

Selection of the starting material of lucerne and clover with increased digestibility of dry matter

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Abstract. The purpose of our research was to study the digestibility of dry matter of lucerne and meadow clover, to develop methods for selecting highly digestible plants and to create a starting material with increased digestibility of dry matter. This paper presents data on the study of the digestibility of drymatter of lucerne and meadow clover, which decreases during the vegetation of plants. The content of the digestible dry matter of lucerne from the staking phase to the beginning of flowering in the first mowing can decrease by 27%, or 1% per day. In the second mowing, the digestibility of various varieties decreases more slowly over the same period – by 10-12% (0.4-0.6% per day). The study of meadow clover varieties of various ploidy and precocity showed that from the staking phase to the full flowering phase, the digestibility of dry matter decreases by 14-23%, or 0.4-0.7% per day. The analysis of collection samples showed that among wild forms and samples of European origin, the difference is 8-10%, and in varieties of American origin it exceeds 19%. Varietal differences in the digestibility of the dry matter of meadow clover reach 21%. The proportion of highly digestible plants in populations varies by year. The probability of meeting lucerne plants with a digestibility of 65% and meadow clover plants with a digestibility of 75% is 0.15-16.0%. The amplitude of fluctuations in the digestibility of dry matter of stems in populations reaches 26%, and leaves – does not exceed 19%.

1 Introduction

In recent years, measures have been taken in the Main directions of economic and social development of the Russian Federation to radically improve feed production, strengthen the feed base primarily by expanding crops of legumes and, in particular, lucerne and meadow clover. To accomplish this task, along with a significant increase in the yield of these types of herbs, it is necessary to improve their quality. An important indicator of the feed value of herbs is the digestibility of dry matter. Breeding plays a special role in increasing digestibility [1-4]. Modern breeding involves the creation and introduction into production of new varieties of intensive type with high digestibility of dry matter [6, 12].

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creation and introduction into production of new varieties of intensive type with high digestibility of dry matter [7].

Research aimed at increasing the digestibility of the dry matter of perennial herbs by selective breeding has not yet been widely spread in our country and is mainly carried out abroad [8, 9, 11, 13]. When creating the starting material of lucerne and meadow clover with increased digestibility, it is necessary to isolate the best forms with their involvement in further breeding work. In this regard, the development of methods for evaluating breeding material and selecting highly digestible forms that accelerate the breeding process is of intense relevance [5, 10].

2 Methodology

For the research, zoned varieties were used: lucerne Kevsala and meadow clover Daryal, as well as varieties of lucerne and meadow clover of domestic and foreign selection from the VIR collection.

The digestibility of dry matter by phases of development was studied on samples from the number of plants with 1m². The content of digestible dry matter on average in the sample was taken as the digestibility of the population. Varietal variability of dry matter digestibility was determined by the analysis of mixed samples, intrapopulation variability was determined by the analysis of individual plants.

When identifying the relationship between the digestibility of dry matter with morphological and economically useful signs, the following indicators were taken into account: roughness of stems, foliage and plant weight; the content of crude protein, crude fiber and carbohydrates.

The selection of highly digestible forms was carried out on the basis of an individual assessment of each plant in samples with increased digestibility. The selected plants were propagated to produce offspring and for the purposes of artificial crossing.

3 The results of the research

The decrease in the digestibility of dry matter as plants develop is mainly due to a significant decrease in the digestibility of stems, this indicator does not change much in leaves. If during the stemming phase these parts of the plants almost did not differ, then in the phase of the beginning of flowering, the digestibility of lucerne leaves exceeded the digestibility of stems by 1.7-2.2 times, in meadow clover – by 1.3 times.

The rate of decrease in the digestibility of dry matter by phases of development depends on weather conditions. With a strong growth of lucerne caused by precipitation after a dry period, high digestibility is observed by the beginning of flowering. The digestibility of the dry matter of meadow clover decreases more slowly in a hot and arid year than in a humid one.

