Festulolium plant yield, nutritive and energy value depending on its variety

V N Obraztsov*, S V Kadyrov and D I Shchedrina

Voronezh State Agrarian University named after Emperor Peter the Great, Faculty of Agricultural Science, Department of Soil Management, Crop Science and Plant Protection, d. 1, Mitchurina St., Voronezh, 394087, Russia

*E-mail: oceannn@mail.ru

Abstract. The presented research is the first to study the fodder productivity, nutritive and energy value of new varieties of Festulolium of different morphotypes in the conditions of the forest-steppe of the Central Chernozem Region of Russia. In the green mass of the studied varieties crude protein content was quite low ranging from 6.2 to 9.7%, which was 1.4-2.3 times lower than required by zootechnical norms for cattle feeding. The studied varieties of Festulolium were distinguished by a rather high content of soluble sugars, which was 14.7-19.4%. The Viknel variety contained more digestible protein (68.74-76.01 g), but this value did not differ much from other varieties, in which it ranged from 64.78 to 72.47 g/kg of green mass. Among the studied varieties of Festulolium the highest yield of green mass was obtained in the second and third years of grass stand life. Productivity of the Izumrudnyi fescue-type mowing variety reached 40.31-44.09 t/ha, which was 1.3-1.9 times higher than that of ryegrass-type mowing-and-grazing varieties, the yield of which was 23.07-31.24 t/ha.

1. Introduction

It is known that successful fulfillment of highly productive genetic potential of animals is largely determined by the quality of fodder base, since their productivity depends on feeding by almost 60%. First of all, we are talking about the amount of metabolic energy and crude protein obtained with fodder.

Creation of a solid forage base allows increasing the productivity of animal husbandry and meeting the growing needs of the population for meat, milk and other livestock products [7]. The problem of increasing the production of high-quality fodder and creating a reliable fodder base is especially relevant for the Central Chernozem Region, where 2.5-3.5 million hectares of the total arable land are being allocated annually for the production of succulent and green fodder, hay and haylage. Perennial grasses play a leading role in solving the problem of obtaining complete feeds balanced in protein, essential amino acids and vitamins. Therefore, it is advisable to feed them ad libitum: on pastures in summer and in the form of haylage, hay, or silage from prewilted grasses in winter. The advantage of feeds made of perennial grasses is their high digestibility (over 75%) of the main nutrients, including protein [4, 17]. They serve as the basis for biologizing agriculture, increasing soil fertility, protecting it from wind and water erosion, and increasing the environmental safety and sustainability of cheap feed production [8, 15, 18].

Grasses that are traditional for the Central Chernozem Region and are used in grassland management (e.g. timothy, cock’s-foot, meadow fescue, awnless brome, etc.) are characterized by
insufficient content of water-soluble carbohydrates, extensive rate of regrowth after regular cycles of defoliation, and summer growth depression. In this regard, it is important to expand the range of forage crops by creating, introducing and adapting in production conditions the new species and varieties with better economically useful properties [11, 16].

Festulolium is one of the most resistant and productive species among perennial grasses, especially during the seasons characterized by unfavorable weather conditions. It is a promising crop that meets the high requirements imposed on species being used for creating a high-quality fodder base [1, 6, 20].

A number of researchers [5, 11] note that Festulolium has a better palatability and digestibility compared to other types of grasses, since it forms a large number of tender folious shoots. Hay made from Festulolium has a green color, a flavorful hay smell, and a folious structure. Festulolium increases the productivity of dairy cows grazing on the pasture. When using grass mixtures that contain fescue-ryegrass hybrid, a more uniform supply of high-quality green mass is achieved during the season, and it is possible to use the grass stand for conservation of various forages, as well as for grazing [10, 14]. This allows using Festulolium both in its pure form and in grass mixtures for making hay, haylage and silage, as well as for creating long-term hayfields and pastures [2-3, 9, 12, 19].

In recent years, in connection with the creation of new Festulolium varieties, it has become necessary to study them taking into account the regional adaptability and intended purpose of the phytocenosis. In the Central Chernozem Region the biological potential and zootechnical assessment of grass stands created from various Festulolium varieties have not been studied before. This circumstance determined the objective of our research and the specialized experimental design.

