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Features of growth and development of alfalfa-cereal grass stands depending on the species composition and fertiliser

Abstract. The results of studies on the influence of the species composition of herbage, the level of fertiliser, and growth stimulator Fumar on the density and botanical composition of plants are presented. The experimental part of the study was performed in the scientific laboratories of the Department of feed production, land reclamation and meteorology in the production division of the National University of Life and Environmental Sciences of Ukraine "Agronomic Research Station". The territory of the station is located in the Right-Bank Forest-Steppe and is part of the Bilotserkivsky agro-soil district. Experimental plots were laid on chernozems of typical low-humus large-dusty light loamy mechanical composition, which are characterised by a high content of nutrients. The climate of the region is characterised by unstable humidity and moderate temperature conditions.

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The average annual air temperature is 6-8°C. The annual amount of precipitation reaches 562 mm, during the growing season – 354-394 mm (63-70% of the annual norm), which falls unevenly throughout the year. Based on the conducted studies, it was identified that sown herbage is formed with a density of 686-1250 shoots per 1 m2 and a height of 58-148 cm. Alfalfa-cereal and cereal stands are denser than alfalfa ones. For the period from 1 to 3 years of use of herbage, the density of alfalfa shoots decreases, while that of orchard grass and smooth brome increases, and more intensively with the introduction of N_{60}. During the first three years of use, grass stands are formed with the dominance of sown components with a share of alfalfa in single-species sowing of 85-98%, in alfalfa – cereal mixtures – 30-58%. For the period from the 1st to the 3rd year of use of alfalfa-cereal stands, the share of alfalfa decreases by 11-24%, and more intensively with the introduction of N60. In addition, between the two cereal components, there is a change of co-dominant – from meadow fescue to eastern fescue, eastern fescue to orchard grass, perennial ryegrass to smooth brome, like in the cereal stand, eastern fescue to smooth brome. In the 3rd year of use, ryegrass thins out, reducing the involvement rate to 5-14%

Keywords: alfalfa, cereal stand, shoot density, botanical composition, fertiliser

RELEVANCE

Improving the efficiency of using natural forage land plays an important role in creating a strong feed base for animal husbandry. The latter are a source of cheap grass feed (hay, haylage, green feed, artificially dried grass feed), which are well balanced in protein, minerals, and vitamins, and also act as a factor in improving the ecological situation in agricultural landscapes, protecting soils from erosion and water sources from siltation and pollution.

In Ukraine, the area of such land is approximately 7.8 million hectares, in the Right-Bank Forest-Steppe – 1 million hectares. However, their feed-producing and environmental capabilities are not yet fully used. Productivity in modern conditions of insufficient resource provision of agriculture remains too low (does not exceed 1.0-1.2 t/ha of feed units), which is several times less than the potential capabilities (Bohovin & Kurhak, 2007; Veklenko, 2003; Yarmolyuk, 2001).

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

It is necessary to improve nitrogen nutrition to increase the productivity of sown perennial grass stands because their need for nitrogen is the greatest. The average nitrogen dose per 1 ha of improved hayfields and pastures in Ukraine does not exceed 15-20 kg/ha along with its acute deficit balance. The removal of this element with the harvest is several times higher than the return. The need of meadow lands in Ukraine for nitrogen can be half covered by the effective use of the potential of perennial legumes through the enrichment of meadow stands with legume components (Bohovin, 2009; Davydyuk, 2000; Ohiyenko, 2008). Due to the insufficient supply of forage crops with mineral nitrogen, which is at the first minimum in most soil types, considerable attention should be paid to the creation of legume- cereal stands with an increased proportion of legume components in them (Kurhak & Luk'yanets', 2004; Satsik, 2000).

Among the sown grass stands, the legume-cereal ones fully comply with the principles of organic production, are one of the most promising areas of organic meadow farming, in which legume components ensure high productivity of land and feed quality without the introduction of mineral nitrogen. In the conditions of the Forest-Steppe, the best results in terms of productivity and feed quality in the composition of legume-cereal grass mixtures are provided by the use of alfalfa as a legume component. Its introduction into the composition of legume-cereal coenoses without the introduction of mineral nitrogen increases the productivity of meadow lands by 1.5-2.5, and protein collection – by 2-3 times compared to grass stands (Demydas' *et al.*, 2019, Slyusar, 2002).

