Productivity, biochemical composition and nutritional value of trigonella foenum-graecum green mass depending on seeding rates

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Abstract. The article gives a description of a new culture for the southeast of Western Siberia, which can become one of the valuable sources of obtaining high-quality feed. The nutritional and energy value, biochemical composition in terms of the content of organic substances and mineral elements (calcium and phosphorus) of the dry mass are considered. The yield of green mass, the elements of its structure are shown. The research results indicate that Trigonella foenum-graecum grown in the conditions of the southeast of Western Siberia has a high nutritional and energy value of green mass. Reliable differences in the yield of green mass were revealed on average depending on the seeding rates. The maximum crop yield was obtained when sowing at a rate of 2 million/ha. The seeding rate of 3 million/ha ensured the maximum nutritional value of the dry matter.

Keywords Trigonella foenum-graecum; seeding rates; green mass; productivity; quality.

1 Introduction.

Improving the protein balance of the diet of animals is one of the problems of fodder production. It is necessary to expand the area under legumes, as the main source of vegetable protein in order to solve this problem. Legumes are high-quality feed and play an important role in improving soil fertility [1,2].

Fenugreek (Trigonella foenum-graecum) is an annual, self-pollinating legume that is widely cultivated in parts of Europe, North Africa, western and southern Asia, North and South America, and Australia although it is believed to originate in the Mediterranean region. The plant is a dryland crop. It responds well to minimal irrigation applications. It is an important cash crop in India (the leading producer of fenugreek), Morocco, China, Pakistan, Spain, Tunisia, Turkey, Lebanon, Israel, Egypt, Ethiopia, Kenya, Tanzania, etc. [3].

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According to N. A. Vanghele et al (2021), the widespread cultivation of Trigonella foenum-graecum in the world is explained by its high adaptive capacity to variable climatic and growing conditions [4].

A. Tavangar et al (2021) indicates that Trigonella foenum-graecum is suitable for cultivation in areas with moderate to low rainfall. A moderate and cool growing season without extreme temperatures is favorable for better crop development. Researchers note that this plant is quite drought-resistant but sensitive to frost [5].

Trigonella foenum-graecum does not require special soil conditions, but the soil must be able to provide sufficient moisture throughout the growing season [6].

M. Saadatian et al. (2017) proved that Trigonella foenum-graecum grows best in well-drained loamy soil and fairly well in heavy or sandy soils, but it does not adapt to heavy clay. Researchers note the resistance of this crop to saline soils [7,8].

Ahmad A. et al. (2016) note in their work that Trigonella foenum-graecum is a good animal feed [9, 15]. It has been proposed to use it for forage as an alternative to alfalfa or feed peas. Fenugreek seeds and straw are also reported to be superior to other legume seeds and straw as a balanced feed for sheep in in vivo experiments.

The main chemical constituents of fenugreek green mass are fibers, flavonoids, polysaccharides, saponins, polysaccharides and some identified alkaloids, namely trigonelline and choline.

The unique quality characteristic of Trigonella foenum-graecum is that it contains growth-promoting steroids not found in other fodder legumes and can therefore reduce the use of artificial growth promoters. This culture is a rich source of steroidal sapogenins such as yamogenin, tigogenin, and diosgenin [10].

According to H. Niu et al. (2021), feed from Trigonella foenum-graecum has a comparable nutritional value to early flowering alfalfa and has a positive effect on rumen condition, digestibility and weight gain in cattle. In addition, Trigonella foenum-graecum does not cause bloating in beef cattle. Researchers report high efficiency of rumen fermentation resulting in reduced methane production in cattle fed Trigonella foenum-graecu [11]. This observation suggests that fenugreek feed for cattle may be environmentally beneficial by reducing rumen methane production.

The yield and occupied areas of fenugreek crops are inferior to other legumes, which makes the study and development of individual methods of agricultural technology of this crop especially relevant [12].

In the conditions of the Kemerovo region, the production of vegetable protein remains an important problem in animal husbandry. The quantity and quality of which currently does not meet the needs of animal husbandry.

Despite the high nutritional value of Trigonella foenum-graecum, this crop remains unstudied in the forest-steppe area of southeastern Western Siberia.