2. Materials and methods

Experimental part of the study was performed in 2007–2012 in field trials of the Department of Soil Management, Crop Science and Plant Protection, Voronezh State Agrarian University on the plots of ‘Agrotechnology’ Training, Research and Technological Center (N51.7140416 E39.21545371).

The soil in the experimental plot was leached medium loamy chernozem containing 4.56–5.50% of humus, 78-129 g·kg⁻¹ of labile phosphorus (P₂O₅), 109-118 mg·kg⁻¹ of exchangeable potassium (according to Chirikov), pH_{salt} was from 4.9 to 5.1, the total absorbed bases was from 21.3 to 22.2 mg-eq. per 100 g of soil, and the degree of base saturation was of 74-86%.

The preceding crop for Festulolium was the vetch-oat mixture harvested for green fodder.

The preparation of soil for sowing was conventional for creating seed herbages of perennial grasses in the Central Chernozem Region.

The object of research included six Festulolium varieties of different morphotypes: the Aelita, VIK-90, Viknel, Debut, Izumrudnyi, and Sinta. These varieties were created in the Russian plant breeding centers, included into the State Register of the Russian Federation, and admitted for cultivation in the Central Chernozem Region.

Plants of the studied varieties of Festulolium belong to different morphotypes: ryegrass or fescue. According to its biological features the tetraploid VIK-90 variety (meadow fescue × Italian ryegrass) belongs to the ryegrass morphotype. The hexaploid Izumrudnyi variety (tall fescue × annual ryegrass) is of the fescue morphotype. The Debut, Sinta, and Aelita tetraploid varieties were created in the Ural Breeding Center using the parent material obtained from the Laboratory of Cytology and Genetics of V.R. Williams All-Russian Fodder Research Institute. Their morphotype is closer to perennial ryegrass. The Viknel variety (Italian ryegrass × meadow fescue) was bred at Stavropol Research Institute of Agriculture.

The seeding rate was 12.0 kg per hectare with the skip-row planting system (at 30 cm). The experiment was laid in 4 replicates with the randomized location of the plots. The area of the registration plot was 20 m². Field observations and green mass crop inventories were made in accordance with generally accepted methodological guidelines [13].
3. Results and discussion
One of the objectives of our research was to study the chemical composition and nutritive value of fodders harvested from various Festulolium varieties (Table 1).

Table 1. Content of nutrients and soluble sugars in Festulolium fodder depending on variety. %DM (average for the 2007-2012 period).

| Variety | Crude protein | Crude fiber | Crude ash | Crude fat | Soluble sugars |
|---------|--------------|-------------|-----------|-----------|---------------|
| VIK-90  | 6.4-7.2      | 21.5-22.8   | 6.2-7.2   | 3.4-4.3   | 15.6-18.0     |
| Izumrudnyi | 8.6-8.8    | 21.5-22.8   | 5.5-7.5   | 3.1-4.1   | 16.5-17.3     |
| Sinta   | 8.0-8.8      | 20.0-21.7   | 5.4-6.9   | 3.1-4.1   | 15.5-18.0     |
| Debut   | 9.4-9.7      | 20.5-24.7   | 5.9-7.7   | 3.0-4.1   | 16.2-17.2     |
| Viknel  | 8.1-8.8      | 21.9-23.7   | 5.4-9.3   | 2.4-5.4   | 14.7-18.6     |
| Aelita  | 6.2-7.7      | 22.3-23.7   | 5.6-8.3   | 2.7-5.0   | 15.3-19.4     |

In all years of vegetation crude protein content in the green mass of the studied varieties was quite low ranging from 6.2 to 9.7%, which was 1.4-2.3 times lower than required by zootechnical norms for cattle feeding. The highest crude protein content was registered in the Debut variety. It is known that protein content is the most important indicator of fodder quality, and its lack leads to a decrease in dairy and meat productivity of animals. Therefore, it is advisable to cultivate Festulolium for fodder sowing it together with legume grasses.

Fiber content in fodder dry matter met the requirements of TU 10.01.701-88 and was in the range of 20.0-24.7%. The amount of crude fat in the green mass of the studied varieties was quite high (2.4-5.4%). Crude ash content was at the level of 5.4-9.3% depending on the variety and year of vegetation.

