Mitigating climate impact through stabilized fertilizers: enhancing agricultural sustainability

Magomed Arsanov[1,2], *Madina A.* Tokaeva[2], and *Dzhabrail* Bamatov[1,3*]

[1]V.V. Dokuchaev Soil Science Institute, Pyzhevskiy Pereulok, 7c2, Moskva, Russia
[2]Chechen State University named after A. A. Kadyrova, Prospekt Bul'var Dudayeva, 17, Grozny, Russia
[3]Grozny State Oil Technical University named after M.D. Millionshikov, Prospekt Kh. Isayeva, 100, Grozny, Russia

Abstract. The recognition by the global scientific community that anthropogenic activities are responsible for the negative impact of climate change has led to the emergence of numerous theses and projects aimed at mitigating humanity's adverse effects on the environment. The biosphere's inherent characteristic of movement plays a significant role in the dispersion of pollutants, rendering the notion of a national ecosystem obsolete. In light of this understanding, this project focuses on the reduction of negative climate factors through the application of stabilized fertilizers with controlled nutrient release. The primary objective is to minimize the detrimental consequences of human activities on the Earth by implementing sustainable strategies. Conventional fertilizers often result in rapid nutrient release, leading to inefficiencies and environmental repercussions. This approach optimizes nutrient utilization, mitigates nutrient losses through leaching and volatilization, and reduces environmental contamination. Slow-release fertilizers, coated products, and nutrient-specific delivery systems are potential avenues for achieving this goal. Furthermore, by reducing nutrient runoff, these fertilizers contribute to preserving water quality and safeguarding aquatic ecosystems.

1 Introduction

Agriculture is currently faced with numerous contradictions. Agricultural production systems stand out for climate, water, biodiversity and human health. According to the Ministry of Agriculture of the Russian Federation, in 2015, the share of the agricultural sector accounted for 20% of the accumulation of greenhouse gases in the territory. 45% elimination of methane emissions associated with animal husbandry, 40% nitrous oxide associated with the use of nitrogen fertilizers, livestock effluents and crop residues. The remaining 15% is carbon dioxide from energy consumption fuel oil (gas, energy). In addition, specialization in the production process (livestock, on the one hand, and vegetable growing, on the other) has led to the dependence of agricultural holdings on synthetic fertilizers. Indeed, they no longer have minerals for enrichment of minerals for growing crops, and beneficial properties of soils

* Corresponding author: bamatov93@mail.ru

must be dealt with due to the critical level of organic matter in cultivated soils [1-3]. Such situations cause increased sensitivity to hazards (climatic, economic, etc.) and yield stagnation [4].

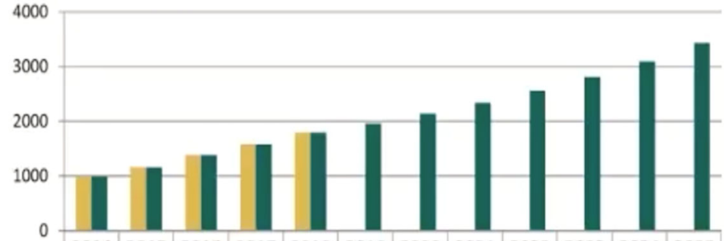
On the other hand, farms are increasingly consuming imported protein-rich feed to feed their animals. Imported soybeans account for 80% of the protein consumed in animal feed [5]. The agricultural sector must find solutions for its environmental impact and protection from the risks associated with the opening of markets.

We need to think about new production methods so that the producer not only has the goal of obtaining a high yield, but also protecting the environment by using more environmentally friendly agrochemicals. The solution proposed by agroecology exports [6-8] is to better exploit the complementarity of agricultural production. The complementarity of the breeding shop and the growing shop can use to close cycles (nitrogen, carbon). This complementarity may also contribute to more efficient feeding of natural resources and mobilization of biological regulators [9]. The interaction of applied cultures and applied applications is becoming a subject of study in various disciplines. Currently, there are several concepts for conceptualizing mixed farming systems at farm and area scales [10-12]. However, in spite of this application, which is well established for the systems in search of fundamentals, there are still few studies on the cooperation of farms in crop production and agriculture. These fees are related to the trade in goods (waste or crops) for an unorganized market and hence little mention of transaction methods and prices.