The purpose of the study is to examine the productivity, biochemical composition and nutritional value of the green mass of Trigonella foenum-graecum plants, depending on the seeding rates in the forest-steppe of the southeast of Western Siberia (on the example of the Kemerovo region-Kuzbass).

2 Materials and methods

The studies were carried out in 2019-2021 on the experimental field of the Kuzbass State Agricultural Academy, located in the forest-steppe zone of the southeast of Western Siberia. The soil is podzolized, heavy loamy chernozem. Physico-chemical indicators of the arable layer of soil 0-20 cm are as follows: pH is 6.8, humus content is 7.93%; availability of mobile phosphorus – 104 mg/kg of soil; exchangeable potassium – 109 mg/kg. The object of the study was Trigonella foenum-graecum. Vegetable crops were the predecessor The experience was laid in three repetitions, the area of the plot was 5 m^2. The location of the plots is sequential. The accounting area of the plot is 1m^2. We studied two seeding rates of 2 million/ha (control) and 3

million germinating seeds per hectare. Sowing row with a row spacing of 30 cm in the second decade of May. The depth of seed placement is 1.5-2 cm. One Shambhala variety was used in the experiment. Records and observations were carried out according to generally accepted methods [14, 15]. The content of organic substances was determined according to the current standards in dried grass: crude protein; crude fat; raw ash; crude fiber; dry matter, natural moisture; calcium and phosphorus content. The collection of metabolic energy, feed units and digestible protein was established by calculation according to the chemical composition of the feed, taking into account its digestibility according to the Guidelines for assessing the quality and nutritional value of feed (Central Scientific Research Institute of Agrochemical Services for Agriculture, 2002). The experimental data were subjected to statistical processing by the method of analysis of variance [11].

3 Results and discussion

We have studied the yield of the vegetative mass of Greek fenugreek (Trigonella foenum-graecum L.) plants. Figure 1 shows the crops. Stems are erect, up to 50 cm tall. Flowers (1-2 in leaf axils) are sessile. The fruit is a bean.

Fig. 1. Trigonella foenum-graecum crops, forest steppe

The height of plants, as well as the weight of 1 plant, the weight of plants per 1 m^2 with an increase in seeding rates, decreased by 1.09, 1.33 and 1.05 times, respectively, in our experiment on average over three years of research. At the same time, it was found that the mass of plants per unit area decreased due to an increase in the number of plants per 1 m^2 (Table 1).

Table 1. Effect of seeding rates of seeds of Trigonella foenum-graecum on the yield and elements of its structure, average for 2019-2021, forest-steppe, Kemerovo region

Index	Units of measurement	Seeding rate	
		2 mln/ha	3 mln/ha
Plant height	cm	25.4	23.1
Number of plants per 1 m^2	pcs.	199.4	248.3
Leafiness of plants	%	58.1	62.3
Weight of 1 plant	g	3.2	2.4

Weight of plants from 1 m^2	g	632.2	604.1
Yield	t/ha	6.3	6.0
Least significant $difference_{05}$ seeding rate/yield	0.15		

Yield was taken into account when mowing Trigonella foenum-graecum in the budding phase in all years of research, by weighing the herbage from the entire plot. At the same time, the plants were analyzed for foliage – the number of leaves in the total green mass. This is one of the important indicators of the nutritional value of fodder crops. According to the results of the research, the most leafy and valuable for animals in terms of palatability were crops with a seeding rate of 3 million/ha. With an increase in seeding rates, the percentage of foliage increases from 58.2% to 62.2%, by 1.07 times.

In the conditions of the forest-steppe of the south-east of Western Siberia, the best seeding rates of Trigonella foenum-graecum for green mass are 2 million germinating seeds per 1 hectare on podzolized heavy loamy chernozem. With a decrease in the seeding rates of seeds of this crop, the yield of green mass was maximum and averaged 6.3 t/ha over three years of research, which is 0.3 t/ha higher than the yield obtained at a seeding rate of 3 million/ha. The analysis of the obtained results showed that the growth in yield was formed due to an increase in the mass of 1 plant and the mass of plants from 1 m^2 preserved for harvesting.

One of the main criteria for the quality of feed is its nutritional value. The indicators of the nutritional and energy value of grass feeds are the content of metabolizable energy, feed units and digestible protein per 1 g of dry matter (Table 2).

