has increased significantly in recent decades. Crop protection products have played an important role in driving this growth, as have other technological innovations. However, the excessive use of inputs such as crop protection chemicals has concomitant impacts on the environment and human health. Pesticides are toxic chemical agents (mostly organic compounds) used in the environment to

control crop pests and disease vectors. The toxicity of pesticides to humans varies widely and can be acute, sub-chronic or chronic. The relevance of this issue is increasing due to the fact that the situation with the increase in the distribution of low-quality and counterfeit plant protection products is becoming alarming worldwide.

Analysis of the latest research and publications. In [2], researchers argue that the need for pest control dates back to ancient times, when both organic and chemical substances were used as pesticides. In article [3], the authors prove that pesticides are pesticides used on agricultural land and urban green spaces to protect plants from various diseases. The authors of [4-5] note that pesticides are substances or mixtures of substances that are mainly used in agriculture or public health programmes to protect plants from pests, weeds or diseases, and humans from vector-borne diseases such as malaria, dengue fever and schistosomiasis. Typical pesticides are insecticides, fungicides, herbicides, rodenticides, plant growth regulators, etc.

Some researchers also emphasise that pesticides are classified based on the way they act to achieve the desired effect, i.e. they are divided into contact and systemic pesticides [6]. Plant protection products are active substances that allow farmers to control various pests, and thus are one of the most important resources in agricultural production [7]. Thus, plant protection products play an important role in ensuring the production of crop products. For example, J. Cooper and H. Dobson in their studies refer to a number of benefits from the use of chemical plant protection products, including: improved shelf life of products; less labour intensity of weeding; reduced fuel consumption; increased yields; protection of garden plants [20]. Many farmers in developing countries consider the use of pesticides to be the best way to protect their crops from pests [8].

According to such domestic scholars as L. V. Vasylenko and O. A. Korchynska, '...the pesticide market should be under strict state control to prevent the use of outdated, environmentally hazardous chemical plant protection products' [9]. For example, China's pesticide control regime is currently undergoing major reforms [10]. According to the Food and Agriculture Organization of the United Nations (FAO), liberalisation of raw material markets, often referred to as a successful market reform, can lead to inefficient use of pesticides with high external costs [11]. When, purchasing and using low-quality pesticides and agrochemicals in accordance with ISO 1750:1981 (as amended), agricultural producers not only lose crop yields, but also cause harm to human health through consumption of products. Thus, the main characteristic of pesticides as hazardous substances is their toxicity, which depends on the chemical and physical properties of their active ingredients. Therefore, the issue of compliance with the current legislation on the use of insecticides, fungicides, herbicides, rodenticides and plant growth regulators in the agricultural sector of the economy should be under the control of the state.

Pesticides are widely used in modern agriculture as they are an efficient and cost-effective way to improve the quality and quantity of crops, which contributes to the food security of the world's growing population. Although pesticides are useful for crop production, their widespread use can have serious consequences for the ecosystem, as they directly or indirectly pollute the air, water, soil and the overall ecosystem, which threatens the health of living beings [12]. At the same time, the issues related to soil protection and groundwater pollution by pesticide residues [13] remain without proper attention. Despite the study of the current state of the plant protection products market in the agricultural sector of the economy, the prospects for the formation and development of the market for chemical plant protection products in agriculture remain insufficiently researched.

The purpose of the research is to analyze the current global trends in the development of the plant protection products market and to propose directions for improving the state policy in this area.

Statement of the main material. Developing countries are usually dependent on agricultural development and are therefore often the destination of banned and severely restricted chemicals [15]. In developing countries, pesticide residues are often found in vegetable crops, and in general, they are much higher than in industrialised countries [16]. Undoubtedly, these organisational, environmental and economic problems of the plant protection products market are particularly relevant for Ukraine, whose current state of economic development significantly depends on the level of development of the agricultural sector.

The peculiarities of agricultural producers' activities and the increasing socio-economic importance of the agricultural sector of the economy necessitate the development and substantiation of methodological conditions aimed at solving multidimensional and diverse problems of ensuring sustainable development of agro-industrial production [17]. Ukraine's agriculture has undergone profound shifts in the production structure of enterprises and in the structure of products. At the same time, the problems of forming intersectoral economic relations at all stages of agricultural production development are extremely relevant [18], especially in the current environment. Since 2014, the agrochemical industry has been experiencing a period of decline, in particular, due to low crop prices and low profitability of farms [19]. Thus, ensuring the effective development of all spheres of the agri-food complex requires attracting investments, including foreign ones, taking into account the European Green Deal, which provides for the strengthening of the transition to a green economy [20]. One of the reasons for the low inflow of foreign investment into the country's economy is the imperfect regulation of the legal framework in the field of investment relations, so there is a need to develop a clear strategy and tactics for attracting foreign investment [21]. Attracting investment in environmentally oriented investment projects and programmes should be based on strengthening the environmental aspects of investment policy as part of the incentive subsystem of the economic mechanism for sustainable rural development [22].

