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GREEN AGRICULTURE WITH NEGATION OF CHEMICALS IN KAZAKHSTAN

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SUMMARY

The use of pesticides in agriculture is constantly rising in the Republic of Kazakhstan. Over the past decade, pesticide use per unit area of agricultural land has almost tripled. In 2008, this figure was 0.2 kg/ha, while in 2018, it reached 0.593 kg/ha. In crop production, pesticide application contaminates the soil, water, and plants with toxic residues, negatively affecting human health and the environment. Organic agriculture provides high-quality food and sustainable rural development. However, the development of organic crop production is slow in Kazakhstan. To date, field areas processed using organic production technologies are about 200,000 ha in Kazakhstan, as confirmed by European certifying organizations. In organic agriculture, employing biological agents (manures, straw, siderates, and biofertilizers), according to biological buffering laws, without disturbing the ecological balance, contributes to maintaining soil fertility and enhancing environmentally safe productivity. Plant protection measures require implementation through producing resistant crop genotypes and non-chemical methods like mechanical and biological in organic agriculture.

Keywords: Pesticides, toxic residue pollution, organic agriculture, environmentally friendly products, manure, straw, siderates, biofertilizers, mechanical and biological methods of plant protection

Key findings: Applying biological agents (manures, straw, siderates, and biofertilizers) in organic agriculture contributes to maintaining soil fertility, enhancing productivity, and obtaining environmentally safe products.

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INTRODUCTION

In Kazakhstan, the agricultural sector ranks first in the national economy. The areas sown with different crops have comprised about 21–22 million hectares over the past five years. Pesticide applications mainly help grow various crops in the Republic. However, the pesticide use in diverse crop plants is constantly increasing in the Republic of Kazakhstan. Over the past decade, the pesticide use per unit area of agricultural land has almost tripled, with the figure of 0.2 kg ha^{-1} in 2008 reaching 0.593 kg ha^{-1} in 2018. Notably, in Kazakhstan, pesticide application rates are lower than in China (13.7 kg ha^{-1} in 2008 and 14.7 kg ha^{-1} in 2014) and in Ukraine (1.6 kg ha^{-1} in 2008 and 2.3 kg ha^{-1} in 2014). Pesticide use is far lower in Kazakhstan (Code of the RK, 2007; Law of the RK, 2007, 2014).

Kazakhstan currently has about 1,021 registered trade names of different pesticides. Updating the list of registered pesticides revealed 15–20 new drugs added yearly. Most pesticides used are insecticides, fungicides, and herbicides (Law of the RK, 2002, 2014). Numerous studies have confirmed the negative impact of dangerous pesticides on human health and the environment. In 2019, a massive fish death occurred in one of the lakes of North Kazakhstan, the Tulumbai Lake in Zhambyl District, where 185 kg of fish died due to pesticide poisoning. The water analysis showed that pesticides and salt contents were twice as high in the water (http://adilet.zan.kz/rus/docs/P080000515).

In the regions of intensive pesticide use, an overall incidence increases, with the number of congenital malformations also rising. Pesticides can cause lymphoma, leukemia, and cancer in various parts of the body, i.e., brain, breast, prostate, thyroid, liver, lung, and colon cancer. Exposing weeds and insects to pesticides significantly enhances the risk of Parkinson's disease. Pesticides also adversely affect the human reproductive system: an elevated number of miscarriages, enhanced infertility, and a reduced level of the hormone testosterone in men. The farming community, crop fieldworkers, children, and pregnant women living near croplands appeared particularly at risk (https://www.gov.kz/memleket/entities/agroindust/documents/details/41094; https://online.zakon.kz/Document/?doc_id=31653900).

Results of an analysis by the Laboratory of Pesticide Toxicology of KazNIIZiKR LLP named after Zh. Zhiembayev of vegetable and fruit samples collected from markets in cities in Kazakhstan confirmed residual amounts of various pesticides in apples, pears, peaches, grapes, cucumbers, tomatoes, cabbages, eggplants, onions, and dills. Organochlorine pesticides were also evident in rice, milk, meat, soil, and in water of large bodies of water in the Ili River, Irtysh, and Balkhash Lake (https://ipen.org/sites/default/files/documents/final_ru_kazakhstan_hhp_report_summary).

