






The modern paradigm of the agricultural technological process efficiency: A review

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Abstract: At present, a deep transformation of the agrobiocenose organisation under the intense anthropogenic factors' influence is of particular importance. Thus, a significant increase in the number and harmfulness of pests', phytopathogens' and weeds species was noted due to the prevailing favourable conditions for their mass reproduction, expansion of habitats, and harmfulness, which inevitably leads to a significant deterioration in the phytosanitary state of cultivated crops. The phytosanitary trouble of agrobiocenoses allows us to say that today plant protection, being the final link in the cultivating technology for agricultural crops, is one of the most important stages in preserving the harvest improving the quality of the products obtained, and reducing their cost. In the current study it was tried to review the modern paradigm of the agricultural technological process efficiency. The relevance of this research is due to the fact that modern technological processes in agriculture cannot be implemented without the practical use of plant protection measures, in particular, the chemical method, which consists in the use of chemical compounds against pathogens of plants, pests, weeds, and is the most common, contributing to a significant increase in the yield of cultivated crops and labour productivity in agricultural production. All this, in our opinion, indicates the high practical significance of the results obtained.

Keywords: agriculture, agrobiocenosis, ecology, economic efficiency, organic farming, pesticides, plant protection, profitability, technological process

INTRODUCTION

All technological processes in agriculture require significant investments. One of the costliest of them is measures to protect agricultural plants [JIAN 2011]. However, today it is possible to achieve the goals set for realising the potential of cultivated crops without resorting to a significant increase in costs – the use of an

integrated plant protection system. A huge scientific and practical experience has been accumulated in the implementation of various protective measures, which have shown both their biological and economic efficiency [MACFARLANE *et al.* 2013]. At the same time, the profitability of the activities carried out on various crops ranged from 97.4% to 220.3% due to their additional harvest [ZHICHKIN *et al.* 2020]. The integrated plant

protection system provides for the rejection of the complete extermination of pests and a gradual transition to the creation of stable phytosanitary relations of agroecosystems, in which the mechanism of self-regulation and reasonable management of the number of pests will operate [GONZALEZ-DIAZ *et al.* 2009; HOLTAPPELS *et al.* 2021; VERJUX 2017]. At the same time, the rational use of chemical, biological, and other methods of plant protection come to the fore, where the leading position belongs to the first method. In an integrated plant protection system, the chemical method is used both for preventing and upon the appearance of the problem [MATYJASZCZYK 2013; OSTAEV *et al.* 2020; PELAEZ *et al.* 2013; PLOTNIKOV *et al.* 2020].

Of course, the chemical method of plant protection in comparison with other means has a number of undeniable advantages [DEGALTSEVA *et al.* 2021; ZHANG *et al.* 2018]. First of all, it is because pesticides, for the most part, have a universal effect and a sufficiently high efficiency, thereby providing a reliable degree of protection against pests, pathogens of plant diseases, and weeds. In addition, it is precise during treatment with chemical agents that it is possible to achieve high labour productivity due to the mechanisation of processes, and, therefore, to carry out large volumes of work in the shortest possible time, which is extremely important when there is a threat of crop production loss [BEZPAL'KO *et al.* 2020; GRAHAM-BRYCE 1977; PERTOT *et al.* 2017].

Thus, in this research, we touched upon the economic efficiency issues concerning technological processes in agriculture in general and, in particular, the rational use of plant protection products as the most important process in agricultural crop cultivation.

MATERIAL AND METHODS

The theoretical and methodological basis of this research consists in the study and analysis of statistical data, research in dynamics, a review of literary sources and proposals of scientists presented at conferences, in monographs and papers on the latest

technological processes in agriculture, the problem of the use of plant protection chemicals and economic feasibility of their use.

The following general scientific and specific cognition methods were used in the process of writing the paper, such as typologisation, comparison, generalisation, synthesis, and analysis.