One of the main conditions for creating highly productive sown herbage is the correct selection of cereal components, considering their cenotic characteristics, and environmental and agrotechnical factors. It is necessary to consider the relationships and interspecific functional relationships between plants in phytocenoses, starting from the moment of seed germination, so that cereals are characterised by low cenotic activity or aggressiveness. In grass mixtures, first of all, those types and varieties of herbs that are more productive and resistant in these soil and climatic conditions are used for sowing them in their pure form (Voloshyn & Sukaylo, 2014; Kurhak & Luk'yanets', 2002).

The purpose of the study consists in establishing the regularities of the development of high productivity of sown perennial grass stands with alfalfa sowing for the use of various cereal components, mineral fertilisers and growth stimulator Fumar on chernozems of typical low-humus Forest-Steppe of the right bank.

MATERIALS AND METHODS

The research was conducted in scientific laboratories of the Department of fodder production, land reclamation, and meteorology in the production division of the National University of Life and Environmental Sciences of Ukraine "Agronomic research station" during 2014-2016. The soil of the experimental field is the typical low-humus chernozem, with a large-dusty medium loamy granulometric composition. The humus content in the arable layer (according to Tyurin) is 4.34%, the pH of the salt extract is 6.8, the absorption capacity – 307 mg-Eq/kg of soil, alkaline hydrolysed nitrogen (according to Kornfield) – 101 mg/kg of soil, mobile phosphorus and exchange potassium (according to Chyrikov) – 113 and 91 mg/kg of soil, respectively. The scheme of the experiment is shown in Table 1.

Table 1. Experiment scheme

No.	*Factor A* – herbage (types of grasses and seeding rate, kg/ha)
1	Alfalfa, 16
2	Alfalfa seed, 12 + eastern fescue, 10 + meadow fescue, 8
3	Alfalfa seed, 10 + eastern fescue, 10 + orchard grass, 8
4	alfalfa, 10 + Smooth brome, 14 + perennial ryegrass, 10

Table 1, Continued

No.	*Factor B* – fertilisers (nutrients and their doses)
5	Alfalfa seed, 10 + stemless bonfire, 14 + eastern fescue, 8
6	Smooth brome, 14 + eastern fescue, 8 (cereal stand), control
1	Without fertilisers (control)
2	P60 K90
3	N60P60K90
4	N60P60K90 + growth stimulator Fumar

The area of the sown plot is 30 m², the accounting plot – 25 m², the repetition rate of the experiment is fourfold. The technology of growing perennial grasses, with the exception of the factors under study, was the generally accepted one for the Right-Bank Forest-Steppe of Ukraine. The following types of perennial grasses zoned with highly productive varieties were used in the experiment, namely alfalfa (*Medicago Sativa L.*), variety Regina; smooth brome (*Bromus inermis Leyss*), variety Mars; perennial ryegrass (*Lolium perenne L.*), variety Kyivska 101; eastern fescue (*Festuca arundinacea Schreb.*), variety Danka; meadow fescue (*Festuca pratensis Huds*), variety Dibrova; orchard grass (*Dactylis glomerata L.*) variety Natalka.

RESULTS AND DISCUSSION

It is known that the density of any grass stands, including alfalfa-cereals, serves as an important indicator because shoots are an important organ where the leaf surface is formed, which is crucial in the development of the crop (Solyanyk *et al.*, 2000).

According to the data obtained from the study of the density of the herbage, on average for 2014-2016, the total number of shoots in alfalfa, alfalfa-cereal, and cereal herbage ranged between 686-1250 pcs./m² (Table 2). Alfalfa-cereal and cereal stands were characterised by a higher density of 372-541 shoots per 1 m² more in comparison with single-species sowing of alfalfa. By the total number of shoots per 1 m² according to the average data, there was no big difference between the fertiliser options for alfalfa-cereal and cereal stands.However, these stands were somewhat thicker against the background of the introduction of $N_{60}P_{60}K_{90}$ + biostimulator of growth Fumar, that is 41-66 more shoots than without fertilisation.Alfalfa-cereal stands with orchard grass and perennial ryegrass were also thicker. With the additional input to the $P_{60}K_{90}$ of nitrogen in dose N_{60} there was a tendency to reduce the density of alfalfa grass stands and alfalfa-cereal mixtures by 29-84 shoots per 1 m² and an increase – on the cereal stand.

