



DOI: 10.22363/2312-797X-2025-20-4-606-617

EDN CDGCKT

UDC691.278:631.84

Research article / Научная статья

## Agrochemical assessment of the effect of vermiculite on reducing ammonium ion mobility

Irina P. Kremenetskaya<sup>1</sup> , Marina V. Slukovskaya<sup>1, 2, 3</sup>  ,  
Liubov A. Ivanova<sup>2, 4</sup> , Maria A. Yartseva<sup>4</sup> ,  
Tatiana K. Ivanova<sup>1, 2</sup> 

<sup>1</sup>I.V. Tananaev Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials — Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”,  
*Apatity, Russian Federation*

<sup>2</sup>Kola Science Centre of the Russian Academy of Sciences, *Apatity, Russian Federation*

<sup>3</sup>RUDN University, *Moscow, Russian Federation*

<sup>4</sup>N.A. Avrorin Polar-Alpine Botanical Garden and Institute, Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”, *Apatity, Russian Federation*

 [slukovskaya.mv@gmail.com](mailto:slukovskaya.mv@gmail.com)

**Abstract.** An agrochemical assessment of the effect of expanded vermiculite on reducing ammonium ions mobility was carried out using methods of phytotesting soil mixtures with determination of nitrogen forms. The studies were conducted using urea, which was added in granular or dissolved form in a wide range of nitrogen dose values, including those exceeding the maximum permissible concentration. We used two types of soil, which differ in the content of the organic component. It has been shown that expanded vermiculite effectively reduces the content of the exchangeable form of ammonium; fixed ammonium turns into the nitrate form more slowly compared to exchangeable ammonium.

**Keywords:** agrochemical research, nitrogen fertilizers, ammonium nitrogen, nitrate nitrogen, fixed ammonium, phytotesting

**Author contributions:** I.P. Kremenetskaya — research concept, text writing; M.V. Slukovskaya — research design; L.A. Ivanova — research design; M.A. Yartseva — collection and processing of materials; T.K. Ivanova — data analysis. All authors approved the final version of the manuscript.

---

Kremenetskaya I.P., Slukovskaya M.V., Ivanova L.A., Yartseva M.A., Ivanova T.K., 2025



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

**Funding.** The study was supported by the Russian Science Foundation (Project No. 24-77-10055). The acquisition of source materials for the study was carried out within the framework of the state assignment No. FMEZ-2025-0059 of the Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials of the Kola Science Center of the Russian Academy of Sciences.

**Conflict of Interest.** The authors declare no conflicts of interest.

**Article history:** received 7 May 2025; accepted 8 October 2025.

**For citation:** Kremenetskaya IP, Slukovskaya MV, Ivanova LA, Yartseva MA, Ivanova TK. Agrochemical assessment of the effect of vermiculite on reducing ammonium ion mobility. *Journal of Agronomy and Animal Industries*. 2025;20(4):606–617. doi: 10.22363/2312-797X-2025-20-4-606-617 EDN: CDGCKT

## Introduction

The intensive use of mineral nitrogen fertilizers in the current stage of agrotechnology development has led to several negative consequences, such as disruption of the natural biogeochemical nitrogen cycle, degradation of soil properties, and inhibition of their functioning processes [1, 2]. Eutrophication of water bodies due to excessive nitrate input, emission of nitrogen compounds from soil into the atmosphere, and nitrate contamination of plant products are consequences of a positive nitrogen balance in agroecosystems due to irrational fertilizer use [3]. To achieve maximum crop productivity, fertilizer doses are often applied that exceed economically justified rates, where yield increase covers fertilizer costs [4].

With the increase in the cost of chemical inputs due to rising energy prices throughout the 1990s, the active use of mineral fertilizers became less economically profitable. Furthermore, during this same period, it was established that active fertilizer use is associated with environmental risks. In developed countries, the focus shifted towards achieving sustainable yields while adhering to ecologically and economically optimal fertilizer doses, rather than on obtaining maximum yield [1].