In the current market conditions of socio-economic and financial-economic development of the state, the basic goal of forming the future model of Ukraine's economy is an active and targeted policy on the state of the agricultural market, organisational and functional relations between market entities, pricing policy for agricultural products, the state of the world market for plant protection products in agriculture.

According to foreign experts, one third of the world's agricultural products are produced in Ukraine. Other researchers also point out that without the use of plant protection products, losses of fruits, vegetables and grains from pests, diseases and weeds would reach 78%, 54% and 32%, respectively [22]. Scientists also point out that the abandonment of chemical plant protection products will not only lead to a sharp decline in food production, but also to a rise in food prices. In such a situation, exports of cotton, wheat and soybeans from the United States would decline by 27% and 132,000 jobs would be lost [23]. According to the calculations of NAAS scientists, due to a possible ban on the Ukrainian market of certain active ingredients of plant protection products, the total losses of the agricultural sector due to crop failure, lower product quality and additional costs for the application of insecticide substitutes may increase by UAH 36.8-74.9 billion, which in dollar terms is equal to USD 1.3-2.7 billion [1].

Environmental losses, which are manifested in an increase in fresh water consumption for crop cultivation, will increase in the range of 4.9 to 6.8 million m3, and CO2 emissions - from 89.4 to 92.4 million kg annually [1]. If glyphosate is banned in the absence of equivalent alternatives, the losses of the agricultural sector could reach UAH 31.0-55.2 billion or USD 1.25-2.23 billion. At the same time, additional CO2 emissions would amount to 23.7-47.4 million kg annually [1]. These environmental consequences are especially

important in the context of global climate change towards warming and the need to adapt to it [24]. The main indicators showing global trends in pesticide use in the world and on individual continents during 1990-2019 are presented in Table 1.

Table 1 - Use of pesticides in 2005-2024, t

Years	World	Asia	America	Africa	Europe	Oceania	Ukraine
2010	3452,2	1819,6	1069,3	71,3	452,8	39,2	23
2011	3501,1	1888	1064,2	77,4	430,5	41,1	28,8
2012	3790,5	2015,1	1203,9	75,6	457,5	38,3	36,5
2013	3838	2042,6	1184,1	79,2	482,3	49,7	54,1
2014	3754,9	2094,8	1116	79,6	420,3	44,2	36,4
2015	4014,6	2156,9	1277,5	84,7	447,1	48,3	62,5
2016	4109,8	2203,2	1272,7	92,5	487,6	53,8	79,5
2017	4152,4	2212,6	1293,9	98,1	492,9	55	90,8
2018	4111,6	2149,8	1325,3	100	485,1	51,4	86,8
2019	4165,4	2174,3	1331	98,7	505,3	56,1	78,2
2020	4125,9	2151,4	1319,5	97,6	487,1	57,2	64,5
2021	4161	2173,4	1338,3	97,5	501,3	69,7	51,8
2022	4186	2185,2	1306,8	102,1	490,3	69,7	38,6
2023	4141	2177,2	1325,2	107	480,3	69,7	25,3
2024	4168,8	2148,8	1364	107,9	478,4	69,7	24,3

Source: developed by the author according to [25].

Thus, as can be seen from the data presented here, on a global scale, in the period 1990-2019, there was a tendency to increase the use of pesticides in agriculture. We present the main indicators of global trends in the use of pesticides in the world and on individual continents in 1990-2019 in Table 1. As can be seen from the data, there has been an upward trend in pesticide use in agriculture globally over the period 1990-2019.Despite the relatively stable performance achieved in the last decade, total pesticide uses in the 2010s increased by more than 50 per cent compared to the 1990s. The regions showing the highest growth rates in terms of total pesticide use are the Americas and Oceania, with 2.2 and 3.2 times the increase in use respectively. The only region where countries have reduced their pesticide use is Europe, where the total decrease was 12106 tonnes, or 2.5%. In Ukraine, the use of pesticides in agriculture has significantly decreased by 42447 tonnes (63.6%) over the period 1992-2019. The upward trend on a global scale is also demonstrated by the rate of pesticide use per 1 ha of sown area (Table 2).

