RESEARCH ON THE BEHAVIOR OF PERENNIAL GRASSES AND LEGUMES IN SIMPLE AND COMPLEX MIXTURES IN THE CONDITIONS OF THE MOLDOVIAN FOREST-STEPPE

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Abstract

Due to the low productivity of permanent grasslands, recent research has focused on sown temporary grasslands, which offer a high potential for production and superior forage quality. This paper presents the results of a bifactorial experiment conducted in the spring of 2024 at the Ezăreni Farm (USV Iași), with the objective of evaluating the influence of the species or mixture of perennial grasses and legumes,and fertilization on plant development in the first year of vegetation. The factors studied were A – the sown species or mixture (10 graduations) and B - the level of fertilization with mineral fertilizers (4 graduations). Observations were made on the number of shoots/m² and the height of the plants at harvest. The results showed that complex mixtures including species such as Medicago sativa and Festuca pratensis generated the highest value of the number of shoots, especially under conditions of high fertilization ($N_{100}P_{100}K_{100}$). Plant height was significantly influenced by the presence of Onobrychis viciifolia, especially in the intensively fertilized variants. The conclusions highlight the efficiency of using perennial mixtures and balanced fertilization in increasing the productive potential of temporary meadows, in the context of climate change

Keywords: *temporary meadows, mineral fertilization, plant height, yield.*

INTRODUCTION

Due to the low productivity of permanent grasslands, the need was felt to closely study temporary sown grasslands. Temporary grasslands are sown and managed with the expectation of achieving high production and high-quality forage (Søegaard K. et al. 2007). Research conducted at national and international levels has shown the benefits of growing forage plants but has also led to the establishment of standard mixtures of such forage plants.

Interspecific competitiveness was influenced by the percentage of participation in the sowing rate of the species in the mixture, the mineral fertilizers used, the biological characteristics of the studied species and the climatic conditions specific to each crop year (Vîntu V. et al. 2024). Fertilization with complex mineral fertilizers leads in most cases to higher dry matter production regardless of the species or mixture of perennial grasses and legumes (Zaiț T. et al. 2022).

The composition of the mixture has a significant effect on biomass yield and quality indices, rather than on species diversity (Tahir M. et al., 2022). Research results have shown that the association of white clover with medium-sized perennial grass could provide the best option for temporary meadows (Piano E. et al., 1995). Some grass species are also studied for their anti-erosion effect, such as *Festuca arundinacea plants,* but also their cultivation on temporary meadows mixed with other grasses or perennial legumes, grass strips in vineyards and orchards, the biomass production being successfully used as green mass or hay in feeding farm animals. (Țîței V. et al., 2019; 2022).

The quality of the forage obtained from temporary pastures is influenced by the doses of fertilizers applied, the proportion of the species' participation in the sowing rate, but also by the climatic conditions during the exploitation period. (Boureanu C. et al., 2016). The quality of forage obtained from sown meadows is influenced by the percentage of participation of each species in the mixture, but also the different degree of fertilization (Samuil C. et al., 2012). Since the 20th century, research on complex mixtures of perennial grasses and legumes has shown benefits in their cultivation, as well as a standardization of perennial grass and legume species across different cropping areas (Sanderson M.A. et al., 2005).

The productivity of grasslands in dry areas can be influenced by the choice of more drought-tolerant plants for sowing. (Skinner R.H. et al., 2004). Moderate use of mineral and organic fertilizers brings higher yields, also having a positive effect on biodiversity and forage quality (Samuil C. et al., 2018).

MATERIAL AND METHOD

The experiment was established in the experimental field of the Ezăreni Farm (47°05'-47°10' north latitude and 27°28'-27°33' east longitude) belonging to the Didactic Station of the Iasi University of Life Sciences, according to the method of subdivided plots with two factors (of the 10x4 type), in 3 repetitions, having the dimensions of a plot of 1 x 9 m (9 m2), the total surface of the experience being of 1280 m^2.

The goal is to develop and standardize mixtures of perennial forage species under the conditions of climate change in the experimental area. In the first part, the influence of the mixture and fertilization on the growth and development of plants within the mixtures will be studied.