The studied varieties of Festulolium were distinguished by a rather high content of soluble sugars, which was 14.7-19.4%.

Table 2 presents the data on energy value, minerals and carotene content in the green mass of different Festulolium varieties.

Table 2. Energy value of Festulolium fodder depending on variety (average for the 2007-2012 period).

| Variety | Feed units | Metabolic energy, MJ | Digestible protein, g | Calcium, g | Phosphorus, g | Carotene, mg |
|---------|------------|----------------------|-----------------------|------------|---------------|--------------|
| VIK-90  | 0.80-0.85  | 9.93-10.25           | 66.33-69.03           | 4.03-5.76  | 2.52-2.69     | 69-75        |
| Izumrudnyi | 0.80-0.83 | 9.93-10.12           | 67.71-71.83           | 4.23-5.38  | 2.52-2.73     | 68-75        |
| Sinta   | 0.78-0.85  | 9.81-10.23           | 67.18-68.87           | 3.97-5.24  | 2.58-2.79     | 69-74        |
| Debut   | 0.76-0.82  | 9.66-10.06           | 66.47-70.42           | 4.18-5.22  | 2.39-2.78     | 65-70        |
| Viknel  | 0.78-0.82  | 9.81-10.06           | 68.74-76.01           | 3.89-4.37  | 2.61-2.80     | 63-75        |
| Aelita  | 0.78-0.81  | 9.80-10.00           | 64.78-72.47           | 3.97-6.35  | 2.58-2.77     | 59-71        |

Our studies showed that the number of feed units in Festulolium fodder ranged from 0.76 to 0.85. Metabolic energy content was at the level of 9.66-10.25 MJ. The Viknel variety contained more digestible protein (68.74-76.01 g), but this value did not differ much from other varieties, in which it ranged from 64.78 to 72.47 g/kg of green mass.

Though having no energy value, minerals (calcium and phosphorus) play a significant role in metabolism in the body of animals. The content of minerals per 1 kg of green mass of Festulolium was quite high and amounted to 3.89-6.35 g for calcium and 2.39-2.80 g for phosphorus. These amounts provide a well-balanced diet rich in these micronutrients. Carotene content in the studied varieties was at the level of 59-75 mg/kg.

In the cultivation of the studied Festulolium varieties for fodder purposes the experimental plots were used as hayfields. In the first year of vegetation two mowing cycles were performed due to low
productivity. The greatest proportion of crop harvest (64-70%) was obtained in the first mowing cycle. Ryegrass-type mowing-and-grazing varieties (VIK-90, Sinta, Debut, Viknel, Aelita) yielded the total of 4.21-6.88 t/ha of green mass over two mowings. The productivity of fescue-type Festulolium (Izumrudnyi) was 1.5-2.5 times higher and amounted to 10.52 t/ha (Table 3).

Table 3. Productivity of green mass of Festulolium depending on variety.

