Optimization methods of phosphorus regime of disturbed lands in the Far North

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Abstract. The results of the studies of the optimization methods of phosphorus regime of disturbed lands in the Far North are presented. In technogenic disturbed soils, the total phosphorus content is very low—0.071-0.087% (reclaimed soils in the area of Bovanenkovo) and 0.03-0.06% (sand in the area of Salekhard). Down the profile its content increases to 0.3-0.5% in accordance with the gross reserves varies and the content of available forms of phosphorus. By the end of the growing season, there is a tendency to reduce the content of mobile phosphorus, especially where high rates of fertilizers were introduced. To preserve the fertility of recultivated soils at a minimum level, it is necessary to periodically apply mineral fertilizers in the form of dressings. The main reserves of phosphorus are consumed by perennial grasses for two years. In subsequent years, the content of available phosphorus is reduced from 1.5 to 2.0 times. A crucial role in providing perennial grasses available phosphorus are mineral fertilizers and peat beauty. Phosphorus intake into plants was particularly intense in the early stages of development (germination–earing (tasseling)), reaching a maximum in the interphase period earing (tasseling) – flowering, and decreased during flowering – the beginning of maturation. Increasing the dose of phosphorus fertilizers by 60 kg, the active substance stimulated its consumption in the phase of earing (tasseling) – flowering.

1. Introduction
"The key of life" is called phosphorus, as it is directly involved in most life processes. The second element of nutrition, after nitrogen, is generally considered to be phosphorus, which is absorbed by plants in smaller quantities, but its role is no less important. Optimal phosphorus nutrition contributes to the development of the plants root system, improves metabolic processes occurring in each cell. Its deficiency, regardless of the vegetation time, negatively affects flowering and seed formation. Phosphorus is especially important at the beginning of the growing season, so every specialist knows about the effectiveness of applying phosphorus fertilizers with seeds. This improves the supply of plant nutrients and moisture, which is especially important for arid conditions characteristic of the Far North.

In combination with potassium, phosphorus increases winter hardness of plants, accelerates their development and maturation. It is vital for the conditions of the Far North [10]. According to numerous research results, optimal phosphorus nutrition accelerates the ripening of grain crops for 5-6 days. This is especially important for areas where they do not mature before low temperatures.

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The growth and development of perennial grasses are determined not only by the presence of phosphorus in the soil, but also by its forms in which this element is located. In addition, in the Far North, phosphorus reduces the negative effect of low temperatures on plants. Therefore, the relevance of studying the phosphorus regime in soils subject to biological remediation is not in doubt.

2. Material and methods
Field experiments to study the nutrient regime of technogenic disturbed soils were conducted on the territory of the Yamal-Nenets Autonomous district of the bovanenkovsky oil and gas condensate field and at the bottom of a 25-year-old sand pit located 15 km from Salekhard [1].

Under perennial grasses (red fescue-40%; boneless rump-35%; meadow fescue-10%; meadow Timothy-5%; Wheatgrass - 5%; meadow bluegrass-3%; becmania vulgaris-2%), azophoska containing 16% nitrogen, phosphorus and potassium (GOST R 51520) was introduced in peat biomate: dry matter-12.2%; nutrient content (NPK) was 120, 140 and 180 mg/kg of soil, respectively. To maintain the optimal acid-base characteristics, calcium was added, the content of which did not exceed 0.35% by weight of the biomate.

The main indicators of the composition and properties of soils were studied by conventional methods. Phosphorus was studied by the molybdenum method of salt extract.

Statistical processing of the research results was carried out according to B. A. Dospekhov using Microsoft Excel.

3. Result
The source of phosphorus for plants are mineral compounds of soil and fertilizers. In The far North, low soil temperature causes a slow flow of phosphorus to plants. At a soil temperature of 5°C, phosphorus is practically not consumed by plants, and only as the temperature increases to 5-20°C, plants are able to absorb it intensively [8,9]. The mechanism of phosphorus absorption at low positive temperatures is described in detail in textbooks of Agrochemistry and plant biochemistry. It should be noted that poor absorption of phosphorus at low temperatures is common to all plants without exception.

As our studies have shown, the initial gross phosphorus content in the reclaimed soils of the Bovanenkovo gas condensate field is very low -0.071-0.087% of absolutely dry soil. This is due to the lack of plant community, which is a biogenic accumulator of organic matter and ash elements in the upper layer of the soil. The sandy rocks on which remediation was carried out initially do not contain phosphorus, as evidenced by the absence of changes in gross reserves deep into the soil profile [3].

The efficiency of phosphate fertilizers is in the inverse direct correlation from soil phosphorus reserves. For nine years of research, in the variant without fertilization, the content of mobile phosphorus in the 0-30 cm layer was 14.1 mg/kg of soil. In all terms of determination its minimum quantity is established in a layer of 0-10 cm (11.1-13.3 mg/kg). The reason for this is the constant leaching of water-soluble phosphates deep into the reclaimed soil or flushing during snowmelt.

