Oilseed flax and alfalfa as sources of nutrient elements in the Central region of non-chernozem zone of Russia

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Abstract. The article presents the results of research for the year 2022. The objects of the research were oilseed flax and alfalfa. Percentages of crude protein, fiber and ash elements were evaluated in the crops. The content of nutrient elements was estimated by infrared spectrometry. In flax the content of the studied elements in seeds was estimated, in alfalfa the content of nutrient elements in green mass after the second cutting was estimated. Among oilseed flax samples, the highest raw protein yield was provided by Raduga variety (3.40 c/ha), it also provided the highest ash element yield among flax samples (0.92 c/ha), and Nilin variety provided the highest fiber yield (2.24 c/ha). Among alfalfa samples, sample Taisia (152.15 c/ha and 154.44 c/ha, respectively) showed the highest values for raw protein and fiber collection, while sample Agnia (54.90 c/ha) was the leader in ash elements collection.

1 Introduction

Flax (*Linum usitatissimum* L.) is one of the most ancient cultures domesticated by man. The exact date of the introduction of flax into culture is still a big question, but already in ancient Egypt, about 3000 BC, linseed oil was used for embalming the mummies of pharaohs, and flax yarn was widely used as a raw material for the production of clothing. Such popularity of flax in ancient Egypt is due to the fact that linen fabric conducts heat perfectly. In agriculture, two main forms are used: intermarriage - oilseed flax (*Linum usitatissimum var. intermedia*), long-stemmed - long-stem flax (*Linum usitatissimum var. elongata*). The interstitial form is characterized by an average length of the stem (50-70 cm), and the flax is 60-120 cm long. This form has a higher branching coefficient than long-stem flax. 15-25 boxes are formed on one plant. On flax, the average number of boxes varies from 2-3 to 10 pieces per stem [14].

Flax oil is considered a unique product. Flax seeds contain about 40-53% fat, which is represented by polyunsaturated acids: alpha-linolenic and linoleic (56% and 16%, respectively), monounsaturated: oleic and eicosan (21% and 0.1%, respectively), as well as

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saturated: palmitic, stearic and arachinic (5%, 1.6% and 0.1% respectively). Depending on the variety, the acid content may vary, as an example, the Nilin variety, which contains 3.9% alpha-linolenic acid in oil. Flax has found application in medicine, its seeds are used as a drug that improves intestinal peristalsis. The products obtained from flax plants have not lost their relevance and are widely used in the textile, food, paint and varnish industry, as well as in medicine.

Do not forget about by-products in the production of oilseed flax. 1 kg of flax oilcake contains 1.15 fodder units. Flax oilcake is considered a high-value product, due to the high content of crude protein (in this indicator, flax is second only to sunflower, cotton and soy).

Alfalfa (*Medicago varia* M.) has been known to mankind for almost 8 thousand years. During this time, it has been used in the production of hay, silage, haylage, green fodder, enzymes, biofuels, food additives, honey on an industrial scale. In addition, alfalfa is a very good fixative of atmospheric nitrogen. In its aboveground part, up to 200 kg / ha of bound nitrogen accumulates annually, and in the underground part from 45 to 200 kg / ha in 3 years. Already from the second year of life, a well-developed root system gives up to 12 t /ha of root mass in the arable layer. A significant increase in nitrogen fixation is given by pre-sowing inoculation of seeds with suitable bacterial strains. The use of mineral and organic fertilizers has a significant impact on the crop, increasing the yield of hay and the amount of laying of the underground part of plants. A powerful root system allows the use of alfalfa both in soil restoration and in anti–erosion measures - dense herbage restrains the leaching processes in the arable layer and does not allow weeds to develop rapidly. For such versatility, balanced composition of nutrients and wide adaptability, manufacturers gave this crop a second name – "Queen of feed" [2, 8].

In addition to the beneficial effect on soil fertility possessed by perennial grasses, reducing the overall density and increasing the proportion of macroaggregates, they are known for their phytosanitary activity [1]. Climatic conditions have a noticeable impact on the development of culture. In the course of a study aimed at studying the chemical composition of alfalfa changeable at the Federal Williams Research Center of Forage Production & Agroecology, ranges of protein and crude fat content were established under average long-term climatic conditions. So, protein is in the range between 17.1 and 20.6%, and crude fat can vary from 2.4 to 3.3%. It was found that excessive waterlogging in autumn slows down the spring regrowth process [5].

The high content of nutrients, in comparison with other feeds, makes alfalfa an attractive crop for widespread use in animal husbandry. The wide ecological plasticity of alfalfa allows it to be grown in high latitudes, demonstrating good yields and low disease incidence [13].

