Feed production on low-lying peat and developed soils of the North-East of the European part of Russia

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Abstract. The results of long-term research on the use of drained lowland peat and developed soils in feed production in the North-East of the European part of Russia are presented. The main agroecological technologies for the production of high-quality feed in soil-protective crop rotations, long-term pastures on drained low-lying peat soils and methods for using developed peatlands in intensive haymaking mode are proposed.

Keywords: forage production, drained lowland peat soils, developed lowland peatlands, perennial grasses, annual crops, mineral fertilizers.

1. Introduction
The most important reserve for the production of dairy and meat products in Russia is reclaimed peat-swamp soils. On the territory of Russia, the total area of swamp ecosystems is about 112 million hectares, including 45 lowland, 60 upper and 7 million transitional hectares. According to the Ministry of agriculture of Russia, in the European part of the country, the development of low-lying swamps is 23, transitional 6 and upper 5 % of their total area [1]. It is known that organogenic soils have high potential fertility, favorable physical properties, and the ability to manage the water regime through modern reclamation systems. These factors make it possible to conduct intensive agricultural production at such facilities. However, arrays of peat soils have less favorable temperature regime, less resistance to wind erosion, a high degree of mineralization of organic matter, unbalanced ratio of macro- and microelements Long research lugobolotnaya Kirov experimental station found that on these sites the most suitable organization of specialized livestock farms producing milk and meat products. For the successful development of such farms, it is necessary to develop a feed production system that operates on long-term grassy vegetation with high adaptive properties [2, 3]. Therefore, modern research of the station is aimed at improving the structure of agricultural land, developing resource-saving and environmentally friendly technologies for creating and managing production processes of long-term use.
2. Methods and materials

Research work on the search for methods for developing peat-swamp soils for agricultural crops was carried out on the Gadovskoe peat massif, located in the Orichevsky district of the Kirov region (Russia). Scientific research on the cultivation and development of low-lying peat bogs in this peat mass has been carried out continuously for more than 100 years. Research on crop rotations and long-term grass stands for pasture and hay use is carried out in stationary experiments. The stationary experiment with crop rotations was established in 1975, is located on drained low-lying peat soil and includes ten variants of the structure of the sown area with different saturation with perennial and annual crops, as well as a link of annual and row crops. Stationary experiment on pasture, located also on drained lowland peat soil. Grazing was carried out in 1935 with a 10-component cereal-legume grass mixture: Trifolium repens L.-1.4 kg, Trifolium hybridum L.-1.4 kg, Poa pratensis L.-2.3 kg, Poa palustris L.-2.3 kg, Festuca rubra L.-3.3 kg, Festuca pratensis Huds.-4.6 kg, Lolium perenne L.-5.0 kg, phlum pretense L.-1.4 kg, Alopecurus pratensis L.-2.4 kg, Agrostis stolonifera L.-1.6 kg. In total, 25.7 kilograms of seeds were sown per 1 hectare. Long-term use of pasture grass in intensive pasture mode without the use of fertilizers provoked the introduction of little-eaten mixed grasses into the grass stand. Therefore, in order to manage the botanical composition of the phytocenosis, in 2011, an experiment was laid on a long-term pasture herbage, including 6 variants of various methods of mineral fertilizer: control (without fertilizers), N_90, N_90P_60, N_90K_90, N_90P_60K_90, N_30P_40K_40, in 4 repetitions. Accommodation options in experience randomination. The soil of both stationary experiments is a drained lowland peatland with an average peat layer thickness of 150 cm, underlain by medium-grained sand. The degree of decomposition of peat is 40 %, lowland peat is sedge-wood. Losses of organic matter due to mineralization are studied at permanent sites. Ground water level (UGV) – 1.0-1.2 m.