Table 2. Density of shoots of alfalfa, alfalfa-cereal, and cereal stands on different fertiliser backgrounds, pcs./ m² (average for 2014-2016)

Fertiliser	Total, pcs./ m²	Including				
		alfalfa	cereals			mixed grasses
			by components		total	
			1st	2nd		
Alfalfa						
Without fertilisers	756	696	–	–	–	60
$P_{60}K_{90}$	770	715	–	–	–	55
$N_{60}P_{60}K_{90}$	686	611	–	–	–	75
$N_{60}P_{60}K_{90}$+ Fumar	709	642	–	–	–	67
Alfalfa + eastern fescue + meadow fescue						
Without fertilisers	1128	508	303	263	566	54
$P_{60}K_{90}$	1160	517	300	293	593	50
$N_{60}P_{60}K_{90}$	1089	457	316	316	632	45
$N_{60}P_{60}K_{90}$+ Fumar	1169	489	300	337	637	43
Alfalfa + eastern fescue + orchard grass						
Without fertilisers	1194	547	330	263	593	54
$P_{60}K_{90}$	1236	558	338	290	628	50
$N_{60}P_{60}K_{90}$	1202	497	300	360	660	45
$N_{60}P_{60}K_{90}$+ Fumar	1250	523	290	394	684	43
alfalfa + stemless plum + perennial ryegrass						
Without fertilisers	1159	531	300	274	574	54
$P_{60}K_{90}$	1199	540	350	259	609	50
$N_{60}P_{60}K_{90}$	1168	478	355	290	645	45
$N_{60}P_{60}K_{90}$+ Fumar	1202	501	358	300	658	43
alfalfa + plumless + eastern fescue						
Without fertilisers	1246	516	326	350	676	54
$P_{60}K_{90}$	1191	530	311	340	611	50
$N_{60}P_{60}K_{90}$	1154	467	341	301	642	45
$N_{60}P_{60}K_{90}$+ Fumar	1192	497	353	299	652	43
Smooth brome + eastern fescue (cereal stand)						
Without fertilisers	1118	–	998	553	1051	67
$P_{60}K_{90}$	1145	–	500	585	1085	60
$N_{60}P_{60}K_{90}$	1178	–	600	521	1121	57
$N_{60}P_{60}K_{90}$+ Fumar	1184	–	616	515	1131	53
HIP_{05}		26	28	24	20	15

When analysing the density of legume-cereal herbage by components, it was identified that Alfalfa formed the most shoots, the number of which ranged between 457-696 shoots per 1 m^2. The number of shoots in cereal components was lower – each in the range of 263 to 353 shoots per 1 m^2. Therewith, the total number of shoots of two cereal components, which ranged between 574-658 shoots per 1 m^2, was approximately on the same level with the shoots of alfalfa.

Notably, both on single-species alfalfa sowing and in alfalfa-cereal stands for applying nitrogen fertilisers at a dose of N_{60} compared to the background of $P_{60}K_{90}$, the number of shoots of the legume component substantially decreased, which confirms the results of other researchers. In this case, in a single-species alfalfa crop, their number decreased by 104 shoots per 1 m^2, on alfalfa-cereals – by 60-63 shoots per 1 m^2.

However, in the case of using the growth biostimulator Fumar on the background of $N_{60}P_{60}K_{90}$, reducing the number of alfalfa shoots from applying N_{60} was about half as much. Therewith with the intoduction of $N_{60}P_{60}K_{90}$, compared to $P_{60}K_{90}$, the total number of shoots sown as part of grass mixtures of cereals is increased by 31-39 units. This was mostly due to an increase in the shoots of perennial ryegrass, smooth brome, and, especially, orchard grass, the number of which in the mixture alfalfa + eastern fescue + orchard grass increased by 70 shoots per 1 m^2.