Table 2 – Pesticide use per 1 ha in 1990-2019, kg

Years	World	Asia	America	Africa	Europe	Oceania	Ukraine
2010	2,28	3,18	2,89	0,29	1,54	1,36	0,69
2011	2,32	3,3	2,87	0,31	1,47	1,55	0,86
2012	2,51	3,52	3,25	0,3	1,57	1,5	1,09
2013	2,54	3,57	3,22	0,31	1,65	1,87	1,62
2014	2,48	3,64	3,06	0,31	1,44	1,49	1,09
2015	2,64	3,75	3,48	0,33	1,54	1,71	1,87
2016	2,69	3,81	3,48	0,35	1,68	1,57	2,38

2017	2,69	3,82	3,53	0,36	1,7	1,6	2,72
2018	2,66	3,7	3,61	0,36	1,67	1,51	2,58
2019	2,69	3,74	3,63	0,36	1,75	1,62	2,32
2020	2,66	3,68	3,63	0,36	1,68	1,7	1,93
2021	2,68	3,7	3,61	0,35	1,74	2,13	1,54
2022	2,68	3,7	3,62	0,37	1,7	2,09	1,15
2023	2,66	3,69	3,54	0,39	1,67	2,07	0,75
2024	2,69	3,68	3,7	0,39	1,66	2,1	0,72

Source: developed by the author according to [25].

The highest growth rates of pesticide use per hectare are demonstrated by the countries of North and South America and Oceania. Ukraine is characterised by a decrease in this indicator, especially in the period after 2014, which is explained, in particular, by the depreciation of the national currency and, as a result, an increase in the cost of pesticides for domestic producers.

The main trends in the global pesticide market indicators during the study period are shown in Fig. 1.

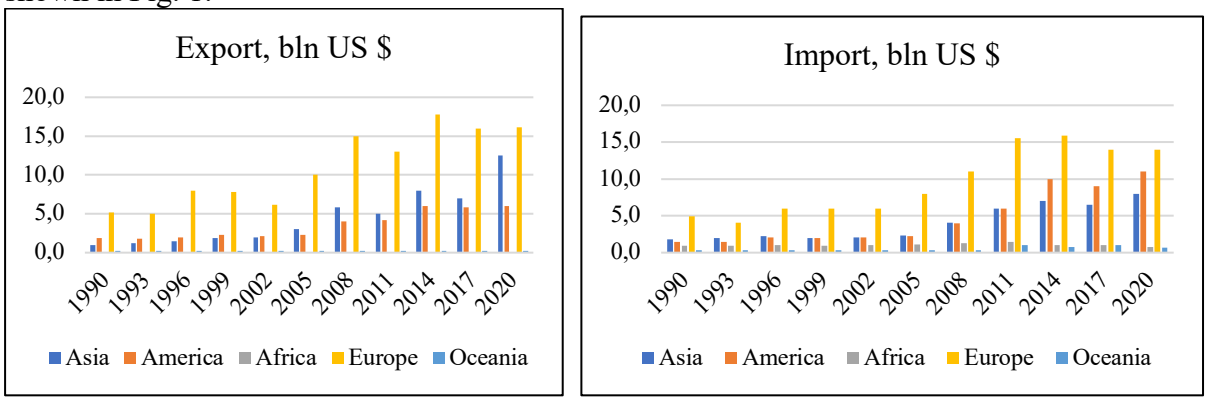

Figure 1 - Exports and imports of plant protection products by regions of the world in 1990-2020, bln US $

Source: developed by the author according to [25].

This data shows that the largest exporters and importers of pesticides are European countries. In 1990, there were more than ten large agrochemical companies in the United States and Europe, but by 2009, the number of these entities had decreased to six large ones due to mergers and acquisitions (M&A), namely Syngenta, Bayer, BASF, Dow Chemical, DuPont, and Monsanto [26]. In 2015, Dow and DuPont merged, and in 2016, the Chinese national company ChemChina bought Syngenta (the world's largest producer of plant and seed protection products), as well as the agreement between the German concern Bayer and the American producer of genetically modified seeds and herbicides Monsanto [27].

China is one of the countries that pioneered the use of chemical plant protection products. In 1950, China began producing the insecticide hexachlorocyclohexane, and in 1957, the first plant for the production of pesticides based on organophosphate compounds was built in China [28].

China's approach to food export safety emphasises the creation of a closed supply chain by elite export-oriented companies and farms that can demonstrate that they have implemented appropriate safety controls and have high sanitary standards, qualified personnel and control over raw materials to ensure the safety of their products [28]. Different

levels of pesticide residues in different countries can significantly disrupt global trade [29]. Therefore, the environmental impact of agro-export production in the world remains an important issue [30].

At the global level, the total use of pesticides in agriculture remained stable in 2019, equalling 4.2 million tonnes of active ingredients. The average global pesticide application per hectare of crop area was 2.69 kg/ha, varying by continent from 0.39 kg/ha in Africa to 3.70 kg/ha in the Americas. Global pesticide trade volumes in 2019 reached approximately 5.6 million tonnes of finished products worth USD 35.5 billion. In the structure of pesticide use, the share of herbicides increased from 38.7% to 53.3% of the total, due to an increase in their use by 1330530 tonnes or 2.5 times. In terms of total pesticide use in 2019, Ukraine ranked 22nd among the world's countries, almost triple the lagging behind India, which ranked 10th. If we take into account the rate of pesticide application per unit area, Ukraine (0.72 kg/ha) is also not in the top 10, which, in turn, can be explained by the longer operating cycle of domestic agricultural enterprises. In 2019, the following countries were among the world leaders in terms of pesticide use intensity (kg/ha): Trinidad and Tobago (24.96), Saint Lucia (19.60), Ecuador (14.03), Hong Kong (13.75), Taiwan (13.35), China (13.07), Israel (12.74), Belize (11.34), South Korea (10.59) and Colombia (7.08) [25].

