



DOI: 10.22363/2313-2329-2023-31-4-791-801

EDN: RZOIQM

UDC 339.1:661.16(470+571)

Research article / Научная статья

Analysis of the chemical crop protection market in Russia

Oleg N. Zhilkin , Mikhail Y. Grigoryev *RUDN University,
6 Miklukho-Maklaya St, Moscow, 117198, Russian Federation*✉ zhilkin_on@pfur.ru

Abstract. The research is devoted to the analysis of the current state of chemical crop protection market in Russia. Significant industry growth has occurred in last decade due to the attractiveness of agriculture as an export-oriented industry. Russian agricultural products are in stable demand all over the world. Countries in the Middle East, South-Eastern Asia and Africa with constantly growing population rely on foodstuff import, including from the Russian Federation. Thus, country makes a significant contribution in a global food security. However, in order to develop and increase competitiveness, Russian farmers need to intensify crop production. One of technological improvement elements, which let growers to get sufficient yield and quality, is application of innovative chemical crop protection products. Pesticides help farmers struggle with crop diseases, pests and weeds, as well as minimize adverse climate factors in some cases. Agrochemicals market in Russia is represented not only by foreign players, but by domestic manufacturers as well. Market share of these two groups in value terms of market players is approximately equal. However, it's worth mentioning, that like in many other industries, this sector is heavily dependent on import inputs. Major part of components for local pesticide production are imported and key technological process is constrained as a type of mixing necessary inputs in proper way. Domestic business, together with Russian Government and, probably, in cooperation with some international players, needs to solve the problem of deepening the production cycle, look for stimulus for development of the entire production chain in the long-term perspective, including development of fundamental science in chemical crop protection industry. Learning and adapting foreign experience can be the first step in the process of structural change of the crop protection industry. Simultaneously, it is critical to maintain openness and desire to use best practices at pesticide market, without which the competitiveness of Russian agricultural production will be constrained and development of the entire industry will have a pace inferior to other countries.

Keywords: agriculture, chemical crop protection market in Russia, active ingredients, import substitution

Article history: received 22 June 2023; revised 18 July 2023; accepted 11 August 2023.

© Zhilkin O.N., Grigoryev M.Y., 2023



This work is licensed under a Creative Commons Attribution 4.0 International License
<https://creativecommons.org/licenses/by-nc/4.0/legalcode>

For citation: Zhilkin, O.N., & Grigoryev, M.Y. (2023). Analysis of the chemical crop protection market in Russia. *RUDN Journal of Economics*, 31(4), 791–801. <https://doi.org/10.22363/2313-2329-2023-31-4-791-801>

Анализ рынка химических средств защиты растений в России

О.Н. Жилкин , М.Ю. Григорьев 

*Российский университет дружбы народов,
Российская Федерация 117198, Москва, ул. Миклухо-Маклая, д. 6*

✉ zhilkin_on@pfur.ru

Аннотация. Исследование посвящено анализу текущего состояния рынка химических средств защиты растений в России. Существенный рост данной индустрии в стране обусловлен привлекательностью сельского хозяйства как экспортоориентированной отрасли. Продукция отечественного растениеводческого сектора пользуется стабильным спросом на мировой арене. Страны Ближнего Востока, Юго-Восточной Азии и Африканского континента с постоянно растущим населением полагаются на импорт продовольствия, в том числе из Российской Федерации. Таким образом, страна вносит существенный вклад в обеспечение мировой продовольственной безопасности. Однако для дальнейшего развития и повышения уровня конкурентоспособности российским аграриям необходимо и дальше увеличивать интенсификацию производства. Одним из элементов совершенствования технологии, в результате которого урожайность и качество сельскохозяйственных культур должны улучшаться, является использование современных химических средств защиты растений. Они помогают фермерам бороться с болезнями растений, вредителями и сорняками, а также в некоторых случаях минимизировать погодно-климатические риски. Рынок химических средств защиты растений Российской Федерации представлен не только иностранными игроками, но и отечественными производителями, которые в совокупности занимают сопоставимую долю рынка. Важно отметить, что, как и многие производства рассматриваемый сектор находится в существенной импортной зависимости. Большинство компонентов для создания готовых препаратов на территории страны завозится из-за рубежа, а технологический процесс в большинстве случаев ограничивается смешиванием необходимых составных частей. Таким образом, отечественному бизнесу совместно с государственными органами, возможно, в кооперации с некоторыми международными компаниями, необходимо решать задачу углубления производственного цикла, искать пути стимулирования развития всей цепочки производства в долгосрочной перспективе, в том числе и научных разработок в данной отрасли, частично опираясь на зарубежный опыт. При этом важно сохранить открытость и стремление использовать передовые практики в применении химических средств защиты растений, без которых конкурентоспособность российской аграрной продукции будет ограничена и развитие всей растениеводческой отрасли будет происходить темпами, уступающими другим странам.

