The problem of vegetable protein and its solutions

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Abstract. The article provides data on improving the raw material base for high protein feeds production on the example of perennial legumes – bird’s foot trefoil, sickle alfalfa, and meadow and hybrid clover. The studied cultures are compared in terms of their vegetation phases, mowing period, chemical composition, yield of green and dry mass. The time and conditions to obtain the highest content of vegetable proteins is indicated.

1. Introduction
One of the world's problems is the deficiency of proteins of plant and animal origin. Proteins are natural high-molecular organic compounds built of amino acids and cannot be replaced with fats, fiber or other organic substances. In addition, they are a basic building material to meet the growing needs of the population for high-quality nutrition. During digestion, proteins break down into separate links that go into the bloodstream. Each tissue needs proteins of a special quality, and collects only the kind of links that are needed to compose a protein of this quality. Animal proteins contain links in the most suitable ratios. There is a great need for protein of animal origin, the receipt of which depends on the development of the feed base in livestock farming.

Plant proteins contain the same kind of links as animal ones, but in different ratios. To get a sufficient amount of the links that are in insufficient quantities in plant proteins, it’s necessary to consume a large amount of plant food. When preparing a feeding ration, it is necessary to balance the feed with protein, which will significantly reduce overspending, increase the animals productivity and decrease the production cost [1, 2, 3]. One of the main ways to solve the problem of feeding agricultural animals is to increase the vegetable protein production [4, 5].

The main sources of raw materials for the production of high-quality feed in the Novgorod region are perennial leguminous plants, the mowing area of which has been significantly reduced in recent years, the yield remains low and amounts to 2.6 t/ha.

2. Materials and methods
The object of the study was populations of bird’s foot trefoil, sickle alfalfa, and meadow and hybrid clover. Studies on the chemical composition and productivity of perennial leguminous grasses were carried out on a dry meadow located on the banks of the Shelon river of the Soletsky district. This meadow was characterized by a high proportion of the bean component, therefore, supporting liming of 3 t/ha of lime was applied superficially in autumn 2014. Fertilization was carried out during the period of active spring regrowth at a dose of 60 kg P₂O₅ and K₂O annually.
Meteorological conditions over the years of the experiment, with the exception of 2016, were favorable for the growth of perennial leguminous herbs, which made it possible to obtain high yields of green mass for two mowings.

Three mowings were carried out: the first - in the phase of stalking in the studied legume species, the second and third when reaching a plant height of 60 to 70 cm of the grass stand mowing ripeness.

In the years of research conducted, the dynamics of shoot formation, the botanical composition of the population, and feed productivity before each mowing were studied according to the methodology of the All-Russian Research Institute of Feed named after V.R. Williams (1983). The biochemical composition and nutritional value of feed was determined according to GOST methods: crude protein – GOST R 51417-99, crude fiber - GOST R 52839-2007, crude fat - GOST 13496.15-97, crude ash – GOST 26226-95.

The study results reliability was checked according to the generally accepted method by B.A. Dospekhov (1985).

3. Results

The soils were characterized by low fertility and high acidity, which slowed down the assimilation of mobile forms of phosphorus and potassium. Therefore, the main condition for obtaining high and stable yields of perennial leguminous herbs is fertilizing and liming of acidic soils.

When liming a dryland meadow located on the banks of the Shelon river in the Soletsky district, the yield of perennial leguminous plants amounted to 4.7 t/ha. We have found that when grown on well-limed soils, perennial leguminous plants need phosphorus and potassium fertilizers to form high yields. Phosphorus fertilizers not only contributed to an increase in the yield of herbs, but also enriched the plants with phosphorus, which is necessary for animals. When phosphorus fertilizers were applied, the quality of feed improved as a result of a change in the botanical composition in the direction of increasing the proportion of legumes in the grass stand [6, 7].

Potassium is necessary for the growth, development and increase of resistance of perennial leguminous herbs to unfavorable growing conditions and winter hardness [8, 9, 10]. In addition, potassium affects many plant functions, including their water balance, as well as carbohydrate and nitrogen metabolism, and accelerates seasonal development. Potassium nutrition increases the resistance of meadow plants to rust, fungi and produces a significant change in the ash content of plants. The availability of potassium affects the rate of chlorophyll formation, contributing, in particular, to an increase in leaf surface and acceleration of CO₂ absorption. Potassium is necessary for the creation and movement of sugars, as well as for protein formation. The dates of the phenological phases of vegetation and their duration depend on the species, year of grass stand usage and environmental factors. Early regrowth over a five-year study period was observed in plants of bird’s foot trefoil and hybrid clover at the beginning of the second decade of April. A week later, regrowth in plants of clover meadow and sickle alfalfa was noted (table 1).

| Species                  | Vegetation phase | spring regrowth | branching | budding | flowering | start of seed ripening |
|--------------------------|------------------|-----------------|-----------|---------|-----------|------------------------|
| Meadow clover            |                  | 29.04           | 20.05     | 18.06   | 24.06     | 22.07                  |
| Hybrid clover            |                  | 23.04           | 6.05      | 7.06    | 25.06     | 9.08                   |
| Sickle alfalfa           |                  | 27.04           | 17.05     | 1.06    | 12.06     | 25.07                  |
| Bird’s foot trefoil      |                  | 22.04           | 14.05     | 6.06    | 15.06     | 12.07                  |

