The state and direction of development of forage production in the Novgorod region of the North-West of Russia

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Abstract. The data on the study of the condition of the forage reserve for the farms of the Novgorod region are given. The directions of improving meadow and field forage production, ways to increase the productivity of the forage hectare are proposed. It has been experimentally proved that in the soil and climatic conditions of the Novgorod region, through the use of field and meadow legume-grass agrocenoses, highly nutritious forages can be obtained: green mass – more than 22 tons, silage – more than 11 tons, haylage – more than 7 tons per 1 ha. An analysis of the energy parameters of the technologies for cultivation and use of field and meadow agrocenoses showed that the energy costs and their structure vary significantly and depend on the composition of cenoses, types and doses of fertilizers, type and amount of seeds of annual crops, their energy consumption. In order to save resources in forage production, it is advisable to cultivate legume-grass agrocenoses. The introduction of the legume component in field and meadow agrocenoses will lead not only to an increase in the nutritional value of the forage, but also to an increase in the agro-energy coefficient. The calculation of the energy efficiency coefficient confirmed the high energy saving in the cultivation of field and meadow legume-grass agrocenoses. The least costly is the use of meadow agrocenoses for green forage. The yield of exchange energy is 8.7 times higher than the energy expended for cultivating legume-grass meadow grass stands and preparing forage from them. Due to the low feed value of natural forage land, summer feeding of animals with more nutritious green forage prepared from legume-grass agrocenoses is recommended.

1. Introduction
The Novgorod region is located in the North-West of the Non-Chernozem Zone of Russia, in the temperate latitudes of the northern hemisphere, in the forest zone. In general, the climate here is temperate-continental, close to marine. It is characterized by excess moisture, a non-hot short summer, warm long autumn, mild winter and cool lingering spring. The Novgorod region belongs to the zone of risky farming, which has a definite effect on the structure of crops and crop yields.

The yield of forage crops of advanced farms in the Novgorod region does not exceed: 15 t/ha of perennial grasses for green forage, from 15 to 20 t/ha of annual grasses for green forage, 2.4 t/ha of barley grain, 2.7 t/ha of oats, 1.9 t/ha of wheat, 2.2 t/ha of winter grain. At the same time, forages do not always meet the requirements of complete feeding.

The development of livestock in the current economic conditions of the Novgorod region with an acute shortage of funds and material resources is constrained by the lack of a cost-effective forage reserve. Such a base should annually provide each agricultural enterprise in the region with the necessary amount of high-quality forage of its own production.
Therefore, to obtain high-quality forage, agricultural enterprises must have the following sources of replenishment: annual grasses, mixtures of grain crops with legumes, row forage crops. Of particular importance are natural and seeded hayfields and pastures, which will provide resource and energy saving in forage production. In agricultural enterprises, it is important to correctly use the feeding area, to rationally combine field and meadow forage production.

Efficient use of land based on intensification of forage production will allow for the proper use of all forage lands and achieve increased output for every 100 hectares of land. The volume of forage production should increase, first of all, by increasing the yield of forage and grain crops, improving the structure of their crops, increasing the productivity of natural and seeded cultivated grasslands. Through resource-saving in forage production and its intensification, it is necessary to achieve the maximum yield of complete forage per unit area with minimal labor and money [3].

The areas of natural forage land and the nature of their use in agricultural enterprises are determined mainly by the natural conditions of the region.

In cases where in the structure of sown areas natural forage lands occupy an average share, for cultivation on arable land, mainly crops such as perennial and annual grasses for haylage and silage are chosen. They give a larger yield from 1 ha at low costs per unit of nutrients [2].

In farms where natural lands occupy a small share and are characterized by low productivity, field forage production should provide forage for both stall feeding and feeding in the summer.

Therefore, in modern agricultural conditions, the main task of forage production is to create a solid forage reserve for animal husbandry by cultivating varietal forage plants on arable land, improving pasture and hayfields and using natural forage lands while maximizing the use of the region’s climatic resources, biological and environmental factors.

The aim of the research was to study the productivity of varietal field and meadow agrocenoses, as well as natural forage lands in the conditions of the Novgorod region.