Ключевые слова: сельское хозяйство, рынок химических средств защиты растений в России, действующие вещества, импортозамещение

История статьи: поступила в редакцию 22 июня 2023 г.; проверена 18 июля 2023 г.; принята к публикации 11 августа 2023 г.

Для цитирования: Zhilkin O.N., Grigoryev M.Y. Analysis of the chemical crop protection market in Russia // Вестник Российского университета дружбы народов. Серия: Экономика. 2023. Т. 31. № 4. С. 791–801. <https://doi.org/10.22363/2313-2329-2023-31-4-791-801>

Introduction

Since early 2000’s Russia has been experiencing significant growth of the entire agricultural industry. Boost in the crop production sector is one of the key drivers of such accelerated development. Twenty years ago, Russia was a net-importer of agricultural products, however, nowadays country is one of the greatest sellers of grain, oilseeds and several other processed agricultural products on the global market. According to FAO data country occupies the first place in export of wheat at the global scale (Figure 1).

Russian Ministry of Agriculture estimates that in the season 2022/2023 (from the 1st of July 2022 to the 30th of June) grain export will reach 60 million metric tons (+18 million metric tons more versus previous season level)¹. Simultaneously, as of United States Department of Agriculture forecast Sunflower oil amount which will be sold abroad from Russia in 2022/2023 can be 3,95 million metric tons (31,2% market share in global trade of this particular oil) by the end of the season.²

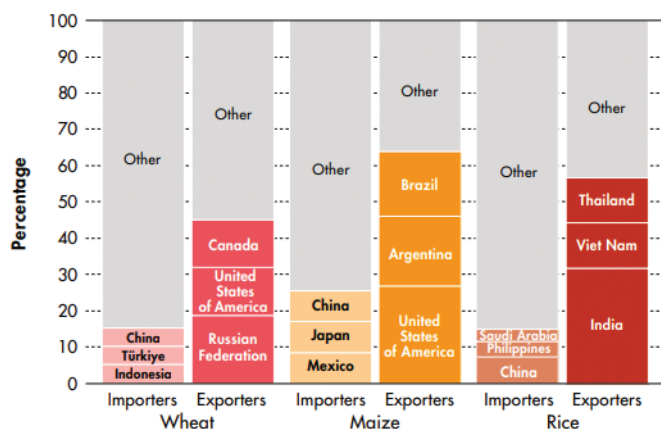


Figure 1. Main traded cereals, top importers and exporters (Quantities, 2020)

Source: FAO. 2022. World Food and Agriculture — Statistical Yearbook 2022. Rome.