One of the critical problems in agriculture is non-production losses of macro – and micronutrients. It is known fact that only 60% of applying nitrogen fertilizers are used in purpose of agro-yield production. Among the reasons for the low absorption of nitrogen by plants are its gaseous losses as a result of nitrate denitrification, at the same time, under these conditions, nitrates are leached with nitrogen leaching by groundwater, a kind of eutrophication process is a deterioration in water quality from excessive intake of so-called biogenic reservoirs, primarily these compounds nitrogen and phosphorus. Also, immobilization processes are the absorption of nitrogen by microorganisms and weeds, which also causes to unproductive losses. According to this fact further increase of nitrogen fertility in agricultural is necessarily which increases the net (production) cost. The high dose application of nitrogen fertilities, which potentially increases the yields can cause the accumulation of nitrogen compounds in soil, water sources, yield and etc.

Global consumption of synthetic fertilizers and crop fertilizers has grown steadily over the past few decades. For example, global nitrogen-phosphorus-potassium (NPK) demand was projected to increase from 135.4 million tons (Mt) in 2000/2001 to 204 Mt in 2023/2024. With the introduction of modern innovative farming systems, manufacturers are increasingly resorting to the use of so-called long-acting fertilizers or controlled release fertilizers (CRF). According to Pitirimova [13], volumes of the world market of such fertilizers in the near future will reach 20 billion US dollars. Wherein the average annual growth is about 7%. High efficiency, ease of application and reduced costs of application to the soil allow the development and maintenance of the market for control release fertilizers at a high level. The problem of increasing soil fertility, increasing productivity and improving the quality of agricultural products is also solved by using CRF. The use of such fertilizers allows farmers to maintain the level of essential nutrients throughout the entire period of growth and development of the plant [14].

Controlled release fertilizers are such a type of fertilizers where nutrients are released from at a certain time, that can be set within a coat size that can be placed over core. In other words, release time can be set by managing the coat size over a core, the more in size coat, the more prolonged release effect of nutrients and the other was as well. The worldwide production of SRF is steadily increasing within every year (Figure 1) and it can be stated that the more production will be caused in near future and new forms of fertility in agro-sector is compulsory. Implementing stabilized fertilizers not only enhances crop productivity but also promotes soil health by fostering beneficial microbial activity and improving nutrient retention.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Produced	994,4	1162	1377	1568	1790	1954	2133					
Used	994,4	1162	1377	1568	1790	1954	2133	2333	2555	2806	3093	3429

Fig. 1. The worldwide production and usage of controlled release fertilization.

2 Methods

Estimating non-production losses of macronutrients from soil entails a comprehensive evaluation of various processes contributing to nutrient losses. These losses can have significant implications for soil fertility and nutrient availability for plants. Here is a detailed and scientifically oriented description of the methods employed to quantify non-production losses.

Leaching: Leaching involves the downward movement of water-soluble nutrients below the root zone due to percolating water. Accurate estimation of leaching losses involves collecting soil solution samples from different soil depths using methods like lysimeters or suction cups. These samples are subsequently analyzed for nutrient concentrations using appropriate laboratory techniques such as ion chromatography or spectrophotometry. By comparing nutrient concentrations at various depths, the extent of leaching losses can be determined.

Erosion: Soil erosion leads to the detachment and transport of topsoil, which contains a substantial portion of the soil's nutrient content. Quantifying nutrient losses resulting from erosion requires a comprehensive assessment of erosion rates. This can be achieved through the utilization of erosion models that consider factors such as slope, rainfall intensity, and land management practices. Additionally, sediment traps or erosion plots can be employed to measure sediment deposition and estimate nutrient losses. Analyzing nutrient concentrations in the eroded sediment can further provide insights into the magnitude of nutrient losses.

Volatilization: Volatilization refers to the loss of nutrients, particularly nitrogen, in the form of gaseous compounds to the atmosphere. Precise estimation of volatilization losses necessitates specialized equipment like flux chambers or collectors. These tools enable the measurement of gas emissions, which can be subsequently analyzed to determine nutrient content. Common techniques include gas chromatography or infrared gas analyzers. By quantifying the nutrient content in the emitted gases and considering factors such as air temperature, moisture, and soil properties, the magnitude of volatilization losses can be calculated.

