

Lucerne as stabilizing factor for intensification of feed processing industry

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The purpose. To increase feed productivity of Lucerne depending on application of inoculation of seeds and soil liming at naked way of sowing and application of herbicide. **Methods.** Systems analysis, field, laboratory, mathematical-statistical, comparative-calculation. Soil cultivation — conventional for zone of Forest-steppe. Calculation of dose of CaCO₃ was carried out according to hydrolytic acidity. Weed control spraying — by herbicide Picador in dose of 1,0 l/hectare — was used in the phase of 3-4 ternate leaves. **Results.** It is fixed that application of bacterization of seeds of Lucerne and soil liming on hydrolytic acidity promoted heightening of productivity of grass stand at mowing of three hay cuttings in budding stage and one — in the beginning of flowering. The greatest yield of feed units and crude protein have gained at inoculation of seeds with Rizobofit in combination with Emistim S and importation of full dose of lime on hydrolytic acidity. Obtained data testify to unconditional efficiency of use of probed factors at growing Lucerne for feedstuff. **Conclusions.** Perspectives of use of Lucerne of intense type as major factor of production of high-protein feedstuffs and biological nitrogen as result of its symbiotic fixing from air that will ensure increase of fertility of soil and saving means for fertilizers is justified. For creation of powerful grass stand and heightening productivity of Lucerne it is expedient to inoculate seeds with biological preparations and lime soil at naked way of sowing Lucerne with importation of herbicide.

Key words: *Lucerne, soil liming, inoculation, productivity, crude protein, exchange energy.*

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At the present stage of the development of agriculture, the issue of provision of the population with ecologically safe food products, especially meat, milk and products of their processing are the most urgent. Solution to this problem depends on the effective development of the livestock industry and supply of high quality products, especially from perennial legume grasses as the main source of plant material for the production of bulk feeds in the form of silage, haylage and hay. In order to ensure full-value feeding of highly productive dairy cows and beef cattle, the average energy consumption of bulky feeds from legume grasses and their legume-and-cereal mixtures should contain dry matter of about 10 MJ of ME per kg (0.80 feed units) and more than 16% of crude protein. Such indicators can be achieved through the use of modern harvesting machinery and advanced technologies of feed harvesting in the optimal phases of growth and development of alfalfa, which meet the State Standard requirements for harvesting hay or haylage, etc.

Long-term research and practice have proved long-range prospects of growing alfalfa as the most popular and widespread crop in the world, which, predominates legume-and-cereal mixtures of annual crops by the gross yield of plant products, the content of protein and biologically active substances.

Alfalfa (*Medicago sativa* L) is the best crop by the output of nutrients in the biological group of perennial legumes. Regardless of the soil and climatic conditions, in the phase of the beginning of budding, it contains about 22-24% of crude protein and up to 22% of crude fiber and its content of dry matter per kg is 10.9-11.0 MJ of ME [1]. It is a major component when harvesting high quality coarse feeds, and recently it has acquired its niche in the market of concentrated feed products in the form of granules produced in the early stages of the growth and development of legumes as the main source of vegetable protein, vitamins under almost 100 % consumption. According to I.I. Ibatullin, granulated feeds should be included in the diets of the dairy cows and young livestock for fattening. Grass flour is very popular in poultry farming being a full-value supplement to the diet of small animals used for a long time if it is produced and stored in accordance with the technology.

Its value is not limited only by fodder qualities, since it performs important biological and genetic functions, and it has a symbiotic ability to fix atmospheric nitrogen from the air with the help of nodules and optimal soil acidity (pH 7-8). Alfalfa completely provides itself with nitrogen and it practically does not depend on its contents in the soil and application of synthetic mineral fertilizers, thus it ensures saving of material resources for the purchase and use of mineral nitrogen fertilizers [2, 3].

However, during the years of reformation of the agricultural production, the areas under forage crops in the general structure of arable lands have significantly decreased. An increase in the areas under grain crops, maize for grain and soybean has been observed. In 1990, forage crops occupied 37% or 11,999 thousand ha in the structure of Ukraine's cropping areas. In more than a quarter of a century, the area under them decreased 6.6 times, and in 2017 it was 6.7% (1,826 thousand ha), including their reduction under perennial grasses from 3,752 thousand ha (11.4%) to 950 thousand ha. Such a rapid reduction of the areas under forage crops, including alfalfa, will lead to deterioration of the structure of high-quality feeds and

indicators of soil fertility. Therefore, the expansion of the areas under legume grass will reduce anthropogenic pressure on the agricultural ecosystem and ensure preservation of the environment.