When analyzing the dynamics of pesticide use in the world, we should pay attention to their efficiency. To measure the production efficiency of pesticide use, scientists have proposed a cost/benefit index that reflects the amount of pesticide use to produce a certain amounts of crops per year [31]. According to this index, at the global level, the efficiency of pesticide use increased during 1990-2007, but has been declining since 2007. Among the major countries, Brazil (1.883) had the highest pesticide use (g/kg of crop) in 2010-2014, followed by Japan (1.846), Mexico (1.678), China (1.243), Canada (0.979), the United States (0.873), France (0.708), Germany (0.673), the United Kingdom (0.550), and India (0.089) [31]. Thus, a higher volume of pesticide application per hectare did not always lead to higher production efficiency.

In contrast to global trends, Ukraine has experienced periods of significant decline in pesticide use, particularly in the 1990s and 2010s. While for the first period, the decline in pesticide use in Ukraine can be explained by a general decline in agricultural production, for the last decade, the decline in the total use of chemical plant protection products, in our opinion, is due to both improved application technologies, the use of plant protection products in optimal doses, constant quality control (which leads to the use of fewer and better pesticides), and the use of organic farming technologies.

When discussing the results of the study, it should be noted that they are of great practical value for producers and exporters in shaping the global chemical market. The identified key indicators of the global pesticide market and the structure of their use are important components in the formation of state policy in the field of pesticides and agrochemicals and are of some value to agricultural producers. The conditions in which the agricultural sector operates are highly volatile and uncertain, and this circumstance requires agricultural producers to find ways to obtain reliable information about the state of the market for these products, organizational and functional relations between market participants [32], as well as the state of the markets for material and technical resources, pesticides and agrochemicals used by agricultural enterprises. For example, C. Collins and other scholars argue that a stable policy is important to ensure a safe economic, environmental and socially acceptable space for further innovation in the production and use of chemicals [33]. To promote truly ‘sustainable development’ in the field of plant protection, the German Federal Environment Agency recommends a comprehensive approach to all relevant policy areas (plant protection, environment, nature conservation and agriculture) based on the following five basic principles: minimization of use; identification, quantification and communication

of risks; internalization of externalities; compensation for unavoidable consequences; and optimization of risk management [34].

Reducing the use of chemicals. The largest market for biological products is concentrated in North America (44%), Latin and South America (10%), and in Asia and India, up to about 6% [35]. Some researchers [36] have concluded that in the future, biological products will become one of the alternative means to synthetic chemicals due to their lower cost, safety, and widespread availability. Crop loss caused by pests is a serious problem for agricultural production. Reducing the cost of pest control and pesticide use can be achieved by introducing or increasing the population of natural enemies [37].

The effectiveness of pesticide market regulation lies in the prohibition or elimination of pesticides that are the most dangerous and have the greatest potential for harm to humans and the environment [38]. As we can see, the consequences of the use of chemical plant protection products against pests and diseases are manifested not only in the production and economic spheres, but also in the issues of identification, quantification, optimization of risk management, microbial degradation and conversion of xenobiotics in the environment, etc. Thus, in the future, the use of biological products instead of chemical pesticides in agricultural production should be encouraged.

Conclusions. The plant protection products market is one of the most important resources in agricultural production, as pesticides, together with technological innovations, play an important role in stimulating global agricultural production. An analysis of current global trends in the development of the crop protection market has shown that it is characterized by upward trends in production, exports, imports and use of pesticides. The highest growth rates of pesticide use per hectare are demonstrated by the countries of America and Oceania, and the lowest - by the countries of Africa. The largest exporters and importers of pesticides are European countries. In contrast to global trends, Ukraine has experienced periods of significant reduction in pesticide use, particularly in the 1990s and 2010s, which can be considered somewhat positive from the perspective of the European Green Deal.

To improve the state policy in the field of pesticides and agrochemicals and to overcome the problems of the plant protection products market in Ukrainian agriculture, it is necessary to:

improve the legislative framework for the state regulation of the market in the field of pesticides and agrochemicals with the provision of equivalent alternatives to substitutes in case of a ban on the use of certain plant protection products on the Ukrainian market;

to amend the Law of Ukraine ‘On Plant Protection’ to increase liability for the use of counterfeit plant protection products - chemical products that do not meet the established international requirements for chemical plant protection products against pests and diseases;

to introduce more effective state supervision and control over compliance with the current legislation on the use of quality pesticides in agricultural production and guaranteeing the safety of their use in accordance with international standards;

to strengthen the responsibility of all participants in the market of chemical plant protection products for violation of the current legislation on environmental protection in the context of sustainable development;

in agricultural production, it is necessary to combine agrochemical protection with various biological and mechanical methods of control, while the state should encourage the use of biological products instead of chemical pesticides.

