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The importance of alfalfa and its growth processes during harvesting phases in the conditions of the right-bank Forest-Steppe

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Abstract. The aim of the study was to investigate the impact of harvesting dates and fertilization levels on the height of alfalfa (*Medicago sativa*) plants in the conditions of the Right-bank Forest-Steppe. The research was conducted at the experimental field of Vinnytsia National Agrarian University with variants of different sowing rates (6.0-8.0 million seeds/ha) and four levels of mineral nutrition. In the sowing year, the lowest height of alfalfa plants was observed at the sowing rate of 8.0 million seeds/ha (63.4-64.4 cm), which increased to 64.4-66.3 cm at the sowing rate of 6.0 million seeds/ha. Complex fertilizers contributed to an increase in plant height from 0.9-1.9 cm to 1.0-2.7 cm compared to the control. It was found that plants, under stress conditions due to high air temperature and insufficient moisture at the root system depth, could not effectively absorb mineral fertilizers from the soil, which led to a reduction in growth rates. In the second year of vegetation, considering the hydrothermal conditions of the summer period, an impact on the growth processes of alfalfa was observed. This affected the plant height during both the cuts and the harvesting phases. After three cuts at the

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budding stage, the average plant height reached 54.3-54.5 cm, regardless of the sowing rate and mineral nutrition level. The results followed a sinusoidal pattern: the tallest plants were at the first cut (73.7-73.8 cm), with the shortest height during the second cut (41.4-41.8 cm), and a further increase to 47.7-47.9 cm at the third cut. At the beginning of flowering, the tallest plants reached 85.7-86.0 cm, while at subsequent cuts, made 40-41 days later, a decrease in height was observed: 43.9-44.4 cm at the second cut and 54.3-55.2 cm at the third cut. The average plant height at the sowing rates was 61.4-61.8 cm. Thus, alfalfa formed three full cuts during the growing season, with an average height of 54.3-54.5 cm. The tallest plants reached 76.8-85.8 cm with the application of mineral fertilizers at the dose of $N_{35}P_{90}K_{150} + S_{23.5}Ca_{30}Mg_{20}$, while the average values were 55.7-62.7 cm at a sowing rate of 6.0 million seeds/ha. The results of the study can be used to optimize the agrotechnology of alfalfa cultivation in the conditions of the Forest-Steppe

Keywords: *Medicago sativa*, budding, beginning of flowering, sowing rate, fertilizers

Introduction

Perennial leguminous grasses are one of the priority areas for the development of forage production and agriculture, as the basis for organic production of plant raw materials for the preparation of various types of animal feed. They play an environmental role in agro-landscapes according to their morphological and genetic characteristics, contribute to soil fertility enhancement and improve its structure, which is particularly relevant in the current conditions of agricultural development. Therefore, significant attention should be paid to perennial leguminous grasses, especially the most widespread and productive crop – alfalfa, which, with strict adherence to cultivation techniques, is capable of fully realizing its genetic potential during prolonged use of the sward (Zhang & Wang, 2025). Breeding programs aimed at improving alfalfa focus on increasing yield and persistence, which are key factors for adaptation to different agroecosystems (Medina et al., 2025).

Alfalfa (*Medicago sativa* L.), known as the “queen of forage crops”, was recognised as the most important perennial forage legume crop cultivated worldwide due to its comprehensive ecological adaptability, high nutritional value, and ability to fix nitrogen. According to W. Wan et al. (2022), fertiliser application not only increased alfalfa yield by 19.2%, but also improved its quality through an increase in crude protein content by

7.7% and a reduction in acid-detergent fibre content by 2.9%. This confirmed the importance of optimising fertilisation systems to achieve maximum productivity. Y. Wang et al. (2024) established that the level of nitrogen fertilisation significantly influenced nitrogen use efficiency, yield, and quality of alfalfa across different cuts. It was noted by the researchers that improper nitrogen application led to reduced nitrogen use efficiency and even adverse effects on yield and forage quality. These findings underlined the importance of optimising nitrogen fertiliser rates. Drought tolerance in alfalfa was considered a critically important characteristic in the context of global climate change.

