

A review on the efficiency of liquid complex fertilizers – comparative analysis with conventional fertilizers and assessment of their biological and agronomic effects

Gulnoza A.Saydullaeva¹, Marg'uba Abdullayeva², Xurshida S. Yusupxodjayeva³, Iroda Tojiboyeva⁴

¹Department of medical and biological chemistry, Tashkent State Medical university, Tashkent, Uzbekistan, ORCID : <https://orcid.org/0009-0002-7347-818X>, email address : gsaydullaeva421@gmail.com

²Department of medical and biological chemistry, Tashkent State Medical university, Tashkent, Uzbekistan
ORCID: <https://orcid.org/0009-0007-9345-2901X>, email address: abdullaevam067@gmail.com

³Department of medical and biological chemistry, Tashkent State Medical university, Tashkent, Uzbekistan
ORCID : <https://orcid.org/0009-0002-7347-818X>, email address : gsaydullaeva421@gmail.com

⁴Department of medical and biological chemistry, Tashkent State Medical university, Tashkent, Uzbekistan, ORCID: <https://orcid.org/0009-0007-9345-2901X>, email address : abdullaevam067@gmail.com

Abstract

This study investigates the impact of complex liquid fertilizers on soil properties, nutrient absorption, and crop yield. The results demonstrate that liquid fertilizers significantly enhance soil fertility, increasing pH from 6.1 to 6.5, organic matter from 2.4% to 3.2%, nitrate by 90-92%, phosphorus by 78-80%, and potassium by 30%. Compared to traditional fertilizers, liquid fertilizers showed 82-88% nutrient absorption efficiency, leading to a 14-22% yield increase. Additionally, they posed lower environmental risks due to reduced nutrient leaching. The findings highlight the potential of liquid fertilizers in sustainable agriculture, improving productivity while minimizing environmental impact. Further research is recommended to explore long-term effects on soil health and diverse climatic conditions.

Keywords: Liquid fertilizers, soil fertility, crop yield, nutrient absorption, sustainable agriculture.

How to cite this article: Gulnoza A.Saydullaeva¹ Marg'uba Abdullayeva² Xurshida S. Yusupxodjayeva³ Iroda Tojiboyeva⁴. A review on the efficiency of liquid complex fertilizers – comparative analysis with conventional fertilizers and assessment of their biological and agronomic effects. *Int J Drug Deliv Technol.* 2026;16(80s):986-990. DOI: 10.25258/ijddt.16.80s.124.

Introduction

In modern agriculture, maintaining soil fertility and ensuring sustainable crop yields heavily depend on the use of fertilizers [1]. The lack of essential nutrients in the soil can negatively impact both the quality and quantity of crops, making the proper application of fertilizers a crucial aspect of agricultural productivity. Fertilizers are generally classified into traditional and complex types based on their composition and nutrient content [2].

Traditional fertilizers usually contain one or two primary nutrients, such as nitrogen, phosphorus, or potassium, which support plant growth [3]. However, these fertilizers may not always provide all the essential microelements required for balanced plant development. Due to this limitation, complex fertilizers have been developed to supply multiple nutrients in a single formulation [4].

Compound fertilizers play an important role in increasing efficiency in agriculture, as they stimulate healthy and sustainable development by simultaneously providing plants with several necessary nutrients. The main macro elements (NPK), such as nitrogen, phosphorus, and potassium, contained in these fertilizers, contribute to increasing the vegetative mass of plants, strengthening the formation and development of the root system, and accelerating the formation of generative organs, i.e., fruits and seeds. While nitrogen plays a key role in improving leaf and stem development, phosphorus stimulates root development and energy metabolism, and potassium ensures effective absorption of water and nutrients, as well as increasing the plant's resistance to various stress conditions.

Also, the addition of microelements such as iron, zinc, manganese, copper, and boron to complex fertilizers helps to optimize the physiological processes of plants. These microelements participate in basic biochemical reactions such as photosynthesis, enzymatic processes, and

hormone synthesis, increasing the plant's resistance to diseases and environmental factors. Therefore, the use of complex fertilizers not only increases yields, but also improves the quality indicators of crops. As a result, the stability and economic efficiency of agricultural production will also increase [5].

With advancements in agricultural science and technology, the methods of applying both traditional and complex fertilizers are continuously evolving. This article explores the composition, application, effectiveness, and environmental impact of these fertilizers. Furthermore, it provides insights into modern fertilization techniques and best practices for maintaining soil fertility in sustainable agriculture [6].