RESULTS AND DISCUSSION

Today, the quality standard all over the world is organic products grown without the use of pesticides and growth hormones because, after using chemical plant protection products with a thorough check of crop products, their negative impact on wildlife and humans is often found. We can safely say that there is a more or less destructive effect on the habitat; that is, pesticides have virtually no lower threshold of action. Of course, common sense dictates that the best solution in this situation would be to reduce the proportion of pesticides used when growing products and, if possible, replace them with biological preparations.

However, the fact that the use of chemical plant protection products contributes not only to a significant increase in labour productivity in agriculture but also to a significant reduction in crop losses from diseases and pests both in the field and during storage does not allow a complete transition to organic farming (Tab. 1). Most of the problems associated with the use of pesticides are solved with well-established control of their rational use. Equally important is the need to improve the economic efficiency of agricultural production from the standpoint of environmental acceptability to eliminate or reduce the damage to the environment.

As you can see from Table 1, the area of agricultural land on which protective measures with pesticide treatment were carried out is steadily growing from year to year. Separately, it should be said about the situation on the market for plant protection chemicals in 2020. The pandemic and the rise in the dollar rate provoked an unprecedented speculative demand for pesticides in

Table 1. Agricultural land in Russia where plant protection with pesticides have been applied (thous. ha)

Indicator	2015	2016	2017	2018	2019	2019 in % to	
						2015	2018
Pesticide processed							
– against pests	21939.4	21947.1	24940.9	24063.3	27976.1	127.5	116.3
– against diseases	14069.3	17776.4	20284.1	19121.2	20315.9	144.4	106.2
– growth regulators	681.4	792.8	1745.0	1439.0	1599.7	230.0	111.2
– against weeds	43206.7	44435.8	47928.5	47521.9	49690.9	115.0	104.6
– defoliation and desiccation	1897.5	2068.2	2312.4	2586.0	2147.2	113.2	83.0
Total	81794.3	87020.3	97210.9	94731.4	101729.8	124.4	107.4
Pesticide processed by air method	4576.3	5280.1	5603.7	4698.9	5113.7	111.7	108.8
Share of the agricultural land area treated with pesticides in the total agricultural land area (%)	36.8	39.2	43.8	42.7	45.8	–	–

Source: own elaboration based on DUDIN *et al.* [2018].

the first quarter of that year. It is expected that it is quite natural, and the area of cultivated land will also be increased.

A solution to this problem was proposed in amendments to the law on the safe handling of pesticides and agrochemicals, approved by parliamentarians at the end of December 2020. It is expected that the implementation of this law will make food products with improved characteristics more accessible to the population. It should be noted that it is not permissible to use the term “organic” in this case, since in the production of products with improved characteristics, in contrast to “organic”, modern intensive, but at the same time the safest agricultural technologies are used. This law will also help increase domestic agricultural products’ competitiveness without reducing the profitability of agricultural production [ŁABĘDZKI 2016; MYSKA *et al.* 2021; PERERA, BAYDOUN 2007; THOMAS *et al.* 2010; THRUPP 2007].

In addition to environmental aspects, the economic efficiency question for both agricultural production as a whole and its individual technological processes arose with the development of commodity production.

The technological processes efficiency in agriculture is a rather complex economic category, which reflects the production effectiveness. When assessing the final result, it is necessary to separate the effect and economic efficiency concepts since the effect obtained from the measures taken do not give an objective idea of the profitability and expediency of their application. Economic efficiency will show us the return on total investment, obtaining the maximum amount of products per unit area at the lowest cost. In other words, when calculating the indicator of economic efficiency, the results of production are compared with material costs [GERASIMOV *et al.* 2019; SHAIMARDANOVICH, RUSTAMOVICH 2018; TYUPAKOV *et al.* 2017; YAKOVENKO *et al.* 2016].

The economic efficiency of technological processes in agriculture is determined mainly by two groups of factors. External factors such as pricing, lending, taxation, inflationary processes, compensation, agricultural legislation, etc. They do not depend on the economic activity of an enterprise. Internal factors will be crop yield, animal productivity, organisation of production, specialisation, production cost, etc.