Modern strategies for sustainable and environmentally safe agriculture are focused on optimizing soil nitrogen regime to increase plant production efficiency. One of the key approaches is the development of technologies for applying mineral and organic fertilizers that allow synchronizing the period of nitrogen availability with phases of its active uptake by plants. Additionally, biological methods for inhibiting nitrification are being developed, offering an alternative to chemical inhibitors.

Available nitrogen forms — ammonium and nitrate — are considered equivalent in theoretical approaches to plant nutrition [5]. However, studies show that ammonium is actively retained by the soil complex in soils with high cation exchange capacity, and only a small part enters the soil liquid phase. Ammonium that enters the liquid phase undergoes nitrification, because of which nitrates become the main nitrogen source for plants [5]. For example, it has been shown using oats that fertilizers such as NPK and organic ones significantly affect plant yield due to nitrate ( $\text{N-NO}_3$ ) reserves that accumulate in the 0–40 cm soil layer before emergence. A high correlation was found between nitrate content in soil and oat yield [5].

When analyzing soil nitrogen regime, it is important to consider not only the total content of nitrogen in various forms but also the duration of their existence in the soil, as well as the rate of their formation and consumption [1]. Soluble organic compounds have the shortest life cycles (from 1 to 10 hours) [6]. With a sufficient level of available carbon, the existence period for  $\text{NH}_4^+$  and  $\text{NO}_3^-$  is less than a day, and for microbial biomass up to 11 days. Under carbon deficiency, this period increases to three days for  $\text{NH}_4^+$ , to 25...136 days for  $\text{NO}_3^-$ , and to 360...425 days for microbial biomass.

Various biotic and abiotic processes influence nitrogen mobility in soil. Abiotic nitrogen mobilization occurs through desorption of exchangeable-adsorbed and release of fixed  $\text{N-NH}_4^+$  with increasing soil moisture and cation concentration, as well as under conditions promoting dispersion of clay particles and organo-mineral colloids. At the same time, adsorption of  $\text{N-NH}_4^+$ , amino acids, and amides by organic and mineral particles, fixation of  $\text{N-NH}_4^+$  by clay minerals, retention of nitrates in micropores, and conservation of simple organic nitrogen compounds in microaggregates contribute to nitrogen stabilization at the abiotic level [7].

**The aim of the research** is an agrochemical assessment of vermiculite application for optimizing plant nitrogen nutrition. It can be expected that the reduction of ammonium nitrogen mobility by vermiculite [8, 9] will contribute to inhibiting its nitrification process.

## Materials and Methods

Experimental studies were performed using granular urea and two types of soil. The first is a standard (reference) mixture for determining chronic toxicity with low organic matter content. The mixture is recommended to be composed of sand, clay, and peat in the ratio, wt.%: 70:20:10. The second soil is garden soil characterized by high organic matter content<sup>1</sup>. The properties of the initial soils are given in the description of the research results.

Thermo-vermiculite fraction 1–2 mm was obtained from the vermiculite concentrate of the Kovdor deposit by calcination in an electric modular-discharge furnace designed by Nizhegorodov at a temperature of 550 °C [10, 11]. The material has the following characteristics: bulk density 500 g/dm<sup>3</sup>, water-holding capacity 100 wt.%,  $\text{pH}(\text{H}_2\text{O})$  9.2,  $\text{pH}(\text{KCl})$  7.4, exchange capacity 80...150 meq/100 g.

In the first series of experiments (label MP), part of the sand was replaced with vermiculite in amounts of 5 and 10 wt.% of the total soil mixture mass (Table 1). Urea was introduced as granules, distributed in the upper part of the vegetation vessel at a depth of 10 cm. Soil mixtures in the amount of 2 kg were placed in a 5 L vegetation vessel, at the bottom of which a drainage layer of expanded clay was laid. The experimental conditions correspond to excess nitrogen content, the additional amount of which compared to the content in the initial soil was 450–1350 mg/kg with a maximum permissible concentration (MPC) of 300 mg/kg. A control experiment without vermiculite and without urea addition (MP10) was set up. All experiments were performed in three replicates.

<sup>1</sup> ISO 22030:2005. Soil quality. Biological methods. Chronic toxicity of higher plants.