The research objectives included:
1) determination of the productivity potential of the yield of field and meadow agrocenoses according to years of research;
2) determination of the species composition and yield of natural forage lands;
3) monitoring the structure of cultivated areas of farms in the Novgorod region and developing recommendations for its improvement;
4) conducting an energy assessment of the cultivation and use of field and meadow legume-grass agrocenoses.

2. Material and methods of research
The experimental part of the study of the productivity of varietal field and meadow agrocenoses in conditions of the Novgorod region was carried out on the experimental field of the Department of Horticulture of the Institute of Agriculture and Natural Resources of Yaroslav-the-Wise Novgorod State University during 2013–2018.

In field agrocenoses, vetch and field pea were studied in a mixture with oats, barley and lupine of different seeding rates and methods of sowing. The method of sowing is row seeding.

In meadow agrocenoses, grass sward, consisting of meadow fescue grass, timothy grass and awnless brome, and legume-grass mixtures with meadow clover of different varieties, hybrid clover, and horned clover were studied. The method of sowing is narrow-row planting.

The experiment was conducted on a medium-acid sod-podzolic soil, medium-endowed with mobile forms of phosphorus and potassium, of heavy mechanical composition. The soil of the experimental plot was typical for the Novgorod region.

The studied natural forage lands was located on the territory of several farms in the Novgorod region. The total area of the studied meadows was about 100 ha.

Accounting for productivity in the experiments was carried out by the mowing method in the phase of complete oversewing of the panicle of cereal crops, and the beginning of flowering of legumes.
During the growth and development of forage crops, biometric measurements and phenological observations were performed.

3. Results and discussion
One of the directions for improving forage production in agricultural enterprises of the Novgorod region is to increase the energy and protein nutritional value of the forage produced. This can be achieved through the widespread use of legume-grass cenoses. The introduction of the legume component into the composition of field and meadow agrocenosises leads to an increase in the protein content of the forage and a significant reduction in the cost of cultivating them.

As a result of studies on field agrocenosises, it was found that the type of components, the method of sowing, and meteorological conditions have a great influence on their productivity. On average, over the years of research, the maximum yield of the joint sowing of vetch and oats was possessed, as well as the sowing of vetch and barley in a ratio of 1:1. In addition, it has been established that vetch and barley mixtures are more technologically advanced, because unlike oats, barley ripens 3–5 days earlier or simultaneously with vetch. At the same time, these crops provided the largest collection of forage per unit area [3].

Perennial meadow herbs, which will provide significant resource saving in forage production, are of great importance in forage production. Due to their use, human and material resources are being significantly saved and, in addition, fertility of the soil is improved. To identify more economical technologies and cultures, various options can be compared in terms of total energy costs and agro-energy ratio.

An analysis of the energy parameters of the technologies for cultivation and use of field and meadow agrocenosises showed that the energy costs and their structure were significantly different and depended on the composition of cenoses, types and doses of fertilizers, type and number of seeds of annual crops, their energy intensity. It has been established that keeping the legume component in the composition of field and meadow agrocenosises reduces the energy consumption for cultivation by 1.5–3 times.

The calculation of the agro-energy coefficient of cultivation of field and meadow agrocenosises confirmed the high energy saving during the cultivation of meadow agrocenosises (figure 1). The yield of exchange energy was 2.2–8.7 times higher than the energy expended for their cultivation. Energy efficiency differed not only in the type of agrocenosises, but also in the type of forage. The field and meadow cenoses had the greatest energy efficiency coefficient when using them for green forage (2.3 for field cenosis and 8.7 for meadow cenosis). The most expensive forage was the preparation of winter forage: silage and haylage. The exchange energy output blocked the energy expended in field legume-grass agrocenosises by 1.4–1.5 times and by 2.2–2.4 times in meadow cenosis.

![Figure 1. Agro-energy coefficient depending on the type of forage and type of cenosis.](image-url)
According to the results of studies, a high nutritional value of legume-grass meadow agrocenosis was established. It has experimentally proven that in the soil and climatic conditions of the Novgorod region, clover-grass swards provided forage income from the main mowing without additional mineral fertilizers up to 22 tons of green mass per hectare with a share of clover – about 33% in the 1st year or more than 60% – in the 2nd year of life (table 1). Moreover, the accumulation of biological nitrogen, depending on the year of life, will be 48 – 58% of the total removal with the yield or 73–84 kg of nitrogen per 1 ha [5].