Today, the economic efficiency of technological processes, as well as agricultural production as a whole, is largely determined by the factors of the first group, while the second group of factors largely forms the level of economic efficiency. Thus, the main indicator of the economic efficiency of technological processes in agricultural production is the amount of profit from the sale of products.

For many years, there has been a discussion about the essence of the economic efficiency of production, the use of resources, and the choice of the main criteria. In addition, there is an opinion that it is important to single out several criteria with the subsequent calculation of a generalised criterion in the study of rather complex dynamic systems, such as agriculture. Accordingly, to assess the overall economic efficiency of plant protection measures, an analysis is made for the indicators representing the ratios of the values of the preserved yield and the cost of using chemical plant protection products for each harmful object on cultivated crops [BERSHITSY *et al.* 2016; GOVDYA *et al.* 2019; KARELAKIS *et al.* 2013; KVASHIN *et al.* 2019; SUGDEN *et al.* 2014].

Considering the agricultural industry’s specifics, in assessing the economic efficiency of technological processes, the yield

comes first as one of the most important economic indicators, reflecting the degree and efficiency of land use. It should be noted that the value of the yield has a direct impact on the value of other indicators.

Some of the country’s agricultural producers currently use outdated technologies, low-quality seeds, apply mineral fertilisers in insufficient quantities, and do not take protective measures against pests and diseases. The reason for this is the minimal desire of agricultural producers for scientific achievements, which is often due to the insufficient economic capabilities of agricultural enterprises [GOVDYA *et al.* 2018; HE *et al.* 2014; JAMAGANI 2013; KLOCHKO *et al.* 2019; WASIKE *et al.* 2011; YOUNG *et al.* 1994]. A way out of this situation may be the transfer of a significant part of the technological modernisation costs in the form of subsidies to the industry on the state [SANCHIS-IBOR *et al.* 2017].

Given the low level of loss prevention and the relatively high effect of protective measures, it is advisable to expand the integrated plant protection system using chemical agents, new areas of biological plant protection, and IT technologies in order to increase the volume of the preserved crop by 1.5 times (to the level of highly developed countries) due to with the need to ensure the gross grain harvest by 2030 at the level of 130 Tg from an area of 50 mln ha.

So, the studying, structuring, and analysing the results of an impressive number of studies conducted to determine the economic efficiency of the chemical method of plant protection over the past 20 years have shown the indisputable advantage of this technological process over the rest. Minimising the negative impact on the environment can be achieved through the use of nano-technologies, the use of new formulas, and a competent approach to the use of pesticides.

CONCLUSIONS

Based on the foregoing, we consider it necessary to increase the economic efficiency of technological processes in agriculture without fail from the standpoint of environmental acceptability to eliminate as much as possible or reduce the harm caused to the environment. For this, it is worth considering the possibility of providing subsidies to agricultural producers receiving environmentally friendly products. In addition, it is important to develop sustainable farming concepts that include the principles of producing high-quality products. A program designed to provide the population with products made on the basis of environmentally friendly technologies is designed to help in this.

Today, there are real opportunities for abandoning the widespread use of pesticides while maintaining high productivity and economic efficiency of the industry’s technological processes thanks to the reasonable use of an integrated plant protection system capable of ensuring the preservation of at least 25–30% of the crop. At the same time, the transition to wider use of biological plant protection products in the near future is not possible, which is due to the lack of a wide spectrum of action of drugs, their instability during storage, and high costs of work, which in many cases significantly exceed the cost of chemical treatments of crops and plantings. At the same time, the agrotechnical method of protecting the crop, as a preventive

technique, can significantly reduce the costs of combating harmful objects.

Of course, for the dynamic development of agriculture in Russia, it is important to apply innovative natural directions for agricultural production development, taking into account world experience and the indisputable competitive advantages of the domestic agricultural sector of the economy.