The relationship of the digestibility of dry matter with economically useful and morphological characteristics of plants makes it possible to increase the efficiency of breeding work. The selection of highly digestible forms can be greatly facilitated if digestibility is associated with any indirect indicators.

The digestibility of the dry matter of lucerne plants is more related to the digestibility of stems ($r=0.82-0.86$) than to the digestibility of leaves ($r=0.42-0.76$). Therefore, when creating highly digestible varieties, selections should be carried out mainly according to the digestibility of the stems.

There is a negative correlation between the digestibility of dry matter and plant weight (Table 1). When it comes to lucerne, this dependence is not constant over the years. A

significant negative correlation was observed in only two samples in 2023 due to the weather features of the growing season. The proportion of plants whose digestibility is determined by changes in their mass in populations is mainly 0.04-20.0%. For arc clover, the relationship between digestibility and plant weight is weak and average. The correlation coefficients, depending on the year of the study and the variety, ranged from -0.24 to -0.41.

Table 1. Correlation coefficients between the digestibility of dry matter and economically useful signs of plants.

Variety	Year of study	Sample size cm ²	Signs		
			dry mass	foliage	crude protein
Lucerne					
Kevsala (standard)	2022	100	-0.15 ^x	0.72	0.56
Syn 292-80	2023	100	-0.44	0.78	0.51
Syn 264-35	2024	100	-0.23 ^x	0.60	0.57
Clover					
Daryal (standard)	2022	100	-0.41	0.48	0.52
TOS-870	2023	100	-0.24	0.28	0.25
Syn 305	2024	100	-0.26	0.40	0.45

Note: ^x – link is not reliable.

The revealed connection does not exclude the possibility of the existence of biotypes combining increased digestibility of dry matter with a larger mass. In our studies, such plants in lucerne and meadow clover populations accounted for 3-14%.

The digestibility of lucerne dry matter negatively correlates with plant height. The correlation coefficients were $r=0.47-0.50$.

A positive correlation has been established between the digestibility of dry matter and the foliage of plants (Table 1). Lucerne has a closer connection ($r=0.60-0.72$) than meadow clover ($r=0.28-0.48$). Plants with high digestibility of dry matter were characterized by increased leafiness, but not all high-leaved forms had high digestibility.

The relationship between the digestibility of dry matter and the content of crude protein is reliable at the average level. The correlation coefficients for lucerne varieties over the years were 0.51-0.57 for meadow clover – did not exceed 0.52. This gives reason to believe that selections based on one of these indicators can contribute to the improvement of the other.

The digestibility of dry matter is inversely related to the content of crude fiber. Lucerne has an average and close connection ($r=0.34-0.80$), meadow clover has a close relationship ($r=0.67-0.72$). When selecting meadow clover for increased digestibility, the content of crude fiber can be used as an indirect indicator.

There was no significant correlation between the digestibility of lucerne dry matter and the content of sugars, water-soluble and easily soluble carbohydrates. An average and close negative connection between digestibility and hemicellulose content was obtained ($r=0.45-0.84$).

When studying the morphological features of meadow clover plants, the connection between the digestibility of dry matter only with the coarseness of the stems was revealed. In all the years of research, the digestibility of coarse stems was 2.7-2.9% lower compared to soft ones (Table 2). The difference in the digestibility of softstemmed and coarsestemmed plants was significant and amounted to 2.3-5.4%. The roughness of the stems can serve as an indirect sign in the selection of highly digestible forms.

Table 2. Digestibility of the dry matter of meadow clover plants with equal coarseness of stems (sample TOS-870).

Year	Roughness of the stems	Stems			Whole plants		
		digestibility %	difference %	F (t)	digestibility %	difference %	F (t)
2022	soft	55.9	2.9	2.91 ^{XX}	65.5	2.5	2.50 ^X
	rude	53.0			63.0		
2023	soft	63.9	2.8	2.77 ^{XX}	67.1	2.3	3.15 ^{XX}
	rude	61.1			64.8		
2024	soft	61.5	2.7	2.74 ^{XX}	67.1	5.4	3.90 ^{XXX}
	rude	58.6			61.7		

Note: ^X is significant at P = 0.95, ^{XX} is significant at P = 0.99, ^{XXX} is significant at P = 0.999.