Research work on the development of technologies for the production of feed on developed peat soils is carried out in a stationary experiment on a long-term grass stand for hay use. Seeded grass was created in 1971 on a drained low-lying developed peat bog, which was released after peat extraction by milling in 1965. Before tinning: pyrite stub 5 C / ha and 60 kg/ha of nitrogen, phosphorus, and potassium. The following varieties and seeding rates of perennial grasses were used in the sown grass mixture: Phleum pratense L. Late-maturing VETCH (8 kg / ha), Festuca pratensis Huds. DedinoVskaya - 8 (14 kg / ha), Bromopsis inermis L. Morshansky- 312 (10 kg/ha). The soil is a drained lowland peatland, underlain by medium-grained sand. Before laying the experiment, the layer of residual peat on the experimental site was 15-45 cm, the degree of decomposition of peat was 25-30 %, ash content was 8-10 %, volume weight was 0.200 mg / cm3, and total water capacity was 472 %. Water supply – ground water (0.6-0.8 m) and precipitation. The developed peat soil of the experimental site during the period of tinning (1971) was characterized by a slightly acidic reaction (pH Sol, 5.5) and contained 8 mg of mobile phosphorus, 248 mg of exchangeable potassium, 1.84% of total nitrogen, Cao – 1.49 %, Al – 2.2 mg per 1 kg of soil (0-20 cm layer). In 1972, on the created grass stand, field experience was laid, including 15 variants of various methods of mineral fertilizer in four repetitions. Each year, the following doses of fertilizers were added to the top dressing: ammonium nitrate-60-90-120-180-240, superphosphate-30-45-60-90, potassium chloride-45-60-120-180 kg of active substance (d.V.) per 1 hectare. To determine the effectiveness of nitrogen fertilizer, the control was a double mixture of P_40K_120, phosphorous – N_120K_120, and potash –N_120P_60. Absolute control for all options - without fertilizers. Phosphorus fertilizers (superphosphate) were applied in the spring in one step, nitrogen fertilizers (ammonium nitrate) and potash fertilizers (potassium chloride) – fractional, equal parts for each mowing. Soil properties and the nature of their changes were studied in dynamics over periods.
The use of herbage is two-mown, for hay in the earing phase of the dominant grain, stalk-free. The main method of research is laboratory-field, according to the methods of the V. R. Williams Institute of feed. Determination of agro-energy efficiency using the "method for evaluating energy flows in meadow agroecosystems" [4]. The account of yield of herbage and underground mass was performed by standard in grassland science techniques, mathematical processing yields and herbage mass of underground organs – method of analysis of variance (for Dospekhov B. A., 1985) using the program Excel, agrochemical soil analysis – on approved methods for studies of peat soils.

3. Results and discussion
For more than 100 years, the Kirov lugobolotnaya experimental station has been developing techniques and technologies for the development and agricultural use of low-lying peat and developed soils, as well as a system for feeding cattle with feed obtained from peat and developed soils. One of the main elements of the technology for restoring degraded peat soils is their use in the system of forage crop rotations. Long-term data obtained in a stationary experiment with crop rotations show that the main group of forage crops on peat soils are perennial grasses that best meet the ecological and economic requirements of reclamation agriculture. An additional group is annual crops that provide a more uniform and stable flow of plant raw materials in the raw material conveyor system

The obtained data on the productivity, energy and protein nutrition of perennial and annual crops in the studied crop rotations show that the greatest adaptive potential and stability of productivity over the years have perennial grasses. The duration of use of perennial grasses in the haymaking regime can be 45 years or more. The grass is a three-component mixture (\textit{Phleum pretense} L., \textit{Festuca pratensis} Huds., \textit{Bromopsis inermis} L.) created in 1975, with two-hauling use and annual application of mineral fertilizers (N$_{60}$P$_{60}$K$_{90}$), it provides an average harvest per 1 hectare: 6-7 tons of dry matter, 4.5-6.5 thousand feed units. The level of variation in productivity does not exceed 12-14%.

The introduction of leguminous grasses (\textit{Trifolium pratensis} L. and \textit{Trifolium hybridum} L.) and their functioning in the first two years of use allowed to increase the productivity of crops without the use of fertilizers by 1.1-1.3 times. Against the background of mineral fertilizer in doses of P$_{90}$K$_{120}$, the productivity of legumes and grasses increased by 1.6 times (up to 7.7-8.0 tons per 1 hectare of dry matter, 6.5-6.8 thousand feed units). The payback of 1 kilogram of fertilizers on grasses when applying N$_{60}$P$_{60}$K$_{90}$ was 8.6 feed units, on legumes and grasses when applying P$_{90}$K$_{120}$ - 8.8 feed units, which indicates the feasibility of including legume types of grasses in grass mixtures and using a limited amount of nitrogen fertilizers as they fall out [5, 6, 7]. The high economic efficiency of including blue-hybrid alfalfa and horned alfalfa in grass stands is established. These crops have the greatest ecological plasticity and stability in the composition of two-mown grass stands. In the first three years, the productivity of grass mixtures with the participation of Hornblower and blue-hybrid alfalfa for collection from 1 hectare (taking into account technological losses) was: dry matter up to 5.9-6.3 tons, feed units – 4580-4750 (table 1), crude protein 810-1170 kilograms.