It was established that the shoot formation in the studied legume species varied depending on the conditions of the growing season and on the morphological features of the vegetative shoots of the species. In favorable vegetation periods, all studied species revealed a dependence of plant height on the number of shoots and the percentage of leafiness. For further use as a starting material for creating varieties of haying use, we recommend sickle-shaped alfalfa with a spreading bush form.
The plant height varied from 34.9 cm (in bird’s foot trefoil) to 85.1 cm (in hybrid clover). In the number of shoots for one plant, 9.5 pcs were indicated for bird’s foot trefoil plant and 29.7 pcs for sickle alfalfa. High leafiness of the shoots and long period before mowing ripeness was indicated for sickle alfalfa. (table 2)

Table 2. Dependence of plant height on their shoot-forming ability (2015-2019).

| Species              | Plant height in budding period, cm | Number of shoots, pcs. | Leafiness, % | Length of period before mowing ripeness, days |
|----------------------|-----------------------------------|------------------------|--------------|---------------------------------------------|
| Meadow clover        | 80.4± 0.13                        | 17.0± 0.18             | 61.8         | 42                                          |
| Hybrid clover        | 85.1± 1.01                        | 15.9± 0.22             | 51.4         | 49                                          |
| Sickle alfalfa       | 73.0± 1.84                        | 29.7± 2.99             | 63.5         | 58                                          |
| Bird’s foot trefoil  | 34.9±0.11                         | 9.5±1.51               | 57.0         | 38                                          |

The plants of bird’s foot trefoil were characterized by early ripening, grew well after mowing (on 24th day), formed up to 7.5 pcs of thin stem short well leafed shoots, more than 55.1%. The leafy shoots are highly nutritious and well eaten by animals, in comparison to simple shoots. Thus, the percentage of leafiness have a positive impact on the obtained feed quality. According to the results of our study, in favorable vegetation periods of 2016 and 2017, an intensive growth of shoots and, respectively, leaves, was noted; therefore, all studied species formed the maximum yield. The leaf yield reached its highest level. In 2018, at high level of precipitation and lack of warm weather, medium leafiness was indicated in the vegetation period.

We established that not only the grass species, but also the time of grass stands mowing has a significant impact on the green mass yield and dry material collection (table 3).

Table 3. Yield of green mass and collection of absolutely dry material (t/ha) in vegetation periods of perennial legumes (2015–2019).

| Species          | Budding period | Beginning of flowering |
|------------------|----------------|------------------------|
|                  | Green mass     | Absolutely dry mass    | Green mass | Absolutely dry mass |
| Meadow clover    | 31.2           | 5.5                    | 24.4       | 6.4                |
| Hybrid clover    | 26.5           | 4.6                    | 21.8       | 5.7                |
| Sickle alfalfa   | 30.7           | 6.1                    | 25.7       | 7.2                |
| Bird’s foot trefoil | 22.1         | 3.9                    | 20.4       | 4.5                |

In mowing during the budding period and in the beginning of flowering, the biggest yield of absolutely dry material per hectare was obtained from meadow clover. Sickle alfalfa was superior to meadow clover when grass mass was mowed in the beginning of flowering.

The quality of the fodder mass of legumes also depends on the mowing time. Thus, when mowed in the budding period, the crude protein in terms of absolutely dry material was 15.9% in meadow clover, 17.4% in hybrid clover. The lowest protein content was in bird’s foot trefoil - 14.4% (table 4).

Table 4. Chemical composition of perennial legumes (2015–2019), % in dry mass.

| Species           | Vegetation period | Protein | Crude protein | Crude fat | Crude fiber | Crude ash |
|-------------------|-------------------|---------|---------------|-----------|-------------|-----------|
| Meadow clover     | budding           | 15.2    | 15.9          | 2.8       | 25.6        | 7.0       |
|                    | budding – beginning of flowering | 18.9    | 17.1          | 2.5       | 28.4        | 6.5       |
Hybrid clover budding 17.6 17.4 2.4 21.8 7.8
budding – beginning of flowering 18.3 20.7 2.1 36.3 6.5

Sickle alfalfa budding 22.5 19.5 1.2 20.1 5.5
budding – beginning of flowering 20.9 21.9 1.0 25.4 6.7

Bird’s foot trefoil budding 22.1 15.4 3.6 20.1 5.4
budding – beginning of flowering 18.5 18.6 3.0 23.5 6.2

In sickle alfalfa, the highest content of nutritious substances was observed when mowing in the budding period: protein – 19.5%, fiber – less than 20%, carotene – 219 mg per 1 kg of absolutely dry material. Moreover, from mowing to mowing, the nutritional value of sickle alfalfa increased. In the first mowing of the grass stand in the budding period, the absolutely dry material of sickle alfalfa contained over 19% of crude protein, while in the second moving – 21% (respectively, carotene was 124 and 342 mg per 1 kg).

At the beginning of flowering in sickle alfalfa, the protein content significantly decreases and the amount of fiber noticeably increases. The carotene content during this period was 230 mg per 1 kg of sickle alfalfa and 172 mg – in bird’s foot trefoil. With age, the content of ash, crude fat, calcium, potassium and phosphorus in plants of sickle-shaped alfalfa decreases significantly in comparison with clovers and bird’s foot trefoil.

4. Conclusion
The vegetation period of perennial legumes depends on the beginning of spring regrowth and favorable weather conditions before budding, these factors determine the period before mowing ripeness.

Shooting of the studied legume species vary depending on the growing season conditions and morphological characteristics of growth and development.

Sickle alfalfa is characterized by high nutritional value when plants are mowed in the budding period; however, the maximum accumulation of aboveground mass in this crop occurs during the period of mass flowering. During the mass flowering, growth processes slow down as the nutrients outflow to the roots. The high content of nutrients is observed when mowing grass during the budding period, which makes it possible to prepare high-protein feeds.

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