Evaluation of long-term pasture chemical composition and productivity

L P Baikalova, I A Gorbachev, Yu F Yedimeichev, A I Mashanov, S G Smolin and N A Tabakov

FGBOU VO “Krasnoyarsk State Agrarian University of the Ministry of Agriculture of Russia”, 90, Mira ave., Krasnoyarsk, 660099, Russia

Abstract. The assessment of perennial legume-grass plants for pasture purposes was carried out on the basis of data from field experience conducted in the forest-steppe of Krasnoyarsk region and data from a qualitative analysis of pasture grass mixtures. The content of macronutrients: calcium, phosphorus, magnesium; green mass yield, collection of dry matter and feed units in three grazing cycles were determined. The chemical composition and productivity of pastures were depended on the type of grass, the cycle of grazing and the composition of the mixture. It was noted an increase in the calcium content in grass mixtures by 3.2–3.9 times to the control of red fescue. The phosphorus content in pasture feeds was at the control level. A higher content of magnesium in comparison with the control was found in the herbal mixture of brome + cat’s-tail grass + red fescue + goat’s-rue + clover. A grass mixture of brome + cat’s tail grass + red fescue + lucerne was the best in terms of yield of green mass, collection of dry matter and feed units.

In single-species stands, even using various fertilizers containing macro- and microelements, it is not possible to synthesize all the food elements, which are necessary for the animal organism, in one plant. This task is successfully solved in mixed crops. In addition to the fact that grass stands give above 15-470% yields, the quality of green fodder is much higher. Animals are more willing to eat grass stands including many species from grass families of cereals and legumes [1, 2]. For livestock breeding, not only quantity is important, but mainly feed quality, i.e. their value, determined by the content of nutrients. Full-fledged diets and feeds are those that contain all the substances which are necessary for the animal’s body and are able to provide normal functions of all its physiological functions for a long time [3].

Such macroelements as calcium, phosphorus, magnesium are the most important components of the feed. Calcium and phosphorus are the main elements that make up the body of an animal. Most of them are found in bones. If young cattle have a lack of calcium and phosphorus it delays their growth and development. At the same time, their limbs and backs are bent, i.e. the characteristic signs of rickets are manifested. In adult animals, a lack of calcium and phosphorus leads to a decrease in productivity (dairy, meat, wool, egg). With a lack of calcium and phosphorus, the reproduction of animals worsens, the number of cases of excesses, barrenness, abortion, the birth of a weak or dead offspring increases. Calcium eliminates the harmful effects of excess sodium, potassium, magnesium and other elements and has a beneficial effect on iron metabolism [4].

Magnesium in the animal body is involved in creating normal acid-base balance and osmotic pressure in body fluids and tissues, and also provides the functional ability of the neuromuscular system. This element is a part of enzymes and acts as their activator, and also regulates oxidative phosphorylation and is involved in thermoregulation. Magnesium ions have an inhibitory effect on the...
function of the nervous system, which is eliminated by the introduction of calcium ions into the blood. A lack of magnesium in feed diets can lead to animals’ excitability, tetany, and in severe cases, to hypomagnesemia, and even to animal’s death. Animals need relatively small amount of magnesium. For example, a dairy cow needs an average of 20-40 g of magnesium per day, depending on the daily milk yield, calves up to 6 months of age need 1-7 g, young cattle - 10-25 g per day, depending on age and average daily growth [5].

The issues of quality and productivity of pasture feeds are still of great importance and have not been studied. Taking into account the importance of the food supply in ensuring food security in Russia in particular and the world as a whole, the high relevance of the topic chosen for the research is noted.

The purpose of the work is to determine the chemical composition and productivity of perennial cereal and bean herbs when cultivated in a pure form and in the mixtures for pasture use.

The main tasks of this research are the following:

1) to assess perennial legume-cereal herbs by the content of such macroelements as calcium, phosphorus and magnesium;
2) to assess pasture grasses and grass mixtures by the yield of green mass, the collection of dry matter and feed units in three grazing cycles.