This is also due to the consumption of phosphorus by perennial grasses during the growing season. At a depth of 10-20 and 20-30 cm, its content was almost the same, which is explained by the fixation of phosphorus due to the chemical absorption capacity, in which calcium or iron triphosphates are formed.

The application of mineral fertilizers provided an increase in the phosphorus content available for plants, compared with the control by 14.3% (NPK)90, 28.5% (NPK)150, 35.7% (NPK)210. There is a close relationship between the content of mobile phosphorus and doses of mineral fertilizers, expressed by correlation coefficients (r) from 0.95 to 0.99, which corresponds to a very strong positive relationship.

By the end of the growing season of perennial grasses of the eighth year of life, there is a tendency to reduce the content of mobile phosphorus in all variants of the experiment, especially where high doses of fertilizers were introduced. This fact indicates that to stabilize the phosphorus regime of reclaimed soils, it is necessary to provide for periodic application of mineral fertilizers at intervals of 5-8 years [4,5].
The influence of perennial grasses on the content of mobile phosphorus in reclaimed soils can be traced by the results of its determination in the experiment to study their seeding rates.

Before sowing the recultivated grass mixture, mineral fertilizers in the dose (NPK)150 were introduced in all variants of the experiment. On average, for nine years, the content of mobile phosphorus in the 0-30cm layer at the rate of grass seeding 40 kg / ha was 10.1 mg, 120 kg / ha-15.3 mg, 280 kg / ha-14.7 mg / kg of soil. Increasing the seeding rate of grasses from 40 to 120 kg / ha increased the consumption of mobile phosphorus by 21.1%, up to 280 kg / ha-by 26.3%. The maximum differences, respectively 28.6% and 35.7%, were established in relatively favorable years of research, which were characterized by the highest possible air temperature and precipitation during the growing season.

In the coldest years of research, there was a minimum consumption of phosphorus, which proves the important role of the temperature regime in the consumption of batteries [7]. For this reason, the accumulation of mobile forms of phosphorus in the permafrost zone is worse, since the unabsorbed part of it during the growing season becomes insoluble, inaccessible to plants forms [10].

Between the content of mobile phosphates in the soil and the seeding rates of perennial grasses, a close feedback is established, expressed by correlation coefficients for the timing of determination from r = -0.84 to r = -0.98.

Gross reserves of soil phosphorus at the facility in Salekhard to a depth of 120 cm do not exceed 0.03-0.06%. Deeper-its content increases to 0.3-0.5%, due to the migration of phosphates in sandy soil varieties. Simultaneously with the gross reserves, the content of phosphorus forms available for plants also changes. The content of mobile phosphates in the 0-30 cm layer before laying the experiment was 5.1 mg / kg of soil. The phosphorus content in the 0-10cm layer was 2.5-3.0 times higher than at depths of 10-20 and 20-30 cm. This is due to its biogenic accumulation [2]. In all subsequent periods of determination of available phosphorus on control plots this feature remained. During the growing season and over the years, the amount of phosphorus in the root layer without fertilization changed insignificantly.

The application of mineral fertilizers increased the content of available phosphorus in the 0-30 cm layer on average for nine years compared to the control from 13.2 to 17.8 mg/kg of soil – the deviation was 30.8% from the initial values. On layers it looks as follows: 0-10 cm, respectively 13.2 and 21.5 mg (61.5%), 10-20 cm – 13.3 and 17.8 mg (30.8%), 20-30 cm – 13.2 and 17.7 mg/kg of soil (30.8%).

The main reserves of phosphorus are consumed by perennial grasses, for two years after fertilization. In subsequent years, the content of available phosphorus in the 0-10 cm layer is reduced by 1.5-2.0 times. At greater depths, its number remains constant. According to A. I. Korovin (1972), ammonium nutrition contributes to the better absorption of phosphorus and its movement to the aboveground organs of perennial grasses. The advantage of ammonia nutrition of perennial grasses at low temperatures has been previously reported [11].

The use of peat biomates in combination with mineral fertilizers increased the content of mobile phosphorus in the 0-30 cm layer from 13.22 to 21.7 mg/kg of soil – an increase of 66.9% from the initial values. Compared with the application of mineral fertilizers in its pure form, its content increased from 17.3 to 21.7 mg / kg of soil (27.6%). This is due to the content of phosphorus in peat, where its amount was 140 mg/kg of soil. For this reason, at all times of determination, the largest amount of phosphorus is found in the 0-10 cm layer, it is at this depth that the biomat is located.