We consider, there is a need for further scientific discussion and further research on the issues aimed at finding methodological and practical approaches to the formation and development of the market for plant protection products against pests and diseases in the context of the implementation of the European Green Deal; soil protection and groundwater

pollution, as well as control over the circulation and use of pesticides in accordance with the requirements of the EU and Ukraine's partner countries in international trade.

СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

1. На засіданні Бюро Президії НААН розглядали питання проблем ринку засобів захисту рослин в Україні. URL: http://naas.gov.ua/newsall/newsnaan/?ELEMENT_ID=7413.
2. Panagiotakopulu E., Buckland P., Day P., Doumas C. Natural insecticides and insect repellents in antiquity: a review of the evidence. *Journal of Archaeological Science*. 1995. Vol. 22. Is. 5. P. 705–710.
3. Nicolopoulou-Stamati P., Maipas S., Kotampasi C., Stamatis P., Hens L. Chemical pesticides and human health: the urgent need for a new concept in agriculture. Frontiers in Public Health. 2016. Vol. 4. 148.
4. Public health impact of pesticides used in agriculture. World Health Organization, 1990. 129 p. URL: https://apps.who.int/iris/handle/10665/39772.
5. Alewu B., Nosiri C. Pesticides and human health. Pesticides in the modern world – effects of pesticides exposure / ed. M. Stoytcheva. London: IntechOpen, 2011. P. 231–250. https://doi.org/10.5772/18734.
6. Zacharia J. T. Identity, physical and chemical properties of pesticides. *Pesticides in the modern world – effects of pesticides exposure* / ed. M. Stoytcheva. London: InTech, 2011. P. 1–18.
7. Thematic strategy on the sustainable use of pesticides. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Al28178.
8. Cooper J., Dobson H. The benefits of pesticides to mankind and the environment. *Crop Protection*. 2007. Vol. 26. Is. 9. P. 1337–1348.
9. Sarkar S., Juliana D., Bernardes G., James K., Niklas M., Kees J. The use of pesticides in developing countries and their impact on health and the right to food. European Parliament, 2021. 44 p.
10. Василенко Л. В., Корчинська О. А. Ринок хімічних засобів захисту рослин: моногр. Київ: АПСВТ, 2020. 176 с. URL: http://www.socosvita.kiev.ua/sites/default/files/Monohrafiia_Korchynskaia_2021.pdf.
11. Snyder F., Ni L. Chinese apples and the emerging world food trade order: food safety, international trade, and regulatory collaboration between China and the European Union. *The Chinese Journal of Comparative Law*. 2017. Vol. 5. Is. 2. P. 253–307.
12. World summit on food security. Summary report. URL: https://enb.iisd.org/events/2009-world-summit-food-security/summary-report-16-18-november-2009.
13. Sharma A., Kumar V., Shahzad B., Tanveer M., Singh Sidhu G. P., Handa N., Kohli S. K. … Thukral A. K. Worldwide pesticide usage and its impacts on ecosystem. *SN Applied Sciences.* 2019. № 1. 1446.
14. Про схвалення Стратегії екологічної безпеки та адаптації до зміни клімату на період до 2030 року: Розпорядження КМУ від 20.10.2021 р. № 1363-р. URL: https://zakon.rada.gov.ua/laws/show/1363-2021-%D1%80#Tex.
15. Colopy J. Poisoning the developing world: the exportation of unregistered and severely restricted pesticides from the United States. *UCLA Journal of Environmental Law and Policy.* 1995. Vol. 13. Is. 2. P. 167–222.
16. Galt R. E. “It just goes to kill Ticos”: national market regulation and the political ecology of farmers’ pesticide use in Costa Rica. Journal of Political Ecology. 2009. Vol. 16. Is. 1. P. 1–33.

17. Vdovenko N., Baidala V., Burlaka N., Diuk A. Management mechanism of agrarian economic system: composition, functioning and factors of development in Ukraine. *Problems and Perspectives in Management*. Vol. 16. Is. 2. P. 179–189. URL: https://doi.org/10.21511/ppm.16(2).2018.16.

18. Tomilin O., Galych O., Kalinichenko A. Economic aspects of development of interbranch relations in the agrarian sector: monograph. Opole: University of Opole, 2016. 171 p. URL: http://dspace.pdaa.edu.ua:8080/handle/123456789/1568. 10. Phillips M. W. A. Agrochemical industry development, trends in R & D and the impact of regulation. *Pest Management Science*. 2019. Vol. 76. Is. 10. P. 3348–3356. URL: https://doi.org/10.1002/ps.5728.