Table 1. Agro-Energy and economic efficiency of forage crops in the structure of crop rotation (2012-2018)

| Experience options | Collection from 1 ha | Total energy consumption, GJ / ha | Direct costs, RUB / ha | Cost of 100 number of units, RUB. | Payback of 1 ruble of expenses, RUB. |
|-------------------|---------------------|----------------------------------|-----------------------|----------------------------------|-----------------------------------|
| Perennial grasses sown in 1975 | 60,0 | 4511 | 59,0 | 17,8 | 3,31 | 3650 | 80,9 | 8,6 |
| Grass mixture seeding in 2011 | 62,8 | 4582 | 60,9 | 18,2 | 3,34 | 3750 | 81,8 | 8,5 |
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| (lyadvenets, timofeyevka, kostret b/o) | Grass mixture sown in 2011 (alfalfa, timofeyevka, kostret b/o) | 58,9 4751 57,5 18,6 3,10 3690 77,6 9,0 |
| | Link of annual crops (pea-oat mixture) | 35,6 2826 35,9 28,9 1,24 51,00 180,4 3,9 |
| | Link of row crops: potatoes | 51,4 4540 50,5 35,6 1,41 7680 169,2 4,1 |

The participation of legume species in herbage allowed to increase not only the yield, but also the protein nutritional value of feed by 20-25%. A significant advantage of long-term grass mixtures with legume species is the reduction of energy costs for the use of nitrogen fertilizers. The total cost of cultivating such grass mixtures is 18.2-18.6 GJ / ha, which is 1.8-2.0 times less than the energy cost of grass stands. Thus, legume-grass mixtures of perennial grasses (3-4 years) can significantly reduce the cost of their cultivation and ensure the production of feed with an optimal energy-protein ratio. Such grass mixtures can be used in short-rotation near-farm crop rotations (6-7 fields) in alternation with annual crops (2-3 fields).

The productivity of two annual crops (peas+oats+rape, peas+oats+annual ryegrass) for 8 years of research was 3.5-5.1 tons per 1 hectare of dry matter, 2.0-3.8 thousand feed units and 370-640 kilograms of raw protein. Energy consumption for the cultivation of annual crops in grass-field crop rotations increased to 29 GJ / ha. In this regard, the area of annual forage crops sown in grass-field crop rotations should be determined by the minimum requirements for such plant raw materials in the raw material conveyor system. The productivity of row crops (potatoes) averaged 5.1 tons per 1 hectare of dry matter, 4.5 thousand feed units at high energy costs for cultivation, up to 36 GJ/ha. Therefore, it is advisable to introduce limited areas of row crops into crop rotations when producing commercial products or for on-farm consumption. In addition, the areas of annual and row crops differ in the intensity of mineralization of soil organic matter during their cultivation. With long-term use of peat-swamp soils for field crops, the degree of peat decomposition increased, the volume mass doubled, and the ash content of peat increased. Annually, on average, 1.25 cm of peat deposits were produced in the peat mass. The parameters of average annual peat losses over the 45-year period of permanent cultivation of crops and in crop rotations are established. The highest average annual loss of organic matter under row crops is 6-8 tons per 1 hectare, the lowest under perennial grasses is 1.5-2.0 tons per 1 hectare. Annual crops in this indicator occupy an intermediate position – 4-6 tons per 1 hectare, due to the fact that in the link of annual crops, soil treatment includes winter plowing of a layer of perennial grasses, and for subsequent crops, surface loosening can be used. In crop rotations on drained lowland peat soils, the lowest loss of organic matter (no more than 2.0 t/ha) was found when 70-80% of perennial grasses and 20-30% of annual crops were present in the structure of sown areas. The most important factors for increasing crop rotation productivity are mineral fertilizers while maintaining the ground water level of 0.9-1.2 m due to the system of double regulation of the water regime.