Pesticide use outcomes contaminate crops and the environment with toxic residues and decrease the regulatory role of beneficial components of agrobiocenoses (entomophages, pollinators, and birds), forming pesticide-resistant populations of harmful species. The formation of resistance in harmful organisms to plant protection measures is one of the most acute problems of modern crop production, as it leads to a sharp decrease in the protective measures' effectivity, raising pesticide use, which contributes to further destabilization of the phytosanitary situation in agroecosystems (Shchukin and Trufanov, 2012). Also contributing to this is the rapid adaptation of pests and pathogens to widely cultivated resistant cultivars developed on a genetically homogeneous basis. At the national level, Kazakhstan needs to reduce and eliminate dangerous pesticide applications by introducing organic farming and an applied ecosystem approach in agriculture.

RESULTS AND DISCUSSION

Organic farming

Organic agriculture is a production system that supports the health of soils, ecosystems, and humans. It relies on ecological processes, biodiversity, and cycles adapted to the local conditions rather than using non-renewable resources. The increased interest in this area is proof of the expansion of coverage: in 1999, at 11 million ha, while in 2020, the said area enhanced 6.5 times, reaching 71.5 million ha), along with an increased demand for environmentally safe products. Currently, employing organic agriculture is prevalent in 186 out of 194 countries worldwide, and 95.9% of states have organic assets. All the countries in the European Union also develop their organic production. Among the states of the African continent, 70% of the countries engaged in organic agriculture, 72% in South America, and almost 80% in Asia. The undisputed leaders in organic agriculture are Australia (17.2 million ha), Argentina (3.1 million ha), and the USA (2.2 million ha) (Grigoruk, 2016).

In 2015, Kazakhstan adopted the law 'On the production and turnover of organic products,' which defines the legal, economic, social, and organizational foundations for organic products production aimed at ensuring the rational use of soils, assistance in the formation of a healthy diet, and environmental protection. In addition, the rules for subsidizing certification costs reached approval, and standards for organic products, including the conformity assessment mark, came into force.

However, in Kazakhstan, the development of organic agriculture is slow. In 2022, Kazakhstan exported organic products worth USD 35 M. However, the primary export positions were wheat, flax seeds, and soybean. According to the FiBL and IFOAM ratings, out of 123 countries, Kazakhstan ranks ninth in the export of organic products, fourth in countries exporting organic wheat, and sixth in organic oilseed export. These organic products are mainly exported commodities to European Union countries.

Currently, the farm area used for organic crop production is more than 200,000 ha (Table 1), as confirmed by the European certifying organizations in Kazakhstan (Grigoruk and Klimov, 2020). The organic crop production opens up new opportunities for the Kazakhstan farming community. The Government of the Republic of Kazakhstan considers the production of organic products promising to enhance the competitiveness of domestic products and develop export potential.

In past years, the United Nations Development Program (UNDP), in partnership with the Government of the Republic of Kazakhstan, has systematically worked on establishing organic agriculture in Kazakhstan. With the coordination of UNDP and the Ministry of Agriculture, Republic of Kazakhstan, they developed the necessary regulatory framework, with various financial mechanisms adopted to boost organic agriculture. In addition, UNDP also assisted in the pilot certification of specific commodity items in the agricultural sector (https://adilet.zan.kz/rus/docs/P2100000960).

Organic farming development is also an agenda of the 'Biodiversity and Ecosystem Services Network (BES-NET)' and the 'Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES),' in Bonn, Germany. The initiative of various states in 2012 developed said platform that still unites about 140 countries worldwide today. The platform aims to create a knowledge-based organization that helps numerous countries globally to take measures for biodiversity conservation and the sustainable use of ecosystem services in the long term. The BAS-NET supports Kazakhstan through the BES Solutions Funds to scale up and implement results of IPBES assessments,

Table 1. Organic agricultural lands in Kazakhstan, thousand hectares (Grigoruk and Klimov, 2020).