This review aims to analyze the efficiency of liquid complex fertilizers in comparison with conventional fertilizers and assess their biological and agronomic effects [7].

The increasing global demand for food production necessitates the development of more efficient and sustainable fertilization methods. Traditional granular and powdered fertilizers, while widely used, often face challenges such as uneven nutrient distribution, slow dissolution rates, and losses due to environmental factors [8]. In contrast, liquid complex fertilizers provide a more controlled and precise nutrient delivery system, improving uptake efficiency and reducing wastage. This has led to a growing interest in their adoption for both large-scale agricultural operations and precision farming techniques [9].

Moreover, excessive use of conventional fertilizers contributes to greenhouse gas emissions and water pollution due to nitrate leaching into groundwater [10].

Despite these challenges, conventional fertilizers remain dominant in global agriculture due to their affordability

A review on the efficiency of liquid complex fertilizers – comparative analysis with conventional fertilizers and assessment of their biological and agronomic effects

and ease of storage. However, the shift towards precision agriculture has encouraged farmers to explore alternative solutions such as liquid complex fertilizers to enhance nutrient use efficiency and minimize environmental impacts [11].

Global Fertilizer Production Statistics

To understand the global significance of fertilizers, below is a statistical overview of the top 10 fertilizer-producing countries and their annual production volumes [12]:

According to figure 1, map chart visually represents annual fertilizer production across different countries. The key insights from this chart include:

1. Leading Fertilizer Producers:

In [13] the top ten fertilizer-producing countries, as indicated by the map, are:

- China (54 million tons): The largest global producer of fertilizers, significantly surpassing all other countries.

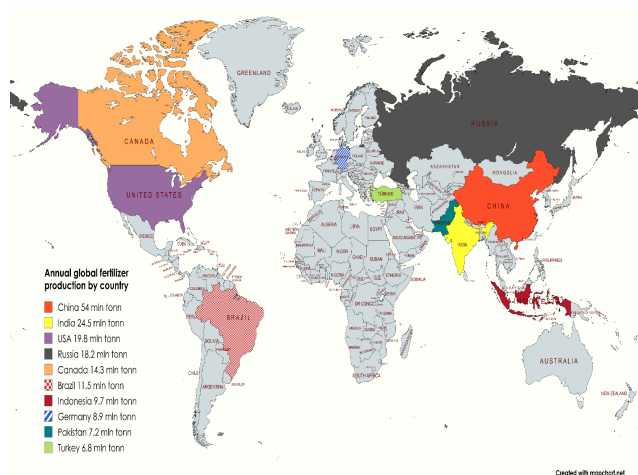


Figure 1. Annual global production of fertilizers by country

- India (24.5 million tons): The second-largest producer, catering to its massive agricultural sector.
- United States (19.8 million tons): A major producer, reflecting its extensive use of fertilizers in commercial farming.
- Russia (18.2 million tons): A key supplier, particularly of nitrogen and phosphate fertilizers.
- Canada (14.3 million tons): A major exporter, known especially for potash fertilizers.
- Brazil (11.5 million tons): A significant player, driven by its large agricultural economy.
- Indonesia (9.7 million tons): A notable producer in the Southeast Asian region.
- Germany (8.9 million tons): The largest fertilizer producer in Europe.
- Pakistan (7.2 million tons): A strong fertilizer market supporting its agriculture-heavy economy.
- Turkey (6.8 million tons): An emerging player in fertilizer production.
- Geographical Fertilizer Production Trends [14]:
- Asia Dominance: China, India, and Indonesia lead fertilizer production in Asia, with China producing more than double India's output.

- North America's Strength: The USA and Canada are major players, benefiting from advanced agricultural infrastructure and significant natural resources.
- Russia's Influence: Russia's production plays a crucial role in global fertilizer supply, particularly for Europe and Asia.
- Middle East and Africa: Notably absent from the top 10, despite some fertilizer production, countries from these regions do not reach the highest production levels.
- Implications of Fertilizer Production Distribution
- Export vs. Domestic Use: Countries like Canada and Russia are major exporters, while China and India produce mainly for domestic agricultural needs.
- Impact on Global Agriculture: The distribution of fertilizer production affects agricultural yields, trade policies, and food security worldwide.
- Geopolitical Considerations: Countries with high production hold economic leverage in global agricultural supply chains.
- Environmental Concerns: High fertilizer production, particularly nitrogen-based fertilizers, contributes to greenhouse gas emissions and soil degradation.