Long-term cultural pastures are an alternative to negative processes in optimal farming on drained low-lying peat soils. The pasture stand on the drained area of the swamp, created in 1935 by sowing a grass mixture consisting of 10 components of perennial grasses, is considered one of the most unique and long-term pastures in Russia, without overfishing. For a long period of time, the created herbage is used in intensive pasture mode: 4-5 grazing cycles per pasture season (on average 152 days) with a load of 3-4 heads of cattle per 1 hectare of pasture. During the 85-year period of use of the pasture, a grass-mixed phytocenosis was formed, which can be considered a meadow monoculture with more than 55
species of herbs in its Botanical composition. Geobotanical survey of the site showed that the species and quality composition of the herbage has significantly improved. Of the cereal species, the main part in the herbage is occupied by: Alopecurus pratensis L. 30-35%, Elytrigia repens L. 28-30%, Poa pratensis L. 10-12%, Festuca rubra L. and Festuca pratensis Huds. 35%. Of the legumes, 10-15 % contain Trifolium repns L., Trifolium hybridum L., Lathyrus pratensis L., Vicia ceracca L., Vicia sepium L. and other legume species. Achillea millefolium, Taraxacum officinale, Geranium pretense L., Veronica officinalis L., etc. account for the bulk (2-3%) of the motley grass group. The system of rational use of pasture, i.e. the corral-portion system of cattle grazing [8, 9], was the basis for preserving valuable herbage. This system ensures the safety of herbs during their regrowth and contributes to the timely implementation of techniques for caring for the herbage. Proper organization of grazing, introduction of optimal doses of mineral fertilizers, timely mowing of non-grazed residues allows maintaining high productivity of pasture grass at the level of 5-6 thousand feed units during the entire period of intensive use of grass. According to soil and microbiological studies on the pasture provided by the relatively high preservation of organic matter in the peat. Over the past 45 years of use, the peat layer has decreased by only 4 cm. Agrochemical indicators allow us to judge the satisfactory acid regime of the soil (salt pH - 5.0-6.0) and a fairly high content of the main elements of nutrition: potassium -18-23, phosphorus 50-60, nitrogen-up to 100 milligrams per 100 grams of soil.

Agrotechnical methods for managing the Botanical composition, productivity and quality of green feed are being developed on long-term pasture herbage. For this purpose, studies are conducted with different doses of mineral fertilizers. As a result of the conducted research, it was found that over the past 8 years in the grass stand without fertilization, the share of little-eaten mixed grasses increased from 18 to 35 %. When applying mineral fertilizers, the share of mixed grasses and Elytrigia repens L. decreased, and the content of valuable perennial grasses – Poa pratensis L. and Bromopsis inermis L.- increased in the stand. The productivity of long-term pasture grass against the background of natural fertility of peat soil averaged 4.8-5.0 thousand feed units per 1 hectare (table 2).

Table 2. Agro-Energy and economic efficiency of pasture feed production with various methods of mineral fertilizer.

| Experience options | Collection of feed units from 1 ha | Total energy consumption, GJ / ha | The cost effectiveness of anthropogenic | Reduce per 1 GJ OE SP, MJ | Cost of 100 feed units, RUB. | Notional net profit, RUB / ha | Payback period of expenses, RUB. |
|--------------------|---------------------------------|----------------------------------|----------------------------------------|---------------------------|-----------------------------|-------------------------------|--------------------------------|
| Control            | 4969                            | 3,4                              | 1243                                   | 80,4                      | 0,49                        | 18310                         | 29994                           | 164                            | 2,6                           |
| N90                | 5580                            | 11,6                             | 389                                    | 256,9                     | 1,45                        | 22956                         | 429                             | 29445                          | 128                            | 2,3                           |
| N90K00             | 5688                            | 12,6                             | 443                                    | 225,9                     | 1,32                        | 25190                         | 391                             | 37912                          | 151                            | 2,5                           |
| N90P60             | 5566                            | 12,8                             | 370                                    | 270,1                     | 1,43                        | 29572                         | 529                             | 25229                          | 85                             | 1,9                           |
| N90P40K00          | 6163                            | 13,7                             | 461                                    | 217,1                     | 1,18                        | 31807                         | 434                             | 40008                          | 126                            | 2,3                           |
| N90P40K40          | 5001                            | 6,6                              | 340                                    | 294,2                     | 1,71                        | 26026                         | 506                             | 24336                          | 94                             | 1,9                           |