Soil mixture composition in the experiment with low organic matter content

Name of experiments	Quantity of soil mixture components, wt.%				Urea dosage, g/kg
	Sand	Vermiculite	Clay	Peat	
MP10 control	70	0	20	10	0
MP1	70	0	20	10	1
MP2	70	0	20	10	2
MP3	70	0	20	10	3
MP4	65	5	20	10	1
MP5	65	5	20	10	2
MP6	65	5	20	10	3
MP7	60	10	20	10	1
MP8	60	10	20	10	2
MP9	60	10	20	10	3

Source: compiled by I.P. Kremenetskaya, M.V. Slukovskaya.

Soil mixtures were analyzed for acute and chronic toxicity using brown mustard (*Brassica juncea* (L.) Czern) and common oat (*Avena sativa* L.), respectively, with exposure durations of 7 and 30 days.

In the second series of experiments (label MO), common cucumber (*Cucumis sativus* L.) was used as the test culture, the seeds of which were pre-germinated. Before being introduced into the soil, vermiculite was enriched with mineral nitrogen by applying a urea solution with different concentrations (3, 6, and 9 g N/L) to achieve amounts of nitrogen added to the soil of 200, 400, and 600 mg N/kg. Then vermiculite was mixed with the soil. This method facilitates the process of uniform fertilizer distribution in the soil mixture volume. In control experiments (without vermiculite), the urea solution was applied to the soil and thoroughly mixed. The experiment was performed in three replicates (the experiment without vermiculite and with added nitrogen content of 200 mg N/kg — in nine replicates).

After the experiments, the content of water-soluble nitrates and exchangeable ammonium (1 mol/L KCl solution<sup>2</sup>) was determined in the soil mixtures at a material-to-water ratio of 1:5, in the salt extract at 1:2.5. The solution was separated from the material by centrifugation at a speed of 4000 rpm for 30 minutes. The determination method is visual-colorimetric and analogue<sup>3</sup>. Biochemical parameters of oat plants were determined using a CI-710s leaf spectrometer (SpectraVue).

## Results and Discussion

In the first MP series, the influence of vermiculite on the distribution of nitrogen by forms in a soil substrate with low (10 wt.%) organic matter content was investigated. The control soil mixture is characterized by extremely low content of mobile nitrogen

<sup>2</sup> GOST 26483–85. Soils. Preparation of Salt Extract and Determination of Its pH by the CINAO methods.

<sup>3</sup> GOST 26488–85. Soils. Determination of nitrates by the CINAO methods.

forms; nitrate nitrogen is absent, and  $N(NH_4^+)$  content is 2 mg N/kg (Table 2). In the experimental variants, the content of exchangeable  $NH_4^+$  increases with increasing urea dose, while the  $NO_3^-$  content changes in a narrow range from 35 to 40 mg N/kg (Table 2). The addition of vermiculite drastically, several times, reduces the content of exchangeable ammonium in the soil mixtures.

Table 2

Nitrogen content and toxicity indicators of soil mixtures

Name of experiments	Nitrogen content N, mg/kg			Germination <i>Brassica juncea</i> L.	Length ( <i>Avena sativa</i> L.), cm	
	applied with urea	$N(NH_4^+)$	$N(NO_3^-)$		plants	roots
MP10 control	0	2	0	100	28.5	7.6
MP1	450	10	35	50	33.9	4.9
MP2	900	20–60	35	2	32.7	4.2
MP3	1350	200	35	0	34.3	3.6
MP4	450	5	35	70	37.1	5.9
MP5	900	15	35	5	35.2	6.1
MP6	1350	50	35	2	26.2	4.0
MP7	450	3	35	100	35.9	6.6
MP8	900	5	40	20	34.5	6.5
MP9	1350	10	40	10	25.1	4.6

Source: compiled by I.A. Mosendz, T.K. Ivanova.

The acute toxicity of soil mixtures is greater the more exchangeable ammonium they contain. Synchronously with the decrease in exchangeable ammonium, the acute toxicity of soil mixtures decreases (Table 2, Fig. 1). This observation indicates the toxic effect of the exchangeable form of ammonium.