In the study by N. Hetman et al. (2025), the role of alfalfa in the greening of agricultural production was investigated, particularly its capacity to enrich soils with nitrogen and improve their physico-chemical properties. The importance of utilising alfalfa to reduce soil erosion and land degradation, as well as to decrease reliance on chemical fertilisers, was emphasised by the authors. It was demonstrated in the work that alfalfa could serve as a key component of sustainable agriculture, contributing to environmentally safe production. V. Greveniotis et al. (2024) conducted research on the yield stability and main qualitative characteristics of alfalfa, including plant height, number of nodes, green mass yield, and dry matter

yield. Statistical analysis revealed significant differences, indicating a high genotype-by-year interaction, which underscored the importance of adapting varieties to specific growing conditions. The study by I.S. Varol *et al.* (2024) established that alfalfa is sensitive to drought in terms of green mass yield, while showing tolerance to water stress in terms of hay yield and protein content, which is significant for developing cultivation strategies under limited water supply. The research by Y. Liu *et al.* (2018) demonstrated that a decrease in yield due to water scarcity was observed in the studied varieties, while crude protein content was reduced as a result of drought stress. Early harvesting provided higher yields, confirming the importance of optimising mowing dates.

The uniqueness of the crop also lies in its ability to prevent the salinisation of irrigated land. Its roots draw moisture from deeper soil layers, thereby lowering the groundwater level and interrupting the upward flow of water from the lower soil horizons (Tyshchenko & Tyshchenko, 2014). According to U.M. Karbivska (2020), around 150-200 kg/ha of nitrogen accumulates in the roots and plant residues of alfalfa, making it an important element in the system of organic farming. Despite the substantial volume of research, the issue of the impact of harvesting dates in combination with different levels of mineral nutrition on the growth processes of forage alfalfa in the Right-Bank Forest-Steppe remains insufficiently studied. S.F. Antoniv *et al.* (2023) highlighted the agroecological importance of alfalfa as the basis of high-protein fodder in the Forest-Steppe and Steppe regions of Ukraine; however, the issue of optimising harvesting dates depending on the developmental phase of the plants requires further study. Given the scientific data provided and the conflicting results regarding the combined effect of harvesting dates and mineral nutrition levels, there is a need for an in-depth study of the growth processes of forage alfalfa under specific soil and climatic conditions. Special attention should be given to evaluating the formation of plant height depending on the harvesting phases, which is of significant practical

importance for optimising cultivation technology. The aim of this study was to establish the patterns of plant height formation in forage alfalfa depending on harvesting phases and fertilisation levels.

Materials and Methods

The research was conducted at the experimental field of Vinnytsia National Agrarian University, focused on the productivity of agricultural crops, including forage alfalfa, during the period from 2024 to 2025. The soil cover of the experimental site is represented by grey forest soils, which, based on morphological characteristics, occupy an intermediate position between light and dark grey soils. According to agrochemical surveys, the arable layer of soil (0-30 cm) has the following physicochemical properties: humus content (according to Tyurin) was 2.69%, alkaline-hydrolysed nitrogen (according to Kornfield) – 81 mg/kg, available phosphorus and exchangeable potassium (according to Chirikov) were 218 and 72 mg per 1 kg of soil, respectively; available sulphur (S) 5.3 mg/kg, available copper (Cu) 0.29, available zinc (Zn) 0.45, available manganese (Mn) 14.6 mg/kg, and the pH of the salt extract was 6.1.

The climatic conditions of the Right-Bank Forest-Steppe zone are heterogeneous, characterised by warm summers and moderately cold winters. During the research period (2024-2025), in the second year of forage utilisation in 2025, the hydrothermal conditions were characterised by an increase in the average monthly air temperature from 19.5°C to 21.5°C, with atmospheric precipitation from June to August amounting to 87 mm. Mineral fertilisers were applied during pre-sowing cultivation according to the experimental variants, which differed in their supply of essential nutrients and accompanying macro- and micro-elements. The control variant involved the application of mineral fertilisers at the rate of $N_{35}P_{90}K_{90}$ with the addition of sulphur ($S_{3.5}$). In the experimental variants, increased nutrient levels were applied with the same rate of nitrogen and phosphorus ($N_{35}P_{90}$), but with a gradual increase in potassium dosage to K_{120} and K_{150} , along with the addition of sulphur, calcium, and magnesium in the corresponding

amounts. This approach allowed the evaluation of the effect of different levels of complex mineral nutrition on the growth processes of forage alfalfa under identical agro-technical conditions. The variety of forage alfalfa 'Radoslava', created at the Institute of Feed and Agriculture of Podillia of the National Academy of Agrarian Sciences, and included in the State Register of Plant Varieties of Ukraine, was sown in the experiment. This variety is tolerant to increased soil acidity (pH of the salt solution 5.0-5.5). The 'Radoslava' variety is characterised by increased drought tolerance, resistance to Fusarium wilt, and productive longevity in both pure and mixed swards.