The use of mineral fertilizers helped to increase pasture productivity to 5.0-6.2 thousand feed units. Indicators of agro-energy and economic efficiency of pasture feed production indicate that without mineral fertilization of pasture grass on drained peat soil, created in 1935, it is possible to get 5.3 tons per 1 ha of high-quality feed, 57 GJ/ha of exchange energy, 670 kilograms per 1 ha of digestible protein, 4.9 thousand feed units at a minimum anthropogenic cost of 3.4 GJ / ha. The effectiveness of anthropogenic costs very high: the production of 1 GJ of metabolizable energy is expended only 80 MJ total energy for production of 1 kg of crude protein to 0.49 GJ total energy. When fertilizing pasture
grass with mineral fertilizer, anthropogenic costs increased by 2-4 times, but the cost efficiency decreased from 12.4 times in the control to 3.4-4.6 times with various methods of mineral fertilizer. In General, the data obtained indicate that mineral fertilization can improve the stability and productivity of forage agroecosystems, and the preservation of organic matter in peat soils. Promising in terms of saving energy resources are studies aimed at stabilizing and extending the productive longevity of meadow and pasture agrophytocenoses due to their biological potential: by rejuvenating the grass stand with the dominance of creeping Wheatgrass and combined haymaking and pasture use of old-seeded grass [10]. Both methods showed environmentally and economically beneficial results.

The use of developed lowland peatlands in intensive forage production requires a particularly careful attitude due to the fact that developed peatlands contain minimal organic matter reserves, among other types of peat deposits, and the rate of mineralization when used is not inferior to unprocessed peatlands. Therefore, the search for low-cost, energy-saving and environmentally safe methods and technologies for increasing the productivity of long-term agricultural crops created on developed peat soils and ways to restore their soil fertility becomes particularly relevant [11]. All these conditions are most consistent with the use of developed peat soils for long-term meadow grasslands of intensive use with regulated fertilizer methods.

In 47 years of use herbage, created on the basis of three component mixtures of perennial grasses (Phleum pretense L., Festuca pratensis Huds., Bromopsis inermis L.) on drained fen peat developed in accordance with the applied doses of fertilizers formed of various Botanical composition and productivity of phytocenoses. With the systematic use of mineral fertilizers, the old-growth herbage is represented by perennial grasses of the cereal type with a predominance of Bromopsis inermis L., 67-99 %. Without the use of fertilizer, a mixed grass-grass stand was formed with a predominance of Salix L.-11-28 %, Leontodon autumnalis L.-7-15 % and non-sown cereals (Agrostis stolonifera L.-8-15 %, Elvirigia repens L.-13-28 %, Poa pratensis L.-11-12 % Deschampsia caespitosa L. -12%. The absence of phosphoric top dressing during the annual application of nitrogen-potassium fertilizer in doses of N$_{120}$K$_{120}$ contributed to the rapid degradation of the grass stand formed due to pre-sowing filling, and a decrease in its productivity by 1.4 times compared to the control (without fertilizers). This is due to the low content of phosphorus in the soil environment of the developed peat bog.

Against the background of natural fertility (without fertilizers), the productivity of long-term cereal grass was on average 2.2-2.6 tons of dry matter (DM) per 1 ha, with the use of mineral fertilizers increased by 2.1-3.9 times. The use of phosphorus-potash fertilizer (P$_{60}$K$_{120}$) contributed to an increase in productivity by an average of 1.3-1.5 times compared to the control (table 3), due to the additional mobilization of nitrogen from the soil environment. At the same time, these costs increased by 3.4 times, which is due to the high cost of phosphorous fertilizers and an increase in the cost of feed preparation by 1.8 times.