Retrieved from <https://www.fao.org/3/cc2211en/cc2211en.pdf>

The first reason of crop output increase over the last 2 decades in Russia is active involvement in crop rotation unused land. Part of this acreage was cultivated in Soviet times and then became abandoned; the other part is a result of breaking fresh ground. All in all, this trend can be characterized as extensive one. It’s worth mentioning that

¹ Grain exports from the Russian Federation reached 40 million tons from July 1, 2022. Economy. Interfact. (In Rus.). Retrieved May 12, 2023, from <https://www.interfax.ru/business/890019>

² Oilseeds: World Markets and Trade (2023). United States Department of Agriculture Foreign Agricultural Service. Retrieved May 12, 2023, from <https://apps.fas.usda.gov/psdonline/circulars/oilseeds.pdf>

in addition to acreage expansion farmers are constantly improving technology of crop production. Key stages which can be emphasized are the preparation of seed material and soil; sowing crops at the optimum time using necessary agrotechnical machinery; application of fertilizers and crop protection products, harvesting with the help of specialized equipment. It's worth noting that crop production in Russia keeps pace with the times. All the above-mentioned stages in majority of agricultural enterprises are entered into specialized farm management systems, where all data is stored in digitized form. Farmers based on the analytics make decisions regarding improvement of technology to find balance between desire of yield improvement and costs optimization.

This article will consider some key features of chemical crop protection market in Russia. Application of pesticides is one of the main components in crop production cycle. Productivity of crops grown for human consumption is at risk due to the incidence of pests, especially weeds, pathogens and animal pests. Crop losses due to these harmful organisms can be substantial and may be prevented, or reduced, by crop protection measures (Oerke, 2006). According to the Food and Agriculture Organization of the United Nations (FAO), 10–15 % of world agricultural production is lost due to plant diseases even before harvest. If we take into account the combined impact of diseases, pests and weeds, then the damage before harvest is from 25 to 40 % (Kolchin, 2021). However, it's worth mentioning that education of farmers plays an important role in ensuring the optimum use of pesticides in order to prevent a heavy toll on the environment (Al Mahmud Titumir, 2023)

Literature and sources review

Russian and foreign scientists as well as international market research institutions are engaged in the topic of chemical crop protection market analysis. In particular, this subject is pivotal for such global transnational agencies as Agbioinvestor and Kynetec. These companies conduct customized insights for clients and create industry overviews on regular basis. The scientific works of Nishimoto R. (2019), Phillips M.W.A. (2020), Kolchin I. (2021), Shishatskiy O. (2021), Zakharenko A. (2020) and others are devoted to the study of chemical crop protection market dynamics and future changes of this sector.

Research methods

While research conducting and material presenting, general scientific approaches and methods were applied. In particular, methods of comparative and economic-statistical analysis, as well as graphic images take place in the article.

Results

Crop yield increase by reduction losses is undeniable priority for global food security. It's worth highlighting several trends which drive development of global agrochemical market. Firstly, it's a rapid planet population growth. According to the

United Nations estimation, number of people all over the world reached 7,88 billion in 2021 and will expand to 8,85 billion by the year 2035 and to 9,69 billion by 2050. It is estimated that between 702 and 828 million people were affected by hunger in 2021³. Moreover, the basis of this growth is projected to take place in the least economically developed regions, in particular, in Sub-Saharan Africa (Nigeria, DR Congo, Tanzania and other countries), where the average annual population growth from 2020 to 2050 is expected to be more than 2 % and most of the countries in this particular region purely rely on food import.⁴ In these countries, unfortunately, climatic conditions and soil fertility do not allow to increase yield significantly.

Considering population of Europe, it will decline. India will outstrip China in terms of population and reach 1,5 billion population by 2030 according to the same United Nations estimation.⁵ Simultaneously, the amount of cultivated area in the world in 2015 was virtually the same as it was in 1965 (Nishimoto, 2019). All this, given the limited land resources in the world, creates prerequisites for intensifying crop production in such states as, for example, Russia, Kazakhstan, Canada, Australia, where it is generally accepted that significant part of the land is in the risky farming zone.