The study factors were:

Factor A: the species or mixture of perennial grasses and legumes, with 10 gradations: a_1– *Onobrychis viciifolia* Scop. (100%) (control); a_2 – *Onobrychis viciifolia* Scop. (75%) and *Bromus inermis* Leyss. (25%); a_3-*Onobrychis viciifolia* Scop. (50%) and *Bromus inermis* Leyss. (50%); a_4-*Onobrychis viciifolia* Scop. (25%) and *Bromus inermis* Leyss. (75%); a_5 – *Medicago sativa* L. (100%); a_6 – *Medicago sativa* L. (75%) and *Festuca pratensis* (25%); a_7 - *Medicago sativa* L. (50%) and *Festuca pratensis* (50%); a_8 – *Medicago sativa* L. (25%) and *Festuca pratensis* (75%); a_9 – *Medicago sativa* L. (20%), *Lotus corniculatus* L. (15%); *Festuca pratensis* (30%); *Lolium perenne* L. (10%) and *Dactylis glomerata* L. (25%) and a_{10} – *Onobrychis viciifolia* Purpose. (20%), *Lotus corniculatus* L. (15%); *Agropyron pectiniforme* L. (30%); *Bromus inermis* Leyss. (25%) and *Lolium perenne* L. (10%).

Factor B - fertilization with mineral fertilizers, with 4 graduations: b_1–unfertilized (C); b_2-$N_{50}P_{50}K_{50}$; b_3-$N_{75}P_{75}K_{75}$; b_4-$N_{100}P_{100}K_{100}$.

Observations and determinations carried out in the field during the entire vegetation period, the following indices being observed: number of shoots/m; plant height at harvest (cm).

The amount of green mass per hectare was determined by weighing the production obtained after each scythe on the harvestable surface of 8 m^2 and reported per hectare. The content in dry matter (s.u.) was determined by drying in an oven, at a temperature of 105ºC, for 3 hours; standard - SR ISO 6496/2001. Height, number of shoots and and yield data were processed using ANOVA, applying the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

The study analyzed the influence of fertilization with complex mineral fertilizers based on nitrogen, phosphorus and potassium on the number of shoots formed by the time of harvest, in the species *Onobrychis viciifolia* and *Medicago sativa*, cultivated both alone and in simple and complex mixtures (table 1).

The data obtained revealed a significant variation in the number of shoots depending on the combination of species type (or mixture) and fertilization level applied.

Thus, the values ranged between 508 shoots/m², in variant a_1 b_1 (*Onobrychis viciifolia* 100%, unfertilized), and 3092 shoots/m², in variant $a_{10}b_4$ (complex mixture consisting of *Medicago sativa* 20%, *Lotus corniculatus* 15%, *Festuca pratensis* 30%, *Lolium perenne* 10% and *Dactylis glomerata* 25%), fertilized with the maximum dose of $N_{100}P_{100}K_{100}$ (table 1).

Table 1

Influence of the interaction between the species or mixture of perennial grasses and legumes and fertilization with mineral fertilizers on the number of shoots/m^2, in the first year of vegetation

