

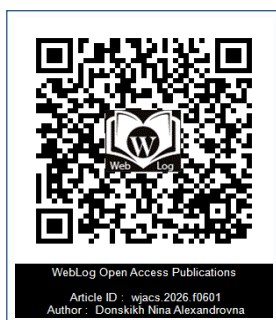


The Period of Mowing of Perennial Grasses is the Key to Obtaining High-Quality Feed in the Conditions of the Leningrad Region

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WebLog Open Access Publications
Article ID : wjacs.2026.f0601
Author : Donskikh Nina Alexandrovna

OPEN ACCESS

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Received Date: 01 May 2026

Accepted Date: 04 Jun 2026

Published Date: 06 Jun 2026

Citation:

Alexandrovna DN, Anatolievich LA. The Period of Mowing of Perennial Grasses is the Key to Obtaining High-Quality Feed in the Conditions of the Leningrad Region. *WebLog J Agric Crop Sci*. wjacs.2026.f0601. <https://doi.org/10.5281/zenodo.20838367>

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Abstract

Currently, meadow feed production pays special attention to the creation and use of legumes and legume-grain herbage that provide cheap and high-quality feed [1, 2]. However, the soil and climatic conditions of both the North-Western region and the Leningrad Region do not allow for the widespread placement and creation of legume and cereal stands, therefore, cereal stands remain the main segment in the wedge of perennial grasses, which are characterized by a high rate of passage of vegetation phases and a sharp decrease in nutrients as they pass [3]. The nutrient content of cereals depends entirely on the growing phase. It has been proven that the maximum nutritional value of the feed is provided when mowing at the optimal time, which is determined by the phase of the dominant plants, the development of which determines the start time of mowing a particular herbage. The technology of haylage and silage harvesting provides for the harvesting of grass stands at an earlier date: at the end of the tube phase, the beginning of earing, hay harvesting provides for mowing at a later date, during the full earing phase, the beginning of flowering. Since cereal plants of the same species go through phases in 7-10 days, in the conditions of the Leningrad region, the first mowing can last from May 20-25 to July 5-10: from the moment of the beginning of earing of the earliest species to the complete earing of the latest species - Timofeevka meadow. Violation of the harvesting time of mowed grass stands, associated with their delay, especially with the dominance of cereals, leads to a decrease in feed quality. Therefore, the studies conducted at the experimental field of St. Petersburg State Agricultural University in 2017 and 2019 convincingly prove the effectiveness of the optimal mowing period for perennial grasses to obtain not only full-fledged harvests, but also to obtain highly nutritious feed and a full yield of feed protein units. The relevance and scientific novelty of our research lies in the fact that in order to establish the optimal start time for mowing grass crops created on the basis of different growth periods when harvesting different types of feed during the period of 1 mowing, the calculations were carried out sequentially, in dynamics after 2-3 days, taking into account the arrival of heat.

Keywords: Mowing Period; Development Phase; Cereal Stands; Feed Nutrition; Yield

The aim of the research was to establish the optimal mowing time for cereal grasses with the dominance of different species during the main mowing period, depending on the temperature factor, the vegetation phase of forage grasses and the chemical composition of raw materials.

The objectives of the research were to identify the quantitative dependence of the yield of cereal stands on the timing of their mowing and the sum of effective temperatures, to conduct a feed assessment of cereal stands for quality, nutritional value and yield of feed protein units.

Materials, Methods and Objects of Research

Nutritional value and yield level at different mowing periods were carried out on the following types of perennial grasses: meadow timothy (*Phlum pratense*) - Leningradskaya 204 variety, meadow fescue (*Festuca pratensis*) - Suidinskaya variety, combined hedgehog (*Dactylis glomerata*) - Neva variety, boneless stalk (*BröMopsis inermis*) -Dragon variety. All species, which we took for research, are the most common in the creation of variously maturing herb stands on farms. The Leningrad region. We conducted field experiments on this topic in the training fields of St. Petersburg State University from 2017 to 2019 on herb stands of 2-3 years of use. The size of the experimental plot

was 10 m². The experience is repeated four times. The placement of plots is randomized. In the spring, during the spring regrowth phase of plants of the studied grass species, the herb stands were fertilized with mineral fertilizers at a dose of N₆₀P₆₀K₆₀. Since the beginning of regrowth of the studied species, the air temperature and precipitation were measured daily.