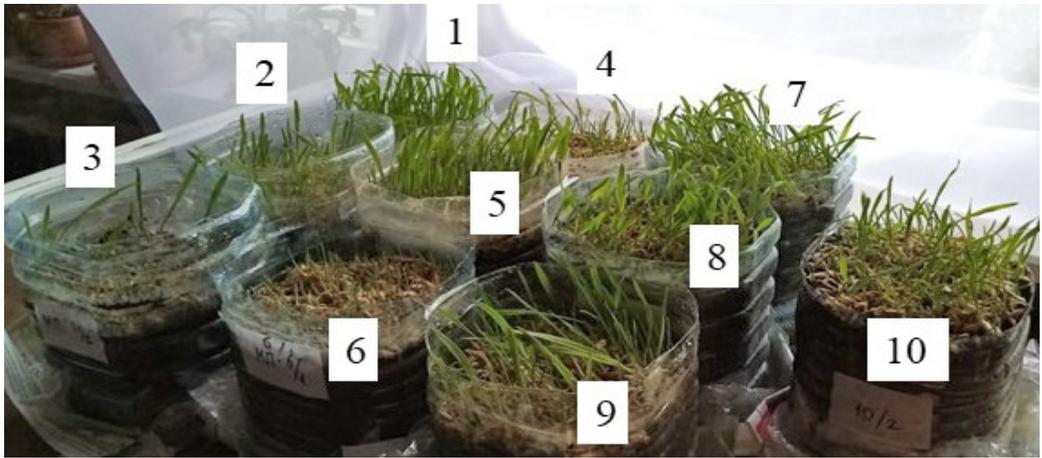


Fig. 1. Appearance of *Brassica juncea* L. seedlings: numerals indicate variant numbers

Source: compiled by I.A. Mosendz, T.K. Ivanova.

Oat (the test culture for determining chronic toxicity) is characterized by high plasticity, i. e., the ability to adapt to unfavorable conditions over a wide range of stress factor impact [12].

One of the early signs of the damaging effect of adverse factors on plants is the inhibition of growth processes, which was observed in the first few days of seed germination (Fig. 2).



**Fig. 2.** Appearance of *Avena sativa* L. seedlings: numerals indicate variant numbers

Source: compiled by I.A. Mosendz, T.K. Ivanova.

At the end of the 30-day experiment, the biometric indicators of the plants leveled off and did not differ statistically significantly between experimental variants (average values of plant and root length are shown in Table 2). One can only note the fact that in the control experiment, the root length is noticeably greater compared to the experimental variants. In the experimental variants, the roots were located mainly on the substrate surface, penetrating to an insignificant depth. This observation confirms the toxicity of the substrates, most pronounced, judging by root length, in the variants with the highest urea dose (MP 3, 6, 9).

No statistically significant differences in biochemical indicators of plants between experimental variants were found (Table 3). The SPAD index values (indicator of leaf chlorophyll concentration) in experiments MP 4–6 are somewhat higher compared to the control and other experimental variants. Plants in the same experiments have higher values of the SIPI indicator — the structural pigment intensity index, which correlates well with carbon assimilation efficiency and growth activity and is also closely related to the absorption of photosynthetically active radiation.

Carotenoids (CRI1) perform functions of light absorption by plants and indicate the presence of weakened plants (contain more carotenoids). This indicator does not change across experimental variants, confirming the high adaptability of the used test culture (common oat). The universal indicator of the presence of green healthy vegetation (CNDVI) — an indicator of the amount of photosynthetically active biomass,

the greener phytomass, the higher the index. For this index (as for SPAD), higher values are observed in experiments MP 4–6. Based on biochemical indicators, it can be assumed that a vermiculite content of 5 wt.% corresponds to the most favorable plant growth conditions.