The second trend which impose significant impact on chemical crop protection market is climate change. Adjustments in plant-protection protocols are already necessary because of recent climatic changes, but further adjustments will become increasingly crucial in the future, assuming the projected climate-change scenarios come true.⁶ For instance, some regions of the world experience primary weather events such as droughts, floods, extreme temperature swings both during the day and at night, and subsequent secondary effects (such as changes in the distribution of pests, diseases and weeds). However, at the same time, global warming is benefiting agriculture at higher latitudes, where farmers can expand their acreage by reducing the risk of too cold weather conditions during the vegetation period. It is worth noting that the above-mentioned trends can lead to the development of pesticide market. In the first case, it is stimulation of crop protection development for plant stress reduction to mitigate impact of adverse weather conditions. In the second circumstance, it is the step-by-step growth of pesticide market due to the expansion farmers' ability to include in the crop rotation land plots those were previously considered as unsuitable for agricultural production.

The third factor that is driving chemical crop protection market and spurring research and development in the industry is limitation of water resources. Pesticide companies are trying to find solutions that minimize the residual amount of active

³ FAO, IFAD, UNICEF, WFP and WHO. 2022. The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO.

⁴ FAO. 2022 Cereal supply and demand balances for sub-Saharan African countries. <https://doi.org/10.4060/cc32>

⁵ 2022 Revision of World Population Prospects. Retrieved May 31, 2023, from https://population.un.org/wpp/?_gl=1*g5b16*_ga*NzQxMzIwMC4xNjc2Njc5MDc4*_ga_TK9BQL5X7Z*MTY4NjY3OTA3OC4xLjEuMTY4NjY3OTIwNi4xMS4wLjA.

⁶ IPPC Secretariat. 2021. Scientific review of the impact of climate change on plant pests — A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat. <https://doi.org/10.4060/cb4769en>

ingredients in crops after application in circumstances of low precipitation or limited watering.

Crop prices and farm incomes are the key determinant for agrochemical market performance as producers have to be able to afford the technology (Phillips, 2020). According to the international research company Agbioinvestor, global chemical crop protection market amounted to 82.6 billion US dollars in 2022, having increased by 12.6 % compared to the previous year and by 35 % compared to 2012. Thus, the average annual growth over the past 10 years has been around 3,1 %⁷ (Figure 2).

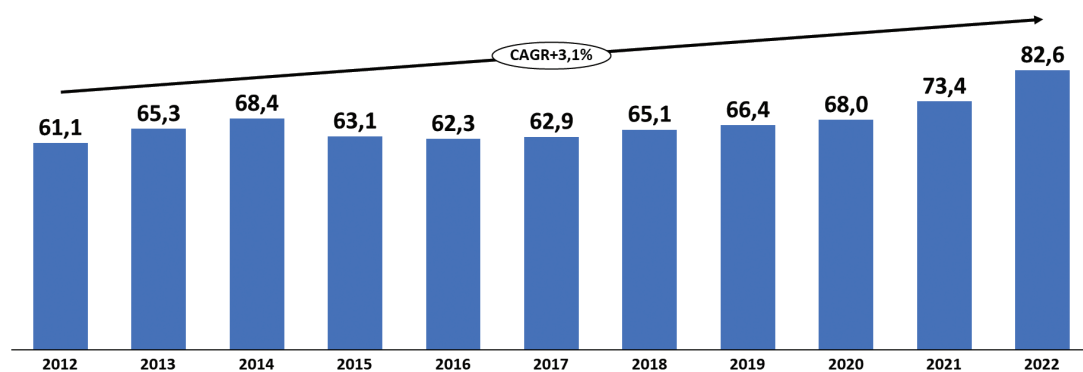


Figure 2. Global Agrochemical market, blnUSD
 Source: Built by author based on Agbioinvestor data.