19. Кучер А. В., Кучер Л. Ю., Пащенко Ю. В. Циркулярна економіка в системі сталого розвитку аграрного сектора в умовах євроінтеграції. *Економіка та суспільство.* 2021. № 32. URL: https://doi.org/10.32782/2524-0072/2021-32-24.

20. Tomilin O. O., Gryschko V. V., Kolomiyets S. A. Features of investment regulation of construction in agriculture / eds. V. Onyshchenko, G. Mammadova, S. Sivitska, A. Gasimov. Proceedings of the 2nd International Conference on Building Innovations. ICBI 2019. Lecture Notes in Civil Engineering. Vol. 73. Springer, Cham. 2020. P. 741–755. https://doi.org/10.1007/978-3-030-42939-3_73.

21. Gorb O., Yasnolob I., Chayka T., Zoria O., Dugar T., Shvedenko P., Kalian O. … Protsiuk N. Ecological-agrochemical land evaluation and classification under organic farming. *Journal of Environmental Management and Tourism*. 2020. Vol. 11. № 6. P. 1588–1595. https://doi.org/10.14505/jemt.v11.6(46).29.

22. Cai D. W. Understand the role of chemical pesticides and prevent misuses of pesticides. Bulletin of Agricultural Science and Technology. 2008. Vol. 1. P. 36–38.

23. Guo X. F., Zhang H. F., Li J. G. The importance of fungicides/bactericides in American agriculture. *World Pesticides*. 2007. Vol. 9. Is. 3. P. 21–25.

24. Кучер А. В. Стратегічні напрями розвитку низьковуглецевого землекористування як запоруки стійкості до змін клімату: моногр. Харків: ФОП Бровін О. В., 2019. 202 с.

25. Food and agriculture data. URL: https://www.fao.org/faostat/en

26. Nishimoto R. Global trends in the crop protection industry. *Journal of Pesticide Science.* 2019. Vol. 44. Is. 3. P. 141–147.

27. Іщук С. О., Созанський Л. Й., Коваль Л. П., Ляховська О. В. Виклики та перспективи розвитку хімічних виробництв у регіонах України / наук. ред. С. О. Іщук. НАН України; ДУ “Інститут регіональних досліджень імені М. І. Долішнього НААН України”. Львів, 2018. 91 с. URL: http://ird.gov.ua/irdp/p20180603.pdf.

28. Zhang W., Jiang F., Ou J. Global pesticide consumption and pollution: with China as a focus. Proceedings of the International Academy of Ecology and Environmental Sciences. 2011. Vol. 1(2). P. 125–144.

29. Gale F., Buzby J. C. Imports from China and food safety issues. Economic Information Bulletin No. 52. U.S. Department of Agriculture, Economic Research Service, 2009. 37 p. URL: https://www.ers.usda.gov/publications/pub-details/?pubid=44392.

30. Hejazi M., Grant J. H., Peterson E. Trade impact of maximum residue limits in fresh fruits and vegetables. Food Policy. 2022. Vol. 106. 102203.

31. Zhang W. J. Global pesticide use: Profile, trend, cost / benefit and more. *Proceedings of the International Academy of Ecology and Environmental Sciences*. 2018. Vol. 8. №. 1. P. 1–27.

32. Kozlovskyi S., Mazur H., Vdovenko N., Shepel T., Kozlovskyi V. Modeling and forecasting the level of state stimulation of agricultural production in Ukraine based on the

theory of fuzzy logic. *Montenegrin journal of economics*. 2018. Vol. 14. №. 3. P. 37–53. URL: https://doi.org/10.14254/1800-5845/2018.14-3.3.

33. Collins C., Depledge M., Fraser R., Johnson A., Hutchisone G., Matthiessenf P., Murphyg R. … Sumpteri J. Key actions for a sustainable chemicals policy. *Environment International*. 2020. Vol. 137. 105463.

34. Frische T., Egerer S., Matezki S., Pickl C., Wogram J. 5-Point programme for sustainable plant protection. Environmental Sciences Europe. 2018. Vol. 30. 8.

35. Bailey K. L., Boyetchko S. M., Längle T. Social and economic drivers shaping the future of biological control: a Canadian perspective on the factors affecting the development and use of microbial biopesticides. *Biological Control.* 2010. Vol. 52. Is. 3. P. 221–229. URL: https://doi.org/10.1016/j.biocontrol.2009.05.003.

36. Pavela R. Larvicidal effects of some Euro-Asiatic plants against Culex quinquefasciatus Say (Diptera: Culicidae). *Parasitology Research.* 2009. Vol. 105. Is. 3. P. 887–892. URL: https://doi.org/10.1007/s00436-009-1511-0.

37. Popp J., Pető K., Nagy J. Pesticide productivity and food security. *A review. Agronomy for Sustainable Development*. 2013. Vol. 33. P. 243–255.

