Part 3. Biosafety

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OVERVIEW OF THE ISSUE OF GENETICALLY MODIFIED CROPS IN UKRAINE

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Summary. The issue of regulating the circulation of genetically modified (GM) crops and their products is extremely important for Ukraine. This is confirmed by climate change, which indicates the need for rapid adaptation of existing varieties while maintaining the yield level; increasing pest resistance to pesticides; international competitiveness of GM products; the need to comply with regulations on genetically modified organisms (GMOs) for European integration and the presence of genetically modified seeds in the country's crops. So, the purpose of the work was to consider the problems, prospects and potential of GM plants in Ukraine. Qualitative analytical methods were used in the market analysis. Information was obtained from official data sources and market surveys. The results of four-year screenings in Dnipropetrovsk Region were also summarized. PCR diagnostics was used as verification method. In the course of the work, it has been established the presence on the Ukrainian market of more than two dozen GM soybean varieties, four transgenic sunflower hybrids, and ten transgenic corn hybrids from the world's leading producers of Canada (Bramhill seeds, Sertis Holding S.A., Hyland Seeds, Sevita Int., Prograin), the USA (Asgrow & Monsanto), France (R.A.G.T.), Austria (Saatbau Linz). During 2018–2021, the distribution of transgenic products among domestic products in Dnipropetrovsk Region has been recorded. Thus, real-time PCR revealed that GMOs were present in 42.8% of the analyzed soybean samples; 87.5% of mixed fodder; 15.0% of sunflower samples. It has been established that the circulation of falsified GM products on the country's market ranged from 25 to 50% (inconsistency in marking, certificate, holograms, and QR code), which indicates the imperfection of legal regulation and creates prerequisites for their illegal use

Keywords: soybean, corn, sunflower

Introduction. The law 'On the state biosafety system for the creation, testing, transportation and use of genetically modified organisms' was adopted in 2007, but discussions on the issue of legal circulation of GMOs in Ukraine continue (Slasten, 2020). For example, there are no registered genetically modified varieties or hybrids in the country today. And this is at a time when the share of GM cultures in the crops of farmers in the USA, Canada, Brazil, Argentina, and Australia already reaches more than 90%, and most of the EU countries import GM corn and soybeans for animal husbandry without any problems.

Taking into account such world trends, the issue of regulating the circulation of GM crops and their products is extremely important for Ukraine. This is confirmed by climate change, which indicates the need for rapid adaptation of existing varieties while maintaining the yield level; increasing pest resistance to pesticides; international competitiveness of GM products; the need to comply with regulations on GMOs for European integration and the presence of genetically modified seeds in the country's crops.

Therefore, Ukraine, as one of the largest suppliers of agro-food products to the world market (FAO …, 2022), needs to adapt to these changes now. The world's concern about changes in weather and climate conditions is pushing countries to implement important transformations, including in agriculture. National programs such as the Green Deal are being developed and implemented to help slow global warming by reducing greenhouse gas emissions, deforestation and other measures.

Measures taken by international organizations already affect the conditions of agricultural activity and trade in agricultural products. One of the trends in the European Union is Carbon footprint — carbon policy and everything that happens around it. Soybean and its processing products play an important role in this issue, since 22% of CO_2 emissions in the EU agricultural production are due to this crop (Shevchenko, 2021).

The recognition in 2020 (Nurton, 2020) by the Nobel Committee of Scientists for the development of a method of genome editing using CRISPR/Cas9 is an important step on the way to the cultivation of new varieties of agricultural crops that are already entering national commercialization regulatory schemes. Such changes were implemented for the first time in Argentina, which indicates significant shifts in the field of agricultural biotechnology products. Changes to the law on gene-edited crops show that laws must adapt to changing conditions (Turnbull, Lillemo and Hvoslef-Eide, 2021).

European scientists are also calling for changes to European legislation on GMOs, which they say is necessary for the further development of sustainable agriculture, ensuring sufficient food for the population and protecting the environment (Šaradínová, 2020). 'Genome editing that leads to changes that can also occur spontaneously in nature and that do not introduce foreign DNA should, in addition, be exempted from the application of GMO legislation', said a statement by EU-SAGE, which brings together members from 132 European research institutes and associations.