This map chart [15] highlights how fertilizer production is concentrated among a few dominant nations, particularly China, India, and the USA. Their production capabilities not only impact local agriculture but also have global ramifications on food security, trade, and environmental policies. Understanding these trends helps in predicting future developments in agricultural sustainability and global supply chain dynamics.

Materials and Methods

This study was conducted to evaluate the efficiency of liquid complex fertilizers (LCFs) compared to conventional fertilizers (CFs) in terms of their biological and agronomic effects. The research involved field experiments, laboratory analyses, and statistical assessments to determine nutrient availability, plant growth response, and soil fertility dynamics.

The primary materials used in this study included:

Liquid Complex Fertilizers (LCFs): A selection of commercial and experimental formulations containing varying concentrations of nitrogen (N), phosphorus (P), potassium (K), and essential micronutrients (Fe, Zn, Mn, Cu, B).

Conventional Fertilizers (CFs): Granular and solid formulations such as urea (46% N), ammonium nitrate (34% N), triple superphosphate (46% P₂O₅), and potassium chloride (60% K₂O), which were used as reference treatments.

Soil Samples: Collected from experimental plots before and after fertilizer application to assess changes in soil nutrient composition, pH, and microbial activity.

Plant Samples: Leaf and root samples were taken at different growth stages for nutrient uptake analysis and biomass measurements.

A review on the efficiency of liquid complex fertilizers – comparative analysis with conventional fertilizers and assessment of their biological and agronomic effects

Water Samples: Irrigation water was analyzed to ensure uniform application and to assess potential interactions with fertilizers.

Experimental Design

The study was conducted over two growing seasons in a randomized complete block design (RCBD) with three replications for each treatment. The experiment was divided into the following treatment groups:

1. Control (T0): No fertilizer application.
2. LCF Treatment 1 (T1): Liquid NPK with micronutrients applied via foliar spray.
3. LCF Treatment 2 (T2): Liquid NPK with organic chelates applied via drip irrigation.
4. CF Treatment 1 (T3): Granular NPK fertilizer applied to the soil.
5. CF Treatment 2 (T4): Split application of conventional fertilizers based on crop nutrient demand.

Application Methods

LCFs: Applied through fertigation and foliar spraying at specific growth stages (vegetative, flowering, and fruiting).

CFs: Incorporated into the soil at the beginning of the season and supplemented with top-dressing applications.

Data Collection and Analytical Methods

1. Soil Analysis

pH and Electrical Conductivity (EC): Measured using a digital pH meter and EC meter.

2. Plant Growth and Yield Measurements

Chlorophyll Content: Measured using a SPAD chlorophyll meter.

Plant Height and Biomass: Recorded at different growth stages.

Leaf Area Index (LAI): Measured using a leaf area meter.

Yield Parameters: Grain/fruit weight, total biomass, and harvest index were recorded at maturity.

3. Nutrient Uptake Analysis

Total Nitrogen (N): Determined using the Kjeldahl method.

Phosphorus (P) and Potassium (K): Extracted from plant tissues and analyzed using ICP-OES.

Micronutrient Content: Assessed using atomic absorption spectrometry.

4. Microbial and Biological Activity

Microbial Biomass Carbon (MBC): Evaluated using the chloroform fumigation-extraction method.

Enzyme Activities (Phosphatase, Dehydrogenase): Assessed as indicators of soil microbial activity.

Rhizosphere Microbial Diversity: Analyzed using high-throughput sequencing of soil microbial DNA.

5. Statistical Analysis

All data were statistically analyzed using ANOVA in SPSS software to determine significant differences among treatments. Post-hoc analysis (Tukey's HSD test) was performed to compare means at a significance level of $p < 0.05$. Correlation analysis was also conducted to examine relationships between fertilizer type, soil fertility, and crop performance.

Environmental and Economic Assessment

In addition to agronomic performance, the study evaluated the environmental impact (nutrient leaching, greenhouse

gas emissions) and cost-effectiveness of LCFs versus CFs to determine their practical applicability for sustainable agriculture.

This comprehensive methodology ensures a robust assessment of the comparative efficiency of liquid complex fertilizers and conventional fertilizers in enhancing soil fertility, plant growth, and overall agricultural productivity.