Crop yield calculations and phenological observations of the regrowth of the studied plants were carried out according to the methodological guidelines for conducting field experiments with forage crops developed according to the All-Russian Institute V.R. Williams Feed [4, 5]. The energy assessment was calculated according to the methodology of the All-Russian Research Institute of Feed (1995).

Research results. During the years of research (2017-2019), the weather conditions were very contrasting. Thus, 2017 was characterized by optimal moisture supply against the background of low heat input: precipitation fell 35 mm more than normal, and the average monthly air temperature was 4.5° lower compared to the average annual figures. The 2018 growing season was characterized by high air temperature with low moisture availability: the monthly average temperature was 8.8° higher than the annual average, while precipitation was 53 mm less than normal. The weather conditions were particularly unfavorable in 2018. In the spring period, during the formation of first mowing, abnormal heat was observed in May with an acute shortage of precipitation. The third year of research (2019) In terms of heat supply, it was approaching normal, but in terms of precipitation, it also turned out to be arid.

The soil of the experimental site is sod-podzolic, heavy loamy, highly cultivated with a humus content of 6.4, pH – 5.4, with a high content of mobile phosphorus forms - 475mg/kg and exchangeable potassium – 499 mg/kg. The amount of absorbed bases is 19.9 mg-eq/100g. The thickness of the arable layer is 22-24 cm.

The high cultivation of the soil of the experimental field is explained by the cultivation of potatoes during the previous two years and the application of high doses of organic fertilizers.

Since the technology of harvesting different types of herbaceous forages dictates appropriate requirements for the quality of raw materials for their preparation, we based our research on the timing of the onset of mowing ripeness: when the herbage reaches a certain height (35 cm) and the vegetation phase of the end of the tube – the beginning of earing of the studied cereals, when the total mass of plants was still in a vegetative state. All subsequent measurements were carried out after 2-3 days during the entire first mowing period, daily recording the air temperature.

The onset of mowing ripeness and the accumulation of phytomass during the first mowing period directly depends on the species composition of cereal stands and, to a large extent, on weather conditions.

The yield of the studied herbage during the first mowing on different dates in 2017 is shown in Table 1.

In 2017, due to the cold, prolonged spring, the onset of mowing ripeness was delayed in all the studied species, and therefore first accounting was carried out only on June 1, mowing all the studied grasses at the same time at the sum of effective temperatures of 289°C. In conditions of low temperature conditions, but with sufficient moisture, Meadow timothy formed the highest yield, which is not

quite typical for this species. Being an obvious mesophyte and the most adapted species to the conditions of the Leningrad region, Meadow timothy provided the highest yield level - 2.2 t/ha per year.

Under the same conditions, the Combined hedgehog, being characterized as the earliest maturing species, was significantly inferior to the Meadow timothy in terms of accumulation of phytomass by this time - 1.8 t/ha, which distinguishes it as a more demanding species for heat. By this time, the Boneless stalk showed almost the same yield as Meadow timothy - 2.1 t/ha.

Meadow fescue, under the same weather conditions, provided the lowest yield, significantly inferior to Meadow timothy by 0.6 t/ha, Boneless stalk by 0.5 t/ha. Carrying out yield accounting after two days (June 3), when the sum of active temperatures reached 305°C, showed that the Combined hedgehog, with an increase in the temperature regime, managed to realize its biological peculiarity, ensuring a yield of 2.6 t/ha, catching up with both Meadow timothy and Boneless stalk. Meadow fescue retains a low yield level after two days, significantly inferior to all the studied types of cereals.

Mowing after 10 days, in the phase of full earing of cereals at a total active temperature of 393°C, the yield of all herbage increased and amounted to: in Meadow timothy - 3.7t/ha, in Combined hedgehog - 3.2t/ha, in Boneless stalk - 3.6t/ha, and by this time the yield of Meadow fescue was significantly inferior to all the studied species, providing the lowest level -2.3 t/ha. In the first mowing, all the studied cereal species were formed only by June 27-30 (6.4 t/ha each – Meadow timothy and Boneless stalk, 5.3 t/ha – Combined hedgehog and 4.7 t/ha – Meadow fescue). However, by the end of June, all the studied species were in the flowering phase and were suitable only for harvesting Class 3 hay.