Previous studies conducted by the Institute of Feeds and Agriculture of Podillia of NAAS have proved long-range prospects of non-cover cultivation of alfalfa, which leaves in the soil nearly 600 kg of nitrogen per ha over three years of life and two years of the grassland utilization under optimal agroecological conditions of growth and development [4, 5]. In particular, due to the deeply penetrating rhabdoid and developed root system of alfalfa, the arable soil layer accumulates about 10.8 t of dry root mass per ha with content (kg/ha) of 55.1 N, 13.8 P₂O, 21.9 K₂O [6]. As a result, the soil structure improves and its fertility increases as the main factor when growing all crops in the crop rotation, especially winter wheat, maize for grain, and the aftereffect of its cultivation is observed for three years.

Availability of a sufficient amount of nitrogen fixing nodules effectively influences the growth processes of plants during the formation of the leaf-stem mass yield during vegetation. On the basis of seed inoculation with highly effective strains of nodule bacteria, 15-50% of the symbiotic nitrogen fixing potential is fulfilled and the rest of the reserve can be used when optimizing the conditions of the symbiosis functioning [7].

Therefore, an obligatory farming practice in the adapted technologies of cultivation should be pre-sowing seed treatment with bio-agents, which increase productivity of legume crops from 10 to 30% [8, 9, 10]. In the southern Ukraine, application of Rhizobophyte increases the yield of the leaf-stem mass up to 5-8 t/ha and crude protein content by 1-3%, while pre-sowing seed bacterization with Rhizotorphyne increases it up to 5.5-7.5 t/ha [11].

Taking into account the diverse effect of alfalfa on the physical and chemical properties of the soil, an increase in its cropping area should be the basis of ecological stabilization in the sowings of grain crops, which will enable to save about 200-250 kg of mineral nitrogen per ha when cultivated in the single-species sowings. Therefore, in the current conditions of intensification of agriculture and feed production, it is necessary to conduct in-depth studies on the issues of increasing nitrogen-fixing ability of nodules of legume grasses, and, above all, alfalfa.

The purpose of research is to determine alfalfa productivity depending on seed inoculation and soil liming.

Materials and methods. Field experiments were carried out during 2011-2013 on fields of agrotechnical crop rotation of the Department of Field Forage Crops, Grassland and Pastures of the Institute of Feeds and Agriculture of Podillia of NAAN.

The soils of the experimental site are gray podzol, mid-loamy loess, typical for the right-bank Forest-Steppe and Vinnytsia region. The arable layer of the soil (0-30 cm) has the following agrochemical characteristics: humus content was 2.06% (by Tiurin), alkaline hydrolyzed nitrogen was 62 mg/kg (by Cornfield), mobile phosphorus and metabolizable potassium was 149 and 80 mg per kg of soil, respectively (by Chirkov), salt pH was 5.9, hydrolytic acidity was 1.14 mg-eq. per 100 g of soil.

Soil tillage was generally accepted for the Forest-Steppe zone. The rate of CaCO₃ was calculated by hydrolytic acidity. Crop spraying with a herbicide (Picador at the rate of 1.0 l/ha) was carried out in the phase of 3-4 ternate leaves.

Hydrothermal conditions in the years of research were somewhat different from the long-term indicators and were characterized by insufficient moisture content and an increase in the average daily air temperature compared with long-term data.

The research was carried out in accordance with generally accepted methods "Methods of the field experiment" [12], "Methods for conducting experiments on feed production" [13].

Research results. During the period of formation of alfalfa grass stand in the year of sowing, the duration of the light day must be within 16 hours with the intensity of light of 35-60 thousand lux. According to the studies, such conditions are provided under non-cover way of alfalfa growing and application of specific herbicides [14].

Phenological observations have shown that the growth processes in the growing season of alfalfa were mainly conditioned by the factors that were investigated and weather conditions. As a result, alfalfa of Siniukha variety formed two yields in the year of sowing, the first one in 64 days after full germination in the phase of the beginning of flowering and the second one in the phase of budding.