The optimal content of more than 10 MJ of exchange energy was obtained in the green mass in the budding phase of Trigonella foenum-graecum at both seeding rates. According to the content of feed units, all variants met zootechnical requirements. 1 kilogram of dry matter contained more than 0.8 feed units.

Analysis of the data obtained during the experiment shows that the highest content of gross energy, metabolic energy and feed units in the dry mass of Trigonella foenum-graecum plants was obtained with an increase in the sowing rates of germinating seeds of this crop. The increase occurs by 1.01 and 1.03 and 1.1 times, respectively. This seeding rate provided an increase in the energy value of the dry mass in comparison with the control variant.

Consequently, in the conditions of the forest-steppe, Trigonella foenum-graecum of the Shambhala variety also has a high fodder value, which is of importance in solving the problem of fodder protein production for the southeast of Western Siberia.

Table 2. Nutritional and energy value of the dry mass of Trigonella foenum-graecum, 2019-2021

Defined indicator	Units of measurement	Seeding rate	
		2 mln/ha	3 mln/ha
Gross energy content	MJ/kg	18,40	18,70
The content of exchange energy	MJ/kg	10,55	10,95
Number of feed units	units/kg	0,89	0,98
Digestible protein	%	14,97	16,39

The high nutritional value of Trigonella foenum-graecum is also determined by its biochemical composition. One of the most important indicators of feed quality is the crude protein content. It was revealed that crude protein in the dry mass of feed increases with an increase in seeding rates. At a seeding rate of 3 million/ha, the highest yield of crude protein was revealed (20.89%), which exceeded the control by 0.4% (Table 3).

Trigonella foenum-graecum not only has a high nutritional value of the dry mass, but is also rich in chemical composition (Table 3). It is believed that to ensure the full nutrition of animals, feed should contain more than 14% of crude protein in 1 kg of dry matter. Both variants of our experiments met this criterion.

Table 3. Influence of seeding rates on the biochemical composition of the dry mass of Greek fenugreek, %, 2019-2021, forest-steppe

Defined indicator	Seeding rate	
	2 mln/ha	3 mln/ha
Mass fraction of natural moisture	82.90	83.42
Mass fraction of dry matter	16.37	16.58
Mass fraction of crude protein	20.49	20.89
Mass fraction of crude fat	2.05	1.81
Mass fraction of raw ash	8.73	11.82
Mass fraction of crude fiber	21.09	17.62
Calcium content	1.07	1.65
Phosphorus content	0.64	0.48
Mass fraction of non-extractive substances	12.15	10.95

On average, over the years of research, the mass fraction of crude protein in dry matter increased in Trigonella foenum-graecum in the budding phase at a seeding rate of 3 million/ha compared to a rate of 2 million/ha and the content of crude fiber decreased. At a seeding rate of 2 million/ha, the content of crude protein was lower by 0.4% than at a seeding rate of 3 million/ha.

The content of crude fiber in the variants was 21.09 - 17.62%, respectively. The highest rates of crude fiber content were obtained with a decrease in seeding rates. Therefore, regulation of the seeding rate leads to a high realization of the adaptive potential of Trigonella foenum-graecum.

4 Conclusion.

The seeding rate influenced the yield, biochemical composition and nutritional value of Trigonella foenum-graecum green mass. On average, for 2019-2021, the highest herbage density (248.3 pcs/m^2) was obtained when cultivated for fodder with a seeding rate of 3 million/ha. A decrease in these norms leads to a reduction in the number of crop shoots per unit area. With an increase in seeding rates from 2 million/ha to 3 million/ha, the height of plants decreases from 25.4 to 23.1 cm, the weight of 1 plant decreases from 3.2 to 2.4 g, the weight of plants per 1 m^2 decreases from 632.2 g to 604.1 g. With an increase in seeding rates, the

percentage of foliage of plants increases by 1.07 times. The optimal seeding rate for green mass is 2 million/ha, which contributes to the formation of a high yield of up to 6.03 t/ha. With a decrease in the seeding rate, the content of crude protein decreases by 0.4%, but the content of crude fiber increases by 3.47%, crude fat by 0.24%.

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