Thus, the data obtained on the dynamics of phytomass growth in different studied species, depending on the environmental situation, allowed us to establish the optimal mowing time in the first mowing for harvesting different types of herbaceous forages.

The spring of 2018 was characterized by abnormally hot weather, with air temperatures significantly exceeding the average long-term values. As a result, the onset of mowing maturity in all the studied cereals occurred significantly earlier than in the previous year, 2017, but at different times according to their phenological patterns. The first mowing of the studied cereal herbage was carried out on different dates, but at the same phase: the end of tillering and the beginning of ear formation. In conditions of high heat availability, Combined hedgehog reached mowing maturity by May 18, while the Boneless stalk and Meadow timothy reached mowing maturity by May 21, and the Meadow fescue reached mowing maturity by May 24.

The early maturity of the studied cereals was caused by hot weather, when the sum of active temperatures reached 400°C, despite the lack of moisture. The extreme environmental conditions caused a reduction in the interphase periods of the cereal grasses and accelerated the process of heading, but the production process and the accumulation of biomass did not occur. All the studied species demonstrated extremely low yields in these environmental conditions, ranging from 0.9 to 1.4 t/ha. Therefore, in 2018, the situation with fodder harvesting during the first mowing was quite complicated: the cereals reached the stage of maturity during the vegetation phase, but the accumulation of phytomass was extremely low due to the drought. The postponement of the mowing date to a later time, during the full earing phase (31.05), when the sum of active

Table 1: The yield of the studied herbage in 2017 (t/ha sm).

Herbage	Dates of mowing of grass stands in 1 season									
	1.06	3.06	5.06	7.06	10.06	13.06	17.06	22.06	27.06	30.06
Meadow timothy	2,2	2,5	2,9	3,6	3,7	4,3	4,8	5,2	6,1	6,4
Meadow fescue	1,6	1,7	2,1	2,2	2,3	3,1	3,5	3,8	4,4	5,3
Combined hedgehog	1,8	2,6	2,8	2,9	3,2	3,5	3,8	4,2	4,6	4,7
Boneless stalk	2,1	2,7	2,8	3,1	3,6	3,9	4,6	4,7	4,9	6,4
HCP05	0,3	0,8	0,5	0,5	0,6	0,8	0,6	0,9	0,9	0,6

Table 2: Yield of the studied herbage in 2019 (t/ha per year).

Herbage	Dates of mowing of grass stands in 1 season												
	16.05	19.05	22.05	24.05	27.05	30.05	2.06	5.06	8.06	11.06	14.06	17.06	20.06
Meadow timothy	-	2,4	2,6	2,8	3,7	4,1	4,7	4,9	5,2	5,9	6,2	6,9	7,3
Meadow fescue	-	-	1,4	1,6	1,5	2,2	2,1	3,1	3,3	3,2	4,1	4,4	-
Combined hedgehog	2,6	2,7	2,9	3,9	4,0	4,3	4,4	5,8	6,6	6,4	6,7	-	-
Boneless stalk	-	3,5	3,2	3,6	4,4	4,4	4,5	5,0	5,4	6,1	6,1	6,5	6,8
HCP05		0,6	0,8	0,5	0,8	0,9	0,9	1,1	1,2	1,2	1,3	1,1.	0,7

temperatures reached 610°C, resulted in an increase in the yield of the studied grass stands, but it did not reach the level of 2017. Thus, the unfavorable weather conditions in the spring, characterized by high temperatures and a lack of moisture, led to the rapid transition of all the studied cereal species to the earing phase, resulting in the formation of maturity during the optimal phase of development 2-2.5 weeks earlier than in 2017.

In 2019, the onset of mowing maturity of the studied cereal species was also closely correlated with the arrival of heat: the sum of effective temperatures (383°C) was reached by May 16. Therefore, the first mowing of Combined hedgehog was carried out on May 16, during the beginning of earing, which was 2 weeks earlier than in 2017 and 3 days earlier than in 2018. The mowing maturity of the Meadow timothy and Boneless stalk was reached on May 19, when the sum of effective temperatures reached 420°C, while the mowing maturity of the Meadow fescue was reached only on May 22, which was a full week later than in the case of Combined hedgehog.