The experiment was laid on the experimental field of the Department of Horticulture at Borsk Scientific and Practical Center of Krasnoyarsk State Agrarian University on May 12, 2011 before the massive precipitation, which is optimal for Krasnoyarsk forest-steppe. The area of each experiment option is 700 m²; the method of sowing is ordinary, SSFK sowing-machine - 7. Field studies were conducted in 2014, 2015 and 2016. The soil of the experimental plot is represented by leached black humus earth.

Laying the experiments and their observations were carried out according to the methodology of All-Russian Williams Fodder Research Institute [6]. Statistical processing of the results was carried out according to the methodology of B.A. Dospekhov [7] using SNEDECOR statistical software package with the help of "One-way analysis of variance" and "Multi-factor analysis of variance" programs. The yield was determined in three grazing cycles. To do this, in four places of each land diagonally on specially fixed meter sites, green mass censuses were carried out three times: in June, July and August-September. The yield of green mass was determined in a continuous way during the branching phase - the beginning of budding of leguminous herbs. Qualitative analysis of pasture mixtures was carried out in the research and testing center for quality control of agricultural raw materials and food products of Krasnoyarsk State Agrarian University. Perennial herbs in pure form and in the form of mixtures were the objects of the research. The following herbs were used for the study: smooth brome, cat’s-tail grass, meadow fescue, red fescue, bastard lucerne, fodder galega, meadow clover and their mixtures in different percentages of the seeding rate recommended for the forest-steppe zone (Table 2).

The zone of Krasnoyarsk forest-steppe, where Borsk Scientific and Practical Center is located, is a part of the central agricultural territory of the region, located on the left bank of the Yenisei River, to the north of Krasnoyarsk. The climate of the zone is continental. Typically, the level of moisture in the territory is confirmed by the value of the hydrothermic coefficient (HTC). For the period of active vegetation, this indicator, according to long-term data, is 1.3, which corresponds to moderate hydration. According to long-term data, the average air temperature for the period from May to September was the following: May - 8.9°C, June - 17.5°C, July - 20.0°C, August - 16.7°C, September - 8.7°C. However, 2014 was characterized by slightly lower air temperatures from May to September, therefore the summer was cool. 2015, on the contrary, was hot, since for all months there was an increase in air temperature. 2016 was at the level of multi-year data. According to long-term data, the amount for the vegetation was 1960°C, but in 2014 this amount was slightly more than 1977°C and was characterized by hot weather. In 2014, 2015 the amount of precipitation during the vegetation exceeded the norm, which indicated hot, but rainy weather. The distribution of temperatures and precipitation over the months of the growing season was extremely uneven. The average annual
precipitation for the period from May to September was 258 mm; over the same period, during the years of research, the average precipitation was from 202 mm in 2016 to 301 mm in 2014. Summarizing, we can note sufficient moisture in 2014, moderate moisture in 2015 and insufficient moisture in 2016. The year of 2015, according to the HTC indicator, was corresponded to the norm, 2016 was lower, and 2014 was higher than the norm.

Significant variation in the calcium content in the dry matter was noted, both depending on the year, the grazing cycle, and the experiment variant. For example, in the first grazing cycle, the calcium content of the red fescue control ranged from 0.38% in 2014 to 0.61% in 2015. The greatest variation in calcium in the first grazing cycle was observed in the following grass mixture: smooth brome + meadow fescue + red fescue + bastard Lucerne, from 1.08% in 2016 to 2.28% in 2014. The calcium content in the dry matter of pasture fodder increased from the first to third grazing cycles (Table 1).