Denitrification: Denitrification is a microbial process whereby nitrate (NO_3^-) is converted to nitrogen gas (N_2), resulting in nitrogen loss from the soil system. Estimating denitrification losses involves measuring nitrous oxide (N2O) emissions, which serve as an indicator of denitrification activity. This can be accomplished using gas collectors or automated monitoring systems. The collected gases are subsequently analyzed using gas chromatography or similar techniques to quantify N2O concentrations. By considering factors such as soil moisture, temperature, and organic matter content, the extent of denitrification losses can be determined.

Runoff: Runoff occurs when water, carrying dissolved and particulate nutrients, flows over the soil surface and eventually leaves the field. To estimate nutrient losses via runoff, water samples from runoff events can be collected and analyzed. The nutrient concentrations in the runoff water, along with the estimated volume of runoff, are used to calculate nutrient losses.

It is important to note that accurate estimation of non-production losses of macronutrients from soil necessitates a thorough understanding of the specific processes involved, access to specialized equipment, and consideration of site-specific factors. Referring to scientific literature, collaborating with soil and water management experts, or engaging with agricultural extension services can provide additional guidance tailored to specific locations and soil conditions.

3 Results and discussion

The results and discussion section of the study presented significant findings regarding the benefits of utilizing stabilized fertilizers. The key advantages of these fertilizers lie in their capacity to release nutrients gradually and align with the specific nutrient requirements of plants, resulting in optimized nutrient use efficiency. This controlled release mechanism plays a vital role in minimizing nutrient losses caused by leaching and volatilization processes, thus reducing environmental contamination and mitigating the overall climate impact.

Furthermore, the study revealed that the implementation of stabilized fertilizers positively influenced soil health by promoting the proliferation of beneficial microbial activity. This microbial activity contributed to enhanced nutrient retention within the soil, thereby ensuring a more sustainable nutrient cycling process. Additionally, the use of stabilized fertilizers resulted in a reduction in nutrient runoff into water bodies, which has significant implications for preserving water quality and safeguarding the integrity of surrounding ecosystems.

Importantly, the findings from this study demonstrated the consistent applicability and efficacy of stabilized fertilizers across a range of crops, soil types, and geographical regions. This universal effectiveness highlights the broad potential of stabilized fertilizers in advancing sustainable agriculture practices globally.

In summary, the study's results underscored the advantages of utilizing stabilized fertilizers in agricultural systems. These fertilizers provide a controlled release mechanism that optimizes nutrient utilization, reduces nutrient losses, improves soil health through enhanced microbial activity, and mitigates environmental contamination. Furthermore, their implementation has a positive impact on water quality by minimizing nutrient runoff. The consistent findings across different agricultural contexts emphasize the universal applicability and efficacy of stabilized fertilizers in promoting sustainable agriculture practices.

4 Conclusion

The study's conclusion reaffirmed the significance of utilizing stabilized fertilizers as a viable approach to mitigate climate impact and enhance agricultural sustainability. The findings emphasized the benefits of controlled release mechanisms in optimizing nutrient management, reducing environmental contamination, and promoting soil health. The study underscored the importance of global adoption of such innovative strategies to address climate change challenges and establish a more resilient and sustainable agricultural system. The future directions section highlighted the need for further research and development in the field of stabilized fertilizers. It suggested investigating novel formulations, delivery systems, and technologies that can improve nutrient release precision and adaptability to diverse agricultural systems. Additionally, the study recommended collaboration among researchers, policymakers, and agricultural stakeholders to promote knowledge exchange and facilitate widespread adoption of stabilized fertilizers as a climate-smart agricultural practice. In conclusion, the study's results demonstrated the effectiveness of utilizing stabilized fertilizers in minimizing climate impact and advancing sustainable agriculture. The findings provided valuable insights for researchers, policymakers, and agricultural practitioners to integrate these innovative approaches into nutrient management strategies and contribute to climate change mitigation efforts.

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