In the conditions of hot, arid weather, the highest yield level in 2019. As of May 22 was provided by Boneless stalk – 3.2 t/ha, Boneless stalk formed – 2.9 t/ha.m., Meadow timothy, being a later-maturing species in terms of phenorhythmics, was somewhat inferior to both Combined hedgehog and Boneless stalk, providing for this period - 2.6t/ha. Meadow fescue, as in the previous two years, was significantly inferior in yield to all the studied species, forming only 1.4 t/ha. When accounting is done in a week, i.e. on 30.05, the yield level of all studied herbage increased significantly and amounted to more than 4t/ha, except for Meadow fescue (Table 2).

Subsequent mowing on June 2, when Meadow timothy and Meadow fescue entered the phase of full earing, and Combined hedgehog and Boneless stalk entered the phase of early flowering, when the sum of active temperatures was 622°C., Meadow timothy in conditions of optimal moisture supply not only caught up with the accumulation of phytomass of Combined hedgehog and Boneless stalk, but also provided the highest the yield level of dry weight is 4.7 t/ha [6].

The maximum yield of all the studied herbage was formed during the full flowering phase: Combined hedgehog – 6.7 t/ ha, Meadow

timothy – 7 t/ha, Boneless stalk – 6.8 t/ha. Meadow fescue, as in the first two years, even during the full flowering phase provided the lowest yield of - 4.4t/ha, which puts it in the category of low-yielding species in the Leningrad region (Table 2).

Proper feeding of cattle is possible only if the nutritional value of the feed is known. The chemical composition of feeds is the primary indicator of their nutritional value [7]. In our research, an analysis of the chemical composition of the studied herbage showed that the content of crude protein, the main indicator of feed nutrition, was high (18.78-29.49%) when plants were in the tube phase - the beginning of earing, and corresponded to the needs of highly productive animals, but after 10 days in the earing phase, there is a sharp decrease in this indicator. from 14.46 to 16.4 (Table 3).

Despite a sharp decrease in this important nutritional value after 10 days, it still meets the zootechnical feeding standards for haylage and first-class hay. But after 17 days, this indicator is acceptable only for harvesting hay. Thus, our studies on the crude protein content in cereal plants indicate that this indicator remains at a high level for no more than 10 days.

In 2018, in conditions of hot weather with a clear lack of moisture in May the nutritional value of the feed mass of all the studied species was significantly lower than the previous year, but at the same time, the highest crude protein content also corresponds to the phase of release into the tube - the beginning of earing of cereals. Despite the general tendency to decrease the concentration of crude protein over a 10-day period, but with optimal hydration, which was typical for 2017. its level still corresponds to the zootechnical norm of highly productive animals, which allows for high-quality feed to be harvested during this period.

Table 3: The content of crude protein in the studied grasses (% of total revenue) 2017.

Herbage \ Date	1.06	5.06	10.06	17.06	22.06
Meadow timothy	18,78	19,74	14,46	10,41	9,29
Meadow fescue	27,13	19,72	16,40	11,38	12,40
Combined hedgehog	29,49	21,10	15,75	11,68	10,57

Table 4: Crude fiber content in the studied cereal stands (% of annual average) in 2017.

Date	1.06	5.06	10.06	17.06	22.06
Herbage					
Meadow timothy	22,99	21,68	29,18	30,74	30,96
Meadow fescue	20,24	21,49	27,95	29,25	28,41
Combined hedgehog	19,98	23,02	29,98	28,73	31,00

An important indicator of the nutritional value of feed is the content of crude fiber, which is an indispensable element for ruminants, stabilizing the digestive tract and the digestibility of all feeds.

In 2017, the optimal fiber content in herb stands was on the date of mowing on June 1, during the phase of the beginning of the earing of grasses. At a later time of mowing, the crude fiber content increases, so if on June 5 it was 21-23%, then by June 10 it increased by 7-8% and amounted to 28-29%, which corresponds to the norm for haylage and hay harvesting (Table 4).

In 2018, the optimal fiber content was on May 24, during the phase of the beginning of grain earing, from 21% to 26%, mowing in subsequent periods contributes to an increase in this indicator by 2-5%: in Meadow timothy it was 28%, in Meadow fescue - 24%, in Combined hedgehog and Boneless stalk - 27-29%. It has been established that the content of crude fiber is closely related to the vegetation phase: its accumulation occurs during the transition of cereals to the generative stage.