The maximum reserves of available phosphorus in this variant were established during the growing season of 2009. It was characterized by relatively favorable hydrothermal conditions. It is known that the more favorable hydrothermal conditions for decomposition of organic substances, the more phosphorus available for plants is mobilized. This to some extent applies to phosphorus, which is part of the mineral part of the soil. There is a close relationship between the content of mobile phosphates in the 0-30 cm soil layer and mineral fertilizers, peat biomates, expressed by correlation coefficients from r = 0.58 to r = 0.97. Consequently, mineral fertilizers and peat biomates play a crucial role in providing perennial grasses with available phosphorus in The far North.
In field experiments the requirements of perennial grasses to phosphorus nutrition in different phases of growth and development were studied. This made it possible to determine the need of perennial grasses in nutrients at the main stages of its development. In the far North, phosphorus is especially important for plants. Our research has shown that it is most heavily consumed in the phase of tillering and earing. Its content in plants was 0.46-0.76\% (table 1).

### Table 1. Dynamics of total phosphorus content in different phenological phases of plant development, \% of dry matter.

| Variant          | Phase of development                  | %    |
|------------------|--------------------------------------|------|
| control (without fertilizers) | germination – earing (tasseling)      | 0.76 |
|                  | earing (tasseling) – flowering        | 0.47 |
|                  | flowering- beginning of maturation    | 0.46 |
| (NPK)\(_{90}\)   | germination – earing (tasseling)      | 0.77 |
|                  | earing (tasseling) – flowering        | 0.45 |
|                  | flowering- beginning of maturation    | 0.45 |
| (NPK)\(_{150}\)  | germination – earing (tasseling)      | 0.74 |
|                  | earing (tasseling) – flowering        | 0.56 |
|                  | flowering- beginning of maturation    | 0.52 |
| (NPK)\(_{210}\)  | germination – earing (tasseling)      | 0.76 |
|                  | earing (tasseling) – flowering        | 0.52 |
|                  | flowering- beginning of maturation    | 0.52 |

As the plants grew and developed, it decreased, reaching a relative minimum in the early ripening phase. An increase in the dose of phosphorus introduced had a positive effect on its consumption by perennial grasses [6].

A marked decrease in phosphorus was observed before the flowering phase. By the time of maturation, its consumption was not significantly reduced. The highest phosphorus uptake was in the sweep phase-0.67-0.79\% of dry matter.

Considering the absorption of phosphorus from the soil and fertilizers, it should be noted that consumption increased from the early stage of development (germination – earing (tasseling)) reaching a maximum in the interphase period (earing (tasseling) – flowering, and decreased during flowering-the beginning of maturation. Increasing the dose of phosphorus fertilizers by 60 kg of the active substance stimulated its consumption in the phase of earing (tasseling) – flowering.

### Table 2. Nutrient removal and utilization rates OF P2O5 by perennial grasses from mineral fertilizers.

| Variant          | Removal from 1 ton of dry weight, kg | The utilization ratio of fertilizers, % |
|------------------|--------------------------------------|----------------------------------------|
| control (Without fertilizers) | 2.1                                  | 1.1                                    |
| (NPK)\(_{90}\)   | 2.4                                  | 10.2                                   |
| (NPK)\(_{150}\)  | 2.9                                  | 8.8                                    |
| (NPK)\(_{210}\)  | 3.0                                  | 6.6                                    |

Considering the use of nutrients from fertilizers by perennial grasses, it should be noted that the coefficient of use of phosphorus fertilizers by perennial grasses was at the level of 6.6-10.2\%. An increase in the dose
of mineral fertilizers above (NPK)150 led to a decrease in the utilization rate of phosphorus fertilizers by 1.5-2.2% (table 2). Thus, when applying mineral fertilizers, phosphorus removal from 1 ton of dry mass of perennial grasses increased and the coefficient of its use decreased.

4. Conclusions
- In technogenic disturbed soils the total phosphorus content is very low—0.071-0.087% (reclaimed soils in the area of Bovanenkovo) and 0.03-0.06% (sand in the area of Salekhard). Down the profile its content increases to 0.3-0.5%. In accordance with the gross reserves varies and the content of available forms of phosphorus.
- By the end of the growing season, there is a tendency to reduce the content of mobile phosphorus, especially where high rates of fertilizers were introduced. To preserve the fertility of recultivated soils at a minimum level, it is necessary to periodically apply mineral fertilizers in the form of dressings.
- The main reserves of phosphorus are consumed by perennial grasses for two years. In subsequent years, the content of available phosphorus is reduced from 1.5 to 2.0 times. A crucial role in providing perennial grasses available phosphorus are mineral fertilizers and peat beauty.
- Phosphorus intake into plants was particularly intense in the early stages of development (germination–earing (tasseling)), reaching a maximum in the interphase period earing (tasseling) – flowering, and decreased during flowering – the beginning of maturation. Increasing the dose of phosphorus fertilizers by 60 kg, the active substance stimulated its consumption in the phase of earing (tasseling) – flowering.

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