For the assessment of the growth stages of alfalfa plants, the BBCH scale (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) was used. Statistical data processing was carried out using analysis of variance, with the determination of the confidence interval of the arithmetic mean at the 5% significance level. The research was conducted in accordance with ethical standards, particularly within the framework of the Convention on Biological Diversity (1992).

Results and Discussion

It was established that in the sowing year, under conditions of adequate soil moisture in April 2024 at seeding depth and an average daily air temperature of 12.0°C, the inter-phase period "sowing-emergence" lasted 10 days. Subsequent growth processes were primarily determined

by the biological characteristics of alfalfa and weather conditions. In May, active development of leaf-stem mass was observed, and the beginning of flowering phase (BBCH code 60) occurred 68-69 days after full emergence. Growth and development processes of alfalfa occurred under conditions of coordinated interaction of soil and climatic factors, such as moisture, heat, light, and soil fertility. Regardless of the fertilisation background, the lowest height of alfalfa plants was observed at a sowing rate of 8.0 million viable seeds/ha, measuring 63.4-64.4 cm, which increased to 64.4-66.3 cm at a sowing rate of 6.0 million/ha. With the application of complex fertiliser, an increase in plant height from 0.9-1.9 cm to 1.0-2.7 cm was observed compared to the control.

Research demonstrated that in the second year of life (2025), under conditions of unstable moisture supply and gradual temperature increase throughout the vegetation period, alfalfa cultivar 'Radoslava' responded to environmental conditions through changes in plant height across cuts, which were conducted at two timings at the budding phase and at the beginning of flowering. Across three cuts at the budding phase, the average plant height reached 54.3-54.5 cm, regardless of sowing rates and mineral nutrition level. The obtained values exhibited a sinusoidal pattern, with the highest values observed at the first cut, reaching 73.7-73.8 cm, the lowest at the second cut at 41.4-41.8 cm, followed by subsequent growth to 47.7-47.9 cm in the third cut, which was formed in August (Table 1).

Table 1. Effect of sowing rates and fertilisation on alfalfa plant height at the budding phase, $M \pm m^*$

Fertilisation	Sowing rate, million seeds/ha	Cuts			Average
		1	2	3	
$N_{35}P_{90}K_{90} + S_{3.5}$ (control)	6.0	71.1 ± 8.01	40.6 ± 6.18	46.5 ± 7.89	52.7 ± 7.36
	8.0	73.2 ± 5.45	41.4 ± 6.20	47.8 ± 5.96	54.1 ± 5.87
$N_{35}P_{90}K_{120} + S_{13.5}Ca_{15}Mg_{10}$	6.0	73.4 ± 4.67	41.5 ± 5.22	48.3 ± 6.55	54.4 ± 5.48
	8.0	73.6 ± 5.41	41.6 ± 4.05	47.6 ± 8.39	54.3 ± 5.95
$N_{35}P_{90}K_{150} + S_{23.5}Ca_{30}Mg_{20}$	6.0	76.8 ± 3.03	42.0 ± 5.40	48.4 ± 6.36	55.7 ± 4.93
	8.0	74.4 ± 4.04	42.3 ± 2.17	48.4 ± 5.98	55.0 ± 4.06
Average	6.0	73.8 ± 5.23	41.4 ± 5.60	47.7 ± 6.93	54.3 ± 5.92
	8.0	73.7 ± 4.97	41.8 ± 4.14	47.9 ± 6.78	54.5 ± 5.29

Note: * – $M \pm m$ – confidence interval of the arithmetic mean at the 5% significance level