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Area (ha)	134.9	133.6	196.2	291.2	291.2	291.2	303.4	303.4	277.1	192.1
Percent of 2009	100	99	145	216	216	216	225	225	205	142

Note: According to the statistics of the international organization FIBL IFOAM, The world organic agriculture. Statistics and Emerging Trends for the corresponding year.

where in October 2019, identifying the key priorities emerged during the Central Asian Regional Trialog in Almaty, Kazakhstan (https://fsvps.gov.ru/news/obzor-sokrashhenie-ispolzovanija-pesticidov-i-agrohimikatov- aktualno).

Biological methods in organic farming

In organic agriculture, soil fertility maintenance and increasing productivity commence through employing and activating biological methods of influence, using organic materials (manures, straw, and siderates) and biofertilizers. Manure is one of the most common organic fertilizers. Traditionally, in organic farming, manure application in fields, as a rule, must be in un-composted (fresh) and composted forms. However, some countries restrict using fresh manure for organic farming.

In organic farming, manure composting eliminates harmful effects, as mentioned earlier. Properly prepared compost is a safe fertilizer. There is virtually no free ammonia and soluble nitrates, and a large amount of nitrogen binds in proteins, amino acids, and other biological components. Compost also stabilized the rest of the batteries (Grigoruk, 2016). Past studies on ordinary chernozems in Eastern Kazakhstan have shown that the use of 60 tons of manure/ha for the six-field grain crop rotation contributed to an increase in the humus content (0.24%) in the 0–20 cm layer, compared with its initial content. In the control variant (with no manure), the humus reserves decreased by 0.14% (Kenenbayev *et al.,* 2017; Kenenbayev and Jorgansky, 2018; Kenenbayev, 2020).

On dark chestnut soils of Western Kazakhstan, during the five-field grain-pair crop rotation, the soil humus content decreased slightly in the control variant (by 0.09%). The introduction of 80 tons of manure/ha per rotation positively affected the humus content by increasing 0.23%, compared with the control. Approximately the same pattern of variations in the content and reserves of humus was notable in the ordinary chernozem of Southeastern Kazakhstan. The variant without fertilizers (control) revealed that the humus content decreased over five years. The introduction of 20 tons of manure/ha per rotation contributed to preserving humus in the arable layer at the initial level. By using increased doses of manure (70 t/ha), a significant increase was evident in the humus reserves (0.16%), compared with the initial state (Kenenbayev *et al.,* 2017; Kenenbayev and Jorgansky, 2018; Kenenbayev, 2020).

Straw is an environmentally friendly organic fertilizer compared with manure due to its larger volume, which can provide 3.4 times more organic matter developed at consumption and has seven times lower application cost to the soil (Voronov and Shishov, 2008). Adding to each ton of straw, 8.5 kg of nitrogen, 3.8 kg of phosphorus, 13 kg of potassium, 4.2 kg of calcium, 0.7 kg of magnesium, and several trace elements accumulate more in straw than in grains. i.e., iron (from 10 to 30 g/t), manganese (from 15 to 70 g/t), copper (from 2 to 5 g/t), zinc (from 20 to 50 g/t), molybdenum (from 0.2 to 0.4 g/t), and boron (from 2 to 5 g/t) (Zemlyanov, 2007).

After using the straw, the soil's volume weight decreases, the number of water-resistant aggregates increases, and the humus substances have a high cementing ability, which causes the formation of a water-resistant soil structure (Safonov and Alferov, 2002). Introducing straw residues in the upper third of the arable layer replaces the semi-parasitic microflora with saprophytic microflora, which consumes fresh plant residues. The cellulose-decomposing microflora gains enrichment with bacteria that secrete mucus, which is highly susceptible to destruction by other soil microorganisms. Thanks to these mucous substances, aggregates formed and retained their structure. Past studies indicated the prominent role of straw in enhancing and conserving the soil fertility (Golovach and Luzhinsky, 2007), especially with the advent of zero-tillage technology (Blanco-Canqui *et al.,* 2006; Kunypiyaeva *et al*., 2023; Zhapayev *et al*., 2023).