38. Donley N. The USA lags behind other agricultural nations in banning harmful pesticides. *Environmental Health*. 2019. Vol. 18. 44.

REFERENCES

1. At the meeting of the Bureau of the Presidium of the National Academy of Agrarian Sciences, issues of the problems of the market of plant protection products in Ukraine were considered (2021). Available at: http://naas.gov.ua/newsall/newsnaan/?ELEMENT_ID=7413. 2. Panagiotakopulu E., Buckland P., Day P., Doumas C. Natural insecticides and insect repellents in antiquity: a review of the evidence. Journal of Archaeological Science. 1995. Vol. 22. Is. 5. P. 705–710.

3. Nicolopoulou-Stamati P., Maipas S., Kotampasi C., Stamatis P., Hens L. Chemical pesticides and human health: the urgent need for a new concept in agriculture. Frontiers in Public Health. 2016. Vol. 4. 148.

4. Public health impact of pesticides used in agriculture. World Health Organization, 1990. 129 p. URL: https://apps.who.int/iris/handle/10665/39772.

5. Alewu B., Nosiri C. Pesticides and human health. Pesticides in the modern world – effects of pesticides exposure / ed. M. Stoytcheva. London: IntechOpen, 2011. P. 231–250. https://doi.org/10.5772/18734.

6. Zacharia J. T. Identity, physical and chemical properties of pesticides. Pesticides in the modern world – effects of pesticides exposure / ed. M. Stoytcheva. London: InTech, 2011. P. 1–18.

7. Thematic strategy on the sustainable use of pesticides. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Al28178.

8. Cooper J., Dobson H. The benefits of pesticides to mankind and the environment. Crop Protection. 2007. Vol. 26. Is. 9. P. 1337–1348.

9. Sarkar S., Juliana D., Bernardes G., James K., Niklas M., Kees J. The use of pesticides in developing countries and their impact on health and the right to food. European Parliament, 2021. 44 p.

10. Vasylenko, L. V., & Korchynska, O. A. (2020). Rynok khimichnykh zasobiv zakhystu roslyn [Market of chemical plant protection products], Kyiv, APSVT. http://www.socosvita.kiev.ua/sites/default/files/Monohrafiia_Korchynskaia_2021.pdf.

11. Snyder F., Ni L. Chinese apples and the emerging world food trade order: food safety, international trade, and regulatory collaboration between China and the European Union. The Chinese Journal of Comparative Law. 2017. Vol. 5. Is. 2. P. 253–307.

12. World summit on food security. Summary report. URL: https://enb.iisd.org/events/2009-world-summit-food-security/summary-report-16-18-november-2009.

13. Sharma A., Kumar V., Shahzad B., Tanveer M., Singh Sidhu G. P., Handa N., Kohli S. K. … Thukral A. K. Worldwide pesticide usage and its impacts on ecosystem. SN Applied Sciences. 2019. № 1. 1446.

14. The Cabinet of Ministers of Ukraine (2021), Order of the Cabinet of Ministers of Ukraine "On approval of the Strategy of ecological safety and adaptation to climate change for the period up to 2030". Available at: https://zakon.rada.gov.ua/laws/show/1363-2021-%D1%80#Tex.

15. Colopy J. Poisoning the developing world: the exportation of unregistered and severely restricted pesticides from the United States. UCLA Journal of Environmental Law and Policy. 1995. Vol. 13. Is. 2. P. 167–222.

16. Galt R. E. "It just goes to kill Ticos": national market regulation and the political ecology of farmers' pesticide use in Costa Rica. Journal of Political Ecology. 2009. Vol. 16. Is. 1. P. 1–33.

17. Vdovenko N., Baidala V., Burlaka N., Diuk A. Management mechanism of agrarian economic system: composition, functioning and factors of development in Ukraine. Problems and Perspectives in Management. Vol. 16. Is. 2. P. 179–189. URL: https://doi.org/10.21511/ppm.16(2).2018.16.

18. Tomilin O., Galych O., Kalinichenko A. Economic aspects of development of interbranch relations in the agrarian sector: monograph. Opole: University of Opole, 2016. 171 p. URL: http://dspace.pdaa.edu.ua:8080/handle/123456789/1568. 10. Phillips M. W. A. Agrochemical industry development, trends in R & D and the impact of regulation. Pest Management Science. 2019. Vol. 76. Is. 10. P. 3348–3356. URL: https://doi.org/10.1002/ps.5728.

19. Kucher, A. (2019). Stratehichni napriamy rozvytku nyzkovuhletsevoho zemlekorystuvannia yak zaporuky stiikosti do zmin klimatu [Strategic directions of the development of low carbon land use, to strengthen resilience to climate change]. Kharkiv, Publisher Brovin. URL: https://doi.org/10.32782/2524-0072/2021-32-24.