Source: developed by the authors

In the current study, complex fertilisation also positively influenced linear plant parameters, although the effect was less pronounced under drought stress conditions. The obtained results were consistent with data from W. Wan *et al.* (2022), who established that fertiliser application increased alfalfa yield by an average of 19.2%. Specifically, the best linear parameters were obtained at a sowing rate of 6.0 million viable seeds/ha, measuring 76.8 cm with $N_{35}P_{90}K_{150} + S_{23.5}Ca_{30}Mg_{20}$ at the first cut harvest, which decreased in the second and third cuts to a range of 42.0-48.4 cm. The average values across three cuts were 55.7 cm, which was 3.0 cm higher than with the application of mineral fertilisers at a dose of $N_{35}P_{90}K_{90} + S_{3.5}$. Similar patterns were observed by Y. Wang *et al.* (2024), who established that nitrogen fertilisation level significantly influenced nitrogen use efficiency and alfalfa yield

across different cuts. The current study also revealed a differentiated effect of fertilisation depending on the cut and harvesting phase.

Hydrothermal conditions of the vegetation period facilitated regrowth and formation of the third cut of alfalfa forage at the budding phase on 20 August and at the beginning of flowering in the first decade of September (04.09), with forage cutting conducted 37 and 41 days after the second cut, respectively. According to biological characteristics, alfalfa is classified as a long-day crop; therefore, during shortening of daylight hours with increased temperature regime and uneven distribution of atmospheric precipitation, plant height decreased at the budding phase, measuring 46.5-48.4 cm, with the highest values at maximum fertilisation of 48.4 cm. Concurrently, plant height increment during the vegetation period increased compared to the first and second cuts to 1.25-1.31 cm/day (Table 2).

Table 2. Average daily plant height increment of alfalfa across cuts, depending on sowing rates and fertilisation at the budding phase, cm/day

Fertilisation	Sowing rate, million seeds/ha	Cuts			Average
		1	2	3	
$N_{35}P_{90}K_{90} + S_{3.5}$ (control)	6.0	1.02	1.07	1.25	1.11
	8.0	1.06	1.08	1.29	1.14
$N_{35}P_{90}K_{120} + S_{13.5}Ca_{15}Mg_{10}$	6.0	1.05	1.09	1.30	1.15
	8.0	1.05	1.09	1.29	1.14
$N_{35}P_{90}K_{150} + S_{23.5}Ca_{30}Mg_{20}$	6.0	1.09	1.10	1.31	1.17
	8.0	1.06	1.11	1.31	1.16
Average	6.0	1.05	1.09	1.29	1.14
	8.0	1.05	1.10	1.29	1.15

Source: developed by the authors

Research by Z. Zhou *et al.* (2024) confirmed that drought stress represents a significant environmental challenge that impedes alfalfa growth and yield worldwide. Z. Zhou *et al.* identified drought as a major challenge limiting alfalfa production and threatening food security. Water deficit causes damage to plants by disrupting various physiological processes such as carbon assimilation, cellular hydration, and leaf gas exchange. In the current study, a decrease in plant growth rates during the summer period was also observed due to insufficient moisture supply,

particularly in the second cut. When determining plant height increment across cuts, their stability between variants was revealed in the first cut, followed by subsequent growth in the second and third cuts to 1.07-1.31 cm/day. Y. Shen *et al.* (2013) established that cutting height significantly influenced shoot regrowth and alfalfa yield, which was confirmed by current observations regarding differentiated increment across cuts. P. Álvarez-Vázquez *et al.* (2020) investigated alfalfa productivity depending on regrowth age in the spring period, identifying optimal harvesting

timings for yield maximisation. Plant height increment rates increased with application of maximum mineral fertiliser dose from 1.29 to 1.31 cm/day, regardless of sowing rate, with average experimental values of 1.29 cm/day. Observations demonstrated that upon reaching the beginning of flowering phase, the highest plant

height was obtained in the first cut at 85.7-86.0 cm, whilst during the vegetation period, in the formation of subsequent cuts conducted on average after 40-41 days, a decrease was observed: in the second cut to 43.9-44.4 cm and in the third cut to 54.3-55.2 cm, with average values by sowing rates of 61.4-61.8 cm (Table 3).