REFERENCES

- BERSHITSYI Y.I., SAIFETDINOVA N.R., TYUPAKOV K.E., VASILIEVA N.K., ARTEMOVA E.I. 2016. Justification of the structure and size of major productive resources of agricultural organizations. *International Journal of Applied Business and Economic Research*. Vol. 14(10) p. 7267–7287.
- BEZPAL'KO V.V., STANKEVYCH S.V., ZHUKOVA L.V., ZABRODINA I.V., TURENKO V.P., HORYAINOVA V.V., ... MATSYURA A.V. 2020. Pre-sowing seed treatment in winter wheat and spring barley cultivation. *Ukrainian Journal of Ecology*. Vol. 10(6) p. 255–268. DOI 10.15421/2020_291.
- DEGALTSEVA Z.V., GOVDYA V.V., VELICHKO K.A. 2021. Management of expenses for fertilizers and chemical plant protection products in the accounting and control system of agrarian formations. *Journal of Water and Land Development*. No. 49 p. 229–234. DOI 10.24425/jwld.2021.137116.
- DUDIN M.N., PAVLOVA K.P., FROLOVA E.E., SAMUSENKO T.M., POPOVA I.Y. 2018. Information technologies as an incentive for Russian agriculture. *Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development"*. Vol. 18(1) p. 143–152.
- GERASIMOV V.O., SHARAFUTDINOV R.I., KOLMAKOV V.V., ERZINKYAN E.A., ADAMENKO A.A., VASILYEVA A.G. 2019. Control in the human capital management system in the strategy of innovative development of a region. *Entrepreneurship and Sustainability Issues*. Vol. 7(2), 1074. DOI 10.9770/jesi.2019.7.2(20).
- GONZALEZ-DIAZ L., MARTINEZ-JIMENEZ P., BASTIDA F., GONZALEZ-ANDUJAR J.L. 2009. Expert system for integrated plant protection in pepper (*Capsicum annuum* L.). *Expert Systems with Applications*. Vol. 36(5) p. 8975–8979. DOI 10.1016/j.eswa.2008.11.038.
- GOVDYA V.V., DEGALTSEVA Z.V., KHROMOVA I.N., VELICHKO K.A., KOSTYUKOVA E.I. 2018. Accounting and analytical development support of dairy cattle in the Krasnodar region. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. Vol. 9(6) p. 1303–1314.
- GOVDYA V.V., KOSTYUKOVA E.I., DEGALTSEVA Z.V., KHROMOVA I.N., VELICHKO K.A. 2019. The relationship of the effectiveness of the functioning of agrarian formations from land ownership. *Indo American Journal of Pharmaceutical Sciences*. Vol. 6(6) p. 11741–11745. DOI 10.5281/zenodo.3243558.
- GRAHAM-BRYCE I.J. 1977. Crop protection: A consideration of the effectiveness and disadvantages of current methods and of the scope for improvement. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*. Vol. 281(980) p. 163–179. DOI 10.1098/rstb.1977.0131.
- HE B.J., YANG L., YE M. 2014. Building energy efficiency in China rural areas: Situation, drawbacks, challenges, corresponding measures and policies. *Sustainable Cities and Society*. Vol. 11 p. 7–15. DOI 10.1016/j.scs.2013.11.005.
- HOLTAPPELS D., FORTUNA K., LAVIGNE R., WAGEMANS J. 2021. The future of phage biocontrol in integrated plant protection for sustainable crop production. *Current Opinion in Biotechnology*. Vol. 68 p. 60–71. DOI 10.1016/j.copbio.2020.08.016.
- JAMAGANI Z.B. 2013. Relationship between problems and needs of extension workers: A case study of Maigana and Samaru zones of Kaduna State Agricultural Development Project, Nigeria [online]. *Journal of Agriculture and Veterinary Science*. Vol. 3(5) p. 17–23. [Access 15.07.2021]. Available at: https://www.academia.edu/4890622/Relationship_Between_Problems_And_Needs_of_Extension_Workers_A_Case_Study_of_Maigana_And_Samaru_Zones_of_Kaduna_State_Agricultural_Development_Project_Nigeria