**Table 1.** The content of macronutrients in the dry matter of perennial pasture grasses, 2014-2016, %.

| Culture, grass mixture | Ca (calcium) | P (phosphorus) | Mg (magnesium) | Average |
|------------------------|--------------|----------------|----------------|---------|
|                        | 1* 2* 3*     | 1 2 3          | 1 2 3          | Ca P Mg |
| 1. Red fescue          | 0.52 0.50 0.87 | 0.83 0.69 0.54 | 0.31 0.33 0.47 | 0.63 0.69 0.37 |
| 2. Meadow fescue       | 0.82 0.78 1.00 | 0.88 0.64 0.46 | 0.30 0.41 0.67 | 0.87 0.66 0.46 |
| 3. Cat’s-tail grass    | 0.48 0.45 0.85 | 0.88 0.80 0.47 | 0.26 0.37 0.39 | 0.59 0.72 0.34 |
| 4. Brome + meadow fescue + red fescue + lucerne | 1.72 2.53 3.04 | 0.87 0.85 0.53 | 0.41 0.54 0.61 | 2.43 0.75 0.52 |
| 5. Brome + cat’s tail grass + red fescue + lucerne | 1.79 2.79 2.80 | 0.87 0.76 0.48 | 0.43 0.42 0.61 | 2.06 0.70 0.49 |
| 6. Brome + cat’s tail grass + red fescue + galega + clover | 1.37 1.88 2.80 | 0.85 0.67 0.46 | 0.71 0.52 0.64 | 2.02 0.66 0.62 |
| LSD0.05 A grass mixture | 0.43 0.73 0.50 | 0.16 0.21 0.16 | 0.41 0.28 0.26 | 0.58 0.09 0.15 |
| LSD0.05 B year         | 0.30 0.52 0.35 | 0.12 0.15 0.12 | 0.29 0.20 0.19 | 0.41 0.06 0.11 |

* Notes: 1 – the first grazing cycle; 2 – the second grazing cycle; 3 – the third grazing cycle.

The average calcium content in the single-species crops of meadow fescue and cat’s-tail grass was at the control level. The studied perennial legumes and cereal mixtures significantly exceeded the control in the average calcium content: smooth brome + meadow fescue + red fescue + bastard lucerne (option 4) - 1.8%; smooth brome + bastard lucerne (option 4), red fescue + lucerne (option 5) - 1.43%; smooth brome + cat’s tail grass + red fescue + fodder galega + red clover (option 6) - by 1.39%. The phosphorus content in the dry matter of pasture feed was minimal in 2016, maximum in 2014 in the first and second grazing cycles. So, in a grass mixture, smooth brome + cat’s tail grass + red fescue + bastard lucerne (option 5) in the first grazing cycle, the phosphorus content was 1.22%, 0.95% and 0.44%; in the second grazing cycle - 0.90%, 0.90% and 0.48% in 2014, 2015 and 2016, respectively. In the third grazing cycle, the variation in the phosphorus content in the studied variants was smaller. For example, in option No. 5, it was 0.54% in 2014, 0.36% in 2015, and 0.53% in 2016. The phosphorus content in single-species and mixed crops of perennial leguminous-grasses was on the control level both in the first, second, third grazing cycles, and an average of three cycles (table 1).
Figure 1. Collection of fodder units of perennial grasses by grazing cycles, thousand / ha

Notes: 1 - red fescue, control; 2 - meadow fescue; 3 - cat’s tail grass; 4 - brome + meadow fescue + red fescue + lucerne; 5 - brome + cat’s tail grass + fescue + lucerne; 6 - brome + cat’s tail grass + red fescue + galega + red clover.

There were no significant differences on average for 3 grazing cycles in magnesium content between the red fescue control and the experiment variants (table 1). Differences by years and grazing cycles were revealed. The grass mixture of smooth brome + cat’s tail grass + red fescue + bastard lucerne + fodder galega + red clover was exceeded the control of fescue in the first grazing cycle in 2015. Over the years, in the second grazing cycle, significant differences in the magnesium content were observed in the control of meadow fescue, and also in all the studied grass mixtures, with the exception of cat’s-tail grass. In the third grazing cycle according to the years of study, significant differences in the magnesium content were observed in the control of red fescue, meadow fescue,
grass mixture of smooth brome + meadow fescue + red fescue + bastard lucerne; grass mixtures of smooth brome + cat’s-tail grass + red fescue + bastard lucerne.

The collection of feed units depended on the content of feed units in the dry matter of the feed, the weather conditions of the studied years and the grazing cycle. In the first grazing cycle in 2014 and 2015, the collection of feed units of grass mixtures was significantly higher than that of the control level. In 2014 - 2016 according to this indicator, one-species crops were at the level of control of red fescue. In 2016, the red fescue exceeded the 4th and 5th options by 1.98 thousand / ha and 2.54 thousand / ha in gathering feed units in the first grazing cycle.