Table 3. Alfalfa plant height across cuts depending on sowing rates and fertilisation at the beginning of flowering phase, $M \pm m^*$

Fertilisation	Sowing rate, million seeds/ha	Cuts			Average
		1	2	3	
$N_{35}P_{90}K_{90}+S_{3.5}$ (control)	6.0	85.4 ± 5.71	43.0 ± 4.83	50.6 ± 5.12	59.7 ± 5.22
	8.0	87.6 ± 4.85	43.6 ± 5.12	52.4 ± 3.88	61.2 ± 4.95
$N_{35}P_{90}K_{120}+S_{13.5}Ca_{15}Mg_{10}$	6.0	86.8 ± 6.57	44.3 ± 3.59	54.4 ± 4.00	61.8 ± 4.72
	8.0	85.4 ± 5.72	44.4 ± 4.38	54.5 ± 5.67	61.4 ± 5.26
$N_{35}P_{90}K_{150}+S_{23.5}Ca_{30}Mg_{20}$	6.0	85.8 ± 8.11	44.5 ± 3.44	57.8 ± 3.07	62.7 ± 4.87
	8.0	84.2 ± 7.66	45.2 ± 4.00	58.7 ± 3.87	62.7 ± 5.18
Average	6.0	86.0 ± 6.80	43.9 ± 3.95	54.3 ± 4.06	61.4 ± 4.94
	8.0	85.7 ± 6.08	44.4 ± 4.50	55.2 ± 4.47	61.8 ± 5.13

Note: * – $M \pm m$ – confidence interval of the arithmetic mean at the 5% significance level

Source: developed by the authors

It was demonstrated that across experimental variants, the tallest plants were observed at a sowing rate of 8.0 million/ha with mineral fertiliser at a dose of $N_{35}P_{90}K_{90} + S_{3.5}$, measuring 87.6 cm. Under conditions of insufficient moisture supply, plants exhibited decreased nutrient absorption from the soil, particularly with increased mineral fertiliser doses, which influenced height parameters of 84.2-85.8 cm. These results confirmed data from Y. Liu *et al.* (2018), who established that early harvesting ensured higher yield. The current study also revealed that the first cut was characterised by the highest linear plant parameters regardless of fertilisation variant. It was established that in the third cut, plants on average reached a height of 50.6-58.7 cm, or were 4.1-10.3 cm taller compared to values at the budding phase. Concurrently, average daily plant height increment was 1.23-1.43 cm/day. Y. Song *et al.* (2019) described in detail the mechanisms of alfalfa response to abiotic stress, including morphological, physiological, and molecular adaptations. Under the conditions

examined in the current study, a differentiated plant response to hydrothermal conditions was also observed, depending on growth and development phase. When comparing the obtained data with the budding phase, it could be concluded that over 7 days, height increased by 12.0-13.2 cm. Changes in parameters were explained by increased average daily plant increment to 1.71-1.88 cm/day, depending on sowing rates and fertilisation. Research by Y. Sun *et al.* (2022) confirmed that application of nitrogen and phosphorus fertilisers significantly influenced agronomic characteristics of alfalfa, particularly plant height and growth intensity. The obtained data indicated intensive plant height growth upon reaching the beginning of flowering phase compared to budding, regardless of fertilisation level. The trend of increasing plant height increment was maintained across experimental variants (Table 4). In the current study, substantial variability of parameters was also observed depending on weather conditions of the vegetation period. Results from Y. Feng *et al.* (2022) indicated a negative

correlation between alfalfa yield and crude protein content. This emphasised the importance of optimising harvesting timings, which was confirmed by current study data regarding the differentiated influence of harvesting phase on linear plant parameters. Comprehensive research by Y. Feng *et al.* also demonstrated that average alfalfa dry matter yield in China was 11.18 ± 6.69 t/ha

with an average crude protein content of $19.05 \pm 2.87\%$. The authors established a negative correlation between yield and protein content, indicating the necessity of balancing quantitative and qualitative parameters when optimising cultivation technologies. V. Greveniotis *et al.* (2024) in their research on alfalfa yield stability revealed significant genotype-by-year interaction.