Fiber (microfibers) is a complex polymeric carbohydrate of plant origin, which is part of plant food. It is found in almost all plants, since it is this substance that forms the "skeleton" of cell walls.

Flaxseed contains soluble and insoluble fiber. Of particular value is water-soluble, gel-forming fiber, extremely comfortable for the gastrointestinal tract. The enveloping mucus of water-soluble fiber prevents the stomach contents from passing into the small intestine too quickly, which improves the absorption of nutrients in the small intestine. It acts on the human body a little softer than, for example, the fiber of peas, beans, cabbage and other coarse plant foods, without giving gas formation and bloating [9, 11].

The fiber content of alfalfa varies. If the climatic conditions are close to the typical average annual, then its level is about 27%. With a large number of sunny days and moderate precipitation, fiber indicators are observed at about 20.7%. During a long period of cloudy days with low temperatures and high humidity, fiber indicators can rise up to 37% [5]. Late harvesting of grass is accompanied by a decrease in the quality of feed. The level of cellulose and lignin increases. This is due to the active lignification of the stems, affecting the stems [3].

Protein is the main building material of the body. Proteins are a high—molecular organic substance consisting of alpha-amino acids connected in a chain by a peptide bond. There are two types of proteins: full-fledged and incomplete. Full-fledged proteins include all the essential amino acids that are not synthesized independently in the body.

Flax seeds contain a complete set of the most common amino acids and are characterized by a high content of essential amino acids such as valine, isoleucine, phenylalanine, lysine, leucine, and a low content of methionine and threonine.

The proteins in flaxseed are albumin and globulin. They differ from each other in solubility. Globulins of high molecular weight predominate (58-66%), the proportion of albumins is 20-42% [4,10].

Alfalfa protein is a full-fledged amino acid composition and surpasses many forage crops in its quality. Depending on weather conditions, it can vary from 16.1% to 22.3% with average annual values of about 18.5% [5, 7].

Ash elements are chemical elements that are part of the ash of plants and animals. The ash consists mainly of silicon, aluminum, iron, manganese, calcium, magnesium, phosphorus, sulfur, potassium, sodium and a number of trace elements. Flax seeds contain minerals such as phosphorus, potassium, magnesium, iron, manganese, zinc, calcium, sodium. Especially the seeds are rich in potassium, which they contain about seven times more than bananas in terms of dry weight. Potassium participates in the regulation of the body's water balance, the transport of substances into the cell [15].

In alfalfa, the ash level in different growth phases can vary: 103 g/kg in the stalking phase; 111 g/kg at the beginning of flowering and 98 g/kg at the end of flowering [12, 13]. Most of the ash is contained in the leaves [4]. This has a noticeable effect on the level of the buffer capacity of the dry substance. In one study, a connection was found: with an increase in the ash content by 1%, the buffer volume increases by 0.86 mol/l at the first mowing and by 0.39 mol/l at the second.

2 Materials and methods

The objects of the study were 4 varieties of oilseed flax.

Variety Raduga is a medium–ripened variety (80 days). It is included in the State Register for the North Caucasus (6) region. The mass of 1000 seeds is 6.4-8 g. The potential yield is 22-25 kg / ha. The fat content in seeds is 41.8%.

Variety Nilin is a medium–ripened variety (85-90 days). It is included in the State Register for the Volga-Vyatka (4) and Middle Volga (7) regions. The mass of 1000 seeds is 5.1-5.3 g. The potential yield is 19-22 kg / ha. The fat content in seeds is 41.3-42.1% [3].

Variety Y117 is a medium–ripened variety (80-100 days). It is included in the State Register for the Central (3), Volga-Vyatka (4), Central Chernozem (5), North Caucasus (6), Middle Volga (7), Lower Volga (8), Ural (9), West Siberian (10) and East Siberian (11) regions. The mass of 1000 seeds is 4.6-6.2 g. The potential yield is 27.7 c/ha

Variety LM-98 is a late–ripening variety (102-106 days). It is included in the State Register for the Volga-Vyatka (4), Central Chernozem (5) and East Siberian (11) regions. The weight of 1000 seeds is 5-6.2 g. The average yield is 16.3 kg / ha.

The study of oilseed flax was conducted at the Department of Genetics, Breeding and Seed Production of the Russian State Agricultural Academy named after K.A.Timiryazev in 2022. This experience is based on the RSAU-MTAA field experimental station located in the conditions of the Non-Chernozem zone typical of the central region of Russia. The land use of the station is located in one array with a total area of 40 hectares. The territory is located in the northern part of the city of Moscow, in the central part of the Central Russian Upland, on the southern slope of the Klinsko-Dmitrovsky ridge.