Variant		Number of shoots	Difference		Meaning
		Shoots/m^2	Shoots/m^2	%	
		Control: a_1b_1 - *O.v.* (100%), unfertilized			
a_1 - *O.v.* (100%) (mt.)	b_1 - unfertilized (mt.)	508	Control	100	Control
	b_2 - $N_{50}P_{50}K_{50}$	620	112	122,0	
	b_3 - $N_{75}P_{75}K_{75}$	664	156	130,7	
	b_4 - $N_{100}P_{100}K_{100}$	736	228	144,9	
a_2 - *O.v.* (75%) + *B.i.* (25%)	b_1 - unfertilized	792	284	155,9	
	b_2 - $N_{50}P_{50}K_{50}$	956	448	188,2	**
	b_3 - $N_{75}P_{75}K_{75}$	1072	564	211,0	***
	b_4 - $N_{100}P_{100}K_{100}$	1124	616	221,3	***
a_3 - *O.v.* (50%) + *B.i.* (50%)	b_1 - unfertilized	1000	492	196,9	**
	b_2 - $N_{50}P_{50}K_{50}$	1160	652	228,3	***
	b_3 - $N_{75}P_{75}K_{75}$	1240	732	244,1	***
	b_4 - $N_{100}P_{100}K_{100}$	1348	840	265,4	***
a_4 - *O.v.* (25%) + *B.i.* (75%)	b_1 - unfertilized	688	180	135,4	
	b_2 - $N_{50}P_{50}K_{50}$	744	236	146,5	
	b_3 - $N_{75}P_{75}K_{75}$	880	372	173,2	*
	b_4 - $N_{100}P_{100}K_{100}$	964	456	189,8	**
a_5 - *M.s.* (100%)	b_1 - unfertilized	1200	692	236,2	***
	b_2 - $N_{50}P_{50}K_{50}$	1700	1192	334,6	***
	b_3 - $N_{75}P_{75}K_{75}$	1308	800	257,5	***
	b_4 - $N_{100}P_{100}K_{100}$	1816	1308	357,5	***
a_6 - *M.s.* (75%) + *F.p.* (25%)	b_1 - unfertilized	1492	984	293,7	***
	b_2 - $N_{50}P_{50}K_{50}$	2100	1592	413,4	***
	b_3 - $N_{75}P_{75}K_{75}$	2508	2000	493,7	***
	b_4 - $N_{100}P_{100}K_{100}$	2668	2160	525,2	***
a_7 - *M.s.* (50%) + *F.p.* (50%)	b_1 - unfertilized	1764	1256	347,2	***
	b_2 - $N_{50}P_{50}K_{50}$	2024	1516	398,4	***
	b_3 - $N_{75}P_{75}K_{75}$	2100	1592	413,4	***
	b_4 - $N_{100}P_{100}K_{100}$	2664	2156	524,4	***
a_8 - *M.s.* (25%) + *F.p.* (75%)	b_1 - unfertilized	2160	1652	425,2	***
	b_2 - $N_{50}P_{50}K_{50}$	2284	1776	449,6	***
	b_3 - $N_{75}P_{75}K_{75}$	2600	2092	511,8	***
	b_4 - $N_{100}P_{100}K_{100}$	2704	2196	532,3	***
a_9 - *M.s.* (20%) + *L.c.* (15%) + *F.p.* (30%) + *L.p.* (10%) + *D.g.* (25%)	b_1 - unfertilized	2236	1728	440,2	***
	b_2 - $N_{50}P_{50}K_{50}$	2732	2224	537,8	***
	b_3 - $N_{75}P_{75}K_{75}$	2968	2460	584,3	***
	b_4 - $N_{100}P_{100}K_{100}$	3092	2584	608,7	***
a_{10} - *O.v.* (20%) + *L.c.* (15%) + *A.p.* (30%) + *B.i.* (25%) + *L.p.* (10%)	b_1 - unfertilized	1440	932	283,5	***
	b_2 - $N_{50}P_{50}K_{50}$	1800	1292	354,3	***
	b_3 - $N_{75}P_{75}K_{75}$	1592	1084	313,4	***
	b_4 - $N_{100}P_{100}K_{100}$	1936	1428	381,1	***
		DL 5% =	319		
		DL 1% =	423		
		DL 0,1% =	547		

The highest values of shoot number were recorded in the variants that included *Medicago sativa* and *Festuca pratensis* , grown in various mixtures, both simple and complex.

In general, regardless of the composition of the species used, fertilization with complex mineral fertilizers resulted in a significant increase in the number of shoots per unit area.

Compared to the control variant, all other variants analyzed presented very statistically significant differences.

During the observations, the height of the shoots at the time of harvest was determined for the species *Onobrychis viciifolia* and *Medicago sativa* , cultivated either individually or in simple or complex mixtures, under different fertilization conditions with complex mineral fertilizers based on nitrogen, phosphorus and potassium (table 2).

The analysis of the interaction between the type of species (or mixture) and the applied fertilization revealed values ranging from 36.7 cm, in variant a_8 b_1 (simple mixture consisting of *Medicago sativa* 25% + *Festuca pratensis* 75%, unfertilized), and 77.5 cm, in variant a_1 (*Onobrychis viciifolia* 100%), fertilized with the maximum dose of $N_{100}P_{100}K_{100}$ (table 2).

Regarding plant height, the highest values were recorded in the variants where Onobrychis viciifolia Scop. was present, either grown alone or in mixtures.

In general, fertilization with nitrogen and phosphorus-based mineral fertilizers led to an increase in plant height, regardless of the type of species or mixture used. With the exception of the variant grown exclusively with *Onobrychis viciifolia*, all other fertilized variants showed statistically significant differences compared to the control (table 2).