Table 4. Average daily plant height increment of alfalfa across cuts depending on sowing rates and fertilisation at the beginning of flowering phase, cm/day

Fertilisation	Sowing rate, million seeds/ha	Cuts			Average
		1	2	3	
$N_{35}P_{90}K_{90} + S_{3.5}$ (control)	6.0	1.08	1.08	1.23	1.13
	8.0	1.11	1.09	1.27	1.16
$N_{35}P_{90}K_{120} + S_{13.5}Ca_{15}Mg_{10}$	6.0	1.10	1.11	1.33	1.18
	8.0	1.08	1.11	1.32	1.17
$N_{35}P_{90}K_{150} + S_{23.5}Ca_{30}Mg_{20}$	6.0	1.09	1.11	1.41	1.20
	8.0	1.06	1.13	1.43	1.21
Average	6.0	1.09	1.10	1.32	1.17
	8.0	1.08	1.11	1.35	1.18

Source: developed by the authors

Research by M. Daud *et al.* (2025) emphasised that alfalfa drought tolerance was relatively high compared to other forage crops due to a deep root system that could reach 1.5-4 m. This was confirmed by observations from the current study: despite unfavourable hydrothermal conditions, alfalfa cultivar 'Radoslava' formed three full cuts across the studied growth and development phases. With available hydrothermal resources during the alfalfa vegetation period in 2025, three full cuts were obtained at the budding phase and at the beginning of flowering. On average, plants reached a height within the range of 54.3-61.8 cm with plant leafiness at 53.0-54.5%, depending on growth and development phase and the factors studied. It was established that the effect of studied factors was stable and ensured the best linear plant parameters of 62.7 cm at the beginning of flowering phase under conditions of alfalfa sowing at both sowing rates and use of complex fertiliser with increased macro and micro-element levels. Height was 3.0 cm (5.0%) higher than the control with application

of $N_{35}P_{90}K_{90} + S_{3.5}$. The difference between average plant height values across growth and development phases was 7.0 cm; that is, plant height from the budding phase to the beginning of flowering increased by 7 cm.

Results obtained in the study were consistent with principles presented in works by V. Petrychenko *et al.* (2018), where alfalfa was considered as a stabilising factor in forage production intensification due to high productivity and forage quality. The established dependence of plant height on harvesting phases confirmed the feasibility of a differentiated approach to forage cutting timings, which influenced the formation of its structure. This was explained by research results from V.F. Petrychenko & H.P. Kvitko (2010), according to which the highest protein proportion was concentrated in alfalfa leaves, buds, and flowers, whilst stems were characterised by significantly lower nutritional value, which substantiated the advantages of harvesting at budding and beginning of flowering phases. Research by G. Bélanger *et al.* (2020) confirmed that harvesting

alfalfa at the early budding phase compared to the beginning of flowering reduced dry matter yield by 2.03 t/ha; however, it increased total digestible nutrient concentration by 44 g/kg, indicating the necessity of optimising harvesting timings depending on the target purpose of forage. Research by H. Wang *et al.* (2023) demonstrated that alfalfa populations exhibited significant genetic diversity and capacity for local adaptation, ensuring their suitability to various agroecological conditions and prolonged productive utilisation of forage. Results obtained from the current study confirmed the determining role of weather conditions in the formation of alfalfa growth processes, which was consistent with conclusions by M.H. Kvitko (2017), obtained for conditions of the Right-Bank Forest-Steppe on grey forest soils. The variability of plant height across cuts and harvesting phases established in the experiment was explained by fluctuations in temperature regime and moisture supply throughout the vegetation period, which significantly influenced the intensity of growth and forage regrowth. Under conditions of elevated temperatures and moisture deficit, a decrease in growth rates was observed, which confirmed the high sensitivity of alfalfa to hydrothermal factors, regardless of mineral nutrition level. Thus, the obtained data supplemented results from previous research and indicated the necessity of accounting for weather conditions when interpreting the effects of agrotechnical measures on alfalfa growth and development.

The obtained experimental data demonstrated a stable effect of studied factors on alfalfa growth processes under conditions of the Right-Bank Forest-Steppe. The identified patterns of plant height changes depending on harvesting phases and mineral nutrition levels indicated the determining role of cutting timings in the formation of linear forage parameters. Under the influence of hydrothermal conditions of the vegetation period, a differentiated plant response to fertilisation was observed, which determined the variability of growth parameters across cuts.