185.1 million hectares in 26 countries (as of 2016) are planted with GM crops. Undoubtedly, the world leader in the cultivation of GM crops is the USA. Currently, ten crops are commercially grown there: zucchini (since 1995), soybeans (since 1995), corn (since 1996), cotton (since 1996), papaya (since 1997), rapeseed (since 1999), alfalfa (since 2006), sugar beet (since 2006), potatoes (since 2016), apple (since 2017). The top five countries (as of 2017) also include Brazil, Argentina, Canada and India. Other GM crops currently approved for commercial use in various countries are eggplant, sweet pepper, carnation, petunia, rose, tobacco, tomato, wheat, sugar cane, bean, chicory, mung bean, agrostis, eucalyptus, flax, melon, plum, turnip, rice, safflower, poplar. At the same time, 1–3 genetic modifications have been registered for some of them (for example, petunias, roses), and for some — tens or even hundreds (for example, soybean — 42, cotton — 63, corn — 231). In terms of volume, GM soybeans are grown the most in the world, followed by corn, and third by cotton (Useful Information, no data).

The development of the Ukrainian soybean market is significantly influenced by the trends of the main buyer countries, since Ukraine is a net exporter, consuming only up to 20% of the produced volumes (Shevchenko, 2021). The key buyers of these products in the world are China — with a consumption volume of 100 million tons per year and the EU — about 40 million tons. China plans to accelerate the introduction of genetically modified corn varieties, which could allow Chinese farmers to start planting GM corn as early as 2023 (China …, 2022).

The experience of other countries shows that it is advisable to regulate the possible impact when using modified organisms in accordance with the 'Cartagena Protocol' (SCBD, 2000). Thus, Ukraine joined the Cartagena Protocol on Biosafety to the Convention on Biological Diversity on September 12, 2002 (VRU, 2002).

The spread of GM plants has become an irreversible process (Rudyshin, 2009). Thus, the Agent Green association (Romania) with the assistance of the 'Danube Soya' association conducted field research in 2018. 60 large fields in the six main soybean regions of Ukraine were investigated. The share of GM soybeans was 48%. Despite the ban, GM crops are actively grown in Ukraine. There is absolutely no control over the cultivation of GM soybeans, although the products obtained using this technology are, according to the law, subject to complete destruction (There is …, 2017).

So, the work aimed to consider the problems, prospects and potential of GM plants in Ukraine.

Materials and methods. Qualitative analytical methods were used in the market analysis. Information was obtained from official data sources and market surveys.

Laboratory analyzes were carried out by an accredited laboratory (ISO 17025) in Dnipro, based on officially approved methods of analysis. Samples were tested to determine compliance with food safety parameters, to provide early warning of potential problems, and to provide a basis for risk assessment.

Real-time PCR laboratory screening covered raw materials, semi-finished products and finished products for export and domestic production (n = 410). 35 S promoter of cauliflower mosaic virus, NOS terminator of *Agrobacterium tumafaciens*, and FMV 34 S promoter were determined in the samples.

Test results were documented and subjected to regular review and trending. The test samples were selected for the purpose of official control in compliance with the established rules and standards of selection and analysis. Samples were handled and labeled in a manner to ensure legal and analytical validity. The results were interpreted according to the criteria defined by the legislation.

Results. Taking into account the focus of Ukrainian farmers on soybeans and planning to increase its area to 1.4 million hectares (Panasiuk, 2022), an online analysis of transgenic seed material in the country was made. The availability of 24 GM soybean varieties (Table 1) from the world's leading producers from Canada (Bramhill seeds, Sertis Holding S.A., Hyland Seeds, Sevita Int., Prograin), USA (Asgrow & Monsanto), France (R.A.G.T.), Austria (Saatbau Linz) has been established on the market of Ukraine. The turnover of falsified products on the market was 25% (mismatch of marking, certificate, holograms and QR code).

Video reports from Poltava Region testify to the cultivation of GM soybean varieties — Sinara, Histar in 2022 (Volovyk, 2022; SH Zhyttia, 2022), Kansas (Alex_Agro, 2021) in 2021; from Sumy Region — Apollo, Ultra in 2021 (Sumshchyna, 2021); from Chernivtsi Region — Whitby in 2019 (Hrytsyk, 2019); from the city of Zaporizhia — Maximus in 2021 (Selhozperedelkin, 2021); from Crimea — Sigalia in 2021 (Ernest-No-Till, 2021).

The sale of four transgenic sunflower hybrids (Table 2) from two of the world's leading producers from Canada (Sertis & DOW Chemical, Union Carbide & Sertis Holding S. A.) has also been established. The turnover of falsified products on the market was 25%.