**Table 3.** Economic assessment of various methods of mineral fertilizer for long-term grass haymaking on a drained lowland developed peat bog

| Fertilizer for the season | Productivity of 1 ha | Cost of 100 feed units, RUB | Conditional net income (CNI), RUB per 1 ha | Profitability, % | Payback of 1 RUB of expenses, RUB | Payback period (according to accounting CNI), years |
|--------------------------|----------------------|-----------------------------|------------------------------------------|------------------|-----------------------------------|-----------------------------------------------|
| Without fertilizers      | 1787                 | 288                         | 5912                                     | 331              | 11602                             | 196                                           | 3,0                                           | 0,8 |
| P$_{60}$K$_{120}$        | 2726                 | 376                         | 20467                                    | 751              | 6248                              | 31                                            | 1,3                                           | 1,5 |
| N$_{60}$P$_{60}$K$_{120}$| 3311                 | 454                         | 24903                                    | 752              | 7549                              | 30                                            | 1,3                                           | 1,2 |
| N$_{90}$P$_{60}$K$_{120}$| 4117                 | 526                         | 28860                                    | 701              | 11482                             | 40                                            | 1,4                                           | 0,8 |
| N$_{120}$P$_{60}$K$_{120}$| 4035                | 567                          | 29499                                    | 731              | 10047                             | 34                                            | 1,3                                           | 0,9 |
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The use of a complete mineral fertilizer (NR), including increasing doses of nitrogen from N60 to N240, increased the above costs by 1.2-1.6 times compared to the background of the ROK. Taking into account the previously established effective doses of nitrogen N90 and N120, the cost of 100 feed units decreased from 751 (against the background of RK) to 701-731 rubles. For 1 ruble of expenses due to the increase in productivity of haymaking, 1.4 rubles were received against 1.3 rubles when using PK. In addition, the increase in the cost of using ammonium nitrate as part of a complete mineral fertilizer with the inclusion of these nitrogen doses accelerated the payback period for capital investments (up to 0.8-0.9 years). Application of phosphorous fertilizer in doses from 30 kg d. V. to 90 kg d. V. per 1 ha allowed to increase the productivity of long-term haymaking by 2.4-3.1 times. In the production of 3.1-4.0 thousand feed units, 570-620 kilograms of raw protein from 1 ha, the cost of production decreased by 1.2-1.3 times and the conditional net income increased from 439 to 7834-10047 rubles from 1 ha, compared to N120K120. The payback period for capital expenditures accelerated to 0.9-1.2 years. A double mixture of nitrogen-phosphorus fertilizer in doses of N120P60 on a low-lying developed peat bog is less effective than phosphorus-potassium fertilizer in doses of P60K120. The productivity of 1 ha of hay for collecting feed units decreased by 20 %. With a slight decrease in the above costs (by 6 %), the decrease in haymaking productivity was reflected in an increase in the cost of feed (up to 875 rubles per 100 feed units against 751 rubles in the Republic of Kazakhstan) and a decrease in the profitability of hay production to 12 % against 31 % on a phosphorus-potash background. The study of four doses of potash fertilizer as part of a complete mixture of mineral fertilizer showed that the use of potassium in a dose of K60 in the conditions of a developed peat bog is most effective. Feeding long-term cereal hay with a full mineral fertilizer with a dose of potassium 60 kg of active substance per 1 ha provided productivity of 3.6 thousand feed units and 590 kilograms per 1 ha of raw protein with a 40 % profitability of hay production and the cost of feed received 699 rubles per 100 feed units. The conditional net income from the received products due to the use of a complete mineral fertilizer with a dose of potassium of 60 kg DW per 1 ha was 10207 rubles. Capital expenditures were recouped within 0.9 years. Consequently, the creation of seeded haymaking on a drained low-lying developed peatland due to residual fertility provides 1.7 thousand feed units per 1 ha, 290 kilograms of raw protein. The developed methods of mineral fertilizer allow producing 3.3-4.2 thousand feed units per 1 ha on these economically most valuable lands in a cool and moderately humid climate (taking into account technological losses) and receiving up to 10-11 thousand rubles of conditional net income from working capital for production costs without additional capital investments for radical improvement of the long-term grass stand of.