Table 2. The influence of the species composition of perennial legumes-cereal grasses on productivity of pastures for three grazing cycles, 2014-2016.

| Culture, mixture, percent of the seeding rate in its pure form | Green mass yield | Dry matter collection | Collection of feed units |
|---------------------------------------------------------------|------------------|-----------------------|--------------------------|
|                                                               | Thd./ha increase in control, % | Thd./ha increase in control, % | Thd./ha increase in control, % |
| 1. Red fescue, 100 % control                                  | 7.55 -0.55       | 2.19 -0.46            | 1.42 0.88               |
| 2. Meadow fescue, 100 %                                      | 7.73 0.25        | 2.09 -0.70            | 1.54 8.66              |
| 3. Cat’s-tail grass, 100 %                                   | 7.03 -6.89       | 1.98 -9.68            | 1.34 -5.49            |
| 4. Brome 35 % + meadow fescue 70 % + red fescue 50 % + lucerne | 29.20 286.75     | 8.28 277.63           | 7.10 400              |
| 5. Brome 35 %+ cat’s-tail grass + red fescue + lucerne        | 30.41 302.65     | 8.64 294.06           | 7.63 437.32           |
| 6. Brome + cat’s-tail grass + red fescue + galega + red clover| 22.60 199.34     | 5.80 164.39           | 4.80 237.75           |
| LSD<sub>05</sub> A mixture                                    | 1.24 -0.32       | 0.32 -0.26            | 0.26 -                |
| LSD<sub>05</sub> B grazing cycle                             | 0.88 -0.23       | 0.23 -0.19            | 0.19 -                |
| LSD<sub>05</sub> A + B                                       | 2.14 -0.55       | 0.55 -0.46            | 0.46 -                |

In the second and third grazing cycles in all years of the study of grass mixtures, they significantly exceeded the cereal control for the collection of feed units. The single-species crops for collecting fodder units were at the control level, with the exception of cat’s tail grass in the third grazing cycle in 2016, the collection of fodder units of which was lower than that of the control level (Figure 1).

Grass mixtures of long-term pastures significantly exceeded cereal control of fescue in terms of yield of green mass, collection of dry matter and feed units. The meadow fescue was superior in yield to green mass and the collection of fodder units than the red fescue, losing to it in collecting dry matter. Cat’s-tail grass was inferior to control in all presented productivity indicators (table 2).

1. The content of macronutrients and productivity depended on the weather conditions of research years, the grazing cycle, the species composition of herbs and grass mixtures, and the ratio of components in mixtures.

2. An increase in the calcium content in perennial legume-cereal mixtures was noted. All the studied grass pasture mixtures exceeded the red fescue control in calcium content by 3.2-3.9 times. The magnesium content increased from the first to the second grazing cycle. Depending on the species composition, the phosphorus content in the pasture feed did not change; it was at the control level. The phosphorus content in the dry matter of perennial grasses and grass mixtures decreased from the first to the third grazing cycle. In terms of magnesium content, on average, over three control cycles the mixture of smooth brome + cat’s-tail grass + red fescue + fodder galega + red clover exceeded the red fescue by 0.25%. The magnesium content increased from the first grazing cycle to the third, with the exception of the grass mixture of smooth brome + cat’s-tail grass + red fescue + fodder galega + red clover, which has the highest magnesium content in dry matter in the first grazing cycle of 0.71% with similar indicators in the second and the third grazing cycles - 0.52% and 0.64%.
3. The collection of feed units varied significantly depending on the crop cycle and weather conditions of the research years. Greater mixtures of feed units were higher in comparison with the red fescue control.

4. On average, for the three grazing cycles, the best in terms of green mass yield, dry matter collection and collection of fodder units were pasture mixtures of smooth brome + cat’s tail grass + red fescue + bastard lucerne: 30.41 t / ha, 8.64 t / ha, 7.63 thousand / ha and smooth brome + meadow fescue + red fescue + bastard lucerne: 29.20 t / ha, 8.28 t / ha, 7.10 thousand / ha. The additions of the above mixtures in terms of green mass to control red fescue were 303% and 287%, for the collection of dry matter - 294% and 278%, for the collection of feed units - 437 % и 400 %.

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