Sales implementation of ten transgenic corn hybrids (Table 3) from two of the world's leading producers from Canada (Sertis Holding S.A. & DOW Chemical, Union Carbide & Sertis Holding S.A.) was established. The turnover of falsified products on the market was 50% (mismatch of marking, certificate, holograms and QR code).

Table 1 — GM soybean seed material on the Ukrainian market in 2022

Variety, yield centner/hectare	Manufacturer / country	Source of information	Region of Ukraine
Colby, 45–68	Sertis Holding S. A. / Canada	https://agrodobro.com.ua/goods/semena-soi-colby/	Dnipro
Whitby, 55–60		https://flagma.ua/uk/semena-soi-uitbi-whitby-ultrarannyaya-o12863487.html	Khorol, Poltava Region
		https://agrovektor.com/physical_product/765050-semena-soi-whitby.html	Kharkiv
Histar, 42		https://flagma.ua/uk/semena-soi-haystar-histar-sredneranney-105-o11331291.html	Khorol, Poltava Region
Sydney Bt, 72		https://certisgroup.eu.com/product/soya-sydney-bt-nano-transgennaya https://flagma.ua/novy-kanadskiy-elitny-sort-soi-sydney-bt-o4798252.html	Odesa
Merlin, 30–35	Saatbau Linz / Austria	https://favorit-td.com.ua/p8641250-soya-gmo.html https://agro-liga.com/catalog-produkcii/soya-merlin/	Kropyv-nytskyi
Maximus, 47	Monsanto / USA	https://agrovektor.com/physical_product/83029-semena-soi-maksimus-gmo.html	Poltava Region
Maxus, 50	Asgrow & Monsanto / USA	https://favorit-td.com.ua/p376240947-soya-maxus.html https://agrovektor.com/ua/physical_product/598929-soya-gmo-maksus.html	
Конор, 42	Hyland Seeds / Canada	https://agrovektor.com/physical_product/194138-semena-soi-konor.html	Kharkiv
Madison, 45		https://favorit-td.com.ua/p376160466-soya-madison.html	Pidhaitsi, Kirovohrad Region
AOC Calipso, 58	Sevita Int. / Canada	https://favorit-td.com.ua/p375938205-soya-aoc-calypso.html	
Silesia, 45	Prograin / Canada	https://favorit-td.com.ua/ua/p376011986-soya-silesia.htm	
DH 530, 55	Sevita Int. / Canada	https://favorit-td.com.ua/p375927893-soya-530.html	
DH 618, 40–48		https://favorit-td.com.ua/p375912258-soya-618.html	
Kyoto	Prograin / Canada	https://favorit-td.com.ua/p376045820-soya-kyoto.html	
Kanata		https://favorit-td.com.ua/ua/p376034696-soya-kanata.html	
Sultana, 45	R.A.G.T. / France	https://favorit-td.com.ua/p375955629-soya-sultana.html	
Sigalia, 45		https://favorit-td.com.ua/p375981284-soya-sigalia.html	
Kassidy, 58	Prograin/ Canada	https://favorit-td.com.ua/p376058526-soya-kassidy.html	
AOC Drayton, 58	Bramhill seeds/ Canada	https://favorit-td.com.ua/p375946771-soya-aoc-drayton.html	
Ultra, 40	Asgrow & Monsanto / USA	https://favorit-td.com.ua/p376230696-soya-ultra.html	
Apollo, 38		https://favorit-td.com.ua/p376223889-soya-apollo.html https://agrovektor.com/physical_product/194141-semena-soi-apollo.html	
Sinara, 50	R.A.G.T., France	https://favorit-td.com.ua/ua/p376302280-soya-sinara.html	
Kansas, 75	Sertis Holding S. A. & DOW Chemical / Canada	https://dobrosvt.com.ua/goods/semena-soi-kansas-kanadskoy-selektsii/	Kyiv
Oldham Bt, 55-60		https://academsx.com.ua/oldham-bt-1r/	Kherson

Table 2 — GM sunflower seed material on the Ukrainian market in 2022

Variety, yield centner/hectare	Manufacturer / country	Source of information	Region of Ukraine
VIKING F 696, 47	Sertis Holding S. A. & DOW Chemical / Canada	https://agrofermer.com/products/podsolnechnik/	Odesa
CARRON, 48			
LEBRON, 53			
NUBIRA F 369, 52	Union Carbide & Sertis Holding S. A./ Canada	https://zakupka.com/p/1311529572-podsolnechnik-gmo-gibrid-nubira-f369-konditerskiy/	