Table 3

### Biochemical parameters of plants (*Cucumis sativus* L.)

Name of experiments	Biochemical parameters of plants							
	SPAD		SIPI		CRI1		CNDVI	
	AVG*	C.I.*	AVG	C.I.	AVG	C.I.	AVG	C.I.
MP10	14.6	7.9	0.65	0.12	0.036	0.019	0.26	0.15
MP1	15.2	2.9	0.60	0.06	0.030	0.008	0.25	0.05
MP2	16.8	7.2	0.63	0.08	0.034	0.012	0.27	0.11
MP3	22.2	9.2	0.63	0.05	0.032	0.009	0.28	0.06
MP4	25.2	10.9	0.65	0.03	0.034	0.007	0.27	0.05
MP5	23.0	4.4	0.69	0.03	0.043	0.009	0.33	0.03
MP6	22.7	6.6	0.99	0.01	0.047	0.014	0.34	0.05
MP7	16.9	2.5	0.64	0.02	0.037	0.007	0.27	0.04
MP8	25.6	33.5	0.67	0.12	0.039	0.007	0.32	0.13
MP9	19.9	8.6	0.69	0.16	0.043	0.051	0.27	0.09

Note. \* AVG – average value, C.I. – confidence interval.

Source: compiled by I.A. Mosendz, M.V. Slukovskaya.

In the second experimental series, the influence of vermiculite on the content of nitrogen forms at high organic matter content in the soil mixture was investigated (Table 4). In the experiment without vermiculite addition, excess mineral nitrogen has a toxic effect on the test culture (cucumber), the number of dead plants is 1–2 specimens in experiments with threefold replication. In variants with vermiculite at the same amounts of nitrogen added as part of urea, 100% plant survival is observed. In terms of the number of leaves, higher indicators were recorded in the series with the addition of 10% vermiculite, and in terms of the number of fruits — in the series with 5% vermiculite. The same series has more buds and flowers.

In variants with 5% vermiculite, there is a tendency for a decrease in the content of exchangeable nitrogen relative to the first and third series (without vermiculite and with 10% vermiculite), and the toxicity of soil mixtures also decreases. The content of nitrate nitrogen changes in a narrow interval of 45...55 mg N/kg; its concentration in this range does not have a negative effect on plant organisms. In terms of the total

content of mobile nitrogen forms, the difference between variants is most pronounced: in experiments with 5% vermiculite content, N is no more than 75 mg N/kg, while in the other two variants the value of this indicator is not less than 75 mg N/kg.

Table 4

#### Scheme and results of the experiment with high nitrogen content

Experiment	Content vermiculite, wt. %	Amount of added nitrogen, mg N/kg	N content, mg/kg			Plants survived / total	Quantity per plant			
			NH <sub>4</sub> <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>	Sum N		Leaves	Bud	Flowers	Fruit
PO 1	0	0	20	55	75	2/3	10	6	3	0.5
PO 2	0	200	20	55	75	3/9	9	6	3	1.3
PO 3	0	400	40	45	85	1/3	11	11	1	0
PO 4	0	600	30	50	80	2/3	7	0.5	1.5	0.5
PO 7	5	0	20	55	75	3/3	10	5	3	1.3
PO 8	5	200	10	55	65	3/3	11	4	3.3	1
PO 9	5	400	15	45	60	3/3	11.3	5.6	2.3	2.3
PO 10	5	600	30	45	75	3/3	11	7	2	1.6
PO 11	10	0	40	45	85	3/3	8.6	2.6	1.6	0
PO 12	10	200	30	45	75	3/3	8.6	3.3	1.3	0
PO 13	10	400	30	45	75	3/3	13.3	7.3	3.3	1.3

Source: compiled by M.A. Yartseva, L.A. Ivanova.

Urea (NH<sub>2</sub>)<sub>2</sub>CO is the most concentrated nitrogen fertilizer. In an aqueous environment, urea hydrolysis occurs with the formation of ammonium, which in the next stage is oxidized to the nitrate ion. Both nitrogen forms (ammonium and nitrate) can be used by plants as nutrition sources. Vermiculite can influence the rate of the ammonium nitrification process due to its ion-exchange properties.