With the systematic use of mineral fertilizers for 47 years, significant changes in the soil fertility of low-lying developed peatlands were noted. The content of mobile phosphorus when applied in doses of
60-120 kg d. V. per 1 ha as part of the complete mixture increased to 450-950 mg/kg of soil, which corresponds to a good supply of this element of the soil of the developed peat bog. When phosphorus was added at a dose of 60 kg d. V. per 1 ha in double mixtures N120P60 and P60K120, its accumulation in the soil increased to 1372 and 1688 mg/kg of soil, respectively. A low content of mobile phosphorus (140 mg/kg) was observed when this element was added as part of a complete mixture of mineral fertilizers at a dose of 30 kg d. V. per 1 ha. Soil enrichment with phosphorus (80 mg / kg) and potassium (391 mg/kg) was also observed in the soil of non-fertilized hay, due to the receipt of these elements as a result of peat mineralization and after decomposition of plant residues. The return on anthropogenic costs of accumulated gross energy in the studied agroecosystems reached 670-1411 %. The highest payback rate was set in the version without fertilizers, where the cost of anthropogenic energy was minimal. When using a complete mineral fertilizer, this indicator decreased to 877-987 %, and when using an incomplete mixture (NR), it decreased to 670 %. This reflects the well-known exponential nature of the return on anthropogenic costs: as the technological process intensifies, the return per unit of resources spent decreases [11, 12]. Thus, the systematic use of mineral fertilizers for the care and improvement of long-term cereal hayfields created on low-lying developed peat soils in scientifically-based doses contributes not only to the preservation of the valuable Botanical composition of agrophytocenosis, increasing its productivity and nutritional value, but also allows you to increase the reproduction of soil fertility by attracting natural potentials without additional capital investments for radical improvement.

Numerous studies conducted at the Kirov lugobolotnaya experimental station have proved the effectiveness of using low-lying drained peat and developed soils for long-term cultural pastures, highly productive cultural lands for hay use. However, feed obtained from peat soils, as a rule, is not balanced in the content of elements such as: calcium, potassium, phosphorus. In addition, the feed has a low content of copper, zinc, manganese, iodine, and cobalt. As a result, the supply of animals with macro- and microelements at the expense of basic feed is insufficient, so it was necessary to enrich the diets with salts of the corresponding macro- and microelements. In this regard, based on the needs of the cows in the mineral substances, the scientists of the station was designed vitamin and mineral Supplement “Lugovit”. To test the drug, an experiment was conducted on cows with an average daily milk yield of 14 kg in the summer pasture period. Feeding vitamin and mineral supplements “Lugovit” on detailed rules contributed to increasing the average daily milk yield by 10.9 %, increase in live weight of cows in an average of 19.2 %. The introduction of mineral supplements in diets did not affect the quality characteristics of milk. The content of dry matter, fat, protein and casein in the milk of cows in the experimental group was at the control level. The use of a mineral Supplement in rearing young animals also contributed to an increase in the average daily growth of live weight and provided a normal clinical and physiological state of animals [13].

4. Conclusion
1. Feed production on peat and especially on developed soils should be based mainly on the principles of the most "sparing" eco-reclamation agriculture. First of all, this means creating an optimal water regime for the root layer. This is achieved through an operational season-by-season system of two-way regulation of the ground water level (UGV). The drainage rate is set depending on the peat reserves – the greater its depth, the lower the temporary reduction of ground water is allowed (up to 120-150 cm). And, conversely, the smaller the peat layer, the higher to the surface should be UGV. For example, on strongly or completely worked out peatlands covered with sand, ground water should not fall below 60-80 cm during the growing season.
2. The location of forage crops in time and space largely depends on the thickness of the Deposit and the Botanical composition of peat in its upper part. On thick (more than 2 meters) and medium-sized (1-2 m) areas where woody peat species predominate, the share of annual crops, including row crops, can reach 30-50%. With a decrease in the peat layer, the share of perennial grasses in the crop rotation structure should increase and be at least 70-80% both on low-power peat and on developed soils with gypsum-sedge peats.

3. Long-Term research and observation data on production fields indicate that even on extremely well-worked workings, organic matter can be preserved for a long time, and therefore fertility, if they create long-term mowing or pasture stands. The share of annuals here should not be more than 5-10%. In these conditions, in addition to cereals, legumes, in particular, clover, provide a stable and high yield. Clovers develop especially well when applying high doses of manure before tinning. (80-100 t/ha). In contrast, organic fertilizers do not have any advantages over mineral fertilizers in workings with large reserves of peat, i.e. the fertilizer system also largely depends on the capacity of the peat deposit.