Table 1. Sources of forage income in the farms of the Novgorod region.

| Cenosis                        | Type of forage | Forage yield from 1 ha, t |
|--------------------------------|----------------|--------------------------|
| Field legume-grass agrocenosis  | Green mass     | 25.5                     |
|                                 | Silage         | 12.8                     |
|                                 | Haylage        | 8.5                      |
|                                 | Green mass     | 22.0                     |
| Meadow legume-grass agrocenosis | Silage         | 11.0                     |
|                                 | Haylage        | 7.3                      |
| Grain forage crops             | Grain          | 2.5                      |
| Natural grassland              | Hay            | 2.8                      |
|                                | Gramma grass   | 10.1                     |

It has been experimentally proven that in the soil and climatic conditions of the Novgorod region, clover-grass swards provided forage from the main mowing without additional mineral fertilizers up to 22 tons of green mass per hectare with a share of clover – about 33% in the 1st year or more than 60% – in the 2nd year of life. Moreover, the accumulation of biological nitrogen, depending on the year of life, will be 48 – 58% of the total removal with the yield or 73–84 kg of nitrogen per 1 ha [5].

The cultivation of row crops is the most time-consuming technological process, therefore, at present, in most farms of the Novgorod region, the area under them is reduced to a minimum or none at all. In addition, the share of energy-intensive forage such as grass meal has been reduced in the structure of forage production. In most farms, the share of silage is more than 60%. To increase the productivity of dairy cattle, it is necessary to introduce forage root crops into the intake.

In the Novgorod region, as in the entire Non-Chernozem zone, livestock breeding is developing due to the widespread use of natural lands. Natural meadow grass stands do not undergo significant changes in the structural organization of communities, in contrast to seeded meadows. Therefore, their productivity in the years of research is influenced only by weather conditions. On average, over the years of research, the harvest of green mass per unit area of natural forage land is about 9–11 tons per 1 ha. Moreover, these cenoses form only one complete mowing.

The study of the species composition of natural lands showed their floristic usefulness. The vegetation cover of natural meadows is quite diverse. Here there are representatives of such botanical families as legumes, cereals, as well as aster, primrose, bluebell, horsetail and others. An important role in the formation of phytocenosis belongs to the cereal family. They account for more than 50% of the total mass of the crop. The most competitive cereal is couch grass. Its participation is more than 20% of the mass of the crop (figure 2).

The participation of leguminous plants, mainly red clover and Alsatian clover, in natural phytocenosis is low and makes up only 15–20% of the total mass of the crop. The most numerous in the natural vegetation cover is the family of asters, the most common of which are milk-witch gowan, scabiose centaury. All legumes are well-eaten plants [4].

In addition, on natural forage lands, harmful and poisonous plants can be found, such as: meadow pine, absinth sage, prickly thistle, wild chamomile, thousand-leaf, bur beggare. Their participation in
the phytocenosis does not exceed 10% of the total mass of the crop, that is, the presence of these plants in the grass stands does not significantly affect the feed value of natural phytocenosis.

![Figure 2. Floristic composition of natural forage lands.](image)

4. Conclusion
An analysis of the structure of sown areas of farms in the Novgorod region and the yield of field and meadow forage agroecosises showed the need to expand the seeding-down of grain crops, legume-grass field and meadow cenosesises, and increase their productivity in order to provide livestock with their own high-quality forage.

It has been experimentally proven that in the soil and climatic conditions of the Novgorod region, through the use of field and meadow legume-grass agroecosises, highly nutritious forages can be obtained: green mass – more than 25 tons, silage – more than 13 tons, haylage – more than 9 tons per 1 ha. The use of meadow legume-grass agroecosis in forage production will significantly reduce the costs of their cultivation. They will provide highly nutritious forage: 22 tons of green mass, 11 tons of silage and about 7 tons of haylage from 1 ha.

Calculation of the agro-energy coefficient confirmed the high energy savings in the cultivation of field and meadow legume-grass agroecosis. The least costly is the use of meadow agroecosises for green forage. The yield of exchange energy is 8.7 times higher than the energy expended for cultivating legume-grass meadow grass stands and preparing forage from them.

Natural forage lands can be successfully used for grazing animals and for haying. However, in view of their low forage value, summer feeding of animals with a more nutritious green forage prepared from legume-grass agroecosises is recommended.

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