At the same time, despite the positive role of straw in maintaining soil fertility, some studies reported the disadvantages of straw as an organic fertilizer (Smirnov *et al.,* 2005;

Kolsanov *et al.,* 2008). In soil, the straw application is parallel with undesirable processes, such as the immobilization (biological fixation) of nitrogen, the release of toxic substances during the decomposition of plant residues, and an increase in clogging, which may negatively affect soil fertility and crop plants (Steinforth, 1983).

In aerobic conditions of straw decomposition, toxic substances accumulate less than in anaerobic decomposition. In addition, the products of anaerobic fermentation of straw inhibit the growth of crop seedlings and aerobic-stimulation. In this regard, it is better to seal the straw immediately after harvesting and grinding it into the upper, more aerated, and microbiologically active soil layer (8–10 cm). However, the toxic products contained in the straw decompose more intensively and without secondary accumulation of harmful substances (Dvornichenko and Mishustin, 1980).

In addition to embedding straw in the upper layer of the arable horizon, soil-surface mulching is also applicable, which helps to retain moisture and protects the soil from erosion (Steinforth, 1983). Plant residues (including straw) on the soil surface in the form of mulch are fundamental elements of the No-Till technology, which succeeded in application in North and South America, Australia, Europe, and Asia. Past studies mentioned that using this technology with the leaving of plant residues on the soil surface ensures the accumulation of organic matter (Hooker *et al.,* 2005), absorbs the energy of raindrops, and protects soil aggregates from destruction (Peterson, 2008), developing earthworms, which improves the soil's physical properties (Fonte *et al.,* 2007).

The next most important element of organic farming is green manuring (siderates). Green fertilizer first enriches the soil with nitrogen and organic matter. Typical plowing of 35–45 tons of organic matter contains 150–200 kg of nitrogen on a hectare of arable land. Applying green fertilizer causes nitrogen and other nutrients to accumulate in the soil. Green fertilizer decomposes in the soil much faster than other organic fertilizers rich in fiber. Siderates accumulate 110–150 kg of nitrogen, 50–70 kg of phosphorus, and 100–150 kg of potassium per one hectare of arable land, while fresh vegetable matter decomposes to 30% in the first year of plowing and 70%–80% in the second year (Chebochakov *et al.,* 2013). The sealing of green fertilizer has a positive aftereffect for 3–4 years (Chebochakov and Shpedt, 2018). Its validation shows that already during the year of direct action, green fertilizer can increase crop yields by 30%–50% (Tuzhilin and Bykova, 1995). Maintaining the positive effects of siderates on soil fertility and crop yield can last 3–6 years.

The structure improves by plowing the plants green, while the volume mass of the arable layer and the soil composition density decrease. It is crucial since, in this case, the heavy agricultural machinery eliminates the negative consequences of compaction of the arable soil layer. As a result of the plowing of siderates, the soil's water permeability and moisture capacity significantly increase, resulting in a decrease in surface runoff of precipitation, and the soil moisture content sharply enhanced.

As a result, the vital activity of soil microorganisms improves dramatically. The considerable enhancement of microbiological processes in soil manifests during the growth and development of siderates, and even better conditions for soil microflora emerge after green manuring. It is because siderates enrich the soil with nitrogen, phosphorus, and other macro- and micro-elements necessary for developing microflora and plant nutrition. At the same time, nutrient absorption by soil microorganisms also happens, dramatically reducing the possibility of leaching, particularly nitrogen, in the lower horizons of the soil.