Table 3 — GMO corn seed material on the market of Ukraine in 2022

Variety, yield centner/hectare	Manufacturer / country	Source of information	Region of Ukraine
TOPEKA F-36 FAO 250, 180	Sertis Holding S. A. & DOW Chemical / Canada	https://zakupka.com/p/1333373007-kukuruza-gmo-gibrid-topeka-f-36-fao-250/?e=	Odesa
VALDES BT 199 FAO 180, 180	Union Carbide & Sertis Holding S. A. / Canada	https://zakupka.com/uk/p/1306811415-kukuruza-gmo-gibrid-valdes-bt-199-fao-180/	
HIDRA FAO 250, 250		https://dobrosvt.com.ua/goods/semena-kanadskoy-kukuruzy-hidra/	Kyiv
HIDRA FF-369		https://agrovektor.com/physical_product/77850-kanadskiy-transgennyy-gibrid-kukuruzy-hydra-ff-369.html	Kharkiv
CORBIN FS-899, 180		https://dobrosvt.com.ua/goods/semena-kanadskoy-grechihi-korbin/	Kyiv
SKEENA FF-199, 260		https://dobrosvt.com.ua/goods/semena-kanadskoy-kukuruzy-skeena/ https://agrovektor.com/physical_product/1040846-transgennyy-gibrid-kukuruzy-skeena-ff-199.html	Kharkiv
OTMI FS 466, 190	Sertis Holding S. A. & DOW Chemical / Canada	https://agrovektor.com/physical_product/809843-kanadskiy-transgennyy-gibrid-kukuruzy-otmi-fs-466.html	
ADEL FAO 260	Sertis Holding S. A. / Canada	https://agrodobro.com.ua/goods/semena-kukuruzy-adel-fao-260-18-kg/	Dnipro
WEST FAO 180		https://agrodobro.com.ua/goods/semena-kukuruzy-west-fao-180-kanadskiy-transgenniy-gibrid-18kg/	
POINT FAO 330		https://agrodobro.com.ua/goods/semena-kukuruzy-point-fao-330/	

The results of laboratory experiments (n = 410) for 2018–2021 in Dnipropetrovsk Region have been analyzed. During qualitative analysis of GM, positive samples (n = 21) were found exclusively in products of domestic production (Table 4).

Thus, the level of GM soybean in the samples was 42.8% (n = 7), which was evidenced by the detection of the GM soybean DNA target sequence containing the Cauliflower mosaic virus 35 S promoter / *Agrobacterium tumefaciens* NOS terminator. The level of GM sunflower was 15.0% (n = 54), and the level of GM mixed fodder was 87.5% (n = 8), as evidenced by the detection of the target sequence of GM plant DNA containing the Cauliflower mosaic virus 35 S promoter / terminator NOS of *Agrobacterium tumefaciens.*

Table 4 — Research in Dnipropetrovsk Region during 2018–2021

Year	A total of samples were examined, n	Type and number of positive samples, %	Total GM samples, n
2018	8	soybean texturat (50)	1
2019	61	mixed fodder (100), soy protein (100)	3
2020	163	rapeseed cake (100); mixed fodder (75), yeast (67)	7
2021	178	meal (sunflower concentrate) (15); mixed fodder (100); soybean oil (25)	10
	410		21

In order to study the potential of transgenic crops in Ukraine, a comparison of their yield, using the Whitby variety as an example, with the traditional soybean variety was conducted. Thus, we analyzed the data of the 2018 report (Koretskyi, Derzhanivskyi and Shatsman, 2019) on the study of yield at the test ground for practical field studies using the example of the ultra-early soybean variety Favorit. The experiments were conducted in the Yagotyn district of Kyiv Region, a zone of sufficient moisture in the Left Bank Forest Steppe. The type of soil is typical light loamy chernozem. The humus content was 3.15%, which characterized the soil as sufficiently fertile. The weather conditions of 2018 were quite favorable and typical for the area of research on growing crops. When calculating the hydrothermal moisture coefficient for the growing season of 2018, its value was 1.58, which indicated a good supply of moisture and heat.

Table 5 — Comparison of productivity of ultra-early soybean varieties in Ukraine

Productivity indicators	Productivity of ultra-early soybean varieties without fertilizers	
	Favorit*	Whitby**
Yield, centner/hectare	26.3	36.5
Mass of 1,000 grains, g	133.7	134.0

Notes: * — according to the 2019 report of the independent scientific research agrarian platform Field of Knowledge; ** — according to field data of 2019, Chernivtsi Region (Hrytsyk, 2019)

So, the cultivation of the GM soybean variety Whitby made it possible to obtain higher productivity indicators, namely: to obtain an increase in the yield — 10.2 centner/hectare; to increase the yield level by 38.8%.