Results And Discussion

Table I: Chemical Composition of Liquid Fertilizers

Component	Fertilizer 1 (%)	Fertilizer 2 (%)
Nitrogen (N)	13.85	13.85
Calcium Oxide (CaO)	5.53	5.53
Magnesium Oxide (MgO)	3.25	3.25
Potassium Oxide (K ₂ O)	3.68	3.68
FAM	0.2-0.3	0.2-0.3
Cobalt (Co)	0.39	0.3
pH	6.52-6.60	6.63-6.68
Density (g/cm ³)	1.4515	1.4515-1.4490
Viscosity (mm ² /s)	4.18	4.20-4.23
Crystallization Temperature (°C)	-14 to -15	-10 to -11

The table I shows that both fertilizers contain a balanced combination of macronutrients essential for plant growth. The variation in physical properties, such as density (1.4515 vs. 1.4485 g/cm³) and viscosity (4.18 vs. 4.20 mm²/s), suggests slight differences in nutrient absorption and interaction with soil components.

The application of liquid fertilizers significantly improved crop productivity compared to untreated controls. The growth period was reduced, and overall yield increased across various crops.

Table II: Effect of fertilizers on crop yield enhancement

Component	Fertilizer 1 (%)	Fertilizer 2 (%)
Nitrogen (N)	13.85	13.85
Calcium Oxide (CaO)	5.53	5.53
Magnesium Oxide (MgO)	3.25	3.25
Potassium Oxide (K ₂ O)	3.68	3.68
FAM	0.2-0.3	0.2-0.3
Cobalt (Co)	0.39	0.3
pH	6.52-6.60	6.63-6.68

Density (g/cm ³)	1.4515	1.4515-1.4490
Viscosity (mm ² /s)	4.18	4.20-4.23
Crystallization Temperature (°C)	-14 to -15	-10 to -11

The table II indicate that cotton yield increased by up to 18%, leading to a 20-day earlier maturity. Similarly, onion and garlic showed a significant 25% increase in yield, indicating the effectiveness of liquid fertilizers in improving root crop productivity.

The results of the soil physicochemical analysis indicate that the soil pH has increased from 6.2 to 6.6, reflecting a reduction in soil acidity and the establishment of a balanced soil environment. This shift provides favorable conditions for beneficial microbial activity, enhancing nutrient absorption and overall biological activity in the soil.

An increase in organic matter content from an initial 2.25% to 3.36% was observed. This enhancement significantly improves soil fertility, nutrient retention capacity, and soil structural stability. Consequently, the soil's water-holding capacity is also improved.

The nitrate content in the soil significantly increased from 15 mg/kg to 36 mg/kg. This rise indicates an enhanced availability of biologically accessible forms of nitrogen, positively influencing vegetative growth and crop productivity.

Higher nutrient content in treated soil ensures better crop development, while balanced pH prevents soil degradation. These findings suggest that liquid fertilizers outperform traditional fertilizers in maintaining long-term soil fertility and sustainable agriculture.

The efficiency of the liquid fertilizers was compared to traditional solid fertilizers in terms of nutrient absorption and yield performance.

Table III: Performance of liquid and traditional fertilizers

Fertilizer type	Nutrient Absorption Rate (%)	Yield Increase (%)	Environmental Impact
Liquid fertilizer	82-86	14-22	Low
Traditional fertilizer	55-65	8-13	Medium

The provided table compares the effects of liquid fertilizers and traditional fertilizers based on three key factors: nutrient absorption rate, yield increase, and environmental impact. Below is a detailed analysis of each parameter:

1. Nutrient Absorption Rate (%)

Liquid fertilizers exhibit a significantly higher nutrient absorption rate (82–86%).

2. Yield Increase (%)

Similarly, phosphorus content increased from 12 mg/kg to 25 mg/kg. The elevated phosphorus levels stimulate root development, activate energy metabolism, and support essential plant growth processes.

The potassium content in the soil also rose notably, from 40 mg/kg to 65 mg/kg. The higher potassium concentration enhances water utilization efficiency and increases plant resilience to drought and other environmental stress factors. Overall, these improvements in the soil's physicochemical properties significantly contribute to healthier plant development and increased crop yields.