| Experimental variants | Cycle 1 | Cycle 2 | Cycle 3 | Total |
|-----------------------|---------|---------|---------|-------|
|                       | Yield of green mass, t/ha | Harvest share, % | Yield of green mass, t/ha | Harvest share, % | Yield of green mass, t/ha | Harvest share, % | Yield of green mass, t/ha |
| VIK-90                | 3.43    | 69.5    | 1.50    | 30.5  | -     | -     | 4.93  |
| Izumrudnyi           | 6.73    | 63.9    | 3.80    | 36.1  | -     | -     | 10.52 |
| Sinta                | 4.70    | 68.4    | 2.17    | 31.6  | -     | -     | 6.88  |
| Debut                | 2.94    | 69.9    | 1.26    | 30.1  | -     | -     | 4.21  |
| Viknel               | 3.75    | 68.2    | 1.74    | 31.8  | -     | -     | 5.49  |
| Aelita               | 3.89    | 69.6    | 1.70    | 30.4  | -     | -     | 5.58  |
| LSD$_{05}$           | 0.21-0.34 | 0.15-0.25 | -     | -     | -     | -     | -     |
| VIK-90                | 15.53   | 55.4    | 7.48    | 26.7  | 5.00  | 17.8  | 28.00 |
| Izumrudnyi           | 22.76   | 51.6    | 11.82   | 26.8  | 9.51  | 21.6  | 44.09 |
| Sinta                | 16.28   | 53.6    | 8.30    | 27.3  | 5.82  | 19.1  | 30.40 |
| Debut                | 13.10   | 56.8    | 6.20    | 26.8  | 3.78  | 16.4  | 23.07 |
| Viknel               | 14.05   | 57.1    | 6.63    | 26.9  | 3.92  | 16.0  | 24.60 |
| Aelita               | 14.54   | 56.9    | 6.84    | 26.8  | 4.19  | 16.4  | 25.56 |
| LSD$_{05}$           | 0.17-0.49 | 0.20-0.46 | -     | 0.22-0.44 | -     | -     | -     |
| VIK-90                | 13.88   | 50.9    | 8.50    | 31.2  | 4.89  | 17.9  | 27.26 |
| Izumrudnyi           | 19.33   | 48.0    | 12.03   | 29.8  | 8.95  | 22.2  | 40.31 |
| Sinta                | 15.58   | 49.9    | 9.54    | 30.5  | 6.12  | 19.6  | 31.24 |
| Debut                | 12.84   | 53.3    | 7.59    | 31.5  | 3.67  | 15.2  | 24.10 |
| Viknel               | 13.91   | 51.1    | 8.46    | 31.1  | 4.83  | 17.8  | 27.20 |
| Aelita               | 14.00   | 51.2    | 8.62    | 31.5  | 4.75  | 17.4  | 27.38 |
| LSD$_{05}$           | 0.31-0.50 | 0.25-0.48 | -     | 0.30-0.41 | -     | -     | -     |
| VIK-90                | 11.39   | 51.2    | 7.87    | 35.4  | 3.00  | 13.5  | 22.26 |
| Izumrudnyi           | 15.67   | 45.0    | 11.81   | 33.9  | 7.37  | 21.1  | 34.85 |
| Sinta                | 13.08   | 50.8    | 8.74    | 33.9  | 3.94  | 15.3  | 25.76 |
| Debut                | 10.21   | 53.4    | 6.88    | 36.0  | 2.03  | 10.6  | 19.12 |
| Viknel               | 11.37   | 51.0    | 7.86    | 35.3  | 3.07  | 13.7  | 22.30 |
| Aelita               | 11.15   | 50.5    | 7.74    | 35.0  | 3.19  | 14.5  | 22.08 |
| LSD$_{05}$           | 0.45-0.58 | 0.28-0.46 | -     | 0.15-0.38 | -     | -     | -     |

In the subsequent years (2nd-4th years of vegetation) three mowing cycles were performed in the forage plots. The greatest proportion of crop harvest (45.0-57.1%) was obtained during the first mowing.

The studied Festulolium varieties gave the highest yield of green mass in the second and the third years of grass stand life. For instance, the productivity of the Izumrudnyi fescue-type mowing variety reached 40.31-44.09 t/ha, which was 1.3-1.9 times higher than that of ryegrass-type mowing-and-grazing varieties, the yield of which was 23.07-31.24 t/ha.
In the fourth year of vegetation the fodder productivity of Festulolium began to decrease. On average the yield of green mass by varieties was 2.3-9.2 t/ha less than in the second and third years of vegetation. The highest yield of 34.85 t/ha was formed by grass stands of the Izumrudnyi variety.

In the first year of Festulolium vegetation its productivity parameters per 1 ha of forage lands were insignificant due to the low yield of varieties (Table 4).

Table 4. Production per 1 hectare of forage lands occupied by Festulolium.