Considering market value parameters, it's worth mentioning that the pace of development in Russia is higher in comparison with global one. According to research agency Kynetec market in Russia is estimated 188,5 billion rubles in 2021 (or 2.56 billion US dollars at the average annual exchange rate of the Central Bank of the Russian Federation in 2021), which is 6.7 times more than in 2011 (28.1 billion rubles or 956 million US dollars).⁸ Thus, the average annual compound growth of the chemical crop protection market in Russia amounted to 10.3 %.

Considering volume terms chemical crop protection treatments in Russia (according to Kynetec data) grew up by more than 3 times in the period from 2011 to 2021. Product area treated (PAT — application area under every crop protection product) in country as of 2021 reached 350 million hectares while in 2011 market this parameter was 111,5 million hectares only. Intensification rates vary greatly between crops based on agronomic needs. For example, PAT under wheat increased by 80 % from 2011 to 2021, however under soybean grew by 350 % due to significant acreage boost under this oilseed crop.⁹

⁷ Agbioinvestor: Crop Protection and Seed Markets: 2022 Market — Preliminary View (2022). Retrieved May 31, 2023, from <https://agbioinvestor.com/>

⁸ Kynetec agency. Retrieved May 31, 2023, from <https://www.kynetec.com/ru>. Crop protection panel data for Russia

⁹ Kynetec agency. Retrieved May 31, 2023, from <https://www.kynetec.com/ru>. Crop protection panel data for Russia

The first feature of the Russian market that is worth being noted is severe competition between transnational companies and domestic players. According to the Kynetec agency, as of 2022, the rating of fifteen largest players in the industry includes such transnational companies as Syngenta, Bayer, BASF, Corteva, FMC and Adama with a total market share of 44 % (In value terms), as well as, the largest Russian players — Firma August, Schelkovo Agrokhim, AgroExpertGroup, Shans, Zemlyakoff, FMRus, Soyuzagrokhim, Listerra, Agrokhim XXI, which together account for 47 %, about 9 % is a group of foreign and domestic companies those mainly import ready-mix products from third countries¹⁰ (Figure 3).

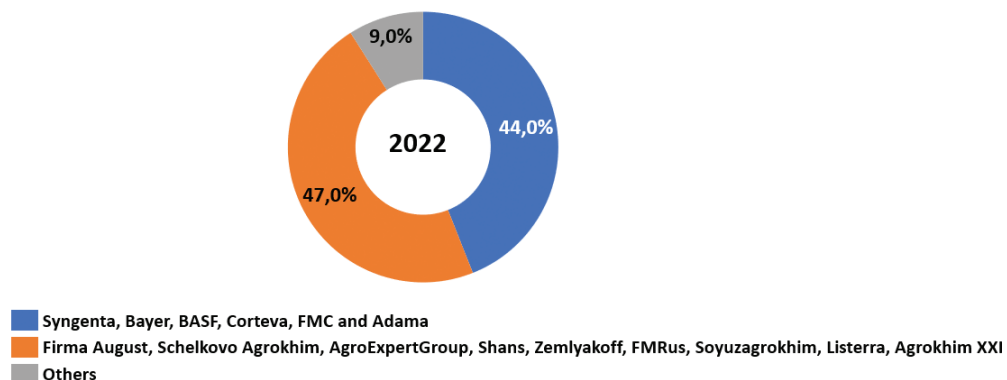


Figure 3. Distribution of players at Russian Crop protection market, 2022

Source: Built by author based Kynetec data.

If we consider market size in volume terms, then according to internet portal RBK, 2022 consumption of pesticides in Russia amounted to about 230 thousand tons. Most of them — 118.8 thousand — were provided by products of domestic manufacturers. Imported pesticides accounted for about a third — 71.2 thousand tons, or 30.9 % of all volumes. About 40 thousand tons are products produced by foreign manufacturers at the local facilities under the tolling agreements (according to this approach, foreign raw materials are imported into the country for processing, which are processed at local factories)¹¹.