An important factor in the development of yield and feed value of grass stands is its botanical composition, which is also determined by soil and climatic conditions, the age of the grass stand, usage regimes and fertilisers. With an increase in the proportion of the legume component in herbage, their productivity increases due to biological nitrogen fixation. Cereal components under conditions of joint cultivation with legumes contain more protein than in single-species crops (Olifirovych, 2008; Prykhod'ko & Kharytonchyk, 2010).

According to the data obtained from the study of the botanical composition of the herbage, on average for 2014-2016, alfalfa dominated the single-species sowing of alfalfa with a share of 88–94% (Table 3). The rest was mixed grasses with a share of 5-12%.

Table 3. Botanical composition of alfalfa, alfalfa-cereal, and cereal stands on different fertiliser backgrounds, % (average for 2014-2016)

[330.131.5: 621.9]:631.55/.86:633.15	Fertiliser	Alfalfa	Cereals by components			Mixed grasses
			1st	2nd	total	
Alfalfa	Without fertilisers	94	–	–	–	6
	$P_{60}K_{90}$	95	–	–	–	5
	$N_{60}P_{60}K_{90}$	88	–	–	–	12
	$N_{60}P_{60}K_{90}$+ Fumar	92	–	–	–	8
Alfalfa + eastern fescue + meadow fescue	Without fertilisers	43	28	23	51	6
	$P_{60}K_{90}$	43	27	25	52	5
	$N_{60}P_{60}K_{90}$	40	25	25	50	10
	$N_{60}P_{60}K_{90}$+ Fumar	41	24	26	51	8

Table 3, Continued

[330.131.5: 621.9]:631.55/.86:633.15	Fertiliser	Alfalfa	Cereals by components			Mixed grasses
			1st	2nd	total	
Alfalfa + eastern fescue + orchard grass	Without fertilisers	49	27	21	48	3
	$P_{60}K_{90}$	50	26	22	48	2
	$N_{60}P_{60}K_{90}$	44	22	26	48	8
	$N_{60}P_{60}K_{90}$+ Fumar	48	21	27	48	5
alfalfa + smooth brome + perennial ryegrass	Without fertilisers	48	28	20	48	4
	$P_{60}K_{90}$	49	29	19	48	3
	$N_{60}P_{60}K_{90}$	43	27	21	48	9
	$N_{60}P_{60}K_{90}$+ Fumar	46	26	22	48	6
alfalfa + plumless + eastern fescue	Without fertilisers	48	22	25	47	5
	$P_{60}K_{90}$	48	23	25	48	4
	$N_{60}P_{60}K_{90}$	42	27	22	49	9
	$N_{60}P_{60}K_{90}$+ Fumar	44	28	21	49	7
Smooth brome + eastern fescue (cereal stand)	Without fertilisers	–	43	47	90	10
	$P_{60}K_{90}$	–	44	49	93	7
	$N_{60}P_{60}K_{90}$	–	50	44	94	6
	$N_{60}P_{60}K_{90}$+ Fumar	–	52	43	95	5
HIP_{05}		3	2	2	2	2

In alfalfa-cereal stands, the share of alfalfa was lower and ranged between 41-50%. Among alfalfa-cereal stands, the smallest amount of it was observed in a mixture of alfalfa + eastern fescue + meadow fescue. The total share of cereals in alfalfa-cereal stands ranged between 47-52%, which was on par with the share of alfalfa. The total share of cereals in alfalfa-cereal mixtures was slightly higher in the same mixture (alfalfa + eastern fescue + meadow fescue), where the share of alfalfa was the largest.

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When analysing legume-cereal stands by components, it was identified that alfalfa was the dominant, the amount of which, as already noted, ranged between 41-50%. In second place in terms of the number of sown crops were cereal components, the share of each of which ranged from 19 to 29%.