| Variety  | Dry matter yield, t/ha | Crude protein, kg | Metabolic energy, GJ | Feed units | Digestible protein, kg |
|----------|------------------------|-------------------|----------------------|------------|------------------------|
| 1<sup>st</sup> year of vegetation (2007-2010) | | | | | |
| VIK-90   | 1.19                   | 84                | 11.9                 | 961        | 81                     |
| Izumrudnyi | 2.56                 | 226               | 25.7                 | 2,088      | 184                    |
| Sinta    | 1.66                   | 132               | 16.2                 | 1,290      | 114                    |
| Debut    | 1.07                   | 104               | 10.3                 | 809        | 71                     |
| Viknel   | 1.44                   | 126               | 14.2                 | 1,136      | 99                     |
| Aelita   | 1.32                   | 85                | 13.1                 | 1,054      | 86                     |
| 2<sup>nd</sup> year of vegetation (2008-2011) | | | | | |
| VIK-90   | 6.67                   | 479               | 66.9                 | 5,444      | 442                    |
| Izumrudnyi | 9.69                 | 833               | 97.7                 | 7,984      | 680                    |
| Sinta    | 7.18                   | 603               | 73.4                 | 6,086      | 485                    |
| Debut    | 5.45                   | 512               | 54.1                 | 4,346      | 368                    |
| Viknel   | 5.82                   | 471               | 58.5                 | 4,772      | 432                    |
| Aelita   | 5.62                   | 349               | 55.9                 | 4,498      | 364                    |
| 3<sup>rd</sup> year of vegetation (2009-2012) | | | | | |
| VIK-90   | 6.13                   | 417               | 60.8                 | 4,896      | 423                    |
| Izumrudnyi | 8.95                 | 779               | 90.6                 | 7,434      | 606                    |
| Sinta    | 6.87                   | 605               | 68.1                 | 5,466      | 462                    |
| Debut    | 5.82                   | 559               | 58.1                 | 4,697      | 406                    |
| Viknel   | 5.81                   | 488               | 56.9                 | 4,527      | 415                    |
| Aelita   | 6.16                   | 468               | 60.4                 | 4,795      | 415                    |
| 4<sup>th</sup> year of vegetation (2010-2012) | | | | | |
| VIK-90   | 5.22                   | 334               | 53.6                 | 4,448      | 354                    |
| Izumrudnyi | 7.68                 | 676               | 76.2                 | 6,132      | 525                    |
| Sinta    | 6.03                   | 506               | 60.1                 | 4,854      | 409                    |
| Debut    | 4.01                   | 377               | 40.3                 | 3,290      | 282                    |
| Viknel   | 5.49                   | 477               | 55.0                 | 4,465      | 417                    |
| Aelita   | 5.23                   | 345               | 52.3                 | 4,237      | 379                    |

The maximum yield of dry matter, crude protein, metabolic energy, feed units and digestible protein per 1 ha was obtained in the second and third years of grass stand life. In the fourth year all Festulolium varieties demonstrated a decrease in the values of these parameters.

The Izumrudnyi fescue-type mowing variety showed the highest productivity during all years of vegetation. For instance, in the 2<sup>nd</sup>-4<sup>th</sup> years of vegetation its dry matter yield was 7.68-9.69 t/ha, and the amount of produced metabolic energy reached 76.2-97.7 GJ/ha. Moreover, 676-833 kg/ha of crude protein and 6.1-7.9 thousand feed units were obtained.

The productivity of 1 hectare of forage land under ryegrass-type mowing-and-grazing varieties was somewhat lower. For instance, depending on the variety, the yield of dry matter ranged from 4.01 to 7.18 t/ha, which was 1.65-4.06 t/ha less than with the Izumrudnyi variety. The production of metabolic energy and feed units in that case did not exceed 40.3-73.4 GJ/ha and 3.3-6.1 thousand units, respectively.
4. Conclusions
To sum up, Festulolium is a nutritionally valuable fodder crop. When harvested for feed in the early phases of vegetation, it contains a large amount of energy, protein, fat and minerals. It is distinguished by high digestibility and palatability (due to its high sugar content) and has an effect on increasing the productivity of livestock animals. A comprehensive assessment of Festulolium allows recommending it for use in the diets of cattle by fresh feeding, preparation of silage, haylage, and harvesting of various types of hay.

The highest plant yield and nutritive value of green mass of the studied Festulolium varieties are achieved during the second and third years of vegetation. Among the studied varieties the Izumrudnyi fescue-type variety showed the most prominent productivity values in all the years of vegetation.