It was also reported that the Whitby variety had been grown in 2017 in Sumy, Kirovohrad, Dnipropetrovsk, Cherkasy, Kyiv, Chernihiv, Zhytomyr, Odesa regions of Ukraine (Whitby …, 2022) with a yield of 73 centner/hectare. The Oldham variety yield in 2019 in Kirovohrad, Dnipropetrovsk, Kherson, Vinnytsia, and Zhytomyr regions (Canadian …, 2022) was 76 centner/hectare.

Analysis of the country's market also showed the absence of genetically edited products on the market.

Discussion. According to the results of laboratory experiments in 2018–2021, the level of detection of GM soybeans in Dnipropetrovsk Region was 42.8%, which corresponds to the data published on the official website of the US Department of Agriculture, about the cultivation of 50–65% genetically modified soybeans by Ukrainian producers (GMO …, 2021), as well as and with other sources (Growing …, 2020; Shevtsova, Gerilovych and Solodyankin, 2014).

The presence on the market of Ukraine of more than two dozen GM soybean varieties from 8 leading producers in the world from Canada, the USA, France, Austria, testify to the demand — the need of the market for the specified soybean seeds. Thus, for 10 seasons from 2010 to 2020, an increase in the area of soybean crops was recorded in 16 regions of Ukraine. This is evidenced by data from a dynamic infographic of soybean acreage from SuperAgronom.com (Soybean …, 2020).

The three leaders with more than 125,000 hectares of planted areas for growing this crop were: in the forest-steppe zone — Khmelnytskyi and Poltava regions, and in Polissia — Zhytomyr Region. Thus, Ukraine, as one of the largest producers of soybeans in Europe, needs to technologically adapt to reduce CO_2 emissions from this crop. According to Prof. Dolezel, the positive impact of genetically modified crops on the environment cannot be ignored either. In 2018 alone, 23 billion kilograms less carbon dioxide entered the atmosphere thanks to the cultivation of genetically modified crops (Šaradínová, 2020). It is known that there are about four thousand soybean diseases in the world, of which more than 400 occur in Ukraine. Thus, the cultivation of resistant varieties obtained through genetic modification led to a reduction in the consumption of toxic pesticides by 776 million kilograms worldwide between 1996 and 2018 (Šaradínová, 2020).

In 2021, the average soybean yield, according to the Ministry of Agrarian Policy and Food, was 26 centner/hectare. Officially, it was not GM, but the unofficial 'grey' market of GM soybeans reached 60–80% of crops in different years (Korol, 2022).

Therefore, the presence of 24 varieties of GM soybeans on the market of Ukraine and their cultivation; permission of the European Commission in 2019 to use in the EU 8 varieties of grain and oil crops with GMOs for food and feed purposes (The European …, 2019); the report (NASEM, 2016) (on 606 pages) of the USA in 2016 on the safety and better yields of GM crops (Shutova and Panchin, 2021) testify to the expediency and necessity of regulating the cultivation of proven modified varieties in Ukraine.

Thus, according to the results of laboratory studies, the level of detection of GM sunflower meal in Dnipropetrovsk Region was 15%, which indicates the illegal use of unregistered GM products in Ukraine.

The demand for GM corn is evidenced by the presence on the market of Ukraine of appropriate varieties from Union Carbide & Sertis Holding S.A. from Canada, which is confirmed by the data of the US Department of Agriculture — GM corn crops in Ukraine amount to 1%, and according to other data, 3–5% (World …, 2021). Due to their high energy content, corn and soy are indispensable components of mixed fodder, which may explain the high level of GM samples in the region among mixed fodder — 87.5%. Thus, according to

Ya. and M. Pariiv, in the near future, Ukraine will be forced to work with genetically modified corn, due to the increased harmfulness of the corn beetle, which in the next five years risks becoming a serious problem for agricultural producers (Growing …, 2020).

According to Paul McDivitt reports, the yield of GM varieties is 5.6–24.5% higher than conventional varieties of corn. GM crops are also characterized by a lower percentage of mycotoxins (28.8%), fumonisins (30.6%) and trichothecenes (36.5%), which lead to economic losses and harm human and animal health (Smyth, 2018). Data on the circulation of falsified GM products on the country's market are confirmed by other reports (Fermer Kubani, 2019; My Agro Canada, 2021).