Crop production biological methods also depended on using highly efficient, economical, and environment-friendly biological fertilizers (Davletshin *et al.,* 2010). Experts predict significant growth in almost any segment of agriculture with the prefix 'bio' in the coming years, including fertilizers. Therefore, one can foresee that this segment will increase annually, and by 2025, the biofertilizer market will reach USD 3.8 billion. In almost all agricultural countries, the consumption of biofertilizers rises, and the number of enterprises that produce them also grows (Rabinovich *et al.,* 2015; Mayer *et al.,* 2015; Vassilev *et al.,* 2015).

Unlike chemicals, biologics have a pronounced selectivity of action and are recognizably harmless to humans and animals, decomposing rapidly in the soil. The introduction of such agricultural technologies, obtaining high yields, makes it possible to ensure the environmental safety of crop production (Villarreal-Romero *et al.,* 2010; Surov and Chukhina, 2012; Nemchenko and Tsypysheva, 2014). Biologics have a long duration of action, do not accumulate in plants, and are addictive to insects. Biologics have biodegradation - the ability to break down plant residues. Many biological products have a unique ability to enhance plant immunity.

Biological products are bacterial fertilizers developed from highly effective strains of associative nitrogen fixers. Their use has justification when applied with seeds into the soil; useful types of microorganisms enter in large quantities, which help to improve the plant root nutrition and synthesize physiologically active substances. Secondly, introducing one kind of microorganism activates the vital activity of others, and as a result, the plant additionally receives more nutrients. Thirdly, bacteria introduced with bacterial fertilizers, antagonists of some phytopathogenic microbes, also play a protective function (Schmitt *et al.,* 2003; Cheremisin and Yakimova, 2011). Overall, applying these resources will preserve soil fertility and optimize plant nutrition, with stable yields of high-quality products while maintaining the ecological status of agrocenoses.

Breeding and seed production in organic farming

In crop production, pesticide use reduction can be due to the pivotal role of crop breeding. Traditionally, breeders have paid more attention to developing disease-resistant cultivars than creating pest-resistant cultivars. However, such cultivars also exist. At the same time, one must know how it came about since utilizing genetically modified crops is impractical in organic production systems. In the nonavailability of pest-resistant cultivars, it is necessary to choose cultivars that are less attractive to insect pests than others are. Plant size, shape, color, leaf pubescence, and chemical composition can attract and repel pests, affecting the crop’s insect colonization. At the same time, engaging cultivars to reduce harmful organisms can also lessen the number of beneficial insects.

Breeders can influence the further improvement of organic crop production not only by propagating the most suitable existing cultivars but also by integrating the characteristics of the organic cultivar into future breeding programs. In addition, great efforts are essential to implement comprehensive and consistent activities related to producing scientific information based on the adaptation and improvement of organic seed production, improving the stability of cultivars for healthy seed production, and the assessment of thresholds. Thus, with the development of more disease- and pest-resistant crop cultivars characterized by higher-yield stability through increased adaptability and biodiversity levels, it is possible to reduce the dependency upon fungicides and insecticides.

Plant protection in organic farming

Given that in organic agriculture, the non-use of pesticides and plant protection from pests, diseases, and weeds is possible with improvement in non-chemical methods (mechanical and biological). The agrotechnical method of plant protection depends on the use of general and special agricultural techniques, with the help of developed environmental conditions that are unfavorable for the growth and reproduction of harmful organisms and increase the self-protective properties of crop plants (tillage, and physical destruction). The biological method relies on the use of predatory and parasitic insects (entomophages), predatory mites (acariphages), microorganisms, nematodes, birds, and mammals, to suppress the number of harmful organisms.

By developing a biointensive integrated approach to plant protection (Dufour, 2001), special attention focuses on environmental approaches, which comply with preventive measures, applying biological methods for regulating harmful organisms and employing less toxic materials to regulate destructive entities. Here, the emphasis is also on the activation of biological processes that contribute to increasing the overall sustainability of agrophytocenosis (Schonbeck, 2007). At the same time, biointensive integrated plant protection will include many components, particularly monitoring and using economic thresholds.