- JIAN F., KE S. 2011. Research on intellectual property rights protection of agricultural plant genetic resources in China. *Asian Agricultural Research*. Vol. 3(8) p. 81–84. DOI 10.22004/ag.econ.121291.
- KARELAKIS C., ABAS Z., GALANOPOULOS K., POLYMEROS K. 2013. Positive effects of the Greek economic crisis on livestock farmer behaviour. *Agronomy for Sustainable Development*. Vol. 33(3) p. 445–456. DOI 10.1007/s13593-013-0136-y.
- KLOCHKO E., ADAMENKO A., BRIZHAK O. 2019. Human potential as a factor of dynamic and competitive development of the regional economy. *Advances in Economics, Business and Management Research*. Vol. 83 p. 447–450.
- KVASHIN A.A., NESHCHADIM N.N., GONTCHAROV S.V., GORPINCHENKO K.N. 2019. Economic efficiency and bioenergetic assessment of predecessors and fertilizer systems in the sunflower cultivation. *Helia*. Vol. 42(70) p. 101–109. DOI 10.1515/helia-2017-0007.
- ŁABĘDZKI L. 2016. Actions and measures for mitigation drought and water scarcity in agriculture. *Journal of Water and Land Development*. No. 29 p. 3–10. DOI 10.1515/jwld-2016-0007.
- MACFARLANE E., CAREY R., KEEGEL T., EL-ZAEMAY S., FRITSCHI L. 2013. Dermal exposure associated with occupational end use of pesticides and the role of protective measures. *Safety and Health at Work*. Vol. 4(3) p. 136–141. DOI 10.1016/j.shaw.2013.07.004.
- MATYJASZCZYK E. 2013. Plant protection in Poland on the eve of obligatory integrated pest management implementation. *Pest Management Science*. Vol. 69(9) p. 991–995. DOI 10.1002/ps.3578.
- MYSKA H., DERUN I., SKLIARUK I. 2021. The role of non-financial reporting in modern ecological problems updating and solving. *Journal of Environmental Management & Tourism*. Vol. 12(1) p. 18–29. DOI 10.14505/jemt.v12.1(49).02.
- OSTAEV G.Y., SHULUS A.A., MIRONOVA M.V., SMOLIN Y.V. 2020. Accounting agricultural business from scratch: Management accounting, decision making, analysis and monitoring of business processes. *Amazonia Investiga*. Vol. 9(27) p. 319–332. DOI 10.34069/AI/2020.27.03.35.
- PELAEZ V., DA SILVA L.R., ARAUJO E.B. 2013. Regulation of pesticides: A comparative analysis. *Science and Public Policy*. Vol. 40(5) p. 644–656. DOI 10.1093/scipol/sct020.
- PERERA H., BAYDOUN N. 2007. Convergence with international financial reporting standards: The case of Indonesia. *Advances in International Accounting*. Vol. 20 p. 201–224. DOI 10.1016/S0897-3660(07)20007-8.
- PERTOT I., CAFFI T., ROSSI V., MUGNAI L., HOFFMANN C., GRANDO M.S., ..., ANFORA G. 2017. A critical review of plant protection tools for reducing pesticide use on grapevine and new perspectives for the implementation of IPM in viticulture. *Crop Protection*. Vol. 97 p. 70–84. DOI 10.1016/j.cropro.2016.11.025.
- PLOTNIKOV K., PASHKOVSKY S., RYABININA V., BLAZHKO N. 2020. Efficiency of the preparation based on *Bacillus thuringiensis* and nuclear polyhedrosis virus against diamond back moth (*Plutella xylostella*). In: *E3S Web of Conferences*. Vol. 222, 02040. EDP Sciences. DOI 10.1051/e3sconf/202022202040.