Conclusions

It was established that despite challenging hydrothermal conditions of the Right-Bank Forest-Steppe (increase in average monthly air temperature from 19.5 to 21.5°C and insufficient atmospheric precipitation of 87 mm during June-August), during the vegetation period, alfalfa cultivar 'Radoslava' formed three full cuts at the budding phase and at the beginning of flowering, which indicated its high adaptability to growing conditions. On average across three cuts, plant height reached 54.3-54.5 cm at the budding phase and 61.4-61.8 cm at the beginning of flowering phase. The tallest plants were observed in the first cut, measuring 76.8-85.8 cm with application of mineral fertilisers at a dose of $N_{35}P_{90}K_{150}+S_{23-5}Ca_{30}Mg_{20}$. Average plant height values were 55.7-62.7 cm at a sowing rate of 6.0 million viable seeds/ha. The difference between harvesting phases was 7.0 cm, which confirmed the feasibility of harvesting at the beginning of flowering phase to obtain maximum vegetative mass.

It was demonstrated that complex mineral fertilisation contributed to plant height increment from 0.9-1.9 cm to 1.0-2.7 cm compared to the control. Average daily plant height increment was 1.05-1.17 cm/day at the budding phase and 1.13-1.21 cm/day at the beginning of flowering phase, which indicated more intensive growth at later harvesting. The highest average daily increment was observed in the third cut, measuring 1.25-1.31 cm/day. It was established that under drought stress conditions, plants were unable to effectively absorb mineral fertilisers from the soil, which resulted in decreased growth rates, particularly in the second cut (41.4-44.4 cm). This indicated the necessity of accounting for hydrothermal conditions when planning fertilisation systems and adjusting fertiliser application rates depending on moisture supply. Prospects for further research lie in studying the influence of different fertilisation systems on dry matter yield and qualitative composition of alfalfa forage production (protein content, fibre, metabolisable energy), as well as investigating crop water consumption

and moisture use efficiency under conditions of climate change in the Right-Bank Forest-Steppe. None.

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Conflict of Interest

None.

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Значення люцерни посівної та ростові процеси за фазами збирання в умовах Лісостепу правобережного

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Анотація. Метою роботи було вивчення впливу строків збирання та рівнів удобрення на висоту рослин люцерни посівної в умовах Лісостепу правобережного. Дослідження проводилися на дослідному полі Вінницького національного аграрного університету за варіантами з різними нормами висіву (6,0-8,0 млн/га) та чотирма рівнями мінерального живлення. У рік сівби найменша висота рослин люцерни посівної була за нормою висіву 8,0 млн/га схожих насінин (63,4-64,4 см), що зросла до 64,4-66,3 см при нормі висіву 6,0 млн/га. Комплексне добриво сприяло приросту висоти рослин від 0,9-1,9 см до 1,0-2,7 см порівняно з контролем. Встановлено, що рослини, перебуваючи в стресових умовах через підвищену температуру повітря і недостатність вологи на глибині кореневої системи, не змогли ефективно споживати мінеральні добрива з ґрунту, що призвело до зниження темпів приросту. На другий рік вегетації, з огляду на гідротермічні умови літнього періоду, спостерігалось впливання на ростові процеси люцерни. Це позначилося на висоті рослин як за укосами, так і за фазами збирання травостою. За три укоси у фазі бутонізації середня висота рослин досягала 54,3-54,5 см, незалежно від норм висіву та рівня мінерального живлення. Результати мали синусоїдальний вигляд: найвища висота рослин була за першого укосу – 73,7-73,8 см, з найменшою висотою при скошуванні другого укосу – 41,4-41,8 см, з подальшим зростанням до 47,7-47,9 см у третьому укосі. У фазі початку цвітіння найбільша висота рослин досягала 85,7-86,0 см, а на наступних укосах, що проводилися через 40-41 добу, спостерігалась знижена висота: у другому укосі 43,9-44,4 см і в третьому укосі 54,3-55,2 см. Середня висота рослин за нормами висіву складала 61,4-61,8 см. Таким чином, люцерна посівна за період вегетації сформувала три повноцінних укоси, із середньою висотою 54,3-54,5 см. Найбільші рослини досягали 76,8-85,8 см при внесенні мінеральних добрив у дозі $N_{35}P_{90}K_{150} + S_{23,5}Ca_{30}Mg_{20}$, а середні показники становили 55,7-62,7 см при сівбі 6,0 млн/га. Результати досліджень можуть бути використані для оптимізації агротехнологій вирощування люцерни посівної в умовах Лісостепу

Ключові слова: *Medicago sativa*, бутонізація, початок цвітіння, норма висіву, добрива