Organic farming excludes most herbicides, with weeds considered the most severe obstacle to a successful transition to organic production (Tẏr *et al.,* 2009) and effective weed control in organic farming. Worldwide, weeds cause more crop losses and enhance production costs than insects, pests, pathogens, and nematodes. Losses from weeds of grain crops range from 20% to 25%, and for row crops and vegetable crops – up to 50% (Zakharenko, 2000). Several bioherbicides based on fungal pathogens exist that act against specific types of weeds. Currently, bioherbicides play a minor role in weed management in organic agriculture.

Understanding the ecological principles underlying the dynamics of insect populations and the interaction of populations within a community can help organic producers manage the number of arthropods on their farm, both from a pest control perspective and to maintain beneficial species to reduce economic crop losses (Barbercheck, 2010). As a rule, pests are not a chief problem in organic farming systems since healthy plants grown in healthy soil have a balanced diet and are more able to resist pests themselves. Under certain conditions, active pest control strategies, including natural pesticides, are acceptable in organic agriculture. However, biological control methods, i.e., crop rotation, will remain the most significant means for organic system pest control.

CONCLUSIONS

The volume of pesticide use in agriculture in the Republic of Kazakhstan is constantly growing. Over the past 10 years, their use per unit area of agricultural land has almost tripled. Pesticide usage in farm production contaminates soil, water, and plants with toxic residues and negatively affects human health and the environment. In organic agriculture, maintaining soil fertility and increasing productivity must be implemented by applying and activating biological methods of influence, particularly by using organic (manure, straw, and siderates) and biological fertilizers. In organic agriculture, plant protection techniques must function based on traditional knowledge, i.e., by improving non-chemical methods (mechanical and biological), viz., employing general and special techniques of agricultural technology and biological procedures for managing diseases and harmful organisms.

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REFERENCES

Barbercheck ME (2010). Ecological Understanding of Insects in Organic Farming Systems. http://www.extension.org/pages/18906/ecological-understanding-of-insects-in-organic-farming-systems.

Blanco-Canqui H, Lal R, Post WM, Izaurralde RC, Owens LB (2006). Owens corn stover impacts on near-surface soil properties of no-till corn in Ohio. *Soil Sci. Soc. Am. J.* 70: 266–278.

Chebochakov EY, Shpedt AA (2018). The effectiveness of methods of biologization of agriculture in different agroecological regions of Central Siberia. *Agriculture* 6: 3–5.

Chebochakov EYa, Edimeichev YuF, Romanov VN, Shpagin AI (2013). Biologization of agriculture in the natural areas of Central Siberia. *Achiev. Sci. Technol. Agro-Indust. Complex* 6: 40–42.

Cheremisin AI, Yakimova IA (2011). The effect of growth stimulants and biofungicides on potato plant productivity. *Achiev. Sci. Technol. Agro-Indust. Complex* 3: 26–28.

Code of the Republic of Kazakhstan of January 9, 2007, No. 212-III 'Environmental Code of the Republic of Kazakhstan" (as amended on December 26, 2019). https://online.zakon.kz/document/?doc_id=30085593 (accessed 05.12.2023).

Davletshin FM, Safin HM, Ayupov DS (2010). The use of the phytosporin biological product in the cultivation of spring wheat in the southern forest-steppe of the Republic of Bashkortostan. *Achiev. Sci. Technol. Agro-Indust. Complex* 10: 12–14.

Dufour R (2001). Biointensive integrated pest management. National Sustainable Agriculture Information Service. Available at: http://www.attra.org/attra-pub/ipm.html (verified March 11, 2023).

Dvornichenko LYu, Mishustin EN (1980). The influence of straw on soil processes and crop yields. The use of straw as an organic fertilizer. M, Nauka. pp. 3–25.

Fonte SJ, Kong AyY, Kessel C van, Hendrix PF, Six J (2007). Influence of earthworm activity on aggregate-associated carbon and nitrogen dynamics differs with agroecosystem management. *Soil Biol. Biochem*. 39: 1014–1022.