- SANCHIS-IBOR C., GARCÍA-MOLLÁ M., AVELLÀ-REUS L. 2017. Effects of drip irrigation promotion policies on water use and irrigation costs in Valencia, Spain. *Water Policy*. Vol. 19(1) p. 165–180. DOI [10.2166/wp.2016.025](https://doi.org/10.2166/wp.2016.025).
- SHAIMARDANOVICH D.A., RUSTAMOVICH U.S. 2018. Economic-mathematical modeling of optimization production of agricultural production. *Asia Pacific Journal of Research in Business Management*. Vol. 9(6) p. 10–21.
- SHICHIYAKH R.A., SMOLENTSEV V.M., SHADRINA Z.A., KOCHYAN G.A., TYUPAKOV K.E. 2017. Methodical basis for the increase in the efficiency of management by objectives of local economic systems (on the example of fruit and berry sub-complex of Krasnodar Region). *International Journal of Applied Business and Economic Research*. Vol. 15(23) p. 305–314.
- SUGDEN F., MASKEY N., CLEMENT F., RAMESH V., PHILIP A., RAI A. 2014. Agrarian stress and climate change in the Eastern Gangetic Plains: Gendered vulnerability in a stratified social formation. *Global Environmental Change*. Vol. 29 p. 258–269. DOI [10.1016/j.gloenvcha.2014.10.008](https://doi.org/10.1016/j.gloenvcha.2014.10.008).
- THOMAS S., DARGUSCH P., HARRISON S., HERBOHN J. 2010. Why are there so few afforestation and reforestation Clean Development Mechanism projects? *Land Use Policy*. Vol. 27(3) p. 880–887. DOI [10.1016/j.landusepol.2009.12.002](https://doi.org/10.1016/j.landusepol.2009.12.002).
- THRUPP L.A. 2000. Linking agricultural biodiversity and food security: The valuable role of agrobiodiversity for sustainable agriculture. *International Affairs*. Vol. 76(2) p. 265–281. DOI [10.1111/1468-2346.00133](https://doi.org/10.1111/1468-2346.00133).
- TYUPAKOV K.E., MELNIKOV A.B., MIKHAILUSHKIN P.V., SHICHIYAKH R.A., POLUTINA T.N. 2017. Priority directions of increasing the economic efficiency of crop production. *International Journal of Applied Business and Economic Research*. Vol. 15(23) p. 327–338.
- VERJUX N. 2017. Integrated plant protection in potatoes: Review of the French situation. *Potato Research*. Vol. 60(3) p. 307–318. DOI [10.1007/s11540-018-9382-3](https://doi.org/10.1007/s11540-018-9382-3).
- WASIKE C.B., MAGOTHE T.M., KAHI A.K., PETERS K.J. 2011. Factors that influence the efficiency of beef and dairy cattle recording system in Kenya: A SWOT–AHP analysis. *Tropical animal health and production*. Vol. 43(1) p. 141–152. DOI [10.3168/jds.S0022-0302\(06\)72195-6](https://doi.org/10.3168/jds.S0022-0302(06)72195-6).
- YAKOVENKO N.V., KOMOV I.V., DIDENKO O.V., DROBYSHEV E.A., KHUDYAKOVA T.M. 2016. Regional socio-economic-geographical system: Definition concepts. *Indian Journal of Science and Technology*. Vol. 9(16) p. 1–7. DOI [10.17485/ijst/2016/v9i16/90614](https://doi.org/10.17485/ijst/2016/v9i16/90614).
- YOUNG S., HOOD N., PETERS E. 1994. Multinational enterprises and regional economic development. *Regional Studies*. Vol. 28(7) p. 657–677. DOI [10.1080/00343409412331348566](https://doi.org/10.1080/00343409412331348566).
- ZHANG L., RENIERS G., CHEN B., QIU X. 2018. Integrating the API SRA methodology and game theory for improving chemical plant protection. *Journal of Loss Prevention in the Process Industries*. Vol. 51 p. 8–16. DOI [10.1016/j.jlp.2017.11.002](https://doi.org/10.1016/j.jlp.2017.11.002).
- ZHICHKIN K., NOSOV V., ZHICHKINA L., ZHENZHEBIR V., RUBTSOVA S. 2020. The agricultural crops production profitability in modern conditions. In: *E3S Web of Conferences*. Vol. 175, 13008. DOI [10.1051/e3sconf/202017513008](https://doi.org/10.1051/e3sconf/202017513008).