Regardless of the fertilization variant or the composition of the mixture, climatic conditions, especially the amount of precipitation, significantly influenced the processes of germination, emergence, growth and development.

The height of the plants in the first cut, in the first year of vegetation, was largely determined by the level of precipitation recorded in the first part of the vegetation period. In the first year of vegetation, a single mowing was carried out. The analysis of the data obtained shows that the dry matter (DM) yields varied significantly depending on the species composition and the fertilization regime applied (table 3). The lowest yields were recorded in variant a_8, a simple mixture consisting of *Medicago sativa* (25%) and *Festuca pratensis* (75%), unfertilized, with a production of 1776 kg/ha DM. At the opposite pole, variant a_1, represented by *Onobrychis viciifolia* (100%) grown in monoculture and fertilized with $N_{100}P_{100}K_{100}$, recorded the highest production, of 5745 kg/ha DM (table 3).

Table 2

Influence of the interaction between the species or mixture of perennial grasses and legumes and fertilization with mineral fertilizers on plant height, in the first year of vegetation

Variant		Plant height	Diferența		Meaning
		cm	cm	%	
		Control: a_1b_1 - *O.v.* (100%), unfertilized			
a_1 - *O.v.* (100%) (mt.)	b_1 - unfertilized (mt.)	77,5	Control	100	Control
	b_2 - $N_{50}P_{50}K_{50}$	75,3	-2,2	97,2	
	b_3 - $N_{75}P_{75}K_{75}$	75,3	-2,2	97,2	
	b_4 - $N_{100}P_{100}K_{100}$	72,0	-5,5	92,9	
a_2 - *O.v.* (75%) + *B.i.* (25%)	b_1 - unfertilized	71,2	-6,3	91,8	
	b_2 - $N_{50}P_{50}K_{50}$	74,8	-2,7	96,6	
	b_3 - $N_{75}P_{75}K_{75}$	69,3	-8,2	89,5	
	b_4 - $N_{100}P_{100}K_{100}$	71,2	-6,3	91,8	
a_3 - *O.v.* (50%) + *B.i.* (50%)	b_1 - unfertilized	69,8	-7,7	90,1	
	b_2 - $N_{50}P_{50}K_{50}$	70,0	-7,5	90,3	
	b_3 - $N_{75}P_{75}K_{75}$	69,2	-8,3	89,2	
	b_4 - $N_{100}P_{100}K_{100}$	68,8	-8,7	88,8	
a_4 - *O.v.* (25%) + *B.i.* (75%)	b_1 - unfertilized	72,7	-4,8	93,8	
	b_2 - $N_{50}P_{50}K_{50}$	69,7	-7,8	89,9	
	b_3 - $N_{75}P_{75}K_{75}$	75,3	-2,2	97,2	
	b_4 - $N_{100}P_{100}K_{100}$	73,3	-4,2	94,6	
a_5 - *M.s.* (100%)	b_1 - unfertilized	45,0	-32,5	58,1	ooo
	b_2 - $N_{50}P_{50}K_{50}$	46,2	-31,3	59,6	ooo
	b_3 - $N_{75}P_{75}K_{75}$	42,8	-34,7	55,3	ooo
	b_4 - $N_{100}P_{100}K_{100}$	50,3	-27,2	64,9	oo
a_6 - *M.s.* (75%) + *F.p.* (25%)	b_1 - unfertilized	44,2	-33,3	57,0	ooo
	b_2 - $N_{50}P_{50}K_{50}$	45,7	-31,8	58,9	ooo
	b_3 - $N_{75}P_{75}K_{75}$	44,7	-32,8	57,6	ooo
	b_4 - $N_{100}P_{100}K_{100}$	47,3	-30,2	61,1	oo
a_7 - *M.s.* (50%) + *F.p.* (50%)	b_1 - unfertilized	49,3	-28,2	63,7	oo
	b_2 - $N_{50}P_{50}K_{50}$	47,0	-30,5	60,6	oo
	b_3 - $N_{75}P_{75}K_{75}$	49,2	-28,3	63,4	oo
	b_4 - $N_{100}P_{100}K_{100}$	53,8	-23,7	69,5	o
a_8 - *M.s.* (25%) + *F.p.* (75%)	b_1 - unfertilized	36,7	-40,8	47,3	ooo
	b_2 - $N_{50}P_{50}K_{50}$	45,8	-31,7	59,1	ooo
	b_3 - $N_{75}P_{75}K_{75}$	44,5	-33,0	57,4	ooo
	b_4 - $N_{100}P_{100}K_{100}$	41,5	-36,0	53,5	ooo
a_9 - *M.s.* (20%) + *L.c.* (15%) + *F.p.* (30%) + *L.p.* (10%) + *D.g.* (25%)	b_1 - unfertilized	43,2	-34,3	55,7	ooo
	b_2 - $N_{50}P_{50}K_{50}$	44,8	-32,7	57,8	ooo
	b_3 - $N_{75}P_{75}K_{75}$	45,3	-32,2	58,5	ooo
	b_4 - $N_{100}P_{100}K_{100}$	47,7	-29,8	61,5	oo
a_{10} - *O.v.* (20%) + *L.c.* (15%) + *A.p.* (30%) + *B.i.* (25%) + *L.p.* (10%)	b_1 - unfertilized	59,0	-18,5	76,1	o
	b_2 - $N_{50}P_{50}K_{50}$	56,5	-21,0	72,9	o
	b_3 - $N_{75}P_{75}K_{75}$	59,2	-18,3	76,3	o
	b_4 - $N_{100}P_{100}K_{100}$	66,3	-11,2	85,6	
		DL 5% =	17,9		
		DL 1% =	23,7		
		DL 0,1% =	30,6		