20. Tomilin O. O., Gryschko V. V., Kolomiyets S. A. Features of investment regulation of construction in agriculture / eds. V. Onyshchenko, G. Mammadova, S. Sivitska, A. Gasimov. Proceedings of the 2nd International Conference on Building Innovations. ICBI 2019. Lecture Notes in Civil Engineering. Vol. 73. Springer, Cham. 2020. P. 741–755. https://doi.org/10.1007/978-3-030-42939-3_73.

21. Gorb O., Yasnolob I., Chayka T., Zoria O., Dugar T., Shvedenko P., Kalian O. … Protsiuk N. Ecological-agrochemical land evaluation and classification under organic farming. Journal of Environmental Management and Tourism. 2020. Vol. 11. № 6. P. 1588–1595. https://doi.org/10.14505/jemt.v11.6(46).29.

22. Cai D. W. Understand the role of chemical pesticides and prevent misuses of pesticides. Bulletin of Agricultural Science and Technology. 2008. Vol. 1. P. 36–38.

23. Guo X. F., Zhang H. F., Li J. G. The importance of fungicides/bactericides in American agriculture. World Pesticides. 2007. Vol. 9. Is. 3. P. 21–25.

24. Kucher, A. (2019). Stratehichni napriamy rozvytku nyzkovuhletsevoho zemlekorystuvannia yak zaporuky stiikosti do zmin klimatu [Strategic directions of the development of low carbon land use, to strengthen resilience to climate change]. Kharkiv, Publisher Brovin. URL: https://doi.org/10.32782/2524-0072/2021-32-24.

25. Food and agriculture data. URL: https://www.fao.org/faostat/en

26. Nishimoto R. Global trends in the crop protection industry. Journal of Pesticide Science. 2019. Vol. 44. Is. 3. P. 141–147.

27. Ishchuk, S. O., Sozanskyi, L. Y., Koval, L. P., & Liakhovska, O. V. (2018). Vyklyky ta perspektyvy rozvytku khimichnykh vyrobnytstv u rehionakh Ukrainy [Challenges and prospects for the development of chemical production in the regions of Ukraine], Lviv, NAS of Ukraine; SI "Institute of Regional Research named after M. I. Dolishniy of the NAS of Ukraine". Available at: http://ird.gov.ua/irdp/p20180603.pdf.

28. Zhang W., Jiang F., Ou J. Global pesticide consumption and pollution: with China as a focus. Proceedings of the International Academy of Ecology and Environmental Sciences. 2011. Vol. 1(2). P. 125–144.

29. Gale F., Buzby J. C. Imports from China and food safety issues. Economic Information Bulletin No. 52. U.S. Department of Agriculture, Economic Research Service, 2009. 37 p. URL: https://www.ers.usda.gov/publications/pub-details/?pubid=44392.

30. Hejazi M., Grant J. H., Peterson E. Trade impact of maximum residue limits in fresh fruits and vegetables. Food Policy. 2022. Vol. 106. 102203.

31. Zhang W. J. Global pesticide use: Profile, trend, cost / benefit and more. Proceedings of the International Academy of Ecology and Environmental Sciences. 2018. Vol. 8. №. 1. P. 1–27.

32. Kozlovskyi S., Mazur H., Vdovenko N., Shepel T., Kozlovskyi V. Modeling and forecasting the level of state stimulation of agricultural production in Ukraine based on the theory of fuzzy logic. Montenegrin journal of economics. 2018. Vol. 14. №. 3. P. 37–53. URL: https://doi.org/10.14254/1800-5845/2018.14-3.3.

33. Collins C., Depledge M., Fraser R., Johnson A., Hutchisone G., Matthiessenf P., Murphyg R. … Sumpteri J. Key actions for a sustainable chemicals policy. Environment International. 2020. Vol. 137. 105463.

34. Frische T., Egerer S., Matezki S., Pickl C., Wogram J. 5-Point programme for sustainable plant protection. Environmental Sciences Europe. 2018. Vol. 30. 8.

35. Bailey K. L., Boyetchko S. M., Längle T. Social and economic drivers shaping the future of biological control: a Canadian perspective on the factors affecting the development and use of microbial biopesticides. Biological Control. 2010. Vol. 52. Is. 3. P. 221–229. URL: https://doi.org/10.1016/j.biocontrol.2009.05.003.

36. Pavela R. Larvicidal effects of some Euro-Asiatic plants against Culex quinquefasciatus Say (Diptera: Culicidae). Parasitology Research. 2009. Vol. 105. Is. 3. P. 887–892. URL: https://doi.org/10.1007/s00436-009-1511-0.

37. Popp J., Pető K., Nagy J. Pesticide productivity and food security. A review. Agronomy for Sustainable Development. 2013. Vol. 33. P. 243–255.

38. Donley N. The USA lags behind other agricultural nations in banning harmful pesticides. Environmental Health. 2019. Vol. 18. 44.