References
[1] Akgun I, Tosun M & Sengul S 2008 Comparison of agronomic characters of Festulolium, Festuca pratensis Huds. and lolium multiflorum Lam. genotypes under high elevation conditions in Turkey Bangladesh Journal of Botany 37 (1) 1-6 (in English)
[2] Cherney J H, Smith S R, Sheaffer C C & Cherney D J R 2020 Nutritive value and yield of reduced-lignin alfalfa cultivars in monoculture and in binary mixtures with perennial grass Agronomy Journal 112 (1) 352-367 DOI: 10.1002/agj2.20045 (in English)
[3] Esedullaev S & Shatalov M 2016 Effect of various ratios of perennial grasses on their productivity and fodder quality in the Upper Volga region Agricultural intensification systems as the basis for innovative modernization of agricultural production (Suzdal IPK PresSto) 300-305 (in Russian)
[4] Evseeva G, Yakovleva K & Golubeva O 2010 Productivity of legume-grass pasture agrophytocenoses in Karelia Proceedings of Petrozavodsk State University 8 54-56 (in Russian)
[5] Fokin I 2012 Changes in chemical composition of VIK-90 Festulolium during vegetation in peatlands of northeastern Russia Fodder Production 2 18-19 (in Russian)
[6] Humphreys M W & Zwierzykowski Z 2020 Festulolium, a century of research and breeding and its increased relevance in meeting the requirements for multifunctional grassland agriculture Biologia plantarum 64 578-590 DOI: 10.32615/bp.2020.108 (in English)
[7] Kosolapov V & Trofimov A 2010 The role of cultivated pastures in the development of agriculture in Russia In: The role of cultivated pastures in the development of dairy cattle breeding in the Non-Chernozem zone of Russia in modern conditions (GNU VNII Kormov, V.R. Williams All-Russian Fodder Research Institute, RAAS. Moscow) p 10-15 (in Russian)
[8] Kostenko S, Kosolapov V, Pilipenko S & Kostenko E 2016 Selective breeding of perennial grasses for adaptive fodder production Fodder Production 8 35-38 (in Russian)
[9] Kulik M 2009 Effect of different factors on chemical composition of grass-legumes sward Journal of Elementology 14 (1) 91-99 (in English)
[10] Lopez-Gonzalez F, Rosas-Davila M & Celis-Alvarez M D 2017 Milk production under grazing of different pasture grasses in small-scale dairy systems in the highlands of central Mexico Journal of Livestock Science 8 92-97 (in English)
[11] Lukashov V & Isakov A 2016 Productivity and quality of fodder from different Festulolium varieties on gray forest soils of Kaluga Oblast Fodder Production 4 39-41 (in Russian)
[12] Mashyanov M & Ganicheva V 2012 Dependence of herbage yield on the included meadow plant species in the edaphoclimatic conditions of Vologda Oblast Vestnik of Dairy Farming 1 (5) 21-27 (in Russian)
[13] Methodological Instructive Regulations on the Conducting of Research in Seed Production of Perennial Grasses 1989 (Moscow VIK) p 135 (in Russian)
[14] Olszewska M, Grzegorczyk S & Baluch-Malecka A 2019 The effect of different proportions of Medicago media Pers. in mixtures with Festulolium braunii (K. Richt.) A. Camus on the yield and feed value of green fodder Agricultural and Food Science 28 (1) 18-26 DOI: 10.23986/afsci.77222 (in English)
[15] Perepravo N 2010 Current condition and development prospects for seed production of forage grasses Fodder Production 8 30-32 (in Russian)
[16] Perepravo N, Ryabova V & Kulikov Z 2011 Agricultural and biological features of seed production of Festulolium generic hybrids In: Adaptive Fodder Production Prospects (GNU VNII Kormov, V.R. Williams All-Russian Fodder Research Institute, RAAS. Moscow) p 96-100 (in Russian)
[17] Provornaya E & Sedova E 2010 Promising grass mixtures based on the Russian varieties of white clover, perennial ryegrass and Festulolium Fodder Production 12 9-13 (in Russian)
[18] Tyapugin E et al. 2015 Technology of creating perennial herbage with Festulolium in the conditions of Northern European Russia Fodder Production 8 23-27 (in Russian)
[19] Vaiciulyte R & Bacenas R 2008 The productivity and feeding value of mixtures of legumes with Festulolium Zemdirbyste-Agriculture 95 (4) 153-171 (in English)
[20] von Boberfeld W O & Banzhaf K 2006 Yield and forage quality of different ×Festulolium cultivars in winter Journal of Agronomy and Crop Science 192 (4) 239-247 (in English)