Golovach AA, Luzhinsky DV (2007). Straw as a direct organic fertilizer. Problems and ways to improve the efficiency of crop production in Belarus: Abstracts of the Jubilee International scientific and practical conference dedicated to the 80th anniversary of the Institute of Agriculture. G. Zhodino. – Minsk: IVC of the Ministry of Finance. pp. 180–183.

Grigoruk VV (2016). The development of organic agriculture in the world and Kazakhstan. Food and Agriculture Organization of the United Nations. Ankara. pp. 168.

Grigoruk VV, Klimov EV (2020). Organic agriculture: A conceptual position. Problems of the agricultural market. pp. 88–101 https://agroeconom.kz DOI: 10.46666/2020.2708-9991.11.

Hooker BA, Morris TF, Peters R, Cardon ZG (2005). Long-term effects of tillage and corn stalk return on soil carbon dynamics. *Soil Sci. Soc. Am. J.* 69: 188–196.

Kenenbayev S, Jorgansky A (2018). Adaptive landscape agricultural development in the southeast of the Republic of Kazakhstan. *Res. on Crops* 19(1): 144–149.

Kenenbayev SB (2020). The role of biological agents in organic farming. *Siberian Bull. Agric. Sci.* 50(3): 103–110. doi:10.26898/0370-8799-2020-3-11.

Kenenbayev SB, Bastaubayeva ShO, Bekbatyrov MB, Ospanova SO (2017). The influence of various means of biologization of agriculture on changes in biochemical properties and fertility of light chestnut soils. *Izvestiya NAS RK. Ser. Agric. Sci.* 5(41): 58–64.

Kolsanov GV, Kulikova AH, Khvostov NV, Zemlyanov IN (2008). The effect of the aftereffect of the systematic use of straw on the productivity of crops of the second rotation of crop rotation. *Agrochemistry* 7: 31–34.

Kunypiyaeva GT, Zhapayev RK, Mustafaev MG, Kakimzhanov Y, Kyrgyzbay K, Seilkhan AS (2023). Soil cultivation methods' impact on soil water-physical properties under rainfed conditions of Southeast Kazakhstan. *SABRAO J. Breed. Genet*. 55(6): 2115-2127. http://doi.org/10.54910/sabrao2023.55.6.23.

Law of the Republic of Kazakhstan of July 21, 2007, No. 302-III "On the safety of chemical products" (as amended on December 27, 2018). https://online.zakon.kz/document/?doc_id=30113861 (accessed 05.12.2023).

Law of the Republic of Kazakhstan of July 3, 2002, No. 331 "On Plant Protection" (as amended on November 27, 2019). http://adilet.zan.kz/rus/docs/Z020000331_ (accessed 05.12.2023).

Law of the Republic of Kazakhstan of May 16, 2014. No. 202-V "On Permits and Notifications" (as amended on January 11, 2020). http://adilet.zan.kz/rus/docs/Z1400000202 (accessed 05.12.2023).

Mayer J, Gunst L, Maeder P (2015). Productivity, quality and sustainability of winter wheat under long-term conventional and organic management in Switzerland. *Eur. J. Agron*. 65: 27–39.

Nemchenko VV, Tsypysheva MYu (2014). The influence of biological products and growth regulators on the yield structure and productivity of spring wheat. *Bull. Altai State Agrarian Uni.* 8: 5–8.

On approval of the Concept of development of the agro–industrial complex of the Republic of Kazakhstan for 2021–2030. https://adilet.zan.kz/rus/docs/P2100000960.

On approval of the list of pesticides (toxic chemicals) allowed for use in the territory of the

Republic of Kazakhstan for 2013–2022 // https://www.gov.kz/memleket/entities/agroindust/documents/details/41094? lang=ru.

On approval of the Technical Regulation "Safety requirements for pesticides (toxic chemicals)". http://adilet.zan.kz/rus/docs/P080000515_ (accessed 05.12.2023).