Another fundamental difference between multinational companies and local producers, apart from geographical scope of business, is a scale of investments in Research and Development function (R&D). This department is responsible for creation of chemical molecules which are the basement for further synthesis and introduction of active ingredients into agronomic practice. It is worth noting the extremely high risk of such investments for companies due to the unpredictability of the result of the scientific study. Currently the probability of obtaining a new agrochemical is estimated as one in around 160 thousand compounds (Nishimoto, 2019).

¹⁰ Kynetec agency. Retrieved May 31, 2023, from <https://www.kynetec.com/ru>. Crop protection panel data for Russia

¹¹ Internet-portal RBC. The Ministry of Agriculture advocated the introduction of quotas for the import of pesticides into Russia. How will this affect food security and crops. Retrieved May 31, 2023, from <https://www.rbc.ru/business/30/05/2023/6474a84b9a79471cc9082627>

Not infrequently, a situation happens when significant financial resources allocated for the development of a particular molecule may not give a return, since scientific research will not lead to outstanding findings. International companies, unlike Russian ones, tend to make long-term investments in R&D, which, as a rule, amount to billions of US dollars on a long-term horizon, up to 10–15 years. Foreign costs for the development of new pesticides, as a percentage, amount to 10–15 % of the sales of finished products (Kolchin, 2021). It is worth mentioning also, that the number of active ingredients in late-stage development has drastically declined because of increased R&D costs, driven by higher regulatory and field-testing costs, as well as increasing scientific complexity (Kurth, 2020). Naturally, these investments are reflected in the price of the final product. However, as a rule, when products which contain innovative components are used in agronomical practice, farmers get additional yield, which in turn is converted into revenue and cover the costs incurred. Currently, Russian pesticide manufacturers are focused on the production of pesticides based on active ingredients that are not protected by patent law and can be purchased from any seller all over the world. Most likely, that in the next few years, domestic companies will increase market share in Russia due to several reasons.

Firstly, this is the need for import substitution against the background of existing geopolitical risks, even though sanctions, formally, do not apply to the agricultural industry. It is worth noting here that companies such as FMC and Corteva, headquartered in the United States, have already left Russian market in 2022, respectively, their market share in 2023 will be redistributed among other players. However, there are also restrictions on the supply to the country of several active ingredients and raw materials for production, so-called, coformulants, which complicates local production for both local companies and international corporations operating in Russia. Foreign players either bring raw materials for the tolling scheme (Bayer, BASF), or for combined capacity utilization: their own and tolling (Syngenta).

Another reason for market share expansion of local companies in the mid-term perspective may be the protectionist state policy. Russian Government is currently discussing measures to impose import quotas aimed at import of ready-mixed pesticides. However, while introduction this measure, it is necessary to take into account needs of farmers who, in their production cycle, rely on crop protection schemes dominated by products from foreign suppliers with patent protection. As a rule, this category includes agricultural producers ,cultivating potatoes, fruits and vegetables, as well as, specialization on orchards and vineyards. Unfortunately, nowadays, portfolio of Russian companies is inferior to foreign competitors in the above-mentioned segments and does not fully cover farmers' needs.

The next feature of the Russian chemical crop protection market is dependence on import of inputs for pesticides production. Despite of significant market share, Russian companies tend to import active ingredients and most of the coformulants. Chinese companies are the main suppliers of raw materials, their share increased significantly during 2022 after introduction of sanctions (from 61.8 % in 2021 to 85.3 % in 2022). But at the same time, demand is partially covered by EU-27 and USA (8.6 % in 2022). Considering detailed structure of active ingredients

import to Russia (Figure 4), 106 thousand tons were delivered in Russia for further production. Among the largest suppliers are China — 85.3 %, Germany — 4.2 % and India — 3 %. Other countries account for 7.5 %.¹² It's worth mentioning boost in deliveries from China versus year 2021. Predominantly it's a consequence of geopolitical shift in 2022.