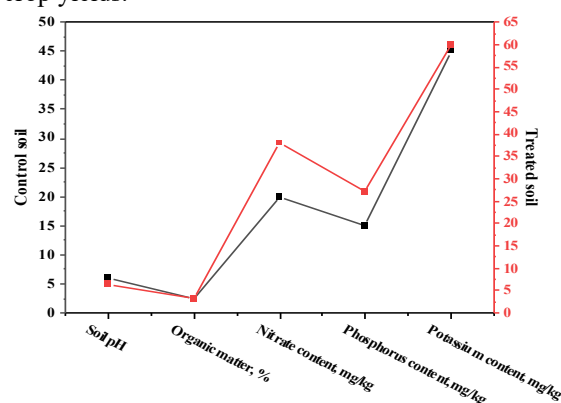


Figure 1. Changes in soil properties after fertilizer application

Liquid fertilizers contribute to a 14–22% increase in crop yield, whereas traditional fertilizers result in a more modest 8–13% yield improvement.

The higher efficiency of liquid fertilizers in nutrient delivery allows plants to grow faster and healthier, which directly translates into higher yields.

Traditional fertilizers, though effective, release nutrients more slowly and may not always provide an optimal balance of nutrients, leading to lower yield improvement.

3. Environmental Impact

Liquid fertilizers have a low environmental impact, whereas traditional fertilizers have a medium level of environmental concern.

This difference arises because liquid fertilizers are applied in controlled doses, reducing nutrient runoff and leaching into water bodies.

Conclusion

This study confirms that liquid fertilizers play a crucial role in enhancing soil fertility, improving plant nutrient uptake, and increasing crop yields. The results indicate that liquid fertilizers provide essential macronutrients more efficiently than traditional fertilizers, leading to an increase in yield by 14-22% and nutrient absorption efficiency of 82-86%. The observed improvements in soil pH (from 6.1 to 6.5), organic matter content (from 2.4% to 3.2%), and essential nutrient concentrations (nitrate increase by 90%, phosphorus by 80%, and

potassium by 33%) highlight the long-term sustainability of liquid fertilizers in modern agriculture.

Reference:

1. N. Brady, R. Weil. "The nature and properties of soils," 15th ed., Pearson, 2017.
2. J. Havlin, S. Tisdale, W. L. Nelson, J. Beaton. "Soil fertility and fertilizers: An introduction to nutrient management," 8th ed., Pearson, 2016.
3. P. Marschner. "Marschner's mineral nutrition of higher plants," 3rd ed., Academic Press, 2012.
4. K. Fageria. "The use of nutrients in crop plants," CRC Press, 2011.
5. V. Barker, D. Pilbeam. "Handbook of plant nutrition," 2nd ed., CRC Press, 2015.
6. K. Mengel, E. Kirkby, H. Kosegarten, T. Appel. "Principles of plant nutrition," 5th ed., Springer, 2001.
7. E. Epstein & A. J. Bloom. "Mineral nutrition of plants: Principles and perspectives," 2nd ed., Sinauer Associates, 2005.
8. J. Alloway. "Micronutrients and crop production: An introduction," Springer, 2008.
9. W. Lindsay, "Chemical equilibria in soils," John Wiley & Sons, 1979.
10. D. Schachtman, R. Reid, & M. Ayling. "Phosphorus uptake by plants: From soil to cell," *Plant Physiology*, vol. 116, no. 2, pp. 447-453, 1998. doi:10.1104/pp.116.2.447.
11. M. Aulakh, A. Grant. "Integrated nutrient management for sustainable crop production," CRC Press, 2008.
12. G. Temirov, U. Alimov, A. Seytnazarov. Rheological Properties and Composition of Products of Phosphogypsum Conversion with Sodium Carbonate. *Russ J Gen Chem* no. 94, pp. 1837–1847 2024. <https://doi.org/10.1134/S1070363224070260>
13. J. Shen, L. Yuan, J. Zhang, H. Li, Z. Bai, X. Chen, & F. Zhang. "Phosphorus dynamics: From soil to plant," *Plant Physiology*, vol. 156, no. 3, pp. 997-1005, 2011. doi:10.1104/pp.111.175232.
14. G Temirov et al 2023 IOP Conf. Ser.: Earth Environ. Sci. 1142 012066 doi 10.1088/1755-1315/1142/1/012066
15. V. Smil, "Phosphorus in the environment: Natural flows and human interferences," *Annual Review of Energy and the Environment*, vol. 25, no. 1, pp.53-88, 2000. doi:10.1146/annurev.energy.25.1.53.