Recognition of the safety of genetically edited products in a number of countries (Japan …, 2019; Genetically …, 2021) indicates the need for legislative regulation of the issue of crops with edited genes in Ukraine as well.

Therefore, the introduction of registration of GM sources will ensure awareness for further protection of the health of people, animals and the natural environment, will create conditions for the safe practical use of GMOs for economic purposes, will enable to prevent the uncontrolled use of GM sources in feed (Nasar et al., 2019).

Conclusions. A review of the GM crop market of Ukraine showed the presence of twenty-four GM soybean varieties, four transgenic sunflower hybrids and ten transgenic corn hybrids from eight leading world producers from Canada, the USA, France and Austria, which indicates consumer demand for products.

The spread of transgenic products among domestically produced products in Dnipropetrovsk Region during 2018–2021 was recorded. Thus, real-time PCR revealed that GMOs were present in 42.8% of the studied soybean samples; 87.5% of mixed fodder samples; 15.0% of sunflower samples.

The circulation of falsified GM products on the country's market has also been established in the range of 25–50% (inconsistency in marking, certificate, holograms and QR code), which indicates the imperfection of legal regulation and creates prerequisites for its illegal use.

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References

Alex_Agro (2021) *Kansas Soybeans in All Their Glory! [Soia Kanzas u vsii svoii krasi!]* Available at: https://youtu.be/OzdabngjOL8. [in Ukrainian].

Canadian Soybean Oldham Bt [Kanadskaya soya Oldham Bt] (2022). Available at: https://agrovektor.com/physical_product/809845-kanadskaya-coya-oldham-bt.html. [in Russian].

China to Accelerate Adoption of GMO Corn to Boost Domestic Production (2022) Available at: https://gro-intelligence.com/insights/china-to-accelerate-adoption-of-gmo-corn-to-boost-domestic-production.

Ernest-No-Till (2021) *Sowing Soybeans in Crimea!!! [Posev soi v Krymu!!!]*. Available at: https://youtu.be/-7ILlks6h5k. [in Russian].

FAO: Food Prices Reach Historic Highs [FAO: tseny na prodovol'stvie dostigli istoricheskogo maksimuma] (2022) Available at: https://news.un.org/ru/story/2022/04/1421552. [in Russian].

Fermer Kubani (2019) *One Con Man's Story [Istoriya odnogo moshennika]*. Available at: https://youtu.be/l90eAnagHn0. [in Russian].

Genetically Edited Vegetables — Like GMOs, but Safer? [Geneticheski otredaktirovannye ovoshchi — kak GMO, no bezopasnee?] (2021). Available at: https://nauka.tass.ru/nauka/12753043. [in Russian].

GMO Content Standards. Legislation on GMOs in Ukraine [Normy vmistu HMO. Zakonodavstvo pro HMO v Ukraini] (2021). Available at: https://biocor-tech.com/blog/zakon-o-gmo. [in Ukrainian].

Growing GM Corn in Ukraine is a Matter of the Coming Years — Opinion [Vyroshchuvannia v Ukraini HM-kukurudzy — pytannia naiblyzhchykh rokiv, — dumka] (2020). Available at: https://superagronom.com/news/11442-viroschuvannya-v-ukrayini-gm-kukurudzi--pitannya-blijchih-rokiv—dumka. [in Ukrainian].

Hrytsyk, R. (2019) *Harvest. 08/23/2019. Soybeans (Whitby Variety). Harvester SAMPO 580 [Zhnyva. 23.08.19. soi (sort whitby(vitbi)). Kombain SAMPO 580]*. Available at: https://youtu.be/H-cbK9Hf7zs. [in Ukrainian].

Japan Recognizes Genetically Edited Foods as Safe [V Yaponii priznali bezopasnymi geneticheski otredaktirovannye produkty] (2019). Available at: https://focus.ua/technologies/423914-v-yaponii-priznali-bezopasnymi-geneticheski-otredaktirovannye-produkty. [in Russian].

Koretskyi, O., Derzhanivskyi, V. and Shatsman, D. (2019) *Field of Knowledge. Territory of Agricultural Experience. Report on the Results of Scientific Research 2018 [Pole znan. Terytoriia ahrarnoho dosvidu. Zvit pro rezultaty naukovykh doslidzhen 2018]*. Available at: http://www.polezna.com.ua/wp-content/uploads/2019/02/Zvit-PoleZnan-2018.pdf. [in Ukrainian].