Table 3

Influence of the interaction between the species or mixture of perennial grasses and legumes and fertilization with mineral fertilizers on the production of DM in the first year of vegetation

Variant		Production of DM	Difference		Meaning
		kg/ha	kg/ha	%	
a_1 - *O.v.* (100%) (mt.)	b_1 - unfertilized (mt.)	3263	Control	100	Control
	b_2 - $N_{50}P_{50}K_{50}$	5159	1895,5	158,1	***
	b_3 - $N_{75}P_{75}K_{75}$	4444	1181,0	136,2	***
	b_4 - $N_{100}P_{100}K_{100}$	5745	2482,0	176,1	***
a_2 - *O.v.* (75%) + *B.i.* (25%)	b_1 - unfertilized	3854	590,5	118,1	**
	b_2 - $N_{50}P_{50}K_{50}$	3913	650,0	119,9	***
	b_3 - $N_{75}P_{75}K_{75}$	3963	699,2	121,4	***
	b_4 - $N_{100}P_{100}K_{100}$	5267	2003,3	161,4	***
a_3 - *O.v.* (50%) + *B.i.* (50%)	b_1 - unfertilized	2893	-370,0	88,7	o
	b_2 - $N_{50}P_{50}K_{50}$	3267	3,3	100,1	
	b_3 - $N_{75}P_{75}K_{75}$	3577	314,0	109,6	
	b_4 - $N_{100}P_{100}K_{100}$	4037	773,5	123,7	***
a_4 - *O.v.* (25%) + *B.i.* (75%)	b_1 - unfertilized	2703	-560,2	82,8	oo
	b_2 - $N_{50}P_{50}K_{50}$	3884	620,7	119,0	***
	b_3 - $N_{75}P_{75}K_{75}$	5093	1830,0	156,1	***
	b_4 - $N_{100}P_{100}K_{100}$	4703	1440,0	144,1	***
a_5 - *M.s.* (100%)	b_1 - unfertilized	2703	-560,2	82,8	oo
	b_2 - $N_{50}P_{50}K_{50}$	3824	560,3	117,2	**
	b_3 - $N_{75}P_{75}K_{75}$	4994	1730,7	153,0	***
	b_4 - $N_{100}P_{100}K_{100}$	4397	1133,5	134,7	***
a_6 - *M.s.* (75%) + *F.p.* (25%)	b_1 - unfertilized	1978	-1285,0	60,6	ooo
	b_2 - $N_{50}P_{50}K_{50}$	2348	-915,0	72,0	ooo
	b_3 - $N_{75}P_{75}K_{75}$	2620	-643,7	80,3	ooo
	b_4 - $N_{100}P_{100}K_{100}$	2838	-425,2	87,0	o
a_7 - *M.s.* (50%) + *F.p.* (50%)	b_1 - unfertilized	2673	-590,0	81,9	oo
	b_2 - $N_{50}P_{50}K_{50}$	2743	-520,8	84,0	oo
	b_3 - $N_{75}P_{75}K_{75}$	2971	-292,5	91,0	
	b_4 - $N_{100}P_{100}K_{100}$	3163	-100,0	96,9	
a_8 - *M.s.* (25%) + *F.p.* (75%)	b_1 - unfertilized	1776	-1487,5	54,4	ooo
	b_2 - $N_{50}P_{50}K_{50}$	2914	-349,7	89,3	o
	b_3 - $N_{75}P_{75}K_{75}$	2167	-1096,0	66,4	ooo
	b_4 - $N_{100}P_{100}K_{100}$	3712	449,0	113,8	*
a_9 - *M.s.* (20%) + *L.c.* (15%) + *F.p.* (30%) + *L.p.* (10%) + *D.g.* (25%)	b_1 - unfertilized	3485	222,0	106,8	
	b_2 - $N_{50}P_{50}K_{50}$	3633	370,0	111,3	*
	b_3 - $N_{75}P_{75}K_{75}$	4867	1603,3	149,1	***
	b_4 - $N_{100}P_{100}K_{100}$	4306	1043,0	132,0	***
a_{10} - *O.v.* (20%) + *L.c.* (15%) + *A.p.* (30%) + *B.i.* (25%) + *L.p.* (10%)	b_1 - unfertilized	2893	-370,0	88,7	o
	b_2 - $N_{50}P_{50}K_{50}$	3233	-30,0	99,1	
	b_3 - $N_{75}P_{75}K_{75}$	3698	435,0	113,3	*
	b_4 - $N_{100}P_{100}K_{100}$	4801	1537,3	147,1	***
		DL 5% =	345,4		
		DL 1% =	458,2		
		DL 0,1% =	591,9		