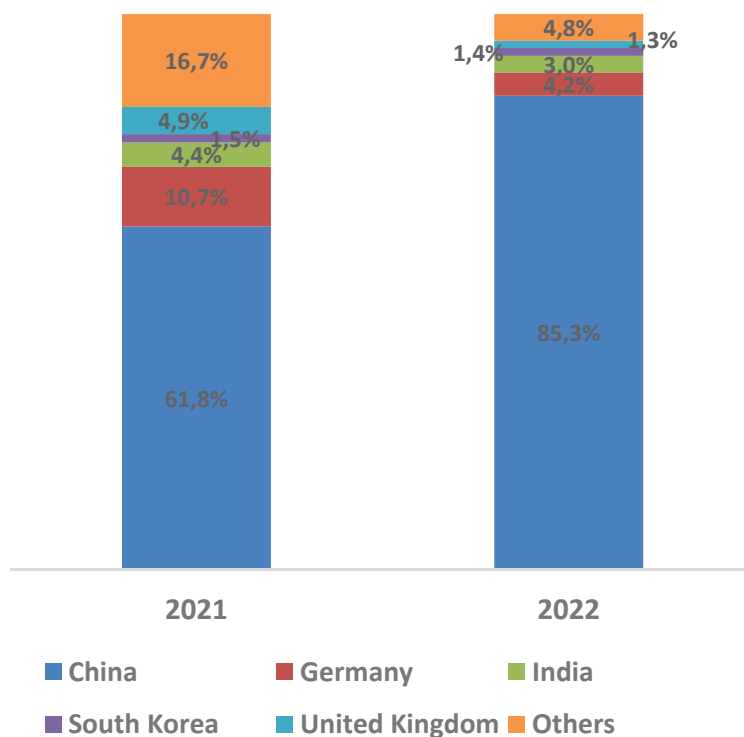


Figure 4. Distribution of active ingredients import flows to Russia, 2021–2022

Source: Built by author based on customs data analysis.

An important feature of import structure is the distribution of active ingredients among product groups: fungicides, herbicides and insecticides. As of 2022, herbicides account for 75 %, fungicides — 10 %, insecticides — 6 %, the remaining categories (biopesticides, growth regulators, rodenticides, etc.) account for 9 %.¹³ Herbicides are the most common and simple chemical crop protection products. Their production that is mainly localized in Russia by international companies, predominantly for usage at field crops with large acreage (wheat, barley, corn, soybeans, rapeseed, sunflower, sugar beet). Considering more complex and technological groups — fungicides and insecticides, majority of products are imported in ready-mix form.

Import of ready-mixed products, as mentioned above, in 2022 amounted to 71.2 thousand tons. It should be noted that 48 % of this volume comes from China, 45 %

¹² Author calculations based on Federal Customs Service of Russian Federation. Retrieved May 31, 2023, from <https://customs.gov.ru/>

¹³ Author calculations based on Federal Customs Service of Russian Federation. Retrieved May 31, 2023, from <https://customs.gov.ru/>

is imported from EU, USA and UK, 5 % from India.¹⁴ Thus, given current geopolitical circumstances, Russian Government is making efforts by possible quota introduction to regulate the part of agrochemicals that enter Russia from EU-27, USA, UK and other countries that have supported the sanctions regime.

Conclusion

Summing up the above, it should be noted that one of the main tasks facing the industry and the state in the coming years is the creation of research and production bases that will allow to start manufacturing sufficient amount of active ingredients, as well as to produce critically important inputs locally, which will partially reduce dependence on import. It may be worth starting from the release of active ingredients that are already known and are not under patent protection. A good example is the industrial development of China and India in this area, which are currently the world's factories for the entire industry with emphasis on off-patent active ingredients production. However, this task cannot be solved in the short and even medium term, so the implementation will require long-run investments, including ones in human capital through the creation of research centers based on universities and partially funded under the program of private-public partnerships. Participation of international companies in these projects may not be popular nowadays due to tense geopolitical circumstances. However, it is important to understand that the development of the entire agricultural industry in Russia is in the interests of the global community and, thus, cooperation with companies who are ready to keep presence in country and give access to latest achievements of world agricultural science is paramount importance. The intensification of crop production on the existing acreage in Russia and on the area that can later be included in crop rotation will, if not fully solve the problem of food for many developing countries, then at least reduce the likelihood of humanitarian crises in the world in the future.