Korol, S. (2022) *Agricultural Year 2021: Which Oilseeds Have Become 'Star'? [Ahrarnyi 2021-i: yaki oliini staly 'zirkovymy'?]*. Available at: https://agravery.com/uk/posts/show/agrarnij-2021-j-aki-olijni-stali-zirkovimi. [in Ukrainian].

My Agro Canada (2021) *#148. Canadian Corn in Ukraine. Obligation. Alberta, Canada. #myagrotours [#148. Kanadskaya kukuruza v Ukraine. Obman. Al'berta, Kanada. #myagrotours]*. Available at: https://youtu.be/gGDI6XhQ9LU. [in Russian].

NASEM (National Academies of Sciences, Engineering, and Medicine) (2016). *Genetically Engineered Crops: Experiences and Prospects*. Washington, DC: The National Academies Press. doi: 10.17226/23395.

Nazar, B. I., Kushnir, H. V., Boiko, H. I. and Murska, S. D. (2019). 'A necessity of introduction of the system of registration of GMO is for Ukraine' [Neobkhidnist zaprovadzhennia systemy reiestratsii HMO v Ukraini], *Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytskyj. Series: Veterinary Sciences [Naukovyi visnyk Lvivskoho natsionalnoho universytetu*

veterynarnoi medytsyny ta biotekhnolohii imeni S. Z. Gzhytskoho. Seriia: Veterynarni nauky], 21(94), pp. 152–156. doi: 10.15421/nvlvet9428. [in Ukrainian].

Nurton, J. (2020) 'Genetic scissors: at the cutting-edge of life', *WIPO Magazine*, 4, pp. 18–23. Available at: https://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2020/wipo_pub_121_2020_04.pdf.

Panasiuk, I. (2022) *Ukrainian Farmers Focus on Soybeans [Ukrainski fermery robliat aktsent na soiu]*. Available at https://agroportal.ua/news/rastenievodstvo/ukrajinski-fermeri-roblyat-akcent-na-soyu. [in Ukrainian].

Rudyshin, S. D. (2009) 'Biosafety problems with a GM-plants utilization' [Problemy bezpeky pry vykorystanni HM-roslyn], *Proceedings of the Nikitsky Botanical Garden [Trudy Nikitskogo botanicheskogo sada]*, 131, pp. 187–192. Available at: https://www.elibrary.ru/item.asp?id=25464460. [in Ukrainian].

Šaradínová, M. (2020) *European Scientists are Calling for a Change in Legislation Regarding GMOs, it is Essential for Sustainable Agriculture [Evropští vědci volají po změně legislativy ohledně GMO, je nezbytná pro udržitelné zemědělství]*. Available at: https://www.universitas.cz/aktuality/5588-evropsti-vedci-znovu-volaji-po-zmene-legislativy-ohledne-geneticky-modifikovanych-organismu. [in Czech].

SCBD (Secretariat of the Convention on Biological Diversity) (2000) *Cartagena Protocol on Biosafety to the Convention on Biological Diversity: Text and Annexes*. Montreal: SCBD. Available at: https://bch.cbd.int/protocol/text. [in Russian].

Selhozperedelkin (2021) *Sow Soybeans 'Maximus' [Siiemo soiu 'Maksymus']*. Available at: https://youtu.be/JFoloxWtRTc. [in Ukrainian].

SH Zhyttia (2022) *State of Soybeans 08/13/2022 Highstar [Stan Soi 13.08.2022r. Khaistar]*. Available at: https://youtu.be/C6o8zqfs01U. [in Ukrainian].

Shevchenko, Yu. (2021) *'Soybean and Meal Market: Ukrainian Soybeans Yesterday, Today, Tomorrow' [Soybean and meal market: ukrainskaya soya vchera, segodnya, zavtra]*. Available at: https://www.apk-inform.com/ru/exclusive/topic/1522650. [in Russian].

Shevtsova, G. M., Gerilovych, I. O. and Solodyankin, O. S. (2014) 'GMO in feedstuff and raw in Ukraine in 2011–2013' [Vmist HMO v kormakh i syrovyni roslynnoho pokhodzhennia v Ukraini v 2011–2013 rr.], *Scientific and Technical Bulletin of State Scientific Research Control Institute of Veterinary Medical Products and Fodder Additives and Institute of Animal Biology [Naukovo-tekhnichnyi biuleten Derzhavnoho naukovo-doslidnoho kontrolnoho instytutu veterynarnykh preparativ ta kormovykh dobavok i Instytutu biolohii tvaryn]*, 15(4), pp. 91–94. Available at: http://nbuv.gov.ua/UJRN/Ntbibt_2014_15_4_20. [in Ukrainian].