The performed experiments with a high dose of urea application showed that vermiculite reduces the content of exchangeable ammonium in soil mixtures. As the results of the experiment with the standard soil mixture showed, the decrease in exchangeable nitrogen content is the result of an increase in the proportion of fixed (non-exchangeable) nitrogen, and not a consequence of nitrogen removal with biomass, since the biometric indicators of plants differed insignificantly between experimental variants.

According to [13], nitrogen fixation occurs when a threshold concentration of ammonium in the solution is reached, above which part of the ammonium ions is fixed in the mineral lattice. In the series with 5% vermiculite content at the same ammonium

concentration in the solution, the probability of reaching such a threshold increase compared to variants with 10% vermiculite.

Soil nitrogen availability is determined mainly by the content of nitrate nitrogen in an available form [14]. The narrow range of change in mobile  $\text{NO}_3^-$  content in soil, both in the first series of experiments with low organic matter content (35...40 mg N/kg) and in the second series with high organic matter content (45...55 mg N/kg), indicates that ammonium fixed by vermiculite has the ability to gradually oxidize with the formation of nitrates, which enter the soil solution and serve as a source of plant nutrition. In terms of nitrogen availability, soil mixtures with vermiculite belong to the medium level (30...50 mg N/kg [15]). Fixed ammonium is released into the soil solution more slowly compared to the exchangeable form, promoting synchronization of plant nitrogen consumption processes with the availability of nutrients in the soil.

## Conclusion

The positive effect of adding vermiculite to soil mixtures was revealed in experiments that differed in nitrogen concentration, method of fertilizer application, and organic matter content in the initial soil. It is shown that high content of exchangeable ammonium nitrogen has a toxic effect on plants. The nitrate nitrogen content in all experiments changed within a narrow range of values, not affecting soil toxicity. The most favorable soil conditions are created when vermiculite is applied in an amount of 5 wt.% due to an increase in the proportion of fixed ammonium, which converts to nitrate form more slowly compared to exchangeable ammonium.

## References

1. Semenov VM. Modern problems and prospects of nitrogen agrochemistry. *Agrochemistry and Ecology Problems*. 2008;(1):55–63. (In Russ.). EDN: JXDATP
2. Bashkin VN. Ecological risks of using nitrogen fertilizers. *Problems of Risk Analysis*. 2022;19(2):40–53. (In Russ.). doi: 10.32686/1812-5220-2022-19-2-40-53 EDN: JNDAFM
3. Buzetty KD, Ivanov MV. The impact of mineral and organic fertilizers on the ecosystem, the quality of agricultural products and human health. *Agricultural Science*. 2020;(5):80–84. (In Russ.). doi:10.32634/0869-8155-2020-338-5-80-84 EDN: DQLGFZ
4. Sharma LK, Bali SK. A review of methods to improve nitrogen use efficiency in agriculture. *Sustainability*. 2018;10(1):51. doi: 10.3390/su10010051
5. Okorkov VV, Okorkova LA, Shchukina VI. Formation of the oat crop depending on the nitrogen nutrition regime of plants on grey forest soils of the Vladimir opolye. *Agrochemistry and Ecology Problems*. 2023;(3):4–16. (In Russ.). doi: 10.26178/AE.2023.76.40.002 EDN: AYRCYI
6. van Hees PAW, Jones DL, Finlay R, Godbold DL, Lundström US. The carbon we do not see — the impact of low molecular weight compounds on carbon dynamics and respiration in forest soils: a review. *Soil Biology and Biochemistry*. 2005;37(1):1–13. doi: 10.1016/j.soilbio.2004.06.010
7. Liao JD, Boutton TW, Jastrow JD. Storage and dynamics of carbon and nitrogen in soil physical fractions following woody plant invasion of grassland. *Soil Biology and Biochemistry*. 2006;38(11):3184–3196. doi: 10.1016/j.soilbio.2006.04.003