Order of the Chairman of the State Inspection Committee in the agro-industrial complex of the Ministry of Agriculture of the Republic of Kazakhstan of December 27, 2012, No. 143. https://online.zakon.kz/Document/?doc_id=31653900 (accessed 05.12.2023).

Overview: Reducing the use of pesticides and agrochemicals is relevant worldwide //https://fsvps.gov.ru/news/obzor-sokrash-henie-ispolzovanija-pesticidov-i-agrohimikatov-aktualno. 03.12.2023.

Peterson G (2008). Saving and storing moisture in the soil is like keeping money in a bank. *The Chief Agron*. 4: 13–16.

Rabinovich GYu, Kovalev NG, Smirnova YuD (2015). The use of new fertilizers and biological products in the cultivation of spring wheat (*Triticum aestivum*) and potatoes (*Solanum tuberosum* L.). *Agric. Biol*. 50(5): 665–667.

Safonov AF, Alferov AA (2002). The content of soil organic matter and its labile fraction. Long-term field experience of TLC 90 years: Results of scientific research. Moscow: *Publishing House of the Ministry of Agriculture*, pp. 95–96.

Schonbeck M (2007). Beating the weeds with low-cost cover crops, intercropping and steel. The Virginia Biological Farmer 30: 7–8.

Shchukin SV, Trufanov A (2012). Ecologization of agriculture (translation of traditional agriculture into organic). A series of training manuals "RUDECO Retraining of personnel in the field of rural development and ecology" M, pp. 196

Smirnov BA, Shchukin SV, Chebykina EV, Smirnova VI (2005). The system of 'surface-dump' treatment on soils with excessive moisture. *Soil protection resource-saving agro-technical complex*. pp. 233.

Steinforth AR (1983). Straw of cereal crops. *M.-Ear.* pp. 191.

Surov VV, Chukhina OV (2012). The effect of fertilizers and flavobacterin on the yield and quality of potato tubers. *Dairy Bull*. 2(6): 12–17.

The current situation of pesticide use in the Republic of Kazakhstan //https://ipen.org/sites/default/files/documents/final_ru_kazakhstan_hhp_report_summary_.2020 г.- 6 s.

Tuzhilin VM, Bykova AV (1995). Donnik as a siderate – in the non-Chernozem region. *Agriculture* 2: pp. 8.

Týr Š, Vereš T, Lacko-Bartošová M, Kristiansen P (2009). Weeds as an important stress in ecological farming. *Cereal Research Communication*. Vol.37. Neum, Bosnia-Yerzegovina.

Vassilev N, Vassilev M, Lopez A (2015). Unexploited potential of some biotechnological techniques for biofertilizer production and formulation. *Appl. Microbiol. Biotechnol*. 99(12): 4983–4996.

Villarreal-Romero M, Parra-Terraza S, Sanchez-Pena P, Hernández-Verdugo S, Osuna-Enciso T, Basilio Heredia J (2010). Soil cover crop, vermicompost and soil microbial activity in the tomato production. *Revista Mexicana de Ciencias Agricolas* 1(2): 217–229. ISSN 2007-0934. https://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S2007-09342010000200008&lng=en&nrm=iso.

Voronov V, Shishov S (2008). Why and how to analyze the composition of the soil. *New Agric.* 2. pp. 54.

Zakharenko AV (2000). Theoretical foundations of the management of the weed component of agrophytocenosis in farming systems. *Moscow: TSKHA*. pp. 108–126.

Zemlyanov IN (2007). The use of straw and mineral fertilizers in crop rotation. *Agriculture* 6: pp. 18.

Zhapayev RK, Kunypiyaeva GT, Mustafaev MG, Doszhanova AS, Isabay BT, Maybasova AS, Kydyrov AK, Omarova ASh (2023). Different tillage regimes' effect on soil-water physical and agrochemical properties under the environmental conditions of Southeast Kazakhstan. *SABRAO J. Breed. Genet.* 55(5): 1831-1842. http://doi.org/10.54910/sabrao2023.55.5.34.