Therewith, both on single-species alfalfa sowing and in alfalfa-cereal stands with the introduction of N_{60} compared to the background of $P_{60}K_{90}$ the amount of legume component substantially decreased, which confirms the results of other researchers. Therewith, in single-species sowing, the amount of alfalfa decreased by 7%, and in alfalfa-cereal stands – by 3-6%. However, in the case of using the growth biostimulator Fumar on the background of $N_{60}P_{60}K_{90}$, the reduction of the share of alfalfa from the introduction of N_{60} was about 2% less. Thus, the biostimulator of growth Fumar, although tendentiously, still reduces to a certain extent the negative impact of fertiliser nitrogen on the stability of alfalfa in legume-cereal stands. Therewith, with the introduction of $N_{60}P_{60}K_{90}$, a tendency to increase the total number of cereals in some variants was observed compared to $P_{60}K_{90}$. The amount of mixed grasses in alfalfa-cereal mixtures ranged between 2-10% and there was a pattern that with the introduction of $_{60}K_{90}$ N_{60}, it was the largest.

CONCLUSIONS

Studies established that in the technology of growing legumes and grasses, important elements on which the density and botanical composition of plants depend are a successful combination of their species composition, optimisation of fertiliser backgrounds, and stimulation with the growth biostimulator Fumar.

Sown herbage is formed with a density of 686-1250 shoots per 1 m^2 and a height of 58-148 cm. Alfalfa-cereal and cereal stands are denser than alfalfa ones. For the period from 1 to 3 years of use of herbage, the density of alfalfa shoots decreases, while that of orchard grass and smooth brome increases, and more intensively with the introduction of N_{60}.

During the first three years of use, grass stands are formed with the dominance of sown components with a share of alfalfa in single-species sowing of 85-98%, in alfalfa – cereal mixtures – 30-58%. For the period from 1 to 3 years of use of alfalfa-cereal stands, the share of alfalfa decreases by 11-24%, and more substantially with the introduction of N_{60}. In addition, between the two cereal components, there is a change of co-dominant – from meadow fescue to eastern fescue, eastern fescue to orchard grass, perennial ryegrass to smooth brome, like in the cereal stand, eastern fescue to smooth brome. In the 3rd year of use, ryegrass thins out, reducing the involvement rate to 5-14%.

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Особливості росту і розвитку люцерно-злакових травостоїв залежно від видового складу та удобрення

Анотація. Наведено результати досліджень з вивчення впливу видового складу травостою, рівня удобрення та стимулятора росту Фумар на густоту та ботанічний склад рослин. Експериментальна частина роботи виконана в наукових лабораторіях кафедри кормовиробництва, меліорації та метеорології у виробничому підрозділі Національного університету біоресурсів і природокористування України "Агрономічна дослідна станція". Територія станції розташована в Правобережному Лісостепу і входить до складу Білоцерківського агроґрунтового району. Дослідні ділянки закладені на чорноземах типових малогумусних крупнопилувато-легкосуглинкових механічного складу, які характеризуються високим вмістом поживних речовин. Клімат регіону характеризується нестійким зволоженням та помірним температурним режимом. Середньорічна температура повітря становить 6-8°С. Річна кількість опадів досягає 562 мм, за вегетаційний період - 354-394 мм (63-70% річної норми), які випадають нерівномірно протягом року. На основі проведених досліджень встановлено, що посіяний травостій формується з густотою 686-1250 пагонів на 1 м2 і висотою 58-148 см. Люцерно-злакові та злакові травостої є більш густими, ніж люцернові. За період від 1 до 3 років використання травостою густота пагонів люцерни зменшується, а пагонів стоколосу лучного та лядвенцю лучного - збільшується, причому більш інтенсивно при внесенні N60. Протягом перших трьох років використання формуються травостої з домінуванням сіяних компонентів з часткою люцерни в одновидових посівах 85-98%, в люцерно-злакових травосумішках - 30-58%. За період з 1-го по 3-й рік використання люцерно-злакових травостоїв частка люцерни зменшується на 11-24%, причому більш інтенсивно при внесенні N60. Крім того, між двома злаковими компонентами відбувається зміна співдомінантів - від костриці лучної до костриці східної, від костриці східної до грястиці садової, від райграсу багаторічного до стоколосу лучного, як і в злаковому травостої, від костриці східної до стоколосу лучного. На 3-й рік використання райграс зріджується, зменшуючи частку участі до 5-14%

Ключові слова: люцерна, злаковий травостій, густота пагонів, ботанічний склад, добриво