8. Mazloomi F, Jalali M. Effects of vermiculite, nanoclay and zeolite on ammonium transport through saturated sandy loam soil: column experiments and modeling approaches. *Catena*. 2019;176:170–180. doi: 10.1016/j.catena.2019.01.014 EDN: XZOOPI
9. Ivanova TK, Mosendz IA, Kremenetskaya IP, Slukovskaya MV, Maksimova VV, Krasavtseva EA. Preparation of nitrogen fertilizers based on serpentine minerals. *Trudy Fersmanovskoi nauchnoi sessii GI KSC RAN*. 2023;20:563–569. (In Russ.). doi: 10.31241/FNS.2023.20.070 EDN: BNAUGR
10. Nizhegorodov AI. Electrical oven with unittypе releasing with energy recovery system for heating vermiculite concentrates. *Novye ognepuropy (New Refractories)*. 2015;(10):22–27. (In Russ.). doi: 10.17073/1683-4518-2015-10-22-27
11. Zvezdin AV, Nizhegorodov AI. Assessing energy efficiency of electric furnace suspended heating system for bulk material heat treatment. *Proceedings of Irkutsk State Technical University*. 2019;23(1):41–53. (In Russ.). doi: 10.21285/1814-3520-2019-1-41-53 EDN: VVBEDE
12. Soldatova VYu, Shadrina EG, Karpova SD. Bioassay of phytotoxicity of soils in Yakutsk using oat (*Avena sativa* L.) as test-object. *Arctic and Subarctic Natural Resources*. 2018;24(2):76–86. (In Russ.). doi: 10.31242/2618-9712-2018-24-2-76-86 EDN: PREG EK
13. Tyrina NS. Investigation of the mechanism and parameters of ammonium sorption on Jurassic clayey rocks of the Moscow region. *Geoekologiya. Inzheneraya Geologiya, Gidrogeologiya, Geokriologiya*. 2009;(2):136–142. (In Russ.). EDN: JWNQBN
14. Gamzikov GP. The forecast of the soils and nitrogen requirements of field crops in the nitrogen fertilizer. *Innovations and Food Safety*. 2015;3(9):11–20. (In Russ.). EDN: VVCCXF
15. Gamzikov GP. Principles of soil diagnostics of field crops' nitrogen nutrition and nitrogen fertilizer application. In: *Sovershenstvovanie metodov pochvenno-rastitel'noi diagno-stiki azotnogo pitaniya rastenii i tekhnologii primeneniya udobrenii na ikh osnove [Improving Methods of Soil-Plant Diagnostics of Plant Nitrogen Nutrition and Fertilizer Application Technologies Based on Them]*. VNIPTIKHIM; 2000:33–55. (In Russ.).

#### About authors:

*Kremenetskaya Irina Petrovna* — Senior Researcher, I.V. Tananaev Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials, Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”, 26a Akademgorodok st., Apatity, Murmansk region, 184209, Russian Federation; e-mail: i.kremenetskaia@ksc.ru

ORCID: 0000-0003-3531-8273 SPIN-code: 7227-0180

*Slukovskaya Marina Vyacheslavovna* — Senior Researcher, Laboratory of Nature-Inspired Technologies and Environmental Safety of the Arctic region, Kola Science Centre of the Russian Academy of Sciences, Russian Federation, 14 Fersmana st., Apatity, Murmansk region, 184209, Russian Federation; I.V. Tananaev Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials, Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”, 26a Akademgorodok st., Apatity, Murmansk region, 184209, Russian Federation; e-mail: m.slukovskaya@ksc.ru

ORCID: 0000-0002-5406-5569 SPIN-code: 8540-8055

*Ivanova Liubov Andreevna* — Chief Researcher, Laboratory of decorative floriculture and landscaping, Polar-Alpine Botanical Garden-Institute named after N.A. Avrorin of the Federal Research Center “Kola Scientific Center of the Russian Academy of Sciences, 18a Akademgorodok microdistrict, Apatity, Murmansk Region, 184209, Russian Federation; Leading Researcher, Institute for Problems of Industrial Ecology of the North of the Federal Research Center “Kola Scientific Center of the Russian Academy of Sciences”, 18a Akademgorodok microdistrict, Apatity, Murmansk Region, 184209, Russian Federation; e-mail: ivanova\_la@inbox.ru