The creation of a starting material with increased digestibility of dry matter is associated with an individual assessment of plants. The alienation of the entire plant for analysis excludes the possibility of obtaining seeds from the best biotypes in the same year. Therefore, in order to accelerate the breeding process, a method was developed for comparative evaluation of the digestibility of dry matter by analyzing only a part of the plant.

As a result of the research, a close correlation was established between the digestibility of the dry matter of the whole lucerne plant and the first flowering shoots. The correlation coefficients were 0.78-0.84. A similar correlation was found between the digestibility of the dry matter of the whole meadow clover plant and the shoot with the first flowering head ($r=0.74-0.91$). The relationship does not depend on the mass of the plant and the proportion of the flowering part in it (Table 3). This allows for a comparative assessment of samples based on the analysis of the first flowering shoots of lucerne and the shoot with the first flowering head of meadow clover without alienating the entire plant, and include the remaining part in further breeding work.

Table 3. Correlation between the digestibility of the dry matter of the whole plant and its flowering.

Variety	Sample size cm ²	The average proportion of the flowering part. %	Digestibility. %		Correlation coefficient
			a whole plant	the blooming part	
Lucerne					
Kevsala (standard)	51	45.5	67.1	66.6	0.82±0.04
Syn 292-80	46	29.0	60.5	59.0	0.78±0.06
Syn 264-35	51	37.9	63.9	63.8	0.84±0.04
Meadow clover					
Daryal (standard)	17	11.2	63.5	62.7	0.74±0.11
TOS-870	49	20.5	64.2	64.0	0.77±0.06
Syn 305	46	35.7	73.2	71.7	0.91±0.02

The heritability coefficients obtained by the method of dispersion and correlation analyses show that the digestibility of dry matter is largely inherited, in this case it is possible to create a starting material with increased digestibility. As a result of forced crosses of highly digestible lucerne and meadow clover plants, offspring of the first and second generation were obtained.

The digestibility of dry matter in the offspring of the first generation of lucerne in the first year of plant life was 67.9-70.6%. A significant excess over the standard was observed in the Syn 292-80 sample obtained as a result of crossing within the Natalie variety (Table 4). In the offspring, after crosses, 2 samples Syn 264-35 and Syn 271-21 were isolated, in

which the maternal form was a clone that retained increased digestibility when evaluating samples. The excess in these samples was 2-2.6%. In the second year of life, only the Syn 292-80 sample differed in increased digestibility relative to the standard. The low and almost identical digestibility of the dry substance did not allow to identify the advantages of the obtained samples. In the third year of life, the Syn 292-80 sample retained a significant excess over the standard. In the offspring of the over-pollinated samples, maximum digestibility was noted in 4 reciprocal combinations in which one of the parental forms was a clone.

Table 4. Digestibility of dry matter of the best samples of lucerne and meadow clover in comparison with standards, % 2022-2024.

Grade. sample	I generation			II generation	
	1 year of life	2 years of life	3 years of life	1 year of life	2 years of life
Lucerne					
Kevsala (standard)	67.9	49.6	59.6	59.2	55.5
Syn 292-80	70.6 ^X	53.9 ^{XX}	63.5 ^X	63.7 ^{XX}	60.4 ^{XX}
Syn 264-35	70.5 ^X	51.3	63.5 ^X	–	–
Syn271-21	69.8 ^X	46.3	64.0 ^{XXX}	–	–
Clover					
Daryal (standard)	72.4	58.4	–	62.3	66.4
TOS-870	75.2 ^X	70.8 ^{XXX}	–	66.1 ^X	68.9 ^X

Note: ^X is significant at P = 0.95, ^{XX} is significant at P = 0.99, ^{XXX} is significant at P = 0.999.