References

- Agbioinvestor: Crop Protection and Seed Markets: 2022 Market — Preliminary View* (2022). Retrieved from <https://agbioinvestor.com/>
- Agbioinvestor: The Future of Agriculture Report* (2022). Retrieved from <https://agbioinvestor.com/>
- Al Mahmud Titumir, R. (2023). Agrarian Transition and Future Sustainability. In *Why Agriculture Productivity Falls: The Political Economy of Agrarian Transition in Developing Countries* (pp. 161–188). Purdue University Press. <https://doi.org/10.2307/j.ctv2x6f0h7.11>
- Al Mahmud Titumir, R. (2023). Production Relations and Agricultural Productivity. In *Why Agriculture Productivity Falls: The Political Economy of Agrarian Transition in Developing Countries* (pp. 69–104). Purdue University Press. <https://doi.org/10.2307/j.ctv2x6f0h7.8>
- Kolchin, I. (2021). *Modern trends in production and application of chemical crop protection in Russia*. Retrieved from https://www.elibrary.ru/download/elibrary_46703179_97927377.pdf (In Russ.)

¹⁴ Author calculations based on Federal Customs Service of Russian Federation. Retrieved May 31, 2023, from <https://customs.gov.ru/>

- Kurth, T., Möller, C., Jerratsch, J.-F., Adolphs, B., Wübbels, G., & Walker, D. (2020). *Reviving agricultural innovation in seeds and crop protection*. Retrieved from <https://www.bcg.com/publications/2020/reviving-agricultural-innovation-seeds-crop-protection>
- Nishimoto, R. (2019). Global trends in the crop protection industry. *Journal of Pesticide Science*, 44(3–4), 141–147. <https://doi.org/10.1584/jpestics.D19-101>
- Oerke, E. (2006). Crop losses to pests. *The Journal of Agricultural Science*, 144(1), 31–43. <https://doi.org/10.1017/S0021859605005708>
- Shishatskiy, O.N. (2021). Global Crop Protection Industry. *Journal of Siberian Federal University. Biology*, 14(4), 541–549. (In Russ.). <https://doi.org/10.17516/1997-1389-0371>
- Phillips, M.W.A. (2020). Agrochemical industry development, trends in R&D and the impact of regulation. *Pest Manag Sci*, 76, 3348–3356. <https://doi.org/10.1002/ps.5728>
- Zakharenko, A (2020). *Use of pesticides in the agricultural sector of Russia in the context of the development of global markets of plant protection products*. (In Russ.). <https://doi.org/10.31857/S000218812003014X>

Bio notes / Сведения об авторах

Oleg N. Zhilkin, Candidate of Science (In Economics), Ass. Professor of the Economical & Mathematical Simulation Department, RUDN University. ORCID: 0000-0002-5371-8724. E-mail: zhilkin_on@pfur.ru

Жилкин Олег Николаевич, кандидат экономических наук, доцент кафедры экономико-математического моделирования экономического факультета, Российский университет дружбы народов. ORCID: 0000-0002-5371-8724. E-mail: zhilkin_on@pfur.ru

Mikhail Y. Grigoryev, Postgraduate Student of the Economical & Mathematical Simulation Department. RUDN University. ORCID: 0009-0009-2335-0656. E-mail: grigoryev.mikhail@gmail.com

Григорьев Михаил Юрьевич, аспирант кафедры экономико-математического моделирования экономического факультета, Российский университет дружбы народов. ORCID: 0009-0009-2335-0656. E-mail: grigoryev.mikhail@gmail.com