Formation of a powerful alfalfa grass stand was provided especially by pre-sowing inoculation of alfalfa seed with Rhizobophyte or Rhizobophhte combined with a growth stimulator Emistym C in a complex with soil liming and mineral fertilizers. The effectiveness of these elements was accompanied during the first and second years of life under intensive use of the grass stand. Production processes were passing in the best way when 1.0 of the lime rate was applied under non-cover method of sowing and application of herbicide Picador (active ingredient imazetapir 100 g/l) at the dose of 1 l/ha during the formation of 3-4 ternate leaves, which ensured the increase in the leaf-stem mass at the level of 12.1-23.9% depending on the years of grass stand use.

However, under cyclic use of the grass stand, the mechanism of the effect of biological agents on alfalfa productivity differed during life periods. It has been found that in the first year of the grass stand vegetation under inoculation of alfalfa seeds with Rhizobophyte, the increase in the leaf-stem mass was 2.88 t/ha and it grew up to 4.90 t/ha when combined with Emistym S. But the highest activity of the nodules in the soil microflora manifested in the second year of alfalfa life with more developed root system under uniform

moisture supply of the soil during vegetation. Due to this, alfalfa provided three yields in the budding phase and the fourth yield at the beginning of flowering with the yield of leaf-stem mass at the level of 66.94 t/ha, while the increase was 10.4-16.3%, or 6.15-9.62 t/ha (Table 1).

1. The yield of the alfalfa leaf-stem mass in Syniukha variety depending on seed inoculation with bio-agents

Years of vegetation	Pres-sowing seed treatment	Leaf-stem mass, t/ha	Increase	
			t/ha	%
First year	Without treatment	13.43	-	-
	Rhizobophyte	16.31	2.88	21.4
	Rhizobophyte + Emistym C	18.33	4.90	36.5
Second year	Without treatment	59.05	-	-
	Rhizobophyte	65.20	6.15	10.4
	Rhizobophyte + Emistym C	68.67	9.62	16.3
Third year	Without treatment	53.95	-	-
	Rhizobophyte	58.11	4.16	7.7
	Rhizobophyte + Emistym C	59.30	5.35	9.9
LSD ₀₀₅ : 1 st year – 0.49; 2 nd year – 0.73; 3 ^d year – 0.69.				

In the third year of life, or in the second year of the grassland utilization, the yield of the leaf-stem mass reached 58.11-59.30 tons per ha, or decreased by 10.88-13.64% if conducted in compliance with the regime of grassland utilization. We revealed a decrease in the growth of the leaf-stem mass yield compared to the second year, which was 7.71-9.92% compared to the control without seed treatment with biological agents.

Along with this, the basic requirement for intensive growth and development and passing of processes of photosynthesis by alfalfa in ontogenesis is soil acidity, for which the most favorable indices of pH are 6.5-7.5. Therefore, liming is a necessary farming practice for alfalfa cultivation, especially on the highly acid soils [14], since it reduces the movement of toxic elements of aluminum and manganese [15], while the direct dependence of the productivity and nitrogen fixation of the nodules on the indices of soil solution is established.

Recently, due to the long-term research work of domestic breeders, there have been produced new alfalfa varieties of intensive type, which tolerate soil acidity [16] and have increased nitrogen fixation [17], which are listed in the “State Register of Plant Varieties Suitable for Distribution in Ukraine” and resistant to root rot and prolonged period of productive longevity (3-4 years).

We have found that over three years of life and two years of grass stand utilization, despite its tolerance to soil acidity, alfalfa of Siniukha variety responded positively to soil melioration, had increased productivity under proper terms of grass mowing, which also ensured the steady flow of plant material during long-term use of agrophytocenosis. A significant increase in the leaf-stem mass of alfalfa at the level of 12.0 t/ha or 32.6% was obtained when 1.0 of the lime rate was applied and pre-sowing seed treatment was conducted with the composition of Rhizobophyte and Emistym C, compared with the control without liming and seed treatment (Table 2).