According to the relief, the territory of the stations is a moraine hilly plain on the watershed of the Moscow and Yauza rivers and rises 60 m above the level of the Moscow River.

The soil of the stations is composed of quaternary sediments, under a layer of which Jurassic clays with a thickness of 20-25 m lie. The upper layers (3-5 cm) are leached. The upper horizons with a thickness of 40-50 cm are represented by sandy-coarse-powdered loam. Boulders are found throughout the thickness.

In addition to flax, 4 varieties of alfalfa were studied in the experiment.

Variety Taisiya – It is included in the State Register for the North-Western (2) and Central (3) regions. The bush is semi-erect, the time of the beginning of flowering is average. The average yield in the North-Western region is 68.1 c/ha.

Variety Agnia – Included in the State Register for the Central (3) region. The bush is semi-erect - intermediate. The time of the beginning of flowering is average. The average yield of dry matter in the region is 71.1 c/ha.

Variety Pastbishnaya 88 – It is included in the State Register for the North-Western (2), Central (3), Volga-Vyatka (4), Ural (9), West Siberian (10), East Siberian (11) regions. The bush is semi-erect and erect. Mixed with grasses, the yield of dry mass reaches 120-140 c/ha.

Variety Vega 87 – it is included in the State Register for the regions of the North (1), North-West (2), Central (3), Volga-Vyatka (4), Central (5), North Caucasus (6), Middle Volga (7), Lower Volga (8), Ural (9), West Siberian (10), East Siberian (11), Far Eastern (12). The bush is erect. Growing season: Mid-early, with a short flowering period. The average yield of absolutely dry matter is 100.4 c/ha

The study of alfalfa was carried out in 2022 at the Experimental Field of the Federal Williams Research Center of Forage Production & Agroecology, located 30 km north of Moscow. Varieties of *Medicago sativa* Mart. were evaluated in edaphic conditions characteristic of the Non-Chernozem zone. The soil of the experimental site is sod-podzolic, medium loamy, the humus content according to Tyurin is 1.74%, the pH of the salt extract is 4.71, the total nitrogen content is 0.148%, mobile phosphorus and potassium according to Kirsanov is 298.2 and 100.8 mg/ kg of soil. The site is flooded with rainwater for a short time (2-3 days) during heavy and prolonged surface rains, in the spring the site was under water for a longer time. In some years, alfalfa plants went into winter, covered with an ice crust. The alfalfa herbage was mown in the phase of the beginning of flowering. During the season, 2 mowing was carried out, depending on weather conditions.

Figure 1 shows the meteorological data of the growing season of 2022. Average temperatures are broken down by decades.

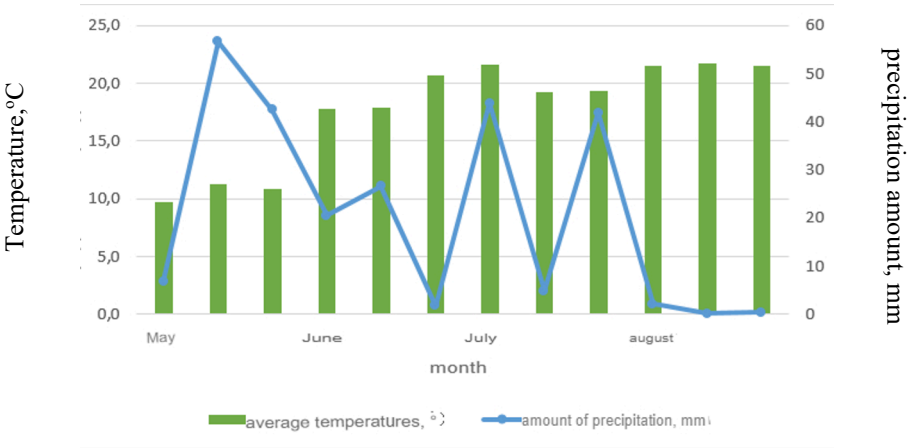

Fig. 1. Meteorological data of the growing season of 2022

As can be seen from Figure 1, the average temperatures in May did not exceed 15℃, and in the first decade the temperature was below 10℃. August turned out to be the warmest month (average temperatures for decades exceeded 21℃). The greatest amount of precipitation fell in the second decade of May.

3 Results

Table 1 shows the results of the collection of nutrients from oilseed flax.

Table 1. Results of research oilseed flax.