Research has shown that the application of mineral fertilizers based on nitrogen, phosphorus and potassium had a positive effect on production, with most of the differences between the variants being statistically significant.
Production was influenced both by the fertilization dose and by the species or combinations used. At the first mowing, in the first year of vegetation, the highest productions were obtained in variant a_1, where *Onobrychis viciifolia* was grown alone and fertilized with high doses of NPK. At the same time, the variants in which this species was predominant generated higher productions even under moderate fertilization conditions or even in the absence of fertilization.
Good yields were also obtained in the case of complex mixtures, such as variants a_8 and a_9, where statistically significant production increases were recorded (table 3).

CONCLUSIONS

In the first year of vegetation, the highest number of shoots was recorded in the variants that included the species *Medicago sativa* L. and *Festuca pratensis* L., cultivated in both simple and complex mixtures.

The average number of shoots per square meter varied between 632 shoots/m² in variant a_1, composed exclusively of *Onobrychis viciifolia* Scop. (100%), and 2757 shoots/m² in variant a_9, a complex mixture composed of *M.s.* (20%), *L.c.* (15%), *F.p.* (30%), *L.p.* (10%) and *D.g.* (25%). The height of the shoots, in the first year of vegetation, ranged between 36.7 cm in variant a_8b_1 (simple mixture: *M.s.* 25% + *F.p.* 75%) and 77.5 cm in variant a_1 (*O.v.* 100%), fertilized with $N_{100}P_{100}K_{100}$.The highest plant height values were observed in the variants in which the species *Onobrychis viciifolia* Scop. was present.

The vegetative development of plants is significantly influenced both by the supply of essential nutrients: nitrogen, phosphorus and potassium, provided by fertilization, and by the genetic potential of the cultivated species.

In the first year of vegetation, a single mowing was carried out, and dry matter production showed significant variations, ranging from 1776 kg/ha DM in variant a_8 - simple mixture consisting of *Medicago sativa* (25%) and *Festuca pratensis* (75%), unfertilized - and 5745 kg/ha DM in variant a_1, where *Onobrychis viciifolia* (100%) fertilized with $N_{100}P_{100}K_{100}$.

The highest productions were obtained in the variants in which *Onobrychis viciifolia* Scop. was present in a proportion greater than 50%, highlighting the favorable influence of this species on the level of production.

The application of mineral fertilizers based on nitrogen, phosphorus and potassium determined significant increases in dry matter production in the first year of vegetation, the differences between the variants being, in most cases, statistically significant.

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