In the second generation, the isolated Syn 292-80 sample exceeded the standard in terms of dry matter digestibility in the first and second years of plant life. The excess was 4.5 and 4.9%, respectively, over the years.

When evaluating the offspring that we obtained from crosses of highly digestible forms of meadow clover within the Orion variety, the CBT-870 sample had an advantage over the standard in the first generation. In the first year of plant life, the digestibility of the dry matter of this sample was 2.8% higher than the standard, which is significant at P = 0.95. In the second year of life, a more significant excess was observed, which amounted to 12.4% and was significant at P = 0.999. The increased digestibility of dry matter in the TOS-870 sample was preserved in the second generation. The sample exceeds the standard Daryal variety in terms of plant life by 3.8 and 2.5%, which is reliable at P = 0.95.

The productivity and foliage of plants in the offspring of highly digestible lucerne forms were taken into account in the first generation in the second and third years of life. The highly digestible Syn 292-80 sample was inferior in plant weight to the standard in the second year of life, but exceeded it in the third year (Table 5). On average, it was at the standard level for 2 years. This sample is earlier maturing than the standard Kevsala variety. In 2023 flowering was noted for 15 days, and in 2024 – 6 days earlier than the standard. The samples obtained as a result of crosses, Syn 264-35 and Syn 271-21, were also earlier ripe, inferior in plant weight to the standard.

Table 5. Characteristics of a highly digestible lucerne sample by dry weight and foliage of plants (2 and 3 years of life).

Grade. sample	Dry weight of plants. g				Foliage. %			
	2023	2024	On average in 2 years	% to standard	2023	2024	On average in 2 years	% to standard
Kevsala (standard)	98.8	68.1	83.5	100	38.6	45.8	42.2	100
Syn 292-80	87.7	78.5	83.1	100	42.0	52.1	47.1	112

In terms of plant foliage, the lucerne sample Syn 292-80 had an advantage over the standard in terms of years of life by 3.4 and 6.3%. In the second generation, in the second year of life, the foliage of plants of this sample was 46.6%, which is 12.4% higher than the standard. The foliage of plants characterized by increased digestibility of the dry matter of the meadow clover sample TOS-870 significantly exceeded the standard. In the first and second generation, the excess was 19.3 and 13.1%. promising in breeding of long-term and stable variety.

4 Discussing

In order to accelerate the breeding process at its first stages, a comparative assessment of meadow clover plants by the digestibility of dry matter should be carried out by analyzing the shoot with the first flowering head, and lucerne plants by the first flowering shoots without alienating the entire plant. This makes it possible to analyze and obtain seeds from selected forms in one year.

To facilitate the selection of highly digestible meadow clover plants, precocity, soft stems and low crude fiber content can serve as indirect signs.

The following scheme is proposed for creating a source material with increased digestibility of dry matter: evaluation of collection material and isolation of populations with digestibility higher than standard varieties; individual assessment of plants in isolated populations and selection of genotypes with high digestibility of dry matter; artificial crosses of highly digestible plants.

The highly digestible lucerne sample Syn 292-80, the meadow clover sample TOS-870 are valuable starting materials for the creation of varieties of lucerne and meadow clover with increased digestibility of dry matter.

5 Conclusions

As a result of the conducted research, methods for selecting highly digestible lucerne and meadow clover plants have been developed, and a source material with increased digestibility of dry matter has been created.

There is a negative correlation between the digestibility of dry matter and the weight of plants. For lucerne this dependence is not constant over the years. The proportion of plants whose digestibility is determined by changes in their weight does not exceed 56%. For meadow clover, the relationship between digestibility and weight is weak and average. The correlation coefficients ranged from -0.24 to -0.41 depending on the year of the variety. Such conjugation does not exclude the possibility of the existence of biotypes combining increased digestibility of dry matter with a large mass.

The foliage of plants is positively associated with the digestibility of lucerne and meadow clover. Lucerne has an average and close correlation ($r=0.60-0.72$), meadow clover has mainly an average correlation ($r=0.28-0.48$).

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