One of the main indicators of the nutritional value of the feed mass is the content of sugars, which are primarily food for microorganisms in the pancreas of animals and perform an important physiological function in the body of cattle, as well as their optimal content during silage is one of the most important conditions for the successful course of this process. The indicators of the chemical composition of the studied herbage in terms of sugar content are presented in Tables 5 and 6.

Due to the cold spring and excessive moisture in 2017, the accumulation of sugars by the time of the first mowing was low and ranged from 5.2% in Combined hedgehog to 7.7% in Meadow timothy. But after 4 days, with an increase in the amount of active temperatures and an increase in phytomass, the amount of sugars increased almost 2 times and amounted to 14.1% and 13.6% in

Table 5: Sugar content in the studied cereal stands (% of annual average) in 2017.

Date	1.06	3.06	5.06	7.06	10.06	13.06	17.06	22.06
Herbage								
Meadow timothy	7,7	8,9	14,1	10,7	7,9	10,7	13,8	8,3
Meadow fescue	5,5	6,0	10,8	10,5	11,8	10,2	11,3	9,8
Combined hedgehog	5,2	15,5	9,2	8,0	7,9	10,7	15,0	9,7
Boneless stalk	7,2	11,5	13,6	11,6	7,8	9,8	10,8	10,9

Table 6: Sugar content in the studied herbage (%) in 2018.

Date	Mowing time for grass in 1 cutting						
	24.05	28.05	31.05	3.06	6.06	10.06	13.06
Herbage							
Meadow timothy	13,6	11,0	14,6	10,2	9,0	10,6	12,8
Meadow fescue	17,4	12,6	14,8	7,2	9,2	14,1	11,0
Combined hedgehog	16,2	6,7	16,4	9,4	9,8	10,2	-
Boneless stalk	15,0	9,6	14,6	10,5	10,0	12,5	16,0

Meadow timothy and Boneless stalk, respectively, 10.8% and 9.2% in Meadow fescue and Combined hedgehog, which was already approaching the optimal indicator.

The abnormally hot spring of 2018 contributed to the accumulation of sugars in all the studied herbage, even in the early stages of mowing. So, on 24.05, when the cereals were in the phase of the beginning of earing, this indicator was: Meadow timothy has 13.6%, Meadow fescue has 17.4%, Combined hedgehog - 16.2%, Boneless stalk - 15%. By June 3, 10 days later, when the plants were in the full earing phase, the amount of sugars decreased by 3% in Meadow timothy, by 10% in Meadow fescue, by 7% in Combined hedgehog, by 7%, which cannot adversely affect the silage process (Table 6).

Thus, based on the conducted studies on the dynamics of sugar content during the first mowing of the main types of grasses, it can be concluded that this indicator is very dynamic and largely depends on both the growing season and weather conditions. Therefore, forage harvesting, especially silage, should be built taking into account the weather conditions.

Conclusions

Studies on the establishment of the optimal mowing time for cereal stands for harvesting different types of feed based on the calculations carried out in relation to the vegetation phase and temperature regime indicate that the studied cereal species provide the highest yield during the flowering phase (up to 6.7-7.3 t/ha per mowing). The highest yield level in all the years of research was provided by the most adapted species in the conditions of the Leningrad region - Meadow timothy 6.4 t/ha in 2017, 4.8 t/ha in 2018 and 7.3 t/ha in 2019.

However, the highest content of the main indicator of feed nutrition - crude protein, accounts for the phase of entering the tube - the beginning of earing and reaches up to 29% in Combined hedgehog in 2017, and up to 19% in Meadow timothy. Mowing at a later date dramatically reduces this indicator. However, very early cutting of cereal stands affects both the shortage of raw materials and the quality of feed, and therefore only mowing of cereal stands at the optimal time ensures the maximum yield of nutrients per unit area.

Acknowledgements

The authors would like to thank Irina Nam, Doctor of Biology,

Coordinator-Secretary of the Eurasian Agricultural Technology Platform, for her offer to publish the results of our research in the WebLog Journal of Agricultural and Crop Sciences and for her assistance in preparing the article.

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