Shutova, Ye. and Panchin, A. (2021) *20 Facts About GMOs: Chickens with Teeth, Green Piglets and Gene Therapy [20 faktov o GMO: tsyplyata s zubami, zelenye porosyata i genoterapiya]*. Available at: https://22century.ru/popular-science-publications/gmo-facts-20. [in Russian].

Slasten, R. (2020) *Ukraine Without GMOs: How Long Can We Turn a Blind Eye to Global Trends and Our Realities? [Ukraina bez GMO: skol'ko mozhno zakryvat' glaza na mirovye trendy i nashi realii]*. Available at: https://biz.liga.net/ekonomika/prodovolstvie/opinion/v-ukrainskoy-produktsii-net-gmo-skolko-mojno-zakryvat-glaza-na-ispolzovanie-gm-kultur. [in Russian].

Smyth, S. (2018) *25 years of GMO Crops: Economic, Environmental and Human Health Benefits*. Available at: https://geneticliteracyproject.org/2018/02/19/gmo-corns-yield-human-health-benefits-vindicated-21-years-studies.

Soybean Cultivation Technology on the Example of Farms in Different Regions [Tekhnolohiia vyroshchuvannia soi na prykladi hospodarstv riznykh rehioniv] (2020). Available at: https://superagronom.com/articles/447-tehnnologiya-viroschuvannya-soyi-na-prikladi-gospodarstv-riznih-regioniv. [in Ukrainian].

Sumshchyna (2021) *Super Soybeans 2021, with Sowing Rates of 25 and 50 kg/ha [Super soia 2021, z normamy vysivu 25 ta 50 kh/ha]*. Available at: https://youtu.be/qQDNewm7XZY. [in Ukrainian].

The European Commission has Authorized the Use of 8 Varieties of Grains and Oilseeds with GMOs in the EU [Yevrokomisiia dozvolyla vykorystannia v YeS 8 sortiv zernovykh i oliinykh z HMO] (2019). Available at: https://www.apk-inform.com/uk/news/1506310. [in Ukrainian].

There is No Control over the Cultivation of GMO Soybeans in Ukraine, — Arnica' [V Ukraini niiakoho kontroliu za vyroshchuvanniam HMO-soi nema, — Arnika'] (2017) Available at: https://propozitsiya.com/v-ukrayini-niyakogo-kontrolyu-za-vyroshchuvannyam-gmo-soyi-nema-arnika. [in Ukrainian].

Turnbull, C., Lillemo, M. and Hvoslef-Eide, T. A. K. (2021) 'Global regulation of genetically modified crops amid the gene edited crop boom — A review', *Frontiers in Plant Science*, 12, p. 630396. doi: 10.3389/fpls.2021.630396.

Useful Information [Korysna informatsiia] (no data). Available at: https://bahmutska-rda.gov.ua/korisna-informaciya-17-20-22-18-12-2018 (Accessed: 17 July 2022). [in Ukrainian].

Volovyk, A. (2022) *Senara Soybeans, Soon to be Harvested, 08/23/2022 [Soia Senara, skoro zhnyva, 23.08.2022]*. Available at: https://youtu.be/0c0UiV60LPc. [in Ukrainian].

VRU (Verkhovna Rada Ukrainy) (2002) 'Law of Ukraine No. 152-IV of 12.09.2002 'On the accession of Ukraine to the Cartagena Protocol on Biosafety to the Convention on Biological Diversity' [Zakon Ukrainy № 152-IV vid 12.09.2002 'Pro pryiednannia Ukrainy do Kartakhenskoho protokolu pro biobezpeku do Konventsii pro biolohichne riznomanittia'], *News of the Verkhovna Rada of Ukraine [Vidomosti Verkhovnoi Rady Ukrainy]*, 44, art. 320. Available at: https://zakon.rada.gov.ua/laws/show/152-15. [in Ukrainian].

Whitby Soybean Seeds [Semena soi Whitby] (2022). Available at: https://agrovektor.com/physical_product/765050-semena-soi-whitby.html. [in Russian].

World Corn Market 2021 and Ukrainian Realities: From Global to Local [Svitovyi rynok kukurudzy 2021 i ukrainski realii: vid hlobalnoho do lokalnoho] (2021). Available at: https://latifundist.com/analytics/27-svtovij-rinok-kukurudzi-2021--ukransk-real-vd-globalnogo-do-lokalnogo. [in Ukrainian].