ORCID: 0000-0002-7994-5431 SPIN-code: 5752-3648

*Yartseva Maria Aleksandrovna* — leading engineer, Laboratory of introduction and acclimatization of plants, graduate student, Polar Alpine Botanical Garden-Institute — Subdivision of the Federal Research Centre, Kola Science Centre of Russian Academy of Sciences, 18a Akademgorodok microdistrict, Apatity, Murmansk Region, 184209, Russian Federation; e-mail: 468975@mail.ru

ORCID: 0000-0001-7560-6339 SPIN-code: 9820-0196

*Ivanova Tatyana Konstantinovna* — Junior Researcher, Laboratory of Nature-Inspired Technologies and Environmental Safety of the Arctic region, Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”, Russian Federation, 14 Fersmana st., Apatity, Murmansk region, 184209, Russian Federation; I.V. Tananaev Institute of Chemistry and Technology of Rare Elements and Mineral Raw Materials, Federal Research Centre “Kola Science Centre of the Russian Academy of Sciences”, 26a Akademgorodok st., Apatity, Murmansk region, 184209, Russian Federation; e-mail: tk.ivanova@ksc.ru

ORCID: 0000-0002-8103-2279 SPIN-code: 8752-2850

## Агрохимическая оценка влияния вермикулита на снижение подвижности ионов аммония

И.П. Кременецкая<sup>1</sup> , М.В. Слуковская<sup>1, 2, 3</sup>  ,  
Л.А. Иванова<sup>2, 4</sup> , М.А. Ярцева<sup>4</sup> , Т.К. Иванова<sup>1, 2</sup> 

<sup>1</sup>Институт химии и технологии редких элементов и минерального сырья им. И.В. Тананаева — обособленное подразделение федерального государственного бюджетного учреждения науки ФИЦ Кольский научный центр РАН, г. Апатиты, Российская Федерация

<sup>2</sup>ФИЦ Кольский научный центр РАН, г. Апатиты, Российская Федерация

<sup>3</sup>Российский университет дружбы народов, г. Москва, Российская Федерация

<sup>4</sup>Полярно-альпийский ботанический сад-институт КНЦ РАН, г. Апатиты, Российская Федерация

 slukovskaya.mv@gmail.com

**Аннотация.** Методами фитотестирования почвосмесей с определением форм азота выполнена агрохимическая оценка влияния вспученного вермикулита на снижение подвижности ионов аммония. В исследовании применена мочевины, которую вносили в гранулированном или растворенном виде в широком диапазоне величины дозы азота, в т. ч. с превышением предельно допустимой концентрации. Использовали два вида грунта, отличающихся по содержанию органического компонента. Показано, что вермикулит эффективно снижает содержание обменной формы аммония, фиксированный аммоний превращается в нитратную форму медленнее по сравнению с обменным аммонием.

**Ключевые слова:** агрохимические исследования, азотные удобрения, аммонийный азот, нитратный азот, фиксированный аммоний, фитотестирование

**Вклад авторов:** Кременецкая И.П. — концепция исследования, написание текста; Слуковская М.В. — дизайн исследования; Иванова Л.А. — дизайн исследования; Ярцева М.А. — сбор и обработка материалов; Иванова Т.К. — анализ данных. Все авторы одобрили окончательную версию рукописи.

**Финансирование.** Исследование выполнено при поддержке Российского научного фонда (проект № 24-77-10055). Получение исходных материалов для проведения исследования выполнено в рамках государственного задания № FMEZ-2025-0059 Института химии и технологии редких элементов и минерального сырья КНЦ РАН.

**Конфликт интересов.** Авторы заявляют об отсутствии конфликта интересов.

**История статьи:** поступила в редакцию 7 мая 2025 г., принята к публикации 8 октября 2025 г.

**Для цитирования:** *Кременецкая И.П., Слуковская М.В., Иванова Л.А., Ярцева М.А., Иванова Т.К.* Агрохимическая оценка влияния вермикулита на снижение подвижности ионов аммония // Вестник Российского университета дружбы народов. Серия: Агрономия и животноводство. 2025. Т. 20. № 4. С. 606–617. doi: 10.22363/2312-797X-2025-20-4-606-617 EDN: CDGCKT