Variety of oilseed flax	yield, c/ha	Raw protei n, %	Fiber, %	Ash element s, %	Collectin g raw protein, c/ha	Collectin g fiber, c/ha	Collecting ash elements, c/ha
Raduga	14.37	23.66	13.97	6.42	3.40	2.01	0.92
LM-98	13.4	23.58	11.98	6.76	3.16	1.61	0.91
Y 117	12.93	23.42	13.05	6.75	3.03	1.69	0.87
Nilin	13.1	23.68	17.10	6.71	3.10	2.24	0.88

As you can see from the table, the highest yield in the experiment among the samples of oilseed flax was shown by the Raduga variety with a yield of 14.37 c/ha. The only variety Y 117 zoned for the central region of Russia showed a yield of 12.93 c/ha. In terms of the percentage of raw protein, the Nilin variety was in the lead (23.68%), while the Raduga variety was not much inferior in this indicator (23.66%). In terms of fiber content, the Nilin variety was in the first place (17.10%).

The largest collection of raw protein was provided by the Raduga variety, this indicator turned out to be at the level of 3.40 c/ha. The Nilin variety leads in the collection of fiber per hectare (2.24%).

Table 2 shows the results of the collection of nutrients from alfalfa.

Table 2. Results of research alfalfa.

Variety of alfalfa	yield, c/ha	Raw protei n, %	Fiber, %	Ash element s, %	Collectin g raw protein, c/ha	Collectin g fiber, c/ha	Collecting ash elements, c/ha
Taisiya	572	26.6	27.0	8.3	152.15	154.44	47.48
Agnia	566	22.3	28.2	9.7	126.22	126.22	54.90
Pastbishnaya 88	511	22.8	29.5	10.4	116.51	150.75	53.14
Vega 87	500	22.3	27.5	8.9	111.50	137.50	44.50

As can be seen from Table 2, the highest yield was shown by the Taisiya variety with a yield of 572 kg / ha. According to the results of the second mowing, the highest percentage of crude protein in the green mass was shown by the Taisiya variety 26.6%, Pastbishnaya 88 variety showed the highest result (29.5%) in terms of fiber content.

In the collection of raw protein, the Taisiya variety took the leading position among all other samples (152.15 c/ha), the same variety was in the lead in terms of fiber collection per hectare (154.44 c/ha).

4 Conclusion

In conclusion, it can be noted that oilseed flax and alfalfa remain promising crops for cultivation in the conditions of the Central non-chernozem zone of Russia. The experience we have conducted allows us to consider flax from the feed production side. Therefore, the most promising for cultivation in the central region in our study to obtain a high collection of raw protein per hectare was the Raduga variety, which provides this indicator at the level of 3.40 c/ha. The greatest collection of fiber was provided by the Nilin variety (2.24 c/ha). Among the alfalfa varieties, the most promising was the Taisiya variety, which provides the collection of crude protein at the level of 152.15 c/ ha and the collection of fiber – 154.44 c / ha.

References

1. A.P. Solodovnikov, Agrarian Scientific Journal, **2**, 29-34 (2017)
2. D. Putnam. M. Russell, J. Kuhn, *The Importance and Benefits of Alfalfa in the 21st Century* (Alfalfa and Forage Association, 2001) 24.
3. D.H. Putnam, The alfalfa genome, 13-27 (2021)
4. E.I. Luppova, et al., Proceedings of the Timiryazev Agricultural Academy **6**, 110-119 (2019).
5. G.V. Stepanova, Adaptive feed Production **2**, 26-39 (2019).
6. M. Dragan, et al., Biotechnology in Animal Husbandry **27.4**, 1505-1511 (2011).
7. N.N. Dyukova, L.N. Skipin, Y.P. Loginov. Proceedings of the Orenburg State Agrarian University **2 (100)**, 58-64 (2023).
8. N.N. Lazarev, O. V. Kukharenkova, E. M. Kurenkova, Feed Production **4**, 18-25 (2019).
9. N.N. Muzaffarova, Central Asian Journal of Education and Innovation, **2.6**, 16-22 (2023).
10. N.V. Moskovchenko, S.L. Tikhonov, N.V. Tikhonova, Agroindustrial Complex of Russia, **27.2**, 372-378 (2020).
11. N.V. Serkova, I. S. Polyanskaya. *"The functional potential of flax products in the development of fermented milk drinks*." Problems and prospects of development of science and education in the XXI century (2021).
12. P.J. Rufino-Moya, M. Blanco, J.R. Bertolín, M. Joy. Animals, **9.5**, 197 (2019)
13. V.G. Kosolapova, S.A. Mousier, Fodder production, **(10)**, 17 (2020).
14. V.V. Kolomeichenko, "Field and garden crops of Russia, Legumes and oilseeds", 520 (2018)
15. Yu.Yu. Pomorova, S.K. Ovsepyan, Yu.M. Serova, " Oilseeds, **1 (193),** 73-84 (2023).