4. It is established that hayfields and long-term pastures on drained and developed lowland peatlands with the use of mineral fertilizers in scientifically justified doses, a set of technological methods for their rational use and care of grasslands, provide stable productivity at the level of 6-7 tons per 1 ha of dry matter for 45-85 years or more.

5. In the agricultural use of drained and developed lowland peatlands, preference should be given to crops of perennial grasses. The soil protection and ecological role of perennial grasses is huge. A powerful root system reduces the dispersion of the arable layer, prevents the spread of weeds. In addition, perennial grasses prevent peat from acquiring the properties of "non-wettability", restrain the processes of its decomposition and the formation of excessive amounts of nitrate nitrogen. The annual intake of organic matter from perennial grasses is about 3-4 t/ha. In General, the developed agricultural techniques can improve the stability and productivity of forage agroecosystems and the preservation of organic matter in peat soils.

References
[1] The concept of protection and rational use of peat bogs in Russia /edited by corresponding member of the Russian Academy of Sciences L.I. Inisheva. Tomsk. 2005. 76p. Russia.
[2] Kosolapov V M, Trofimov I a Perspektywy rozwoju produkcji pasz Rosji //Problem intensyfikacji zwierzęcej z uwzględnieniem ochrony środowiska I stądardow UE: materiały XIII Miedzynarodowa Konferencja Naukowa-Warszawa, 2007. - p. 329-336. Poland.
[3] Kosolapov V M, Trofimov I A, Trofimova L S forage Production in agriculture, ecology and rational nature management (theory and practice) - Moscow: 2014. - 135 p. Russia.
[4] Kutuzova A A, Trofimova L S, Prompt E E 2015 Methodology for assessing energy flows in meadow agroecosystems (3rd edition, revised and expanded) Moscow: Ugresh printing house. 32 p.
[5] Shpakov A C Forage crop rotations: scientific organizational bases //Scientific support of feed production and its role in agriculture, economy, ecology and rational nature management in Russia: materials of the International scientific and practical conference dedicated to the memory of academician A. A. Zhuchenko. - M .. 2013-P. 226-240. Russia.
[6] Kohmann M M, Sollenberger L E, Dubeux, et al. Nitrogen fertilizer and the proportion of legumes affect litter decomposition and nutrient return on grassy pastures /Crop Science, 2018. 58 (5), pp. 2138-2148. DOI: 10.2135/cropsci2018. 01. 0028
[7] Maamouri A, Louarn g, Gastal F, Béguier V, Julier, B Effects of Alfalfa genotype on morphology, biomass production, and nitrogen content of alfalfa and reed faeces in mixed pastures of agricultural crops and pastures science, 2015. 66 (2), pp. 192-204. DOI:
10.1071/CP14164

[8] Kulakov V A, Sedova E G Effect of long-term use of fertilizers on pasture productivity and agrochemical indicators of soil //Forage Production, 2012, No. 9, Pp. 20-23.

[9] Hejcman Michal, Klaudisová Michaela, Schellberg Jürgen, Honsová Dagmar (2007): the Rengen Grassland experiment: plant species composition after 64 years of fertilizer application. Agriculture, ecosystems and the environment, 122, 259-266 https://doi.org/10.1016/j.agee.2006.12.036

[10] Kutuzova A A, Zotov A A, Trofimov I A, etc. Practical guide to resource-saving technologies and techniques for improving hayfields and pastures in the North-West region. /under the General editorship of Kutuzova A A, Privalova K N, Georgiadi N I-M.: FSU RTSSK, 2013. - 40 p.

[11] Kutuzova A A, Privalova K N Efficiency of low-cost ways to improve hayfields and pastures // Achievement of science and technology of the agro-industrial complex, 2012, no. 2, Pp. 52-54.

[12] Hejcman M, Strnad L, Hejcmanová P, Pavlá V (2012): response of plant species composition, biomass production, and chemical properties of biomass to high n, P, and K application rates in pastures dominated by Dactylis glomerata and Festuca arundinacea. The science of the grass and forages, 67, 488-506 https://doi.org/10.1111/j.1365-2494.2012.00864.x