2. The yield of the alfalfa leaf-stem mass in Syniukha variety depending on liming and seed inoculation with bio-agents (on average for three years)

Soil liming	Pres-sowing seed treatment	Leaf-stem mass, t/ha	Increase			
			from seed treatment		from liming	
			t/ha	%	t/ha	%
Without lime	Without treatment	36.77	-	-	-	-
	Rhizobophyte	38.50	1.73	4.7	-	-
	Rhizobophyte + Emistym C	39.58	2.81	7.6	-	-
	On average	38.28	2.27	6.2	-	-
0.5 of the rate by hydrolytic acidity	Without treatment	39.96	-	-	3.19	8.7
	Rhizobophyte	43.19	3.23	8.1	4.69	12.2
	Rhizobophyte + Emistym C	45.02	5.06	12.7	5.44	13.7
	On average	42.72	4.14	10.4	4.44	11.5
1.0 of the rate	Without treatment	42.14	-	-	5.37	14.6

by hydrolytic acidity	Rhizobophyte	46.54	4.40	10.4	8.04	20.9
	Rhizobophyte + Emistym C	48.77	6.63	15.7	9.19	23.2
	On average	45.82	5.52	13.1	7.53	19.6
LSD ₀₀₅ : 1 st year A – 0.49, B –0.49, AB – 0.85; 2 nd year – A – 0.73, B –0.73, AB – 1.26; 3 ^d year A – 0.69, B –0.69, AB – 1.19.						

The obtained data prove undeniable efficiency of the use of investigated factors in the cultivation of alfalfa for forage. In particular, as a result of pre-sowing seed treatment, the leaf-stem mass increased by 6.2-13.1%, or 2.27-5.52 t/ha, however the intensity of grass formation increased when soil liming was applied and the figures were within 11.5-19.6% and averaged 4.44-7.53 t/ha.

The genetic potential of alfalfa agrophytocenoses on the basis of the complex application of agrotechnical methods has ensured complete symbiotic viability and passing of the stages of ontogenesis during the growing period on the background of optimal moisture supply and temperature regime that was based on soil liming with the full rate of lime, pre-sowing seed treatment with Rhizobophyte combined with Emistym C under non-cover growing and herbicide application. Under thorough maintenance of the above-mentioned technological measures, alfalfa of Siniukha variety was the most competitive and ensured the yield of feed units of 8.30-8.66 t/ha with crude protein content at the level of 2.13-2.25 t/ha. The supply of the feed unit with crude protein was 257-260 g, or 192-195 g of digestible protein with an output of metabolizable energy of 100.0-104.4 GJ/ha (9.98-10.0 MJ/kg) [17]. As a result, the maximum amount of biologically fixed nitrogen (299 kg/ha) was obtained, which was 1.87 times more compare to the control (Table 3).

3. The amount of biological nitrogen accumulation by alfalfa and the output of nutrients (average of three years)

Soil liming	Pres-sowing seed treatment	Amount of biological nitrogen, kg/ha	Output of nutrients		
			Feed units, t/ha	Crude protein, t/ha	ME, GJ ha
Without liming	Without treatment	141	6.67	1.54	79.4
	Rhizobophyte	148	6.93	1.62	82.7
	Rhizobophyte + Emistym C	160	7.09	1.67	84.6
0.5 of the rate by hydrolytic acidity	Without treatment	214	7.18	1.74	85.8
	Rhizobophyte	236	7.77	1.94	93.3
	Rhizobophyte + Emistym C	260	8.06	2.03	96.8
1.0 of the rate by hydrolytic acidity	Without treatment	238	7.52	1.87	90.2
	Rhizobophyte	267	8.30	2.13	100.0
	Rhizobophyte + Emistym C	299	8.66	2.25	104.4

Based on the conducted correlation and regression analysis, it has been established that there is a close relationship between the amount of biological nitrogen accumulation by agrophytocenose and leaf mass productivity. So, coefficient of correlation between these figures was ($r = 0,95$), while the adjusted coefficient of determination was ($r^2 = 0,90$). The dependence between the amount of nitrogen fixation and leaf mass productivity can be described by the following equation of regression:

$$Y = -358.5038 + 13.6398 \cdot X \quad (1)$$

where Y – yield of the leaf and stem mass, t/ha;
 X_1 – amount of biologically fixed nitrogen, kg/ha;

Conclusions

Thus, a priority direction of sustainable development of feed production and agriculture is the expansion of areas under perennial legume grasses as the main factor of production of high protein feeds and biological nitrogen due to its symbiotic fixation from the atmosphere, which will increase soil fertility and reduce the cost for mineral fertilizers.

To improve symbiotic nitrogen fixation of alfalfa, it is necessary to inoculate alfalfa seeds with Rhizobophyte combined with the growth stimulator Emistym C on the background of soil liming at the 1.0 rate by hydrolytic acidity), which will ensure long-term grassland utilization.

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